

PRESS DIES TUTORIAL

by MISUMI Corporation

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INTRODUCTION

Accuracy Judgment of Press Dies

In general the dimensional accuracy or the shape accuracy of the product is used as a "measure" of die accuracy. Products that require very strict tolerances, for example, lead frames or IC connectors, etc., are products that require very high accuracy, and dies for producing these are recognized as high accuracy dies. This is a point that no body questions.

Now let us consider where this high accuracy is found in such dies. Since the shapes of punches and dies are transferred to the products, the shapes of punches and dies are produced with high accuracy using multiple cutting and other methods employing profile grinding machining (PG machining) or wire electric discharge machining (W/EDM). Definitely one factor in judging die accuracy is the preparation of the shapes of punches and dies corresponding to the dimensional tolerances of the product.

The preparation of the shapes of punches and dies may also be necessary for maintaining clearances. As the material plate thickness of products becomes smaller, the removal clearance also becomes proportionately smaller. It is very difficult to maintain this uniformly. Therefore, even if the tolerance of the shape and dimensions of the product are large, because small clearances have to be maintained in the case of forming products from thin plates, it is necessary to maintain high accuracy when preparing punches and dies and the assembling position inside the die. It is also possible to say that even the plate material thickness is a "measure" for evaluating the accuracy of the die. Even the accuracy of the shape of products becomes bad with a small change in the mating if the plate thickness of the material becomes small. Of course, the preparation of the shapes of punches and dies becomes important.

Through the preparation of the shapes of the punches and dies, it is possible to obtain satisfactory parts. Since punches and dies are placed as a top die and bottom die, even the guide posts and bushes (guides) that determine the accuracy of the relationship between the top die and the bottom die have very important indirect roles in the die accuracy. Considering that a punch is made into a punch guide using a stripper, this is also related to the preparation of the stripper (inner guide), the stripper bolt, spring, etc.

It is not possible to discuss the accuracy of a die without clarifying what is to be the "measure" of accuracy. For example, one can think of how the inner guide should be. Depending on the accuracy required, even the part used and the method of assembling become different. A die that is prepared without clarifying the details of what is required, even if it looks like a real die, cannot be said to be a high accuracy die.

It is easy to understand once the preconditions have been made clear. For example, if a die is considered with the precondition that a thin material is to be formed, how the die should be formed becomes clear from following the thinking sequence of – small clearance → shape accuracy and surface roughness of punches and dies → die position accuracy → guide preparation.

The accuracy of a die can be said to be determined by the product irrespective of the number of formations of the product that is produced by press formation.

Life of press dies

In press formation, since the growth of removal burrs is the fastest, the time for die maintenance can be determined by the height of the burrs. Therefore, the precondition is the setting of an appropriate removal clearance, and by looking at the removed product, it is possible to judge to some extent the life of the die. Sharp corners on the removal shape are likely to cause chipping and burrs will appear faster. Rounding off corners is well known to be a countermeasure against burrs.

The life of the dies increases in the order of the material of the punches and dies following SKS → SKD → powdered high speed steel → ultra hard alloy. With the same die material, the life increases if the surface roughness of the punch and die is better, and also there will be a difference depending on lubrication. The life becomes shorter if the manner in which the removal scrap falls is close to a state in which chaff gets clogged. Apart from this, the guide of the die set or the stripper guide (sub guide) also affect die rigidity and the dynamic accuracy of the die.

The life of a die can be either the maintenance life (grinding cycle) or the overall life. The overall life can be said to be the life after repeated maintenance lives, and depending on the structure of the die, it may also be difficult to judge. In the case of a solid type die, since the plate becomes thin every time re-grinding is carried out, it is possible to judge the life of the die at one glance. An insert type die is used by grinding only the insert part again and adjusting the level and only the insert part is replaced when the life of the die is reached. Similarly, even when the sub guide, etc., is worn out, only the worn out part is replaced. When this is repeated, it may appear as if the overall life of the die will not be reached for a long time. The method for judging the overall life of the die in such cases is to see the plate. The points to look for are the looseness of the insertion hole and the deformation of the plate. If there is deformation or wear out of the insertion hole, the life is over because it will not be possible to maintain the position accuracy of the inserted part. Regarding the deformation of the plate, during each press formation, the die gets elastically deformed although to a small extent. When the die is used for a long time, this deformation remains in the plate. When this condition happens, even if a new insert part is used, it will not be possible to produce the number of products as before. The overall life can be judged to have been reached if such a maintenance life after such maintenance cannot support production.

When the life of the plate is considered, when the life of the die is to be made longer, the plate should be made thick and it should be tempered, and if a shorter life is sufficient, although the plate is tempered it is made thin, or else, some change is made such as assembling an insert part in a plate that is not tempered. The same is true of the sub guide as well. When the life is to be made longer, a guide bush is used, and when the production quantity is small, the hole in the plate is used as the hole for the guide post.

Dies are used for manufacturing various quantities from very small quantities to very large quantities. It is very difficult to prepare dies with an appropriate life while maintaining the quality. In particular, since even the cost of preparation will be limited in the case of dies for small quantity production, it becomes more difficult to prepare the dies.

Chaff Rising Countermeasures in Punching Work

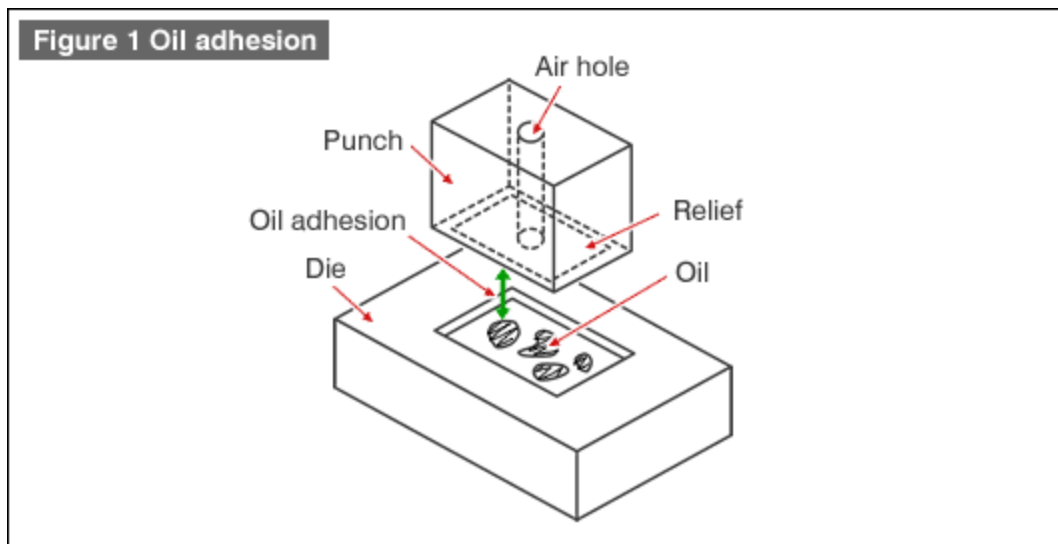
The chaff rising is a defect phenomenon in which the chaff does not remain in the die but rises along the surface of the die. Unfortunately, the fact that countermeasures against burrs have improved and the punching conditions have become better has decreased the frictional force between the punching chaff and the side surface of the die therefore making it easy for punching chaff to rise along the surface of the die.

Cause of chaff rising

The above figures show the main cause. Apart from this, although there are other causes such as magnetism or springing back, etc., their effects are small.

Cause of oil adhesion

The machining oil applied to the surface of the material makes the bottom surface of the punch come into close contact with the material, prevents the inflow of air from the periphery, and raises the material.

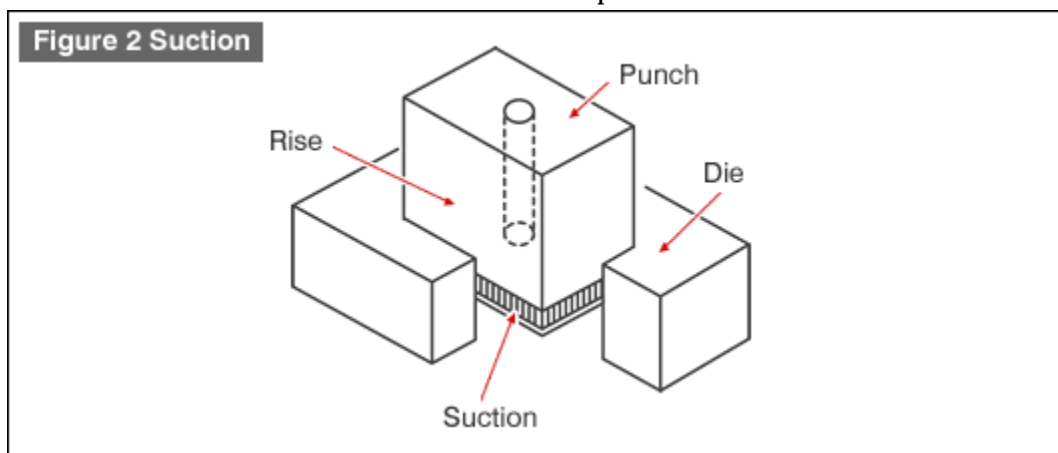


Oil adhesion countermeasures:

- The supply of oil to the material is made large on the side surface of the die and made small on the punch side.
- A relief is prepared on the bottom surface of the punch (the surface that comes into contact with the material) thereby making the contact area smaller.
- An air hole blowing weak air is prepared. (It is better to use this along with the above relief.)

Cause of suction

During the process in which the formation is complete and the punch is returning, the material inside the die becomes a base and the punch becomes a piston, the pressure decreases in the space between the material and the bottom surface of the punch and hence the material is lifted up.



Suction countermeasures

- Since the pressure reduction is proportional to the punch speed, reduce the spm of the operation.
- Open an air inlet hole.

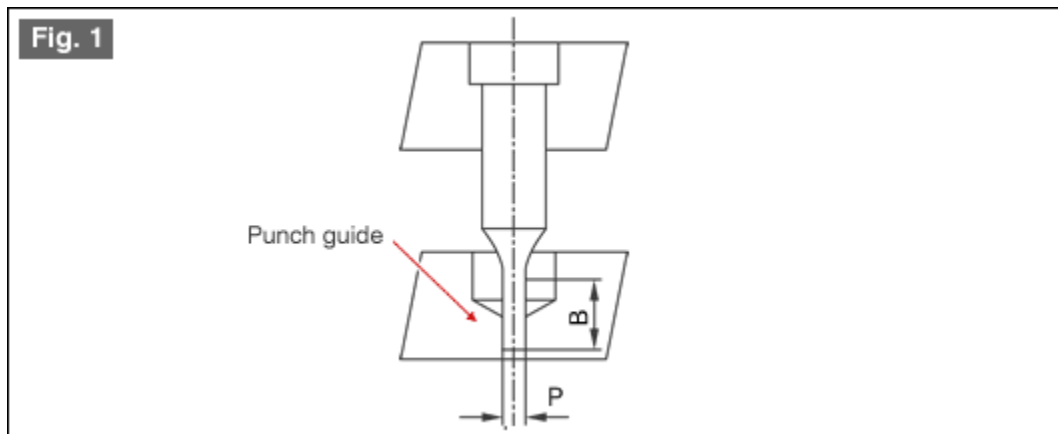
Placing a kicker pin and suppressing the rise of chaff forcibly is a countermeasure that is effective for all chaff rising irrespective of the cause. We have discussed here only other countermeasures that are possible.

DESIGN OF A PUNCH AND DIE FOR SMALL DIAMETER HOLE PUNCHING

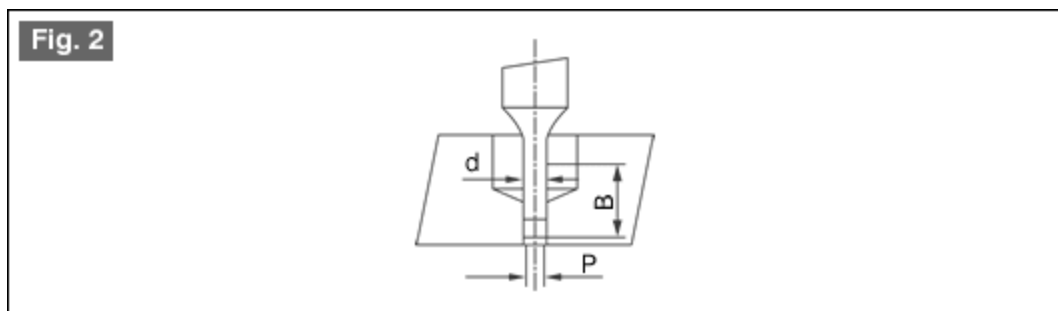
Here, punching small diameter holes assumes a size of roughly less than 1,0 mm in diameter. Also, it is assumed that holes of about \varnothing 1,0 mm are punched in materials with a plate thickness of around 1,0 mm.

Design of the punch

For the sake of preservation, the tip of a punch for hole punching is guided (punch guide) by a stripper as is shown in Fig. 1 thereby preventing the punch from breaking. A guide for the relationship between the dimensions P and B of the punch is a maximum length B less than or equal to $10P$ ($B \leq 10P$). In the case of small diameter punches, the dimension B becomes short and punch guiding becomes difficult.



As a preventative measure for this, a two stage punch is used as is shown in Fig. 2. The dimension d above P will be $d \leq P + 2t$. The reason for this is to avoid causing any deformations in the hole when the punch is withdrawing from the material. The length of the guide at the tip of the punch is – guide length \geq punch diameter. Also, the gap between the punch and the stripper should be 0,003 or more at each side. The reason for this is that 0,003 is the minimum gap that does not cause the oil film to break. It may also be good to wrap the side surface of the punch and make it clean.

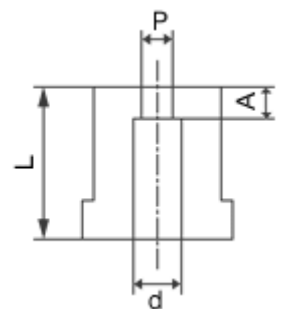


Design of the die

The key point in die design is to make sure that no chaff gets clogged in the die hole. The reason for this is that the force for pushing down the chaff is quite large and the force for punching the hole becomes considerably large.

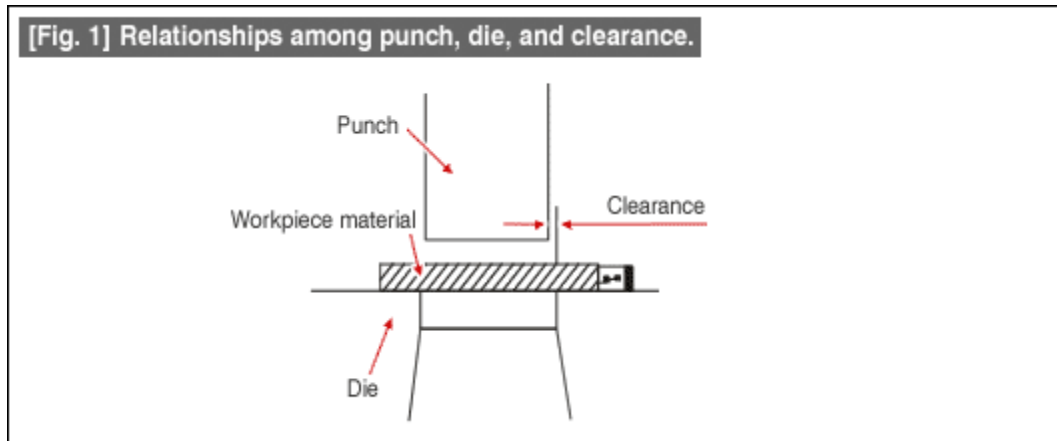
See Fig. 3

As a countermeasure, make the length of the punch tip (A) as short as possible. Also, it is better to remove the punching chaff after punching each hole. Also, as a rule, the chaff dropping hole (d) should not be made too large with respect to the dimension P . At this time, as the dimension d is being made smaller, at the same time the length (L) of the die should also be made smaller. This is a countermeasure against clogging. The clearance should be made larger than normal. This is for reducing the punching force as much as possible. If the punching of small holes is done at a normal clearance, the shear surface will be drawn out longer. This is due to the fact that the punching chaff has gotten crushed.

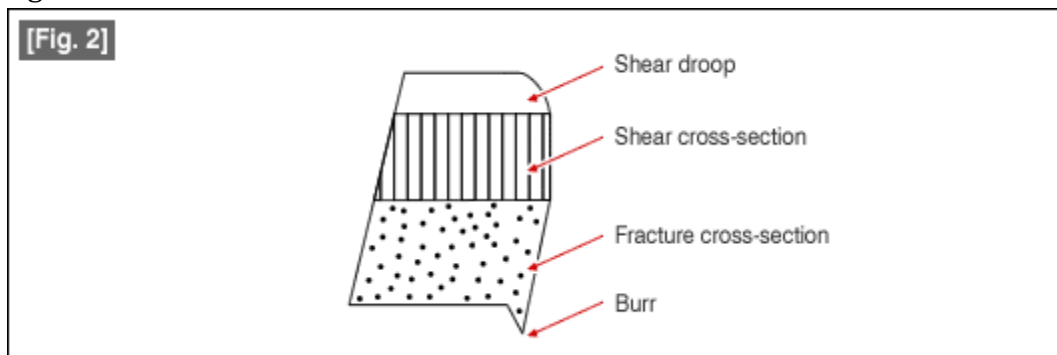


Clearance in the Blanking Operation

Clearance is the gap between the punch and the die as shown in Fig. 1.



If the clearance becomes large, although the force necessary for blanking will be small, the shear droop of the cut cross-section and the inclination of the fracture cross-section shown in Fig. 2 both become large.



The clearance values of the blanking operation are given in Table 1.

[Table 1] Blanking clearance for different materials (as a % with respect to plate thickness)

Material	Precision blanking	Ordinary blanking
Soft steel	2...5	6...10
Hard steel	4...8	9...15
Silicon steel	4...6	7...12
Stainless steel	3...6	7...12
Copper	1...3	4...7
Brass	1...4	5...10
Phosphor bronze	2...5	6...10
German silver	2...5	6...10
Aluminum (soft)	1...3	4...8
Aluminum (hard)	2...5	6...10
Permalloy	2...4	5...8

1. For ordinary blanking, a larger clearance value is used as the plate thickness increases.
2. A smaller value is used when the blanking conditions are good such as for round holes, etc.
3. A larger value is used when the blanking conditions are bad such as for square holes, etc.
4. Secondary shear occurs easily if a small value is used for thick plates or for hard materials.
5. Use a small value (use precision blanking, if possible) in the case of cutting operations.

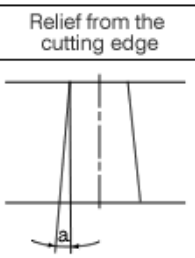
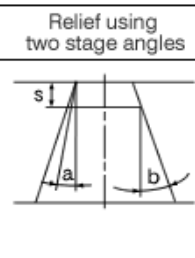
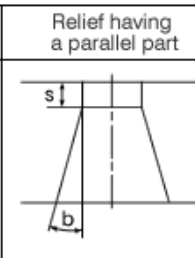
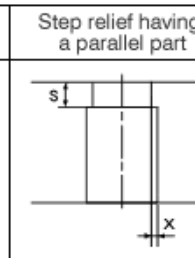
Conventionally, although it was considered good to prepare so that the clearance is uniform in all parts, recently it is considered good to change the clearance partially to suit the changes in the cutting conditions, thereby taking measures against wear of the punch and die, and against distortion of the product.

Shape Design of Blanking Dies

In a blanking die, the material that is blanked out passes through the die and falls down. This part (the die cross section) is composed of a cutting edge section, a land part (also called a parallel part), and a relief part (also called the second part). While the land part is prepared foreseeing a margin for re-grinding, the following problems occur if this is made too long.

1. The side surface wear to the land part becomes severe and it becomes easy for burrs to appear.
2. Bending of the blanked and dropped product becomes large.
3. During hole punching, the pressure for pushing down the punching chaff becomes large increasing the load on the punch (causes breakage of the punch).
4. Scraping and seizing can occur and can easily cause clogging

Figure 1 shows the side surface shapes of the blanking dies.

[Fig. 1] Shapes of blanking dies			
Relief from the cutting edge	Relief using two stage angles	Relief having a parallel part	Step relief having a parallel part
			
Plate thickness: Less than 0.55 $a : 6^\circ \sim 12^\circ$ Plate thickness: 0.55 or more $a : 10^\circ \sim 20^\circ$	Plate thickness: 0.5~3.0 $s : 2.0 \sim 8.0$ $a : 6^\circ \sim 10^\circ$ $b : 1^\circ \sim 2^\circ$	Plate thickness: 0.5~3.0 $s : 2.0 \sim 8.0$ $b : 1^\circ \sim 2^\circ$	Plate thickness: 0.5~3.0 $s : 2.0 \sim 8.0$ $x : 0.2^\circ \sim 1.0^\circ$

Explanation of Blanking Die Shape

Relief from the cutting edge

This is used very frequently at the time of forming the die using wire electric discharge machining. The cost of production will be low. Considering the widening of the die due to re-grinding, a smaller clearance is used.

Relief using two stage angles

Although this is a tedious shape to manufacture, this is an ideal shape because there is no difficulty in the passage of blanked material. This is used very frequently in precision dies in order to form thin plate materials.

Relief with a parallel part

This can be said to be the standard type of die shape. This is used frequently in dies for small to large production quantities of ordinary products. For small production quantities, the use of the "relief from cutting edge" is most common.

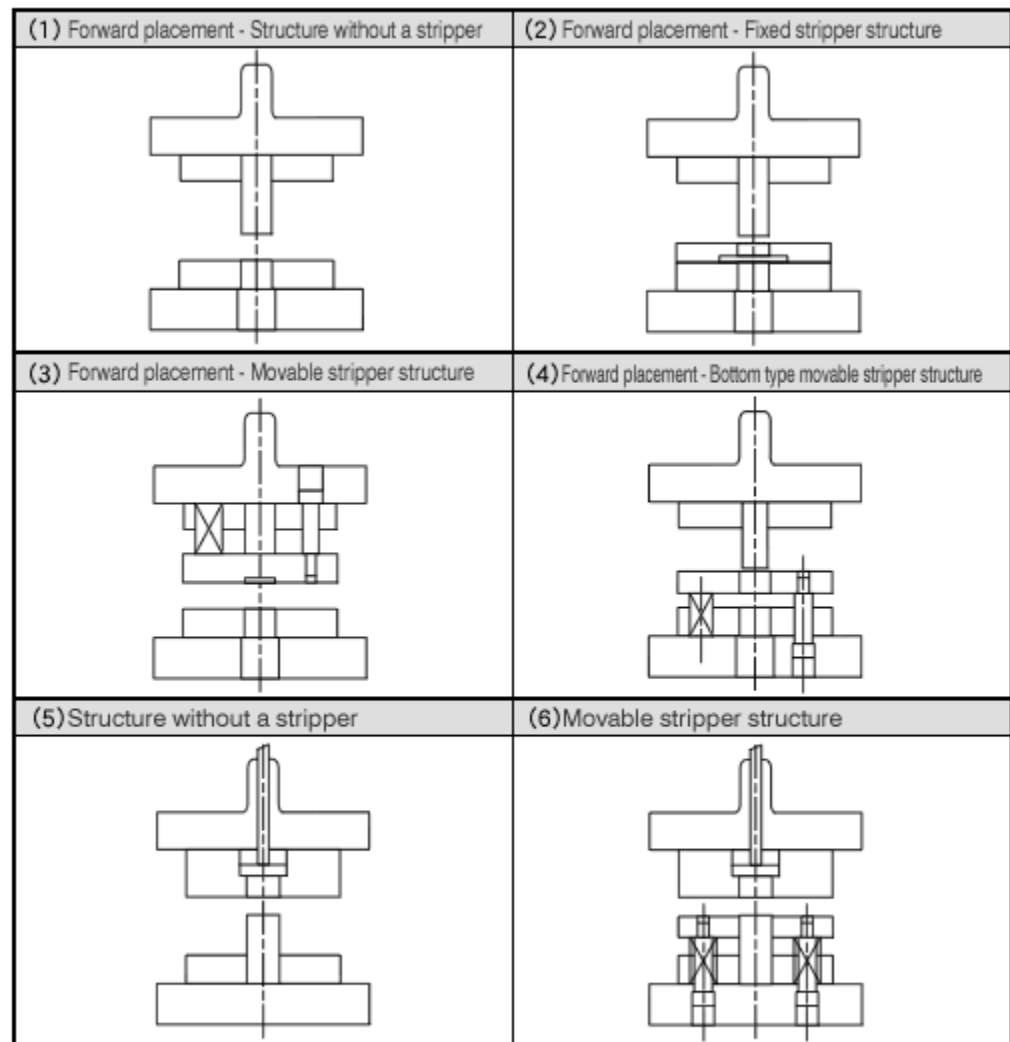
Step relief

This is very frequently used in the case of small shapes such as hole punching, etc. If the step relief is made halfway (about twice the round hole diameter) it makes clogging occur easily. It is better to make the step difference either very small or very large.

BASIC STRUCTURE OF DIES

Punches and dies are very important items in press working. The next item would be stripers. Naturally, the structure of dies is centered on these three elements. Figure 1 shows the orderly arrangement of these three elements.

[Fig.1] Basic structure of dies



The basic structure of a die can be organized in an orderly manner according to the position relationship (top or bottom) between the punch and the die, the presence or absence and the method of using a stripper. The complex structure of a compound die is a combination of these basic structures.

The details of Fig. 1 are summarized by the following two items. The corresponding structures are explained below.

1. *Positions of the punch and die*

Forward placement is one in which the punch is above and the die is below, and the reverse placement is one in which the punch is below and the die is above.

2. *Presence or absence and placement of a stripper*

This is whether the stripper is on the punch side or on the die side, and whether it is of the movable type or of the fixed type.

Forward placement

Structure without a stripper

This is used for work in which the material pressure plate is not necessary and there is no worry of the material biting the punch. This is used in quite a large number of applications. For example, this is used in V-shaped bending dies, extruding and dropping type dies that do not need a wrinkle preventing pressure plate, etc.

Fixed stripper structure

This is a structure in which the stripper is on the die side and is fixed to the die. A typical use of this type of structure is the die for blanking work. This is used when a material pressure plate is

not necessary but the material is likely to bite the punch. This is also used in dies for progressive bending or extruding work. Although the structure is simple and easy to use, but since the working part of the material cannot be seen because it is covered by the stripper, the unnecessary part of the stripper is cut out thereby making the working part visible.

Movable stripper structure

This is usually called the movable stripper structure, and is a very well known structure. This is the type in which the stripper is movable and is on the punch side. This structure is used when a material pressure plate is required and also the material bites the punch. This structure is used very frequently in hole punching dies or progressive punching work. This is also considered to be a type of die structure for precision work. In a die for precision work, the stripper is guided by a stripper guide post (pin) thereby restricting the movement of the stripper. Further, the punch tip is guided by the stripper thereby enhancing the relationship between the punch and the die.

Bottom type movable stripper structure

This is a structure in which the stripper is movable and is on the die side. This structure is used during bending work when a material pressure plate is not required but is necessary to take out the product that has gotten stuck to the punch. This is because it is possible to create a space for inserting the material into the interior of the die by making the stripper movable. This is also used for progressive extruding work.

Reverse placement

Structure without a stripper

This is a structure in which the punch is below and the die is above. In a reverse placement structure a knock out is always necessary in the die. A knock out is a part for the purpose of ejecting a product from the die that has gotten inside the die. This structure has no stripper and is frequently used in trimming dies for extruded products

Movable stripper structure

This is a structure in which a movable stripper is attached on the lower punch side. This structure is used for work requiring a material pressure plate. In addition, since the material passes by sliding over the top surface of the stripper, this surface is also used as a material guide. Since a knock out can also be used as a material pressure plate, it is frequently used for work requiring flatness, or in dies for extruding work.

Even with the same work, the quality changes when the die structure is changed. This is in cases such as when a material pressure plate is not used although it was necessary. On the other hand, care should be taken because the die can be made expensive by pressing the material when a material pressure plate is not required.

The structure should be designed to match the functions necessary for the work.

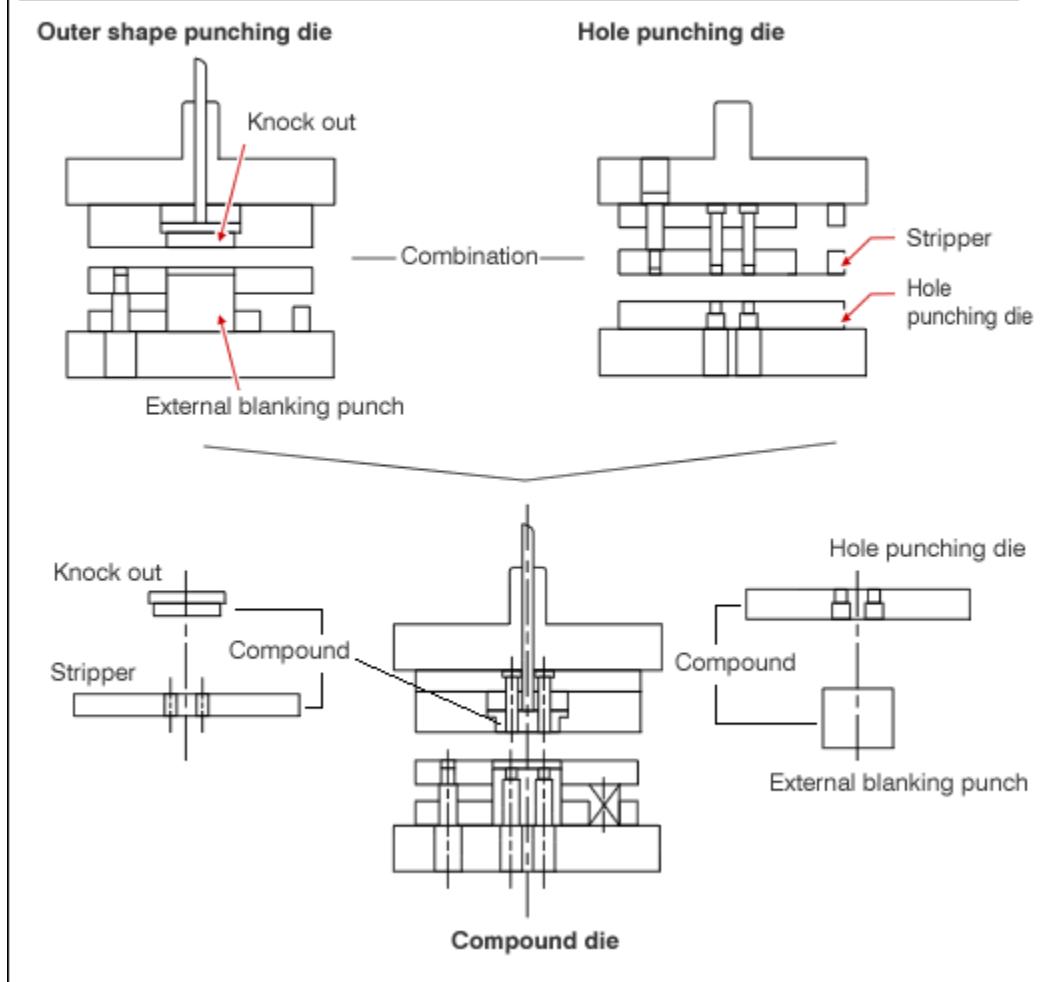
METHOD OF PREPARING COMPOUND DIE STRUCTURES

The structure for compound work such as compound blanking or blanking and drawing, etc., is made by combining the basic die structures. In such work, the outer shape (the blank) is prepared, and then additional work is made on it (such as hole punching, or drawing (extruding)).

In general, very often during such work the blank is punched upwards and the additional hole punching, etc. is done downwards. The basic die structures that permit such work are selected respectively and combined thereby creating a compound die structure.

An example of a compound die is explained below. See [Fig. 1].

[Fig.1] Method of preparing a compound die structure (example of a compound blanking die)



In compound press work, the die carries out external shape punching and hole punching simultaneously. This is used because of its good aspects such as a good positional relationship between the external shape and the hole, even good flatness of the product, and that the direction of burrs is the same in the external shape and the hole. Apart from this, there is also the advantage that the process can be shortened. However, since there is the disadvantage that, since the product enters the die (the top die), problems in taking out the product can easily occur.

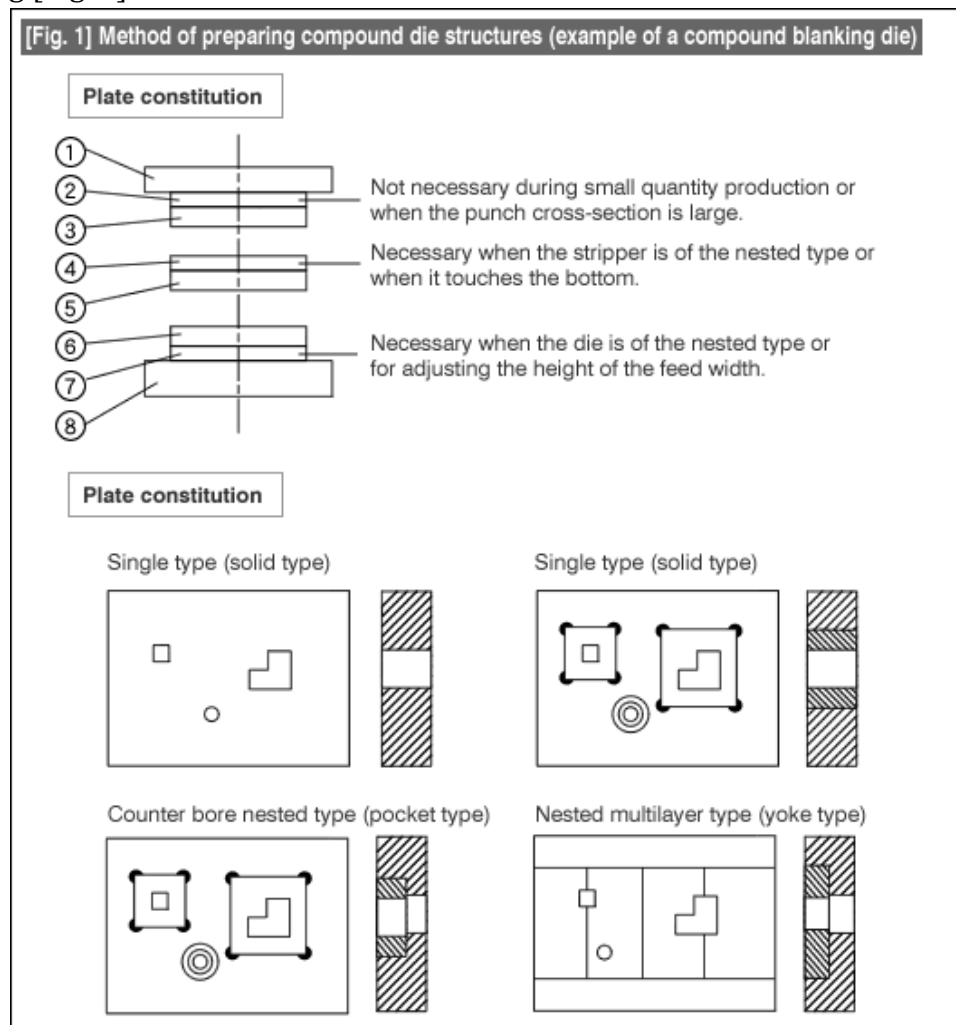
The external shape forming work in [Fig. 1] uses a reverse placement variable stripper type structure and the product is removed upwards. Hole punching is done as usual downwards using the forward placement variable stripper type structure. Because of this relationship, the problem of processing the scrap in hole punching will not be there. These two types of dies are combined into one unified structure. During such unification, the parts that are not common are left as they are. Two of each of the parts that interfere with each other, the external shape blanking punch, the hole punching die, the stripper, and the knock out are combined together and made into single parts. Such parts are called compound parts. The compound die structure is completed because of using these parts.

When interfering parts are unified at the time of carrying out compound work, a judgment should be made as to whether the shape is suitable as a part of the die and as to whether there is any problem in terms of the strength, and the compound die is realized if there is no problem.

Since compound blanking or compound drawing or extrusion are used very frequently, even their structures are found in reference documents and they are used in a manner similar to ordinary dies, and hence these types of structures are used. Even compound dies for hitherto unknown compound works can be prepared using the procedure as described here.

PLATE CONSTITUTION AND PLATE FORM OF DIES

Plate constitution is one of the elements that determine the structure of a die. The plate constitution has a deep relationship to the method of preparing the major plates of a die. The details are explained using [Fig. 1]



The maximum number of plates constituting a die is 8 (excluding compound dies or shoes, etc.).

The basic constitution has the five plates of – (1) punch holder, (3) punch plate, (5) stripper plate, (6) die plate, and (8) die holder.

When the punch is big, it is also possible to omit the punch plate and the punch holder and to attach the punch directly to the shank. In this case, the constitution will consist of the three plates of the stripper plate, the die plate, and the die holder. Even the stripper plate is not necessary in dies such as bending dies, etc., and the constitutions can have only two plates. However, such plate constitutions are a minority and most have a constitution of five plates and possibly an additional backing plate. While the main function of a backing plate is that of backing up the punch, etc., it is also used for fixing nests, or for adjusting the height, and sometimes as a bottom touching plate.

A factor that decides whether or not a packing plate is necessary is the form of the plates. Packing is not necessary, as can be understood from the figures, in the cases of the solid type, pocket type, or yoke type. Among these three types of plates, recently the solid type is being used more frequently. The other two types are not used as frequently.

In the case of the insert type, since a different part (nested part) is assembled inside the plate, it is necessary to fix the nested part or to back it up, and a backing plate becomes necessary.

As is clear from the above explanation, the plate constitution will have a larger number of plates and very often 8 plates in the case of dies using insert type plates such as the die or stripper

plates, that is, in the case of the so called precision type dies.

When the plate constitution has a fewer number of plates, naturally, it is possible to prepare the die cheaply. The plate constitution is determined by judging the method of using the die (whether the number of pressing operations is large or small) or the accuracy of the die.

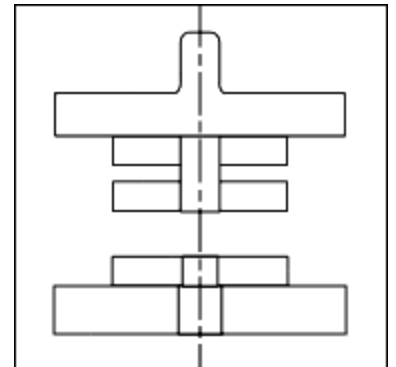
Change in Die Structure Depending on the Guides

The die for press work is made of a top die and a bottom die. If the relationship between the top die and the bottom die is not correct, either the press work cannot be made properly or repairs will become necessary early on. This relationship is created by what are called guides. Such guides are called die matching guides or cutting edge matching guides. The well known form of such a guide is a die set. However, a die set is one form of a cutting edge matching guide. The various forms of guides are explained below while referring to the figures.

STRUCTURE OF DIES: CHANGE IN DIE STRUCTURE DEPENDING ON THE GUIDES

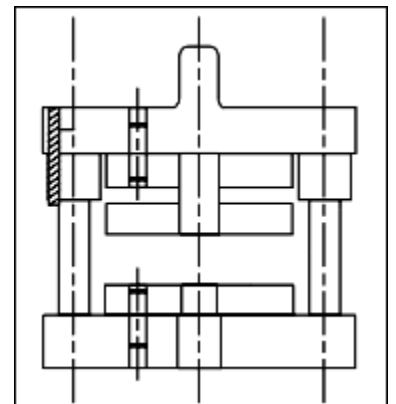
Structure without a guide

Although it may appear strange that this structure appears in the explanation of guides, there are dies with a structure in which the relationship with the die is created directly by the punch. Further, this structure shows the basic form of a die. Guides are secondary structures. Because of the presence of guides, it becomes easy to install the die in the pressing machine, or the assembly of the die becomes easy, or the accuracy during press operation (the dynamic accuracy) becomes better. The die can be used even if there are no guides and the pressing work can be carried out.



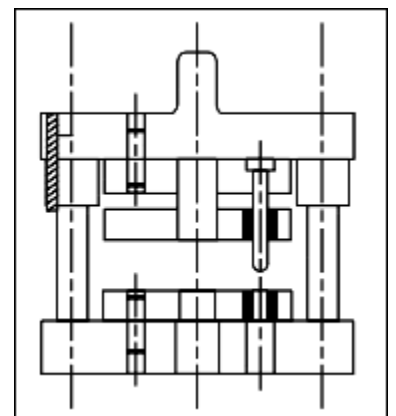
Outer guide structure (die set structure)

This is the most basic guide structure. This was developed for the purpose of making the assembly of the die and the installation of the die in the pressing machine easy. This structure is called the outer guide structure because the guiding is done on the outer side of the plate. The relationship between the punch and the die is established by a coupling using a dowel pin (knock pin). The accuracy of the relationship between the punch and the die is determined by how the dowel pin is inserted.



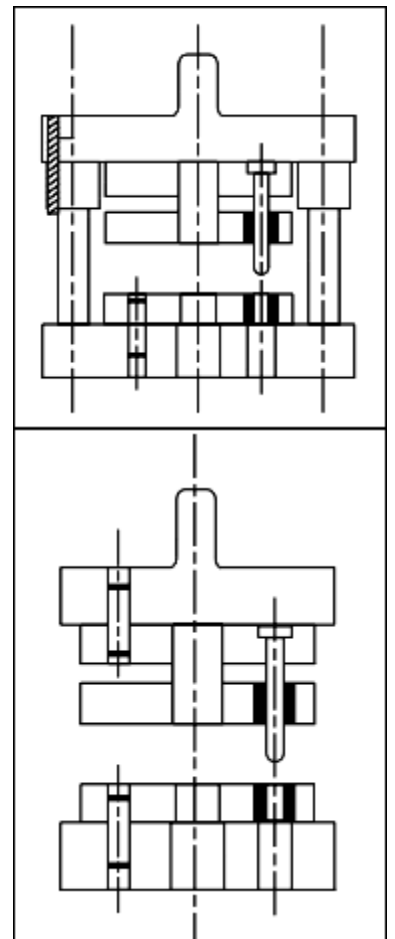
Additional inner guide structure

This is a structure that is a die set structure to which an inner guide (sub-guide) has been added. A guide that is inside the plate and guides the movement of the die relative to the punch is called an inner guide. The inner guide restricts the movement of the stripper plate and increases the accuracy. The inner guide determines the relationship between the punch and the die. The accuracy increases because the relationship between the punch and the die is maintained without needing a coupling through a dowel pin. On the other hand, it is difficult to manufacture. Since a dowel pin is present in this structure, there may be problems due to interference between the outer guide and the inner guide.



Structure without a dowel pin

Interference with the dowel pin may occur if an inner guide is added to a die set structure. In order to avoid this interference, it is better to remove the dowel pin, and hence this is a structure in which the top or the bottom dowel pin has been removed. It is very common to remove the dowel pin from the top die.



Inner guide structure

A guide is a part that establishes the relationship between the punch and the die. A dual structure is one in which the guiding is done by both an outer guide and an inner guide. The inner guide structure is one in which there is only one guide that is the inner guide that can guide directly while eliminating the outer guide. This structure is suitable for small dies. In a large guide, separating the top and the bottom is very difficult.

Quick die change unit

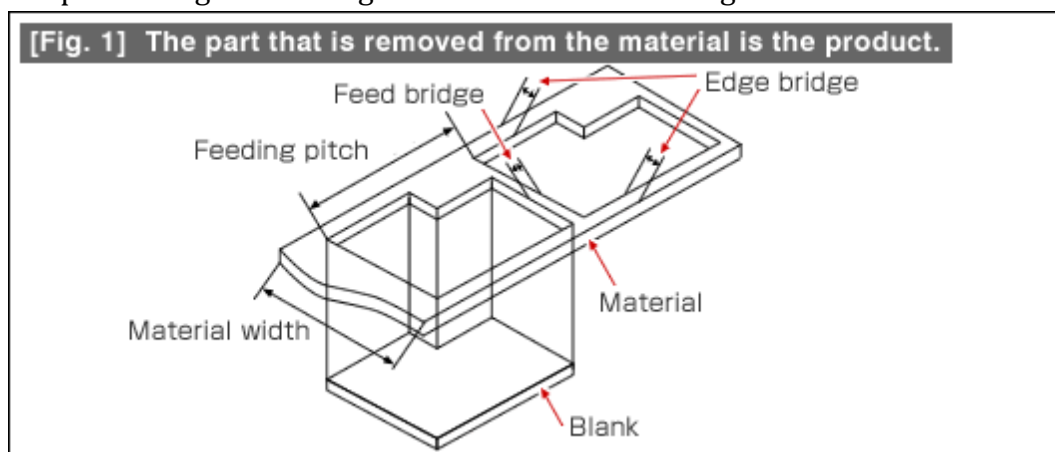
There is a quick die change unit that is used in single preparation stage, etc. This structure can be considered to be one in which only the inside of the die set of the die is a unit that is exchanged. Since a dowel pin having some looseness is used, it cannot be used for dies with small clearances (but can be used if there is an inner guide).

A guide does not function completely if it is only put there for the sake of its form. Guides should be used considering the accuracy of the die and the purpose of using the guides.

BASICS OF BLANKING WORK

Blanking Work

The basics of blanking work are blanking using a press. In blanking work, very often the contour shape of the press fabricated product is formed. The work of forming the contour shape is called external shape forming or blanking work. This is shown in Fig.

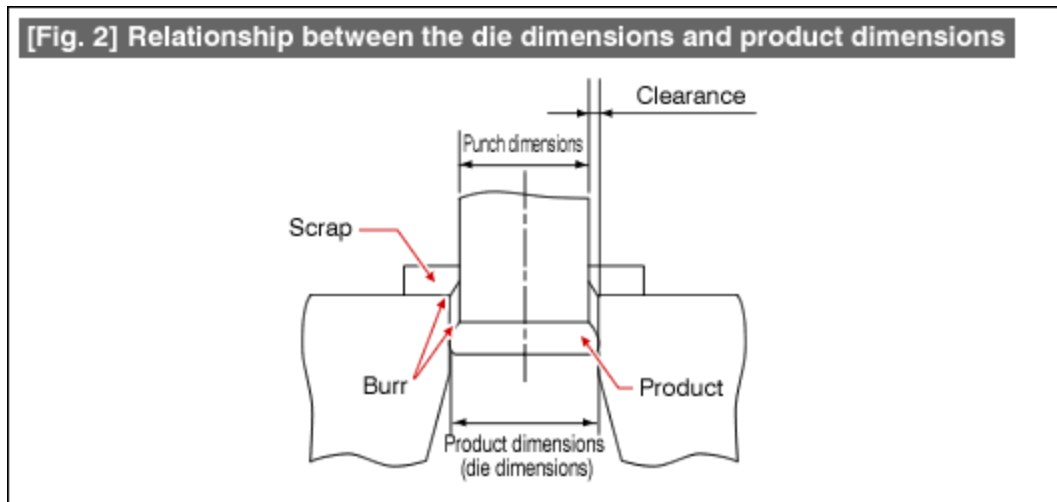


The material is made a little larger in order to prepare blanks. The part by which the material is made larger is called the "bridge". Bridges are of two types, namely, the "feed bridge" and "edge bridge". A guideline for the minimum value of the width of a bridge is as follows:

- Feed bridge = $1.5t$ or $0,7\text{mm}$,
- Edge bridge = $1.5 \times \text{feed bridge}$.

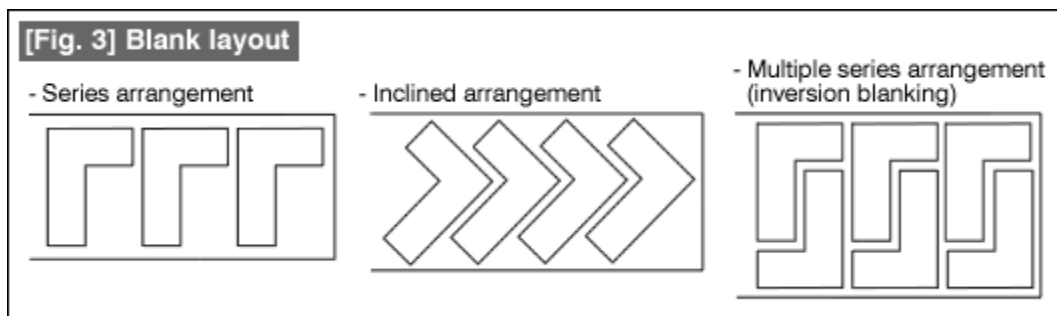
In the case of shapes that are circular or with short straight line parts, it is also possible to make these a little smaller than the above. If the bridge width is made too small, it may not be possible to blank properly, or the wearing out of the punch and die becomes more rapid causing the generation of burrs. The feed pitch and the material width are obtained by adding the feed bridge and the edge bridge to the dimensions of the blank. The bridge widths are adjusted so that these two become integer numbers.

The relationship between the blank dimensions and the dimensions of the die is very important. Making a mistake in this can have very serious consequences. This relationship is shown in Fig. 2.



In blanking work, the blank (product) dimensions are made the die dimensions. The punch will be made smaller by the amount of the clearance. The blank enters inside the die. The method of taking out the blank that is inside the die can be either taking it out by making it pass through the die or by taking it out from where it entered by pushing from inside the die. A part of the die that pushes the blank is called a knock out. Take care also about the direction in which burrs are generated during blanking work. (See Fig. 2.) Depending on the product, very often it is required to make the direction of burrs the same in the outer shape and the holes.

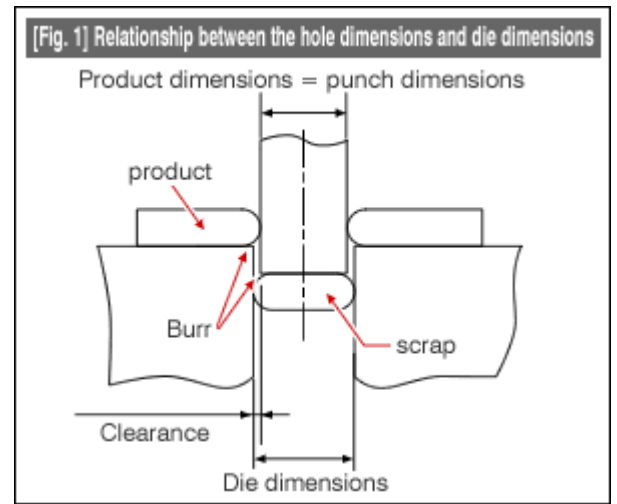
The arrangement of blanks during blanking work is called the blank layout (how blanks are taken from a plate). Some examples of this are shown in Fig. 3. The rate of utilization of the material differs depending on the arrangement. The arrangement is selected so that the material is not wasted.



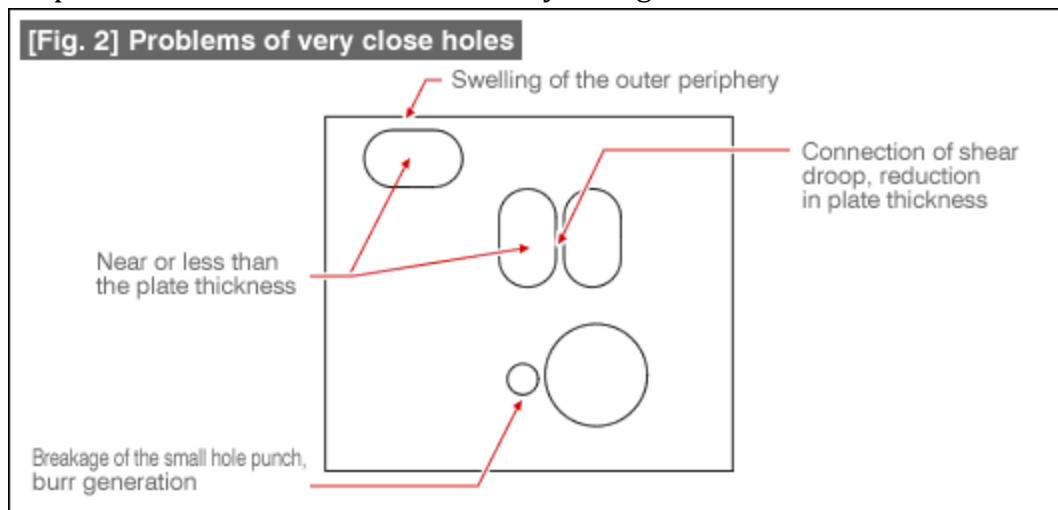
Hole Punching Work

Hole punching is another type of basic blanking work. It is good to know the setting of condi-

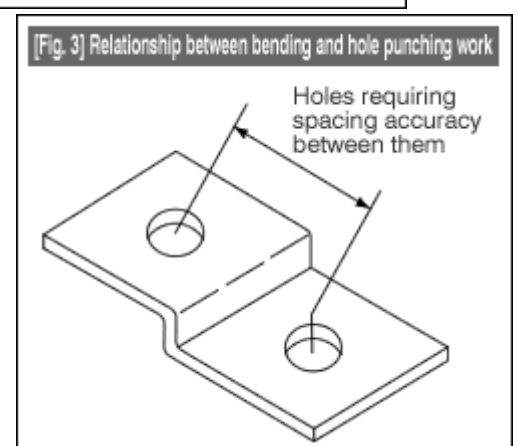
tions and the problems when carrying out this work. Although hole punching is the same as blanking work, the settings of the conditions of the die are different. The details of this are shown in Fig. 1. The punch dimensions are made equal to the dimensions of the hole to be punched. Further, a clearance is given in the die. This is the opposite of the settings in the blanking operation. The product remains above the die. The scrap passes through the die and falls down. In general, in order to make sure that the product does not warp due to hole punching, very often the die is made with a movable stopper structure. This is done in order to allow the material pressing member to move.



Care should be taken during the hole punching operation when the condition is as shown in Fig. 2. This is because the problem shown in Fig. 2 can occur. When there is some effect on the product such as deformations, etc., it is necessary to take precautions in order to avoid these. It is desirable that the problems shown here are avoided by taking countermeasures with the dies.



If the accuracy of the relationship is necessary in the position with a bend in between as is shown in Fig. 3, if the work is done before bending, the dimensions will vary causing problems. The process is designed so that the sequence is "Blanking → Bending → Hole punching" thereby eliminating the cause of variations.

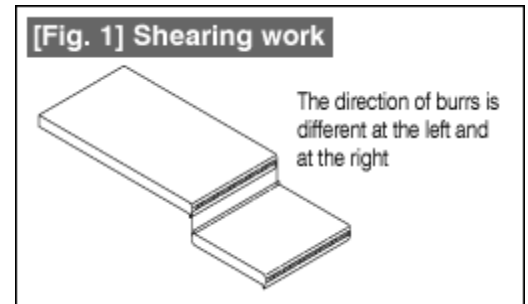


In a similar manner, quite often it is not possible to do all the work simultaneously, such as when there are a large number of holes. In particular, the following precautions should be taken in such cases – (1) Making all the holes requiring relationship accuracy to belong to the same group; (2) Separate when there is the possibility of breakage due to very close holes; (3) Carry out the work in the sequence of "rough holes → holes requiring accuracy", etc. The reason for punching holes requiring accuracy after rough holes is to make sure that the hole does not get deformed due to the effects of the sideward force during hole punching when the holes are very close.

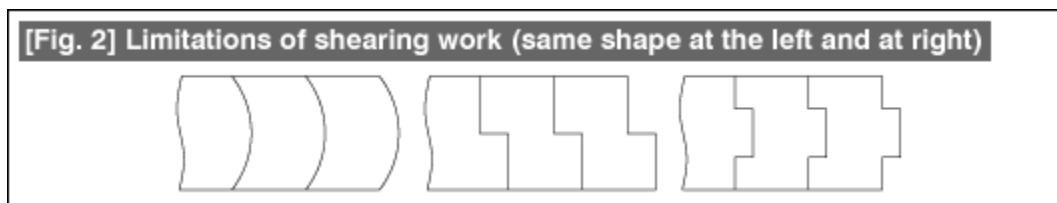
Cutting Operation

Cutting operation is a simple type of shearing work. If this method is used, it is possible to carry out work with a good yield using a simple die.

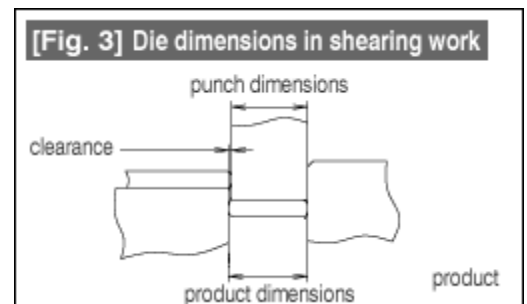
Figure 1 shows a cutting work. The material is cut along a single line. Because of this, the direction of burrs after cutting at the left and at the right will be opposite to each other. Depending on the product, this method may not be able to be used because of the specifications of the direction of burrs, but if this method can be used, it is possible to carry out work without any scraps thereby making the rate of utilization of the material very high.



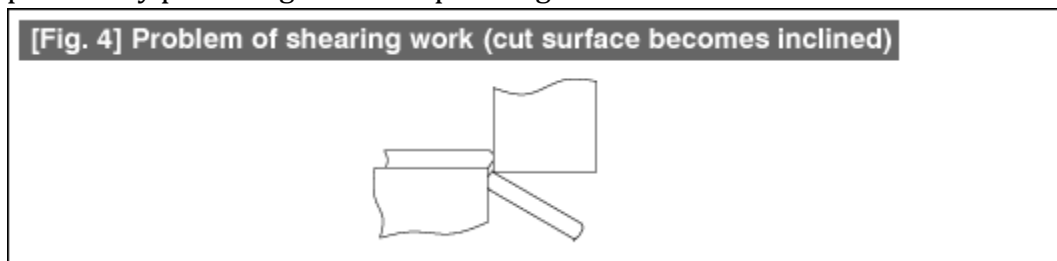
There are limitations such as those shown in Fig. 2 in carrying out the work along a single line. In other words, the shapes should be the same at the left and at the right. Some times it is possible to carry out shearing work by slightly changing the product shape therefore it is desirable to use shearing work.



The relationships among the punch, die, and clearance in shearing work will be as shown in Fig. 3. The product dimensions will be shorter than the length of the feed by an amount equal to the clearance. Among blanking operations, the method of setting the clearance is special only in this type of work, and hence care should be taken in regards to this. The reason for this is that the work is done along a single line.



Another cause of trouble due to working along a single line is shown in Fig. 4. Since this is a one sided piece, because of the bending moment generated at the cut part, the material below the punch becomes inclined. If the cutting is made as it is in that condition, even the cut surface of the product becomes inclined. As a countermeasure, the size of the clearance is made less than half the clearance of normal blanking operations. As a strong measure, the inclination of the material during working is suppressed by providing a reverse pressing member in the die.



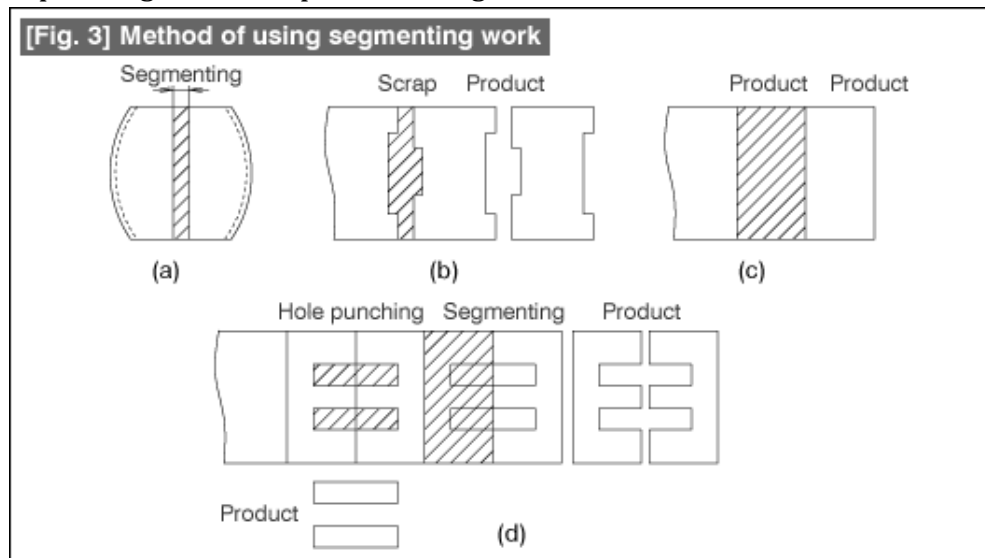
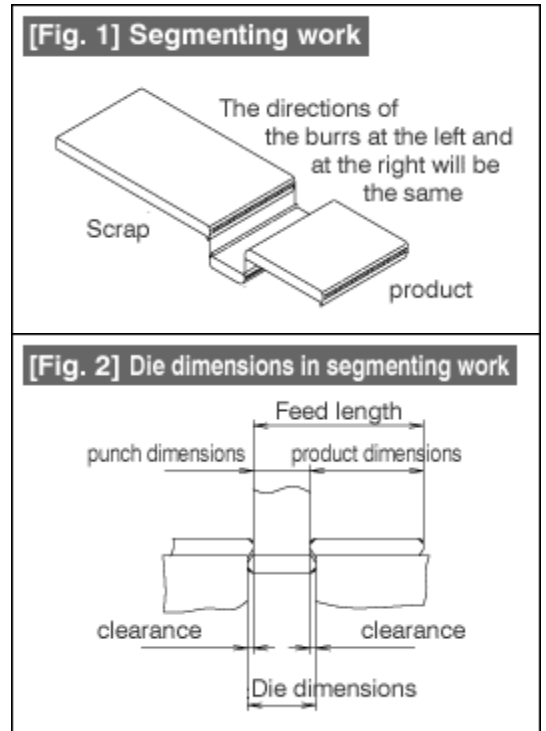
If a simple method of work can be used, even the preparation of dies becomes easy, and the cost gets reduced. It is important to review one's work by remembering the basics.

Segmenting Work

Figure 1 shows a diagram of realizing segmenting work. This is very often compared to cutting work because it is quite similar. While the directions of the burrs at the left and at the right of the product or opposite to each other in cutting work, these directions will be the same in segmenting work. On the other hand, scrap will be generated since the work is done along the width (along two lines). The rate of material utilization becomes somewhat poor compared to the cutting operation. Basically, this method is used when the directions of the burrs at the left and at the right have to be made the same.

The relationship between the die dimensions and the product dimensions will be as shown in Fig. 2. The feed length (the feed pitch) will be equal to the product dimensions + the punch width. Any fluctuations in the feed length will appear as they are in the product dimensions. The clearance is made on the die side.

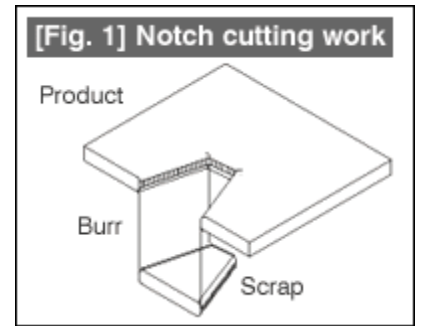
Figure 3 shows a method of using the segmenting work. Fig. 3(a) shows a method of use in which the segmenting work is very clear. Two left and right symmetrical products or two products are produced because of the balance of the working force in bending or flange formation work or when the production quantity is large. Thereafter the segmentation work is made. Fig. 3(b) is the case when blanks are taken from a sheet material or a coil material. Scrap equal to the punch width will be produced. Fig. 3(c) is a modified application of (b). If the shape is as shown in the figure, and if the die dimensions are determined so that even the scrap becomes a product, it is possible to carry out the work without generating any scrap, and even the production efficiency becomes better. Fig. 3(d) is still another modified application. This form is very famous as the method for producing EI cores. In this case, the product has been designed considering the rate of material utilization and the production efficiency. This can be said to be an extremely superior working method that has cleverly matched the features of the product shape and the features of the working method. This can be said to be an example of the result of co-operation between pressing work and product design.



Notch Cutting Work

Although notch cutting work is an unspectacular type of work, it is a method of working that is used extremely frequently. Please learn the features of this work.

Figure 1 shows a notch. The setting of the dimensions of the notch cutting work is the same as in the hole punching work. The dimensions of the notch that is cut out are equal to the punch dimensions. Therefore, the clearance is taken on the die side. As can be seen from Fig. 1, the feature of the notch cutting work is that the entire periphery is not cut and there is a surface of the punch that does not take part in the cutting. This causes some problems.



As is shown in Fig. 2, a lateral force (thrust load) acts on the punch. As a result, the clearance becomes widened which becomes a cause for burr generation. As a countermeasure for this, the punch is backed up. One such method is a back up heel. In the method for using the back up heel, before starting the work, the heel part is put inside the die, and when a lateral force acts, it is received by this part so that the punch does not move. As a countermeasure other than a back up heel, there is also the method in which the die side is made in the form of a projection and the lateral force is taken by that part. This method is called the back up block method. Even this is used for the same purpose. Either of these two methods is selected depending on the details of the work to be carried out.

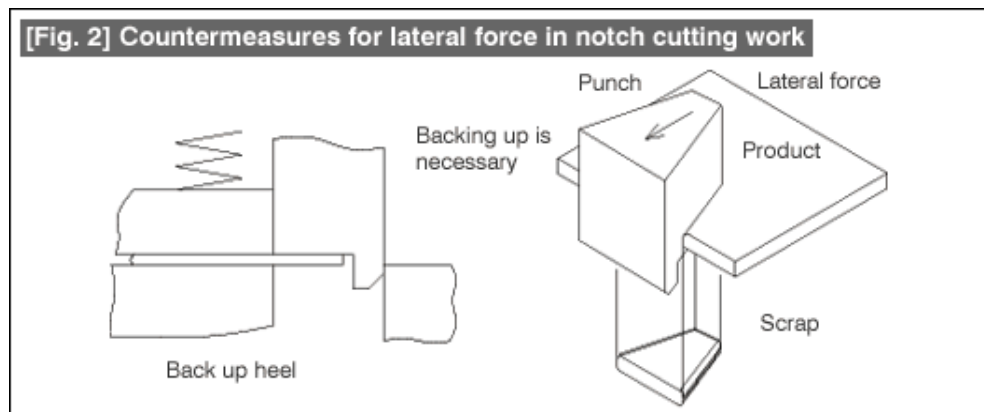
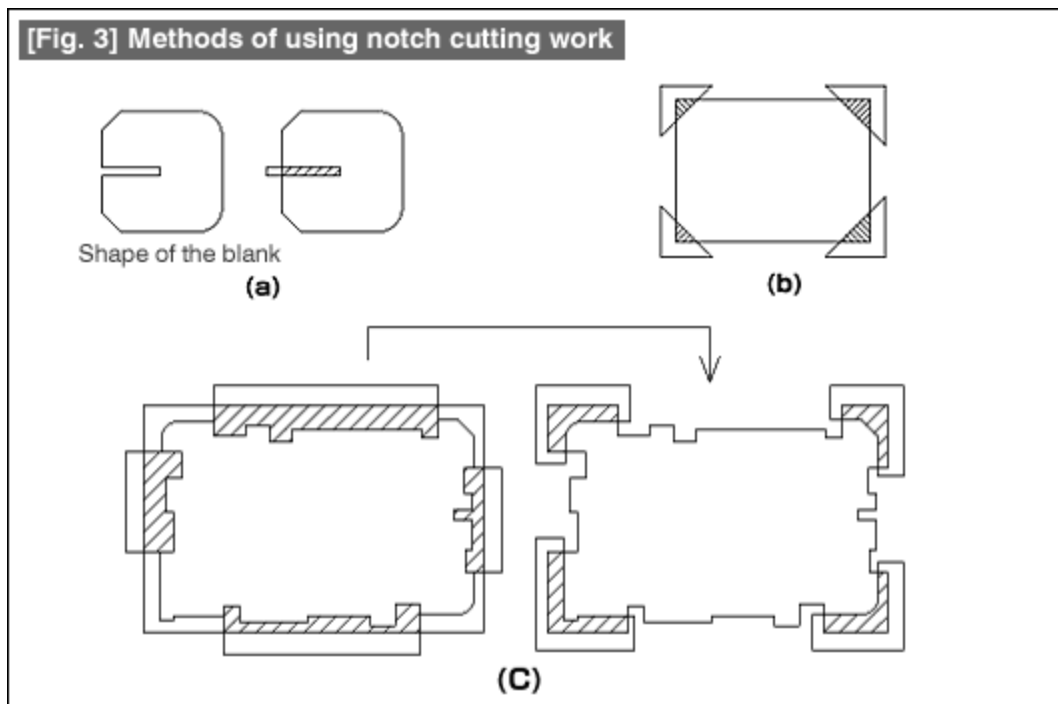


Figure 3 shows some examples of using the notch cutting work. Fig. 3(a) shows a shape in which there is a slot (a notch with a narrow width is usually called a slot) in a part of the blank, and this shape causes the die to break in the part of the slot during blanking. In such situations, the blanking operation is done without the slot part, and a notch cutting operation is made in a separate process (this type of work may also be called slotting work). When there is a hole in the product, the notch cutting operation is combined with the hole punching work. Fig. 3(b) shows a frequently occurring case of carrying out the drawing operation of a rectangular shape from a cut length sheet (sketch material) in which problems in drawing are avoided by cutting the corners. The cutting of the corners in such situations is done by notch cutting work. (Some people may say that this is a type of cutting work because the cutting is made along a single straight line. This is a shape causing conflict between these two opinions.) Fig. 3(c) shows a different case. When the contour of a large shape is cut simultaneously (blanking or trimming, etc.), there may be problems in handling the scrap. In such situations, very often the work is done dividing it into several steps using notch cutting work as is shown in this figure. This is relatively more frequently used for work in the press lines using cut length sheets.



Slit Cutting Work

Slit cutting operations are a type of operation for adding a cutting line. It is possible to form the shape without generating any scrap. Please learn the method for using the slit cutting work.

Figure 1 shows the forms of slit cutting work. There is a method for making incisions from an edge of the material and there is a method for making incisions inside the material. Slit cutting work is a type of shearing work in which the punch is provided with an inclination angle. By starting the cut from the tip of the punch and stopping the cut in the middle of the angle of inclination, a part that is not cut will remain in the material. It is possible to form a shape without generating any scrap.

However, there are also problems. Since the cutting is done using an angled punch with a sharp angle, the tip of the punch gets chipped (the corner gets broken by small amounts), and the generation of burrs starts earlier. Although the cutting material under the punch enters into the die, sometimes it does not get dislodged from the die easily. This is because the cut material bites into the die at the width part of the slit that has been cut. A countermeasure for this type of problem is shown in Fig. 2. The part above the middle line is the shape that is not good. The problem gets reduced if this shape is made into the shape shown below the middle line.

An example of using this method is shown here. Fig. 3 shows a method in which a bent shape is formed while cutting. Although this is a method in which the punch is subjected to a large load, the attraction of this method is that the work can be done in one process.

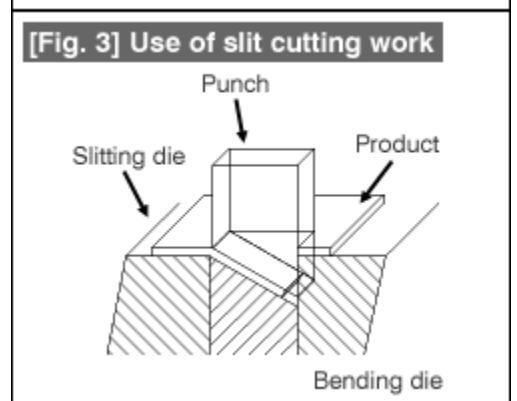
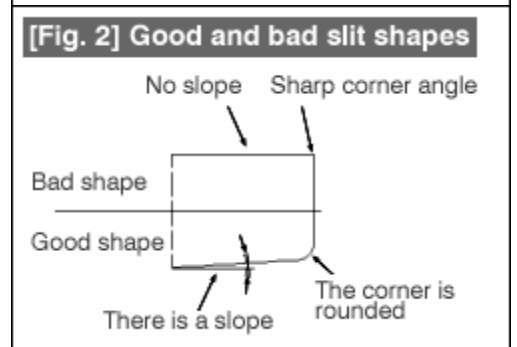
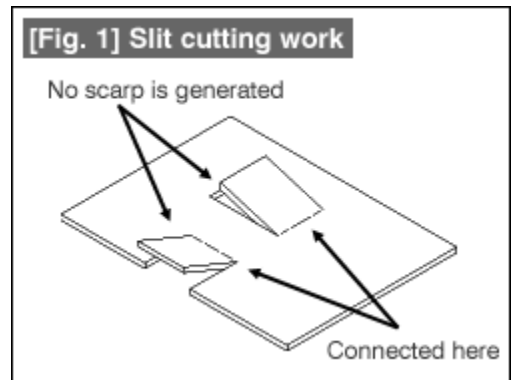
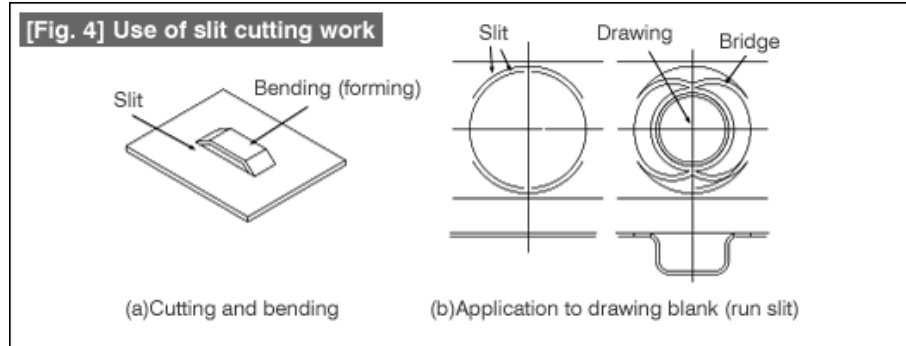
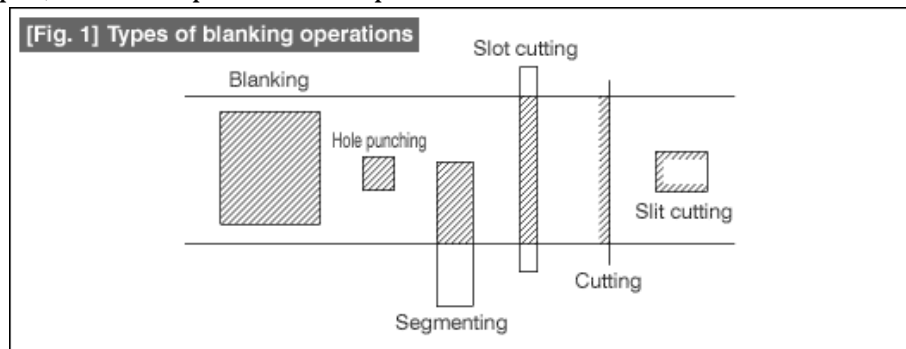


Figure 4(a) shows a method in which slitting and forming are done at the same time. The height of forming is prepared by the elongation of the material. Although both sides are cut in the figure, it is also possible to carry out formation in which only one surface is cut. This type of formation is called louver formation. Louver cutting is used very frequently for vent holes. Fig. 4(b) shows a form in which the slit cutting operation can be used for drawing. By making two slits, the fluctuation of the material due to shrinkage of the blank during drawing work is absorbed.



Outer Cutting Work

The details of the basic types of blanking work are shown in Fig. 1. The contents of blanking work and hole punching work are the same but their methods of use are different. By combining these basic work types, the outer parts of a shape are cut out.



Taking the example of the shape shown in Fig. 2, let us see how the shape of the outer contour is prepared using outer cutting work.

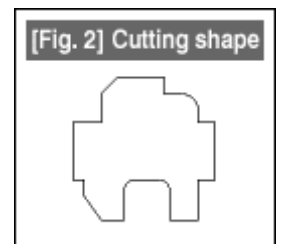


Figure 3 shows the method for preparing the shape of the outer contour using segmenting. Forming this shape can be done using a single punch if there is no problem with the strengths of the punch and die, and if there is no problem in forming the shapes of the punch and the die. In this type of work, a cutting and connecting part is generated as shown by the part indicated as "Matching". The matching part is different from other parts in terms of external appearance. This is also a part in which burrs appear faster than in other parts. Therefore, the design should be made so that the matching part is not included in very important parts. If it is felt that there is some problem in the strength of the punch or of the die, the problem is solved by dividing the punch.

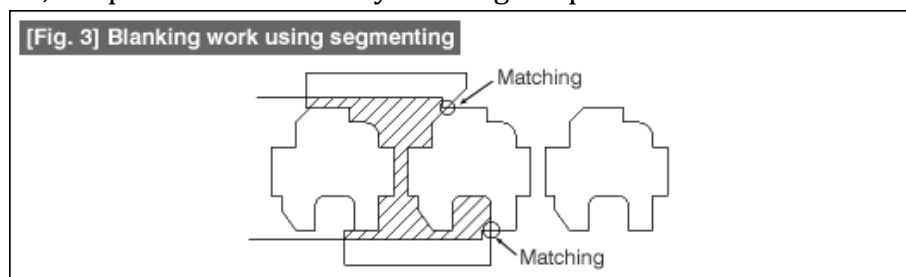


Figure 4 is a form for preparing the shape of an outer contour by combining slot cutting and

segmenting. Note that the matching locations have increased in number. The matching locations increase in number proportionally when the number of punches increases.

In this method for preparing the outer contour, the material is gripped between the die and the stripper, and is used for the purpose of improving the flatness, etc. This method is also very frequently used as the method for forming shapes in progressive pressing formation work. The formed product remains on the die. This indicates that some techniques will become necessary for taking out the product. In outer cutting work, although the designer can freely determine the shapes of punches, this method can also be said to be one that can cause problems depending on how the shapes of the punches are made.

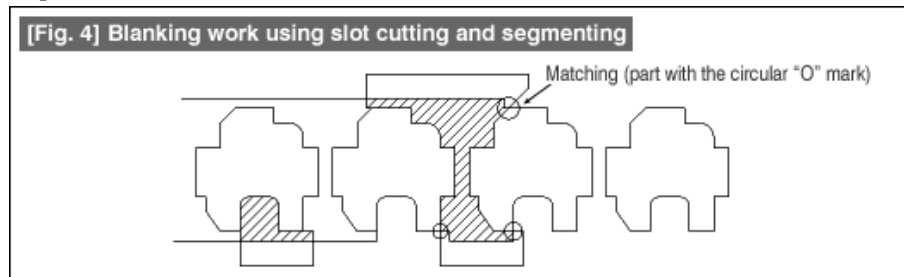


Figure 1 shows an example for forming an outer contour shape using slot cutting and cutting. Slot cutting forms the shape along the width direction of the material and the shape along the feeding direction is formed by cutting, thereby saving material. Since cutting operations are used, the direction of the burrs in the product will be different in some parts when compared with other parts.

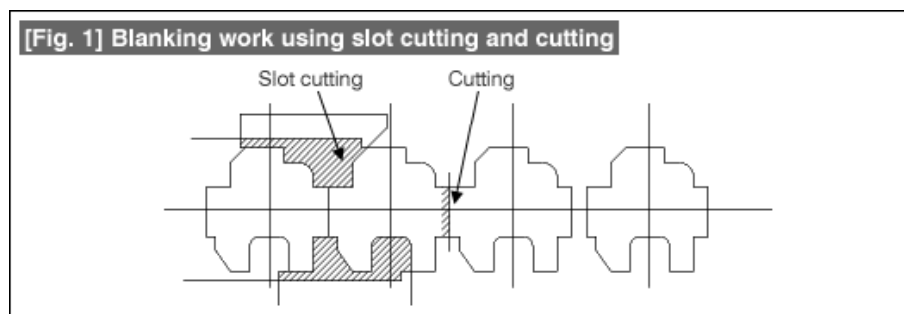
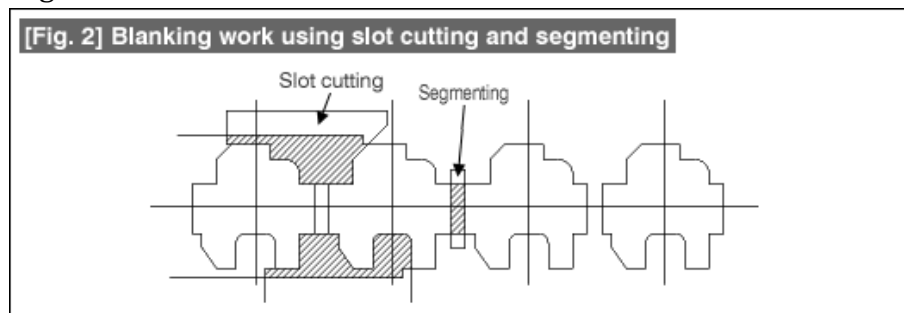
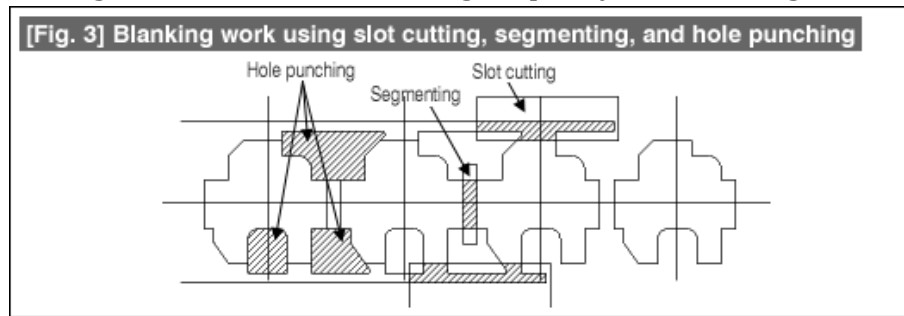


Figure 2 shows an example for forming an outer contour shape using slot cutting and segmenting. In this form, the direction of the burrs is the same along the entire periphery of the product. This method can be said to be the most frequently used one among all the methods of forming shapes by outer cutting.



In this method for forming a shape, one blank and the next blank are connected near the center of the material. Depending on the product, guiding along the width direction may become difficult. As a countermeasure for this, the forming method shown in Fig. 3 can be used. This is a method in which the original material width is made to remain the same by as much as possible. In order to do this, hole punching operations will become necessary in addition to slot cutting work. By using hole punching work, it is possible to form the shape while maintaining the original width of the material. The advantage of this type of method for forming an outer contour shape is that, not only the material can be guided easily, but also it is possible to prevent the reduction in the strength of

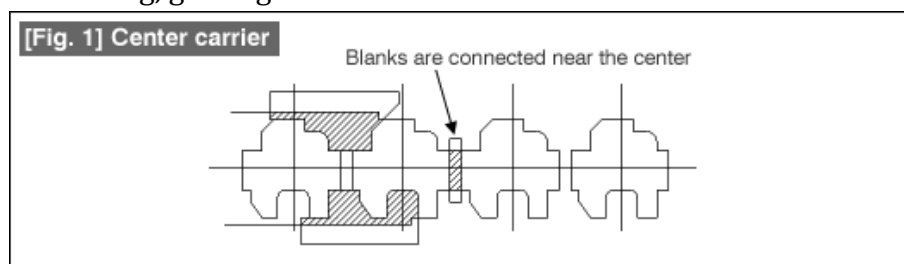
the material. The drawback is that the loss of material becomes somewhat larger. This is an example of forming the outer shape using slot cutting and segmenting. In this form, the direction of the burrs is the same along the entire periphery of the product. This method can be said to be the most frequently used one among all the methods of forming shapes by outer cutting.



Outer cutting work is not merely forming the shape of the outer contour, but is used for forming the blanking shapes of products that include bending, etc., in progressive cutting work. In outer cutting work, the design of the blanking shape punch is free. It is free to use any of the slot cutting, segmenting, hole punching, cutting, and slit cutting works. On the other hand, there are many cases of failures. Designing should be done taking care so that the number of punches used for outer cutting is made as small as possible, that there is a balance among the strengths of different punches, and that the shapes are simple.

Outer Cutting Work Method for Connecting Blanks

In outer cutting work, the shape of an outer contour is cut mainly using slot cutting. Because of this, as is shown in Fig. 1, it is natural for neighboring blanks to be connected at the middle part of the blanks. This form is called the "center carrier" form. The carrier is the part where the material is connected for feeding the material. It is necessary that the carrier has enough strength to move the material so that there is no deformation during feeding of the material. In the case of the center carrier, there is the problem that the material will bend if the connected part is small. It is necessary to connect with as large a width as possible. Further, since undulations will appear on the edge of the material due to slot cutting, guiding the material becomes difficult.



In order to solve this problem, preparing carriers on both sides of the blank is the form of a dual side carrier shown in Fig. 2. This not only makes it easy to guide the material, but also makes it possible to stabilize the strength of the material. This can be considered to be a standard method for preparing a carrier in outer cutting work. As seen relative to the center carrier, it appears that the carrier parts of the dual side carrier are a waste of material. That is certainly true from the aspect of the material. But this can be considered to be a price to be paid for stability in the shape of formation.

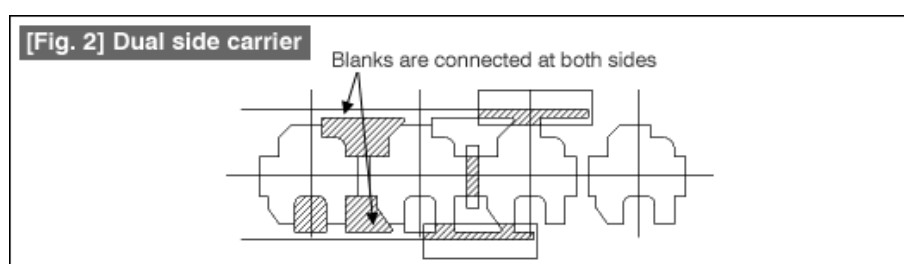


Figure 3 shows the form of a carrier during progressive cutting work when bending, etc., is present at one side. This is called a single side carrier and has properties similar to the center carrier. This is a method of connecting blanks wherein care needs to be taken about the sideward bending of the material.

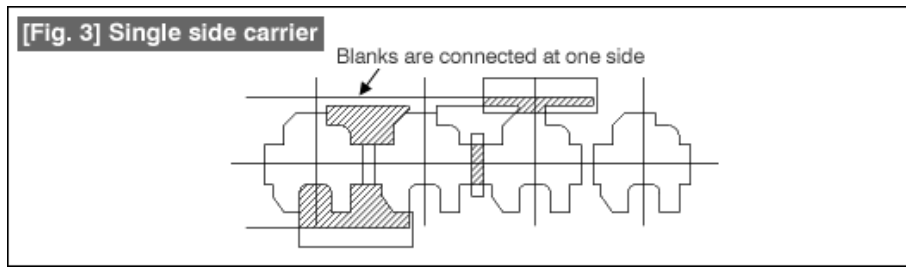
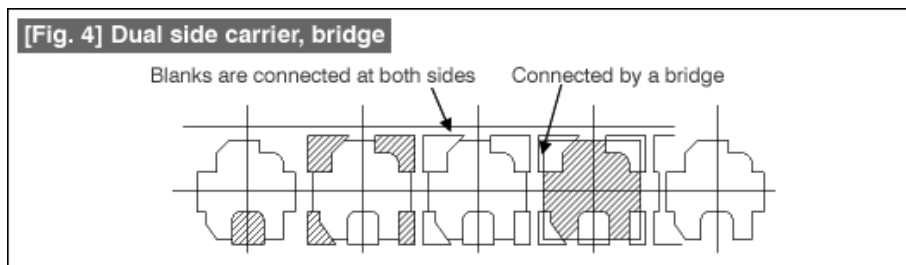


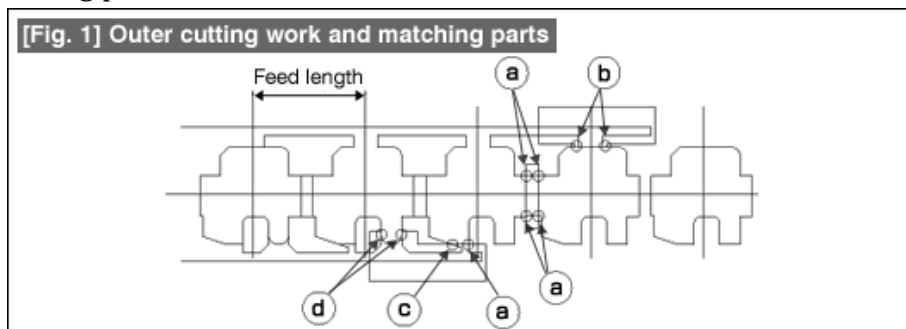
Figure 4 shows a form that is used during the formation of extremely small sized shapes. This is a method for connecting blanks in which priority is given to the stability of holding the blanks rather than to the loss of material.



The purpose of a carrier is to hold the blanks. At the same time, it should also be possible to easily recover the blank that is separated out by cutting in the last process. How the blanks are connected when carrying out outer cutting work is also a very important matter. Although carriers are very often explained to be a part of the progressive cutting work, it should be known that they should also be considered from the point of view of preparing the blanks.

Matching

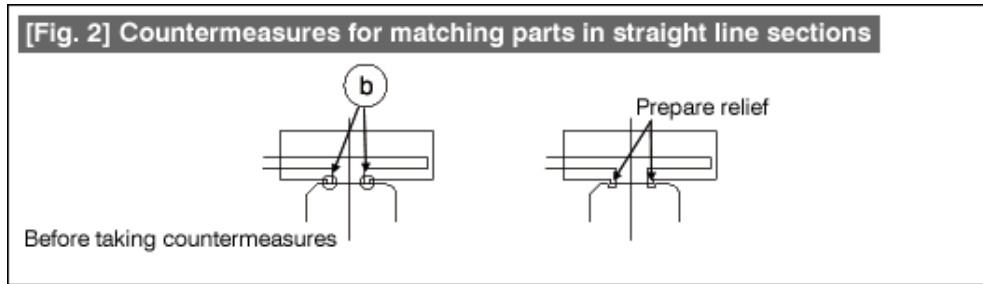
The cutting and joining parts indicated by (a) to (d) in Fig. 1 are generated when the outer contour shape is prepared by outer cutting operation in progressive cutting, etc. The cutting and joining parts are the shape parts prepared due to the intersection of two punches. Such parts are generally called "Matching parts".



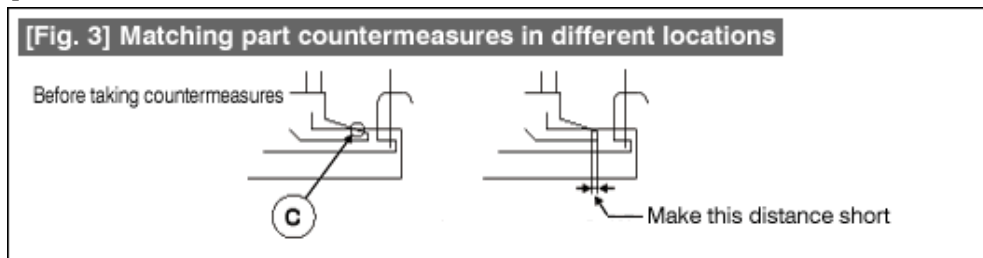
The part indicated by (a) in Fig. 1 is the matching part where there is a 90° right angle intersection. The part indicated by (b) is a matching part that is generated in a straight line part. The part indicated by (c) is a matching part in an angular part and that indicated by (d) is a matching part in a rounded part. These four patterns are the basic matching parts. The 90° right angle intersection matching part does not need any special measures, and can be said to be an ideal matching condition.

Unless countermeasures are taken for the straight line section matching part of Fig. 2, it will lead to generation of steps or burrs. This is because the same part is cut twice by a punch. The action to be taken is to provide a relief at the part which is cut twice, thereby making the cut parts intersect each other. In the external appearance of the formed product, the matching parts will re-

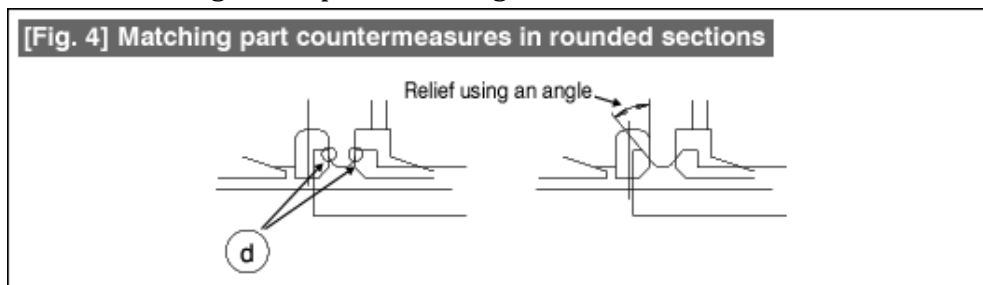
main as depressions. Since the matching parts have some effect in this manner in the external appearance, care should be taken so that matching parts are not created in parts where they can affect the functions of the product.



In the matching parts in angular sections shown in Fig. 3, it is easy for plucking type of burrs to be generated. Design a cutting edge shape (cut punch) in which the extension part of the inclined line is as short as possible.



In the matching part in a rounded section shown in Fig. 4, is the rounding shape is attempted to be made correctly, the same condition as in a matching part in a straight line section occurs. Therefore, the cut punch should be designed so that a tangent is drawn from the rounded section and so that it intersects the straight line part at an angle.

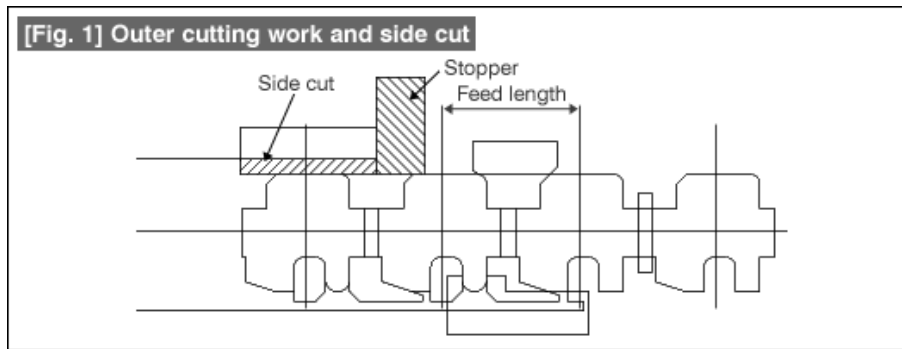


In outer cutting work, although various measures can be taken because the cut punch can be prepared freely, the drawback is the generation of matching parts. If any mistake is made in the countermeasures against matching parts, it can lead to the generation abnormalities such as burrs. When such a thing has happened, it is very difficult to take corrective countermeasures. Therefore, it is very important to think of countermeasures at the time of designing the cut punch so that problems do not occur and then carry out the design.

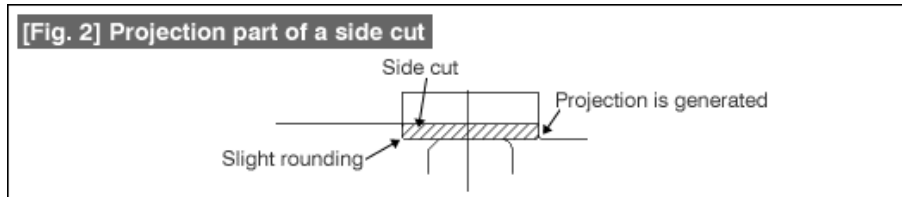
Side Cut

The outer cutting work is also called cut and carry work. This is because the cutting is done after feeding the material by the feed length (feed pitch). If the feed pitch is not accurate, the cut shape will have fluctuations, and the product may not be acceptable at all in some cases. Side cut is used for the purpose of stabilizing the feed pitch.

Figure 1 shows the method of using a side cut. The edge of the material is notched by the feed pitch, and the feed length is determined by making the notched part butt against a stopper. A guideline for the width of the notch is a minimum value of about 1.5 to 2 times the material plate thickness.



If the cut is merely in the shape of the letter L, a projection shaped matching part is generated as is shown in Fig. 2. If this happens, this can lead to problems because it can get caught in the material guide. Further, a side cut also has a shape that can cause rising of chaff. In particular, the simple L-shaped cut can easily cause rising of chaff.



As a countermeasure, the shape of the side cut is made complex thereby solving the problems of projection shaped matching parts and rising of chaff. Fig. 3 is a shape that anybody will try at first. Although it appears as if the problems will get solved, this is not a sufficient countermeasure. Of course, this can also cause the generation of abnormality in the matching parts.

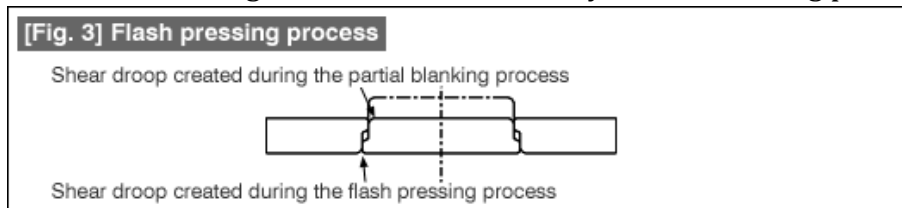
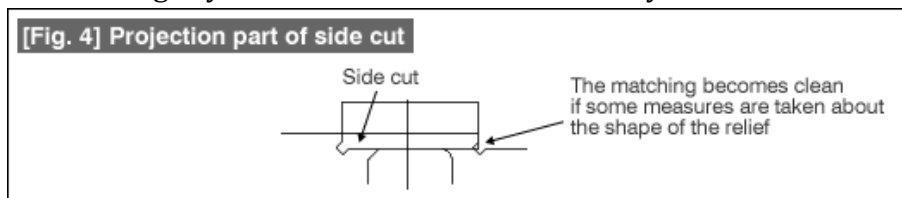


Figure 4 shows a shape that has solved the problems. This can be used against both matching parts and rising of chaff. Slightly wider side cut will be necessary.



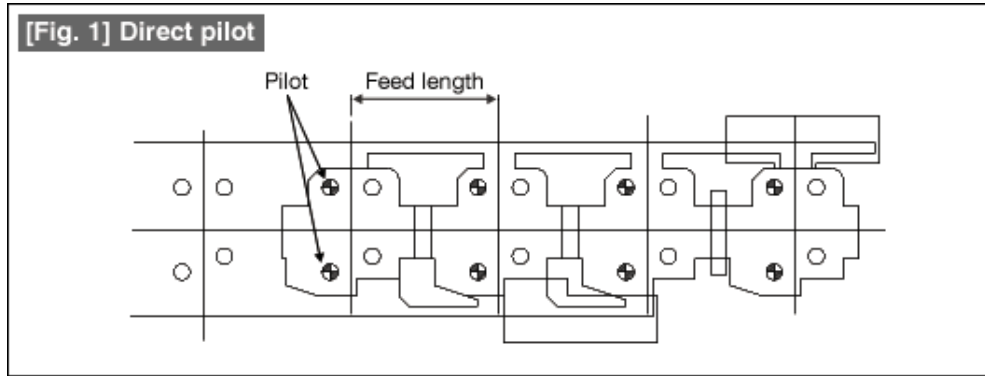
Only the basic details have been given here. In actuality, for the sake of further countermeasures against rising of chaff, very often the shape is made complex. Cutting by combining a side cut and a part of the outer shape of the product is also done. When the feed pitch is determined only by a side cut, although the side cut punch is made the same as the feed pitch, when a pilot is used for positioning, it is common to make the length of the side cut more than the feed pitch. In this case, the material is made to be fed a little excessively and is returned slightly using the pilot.

Pilot

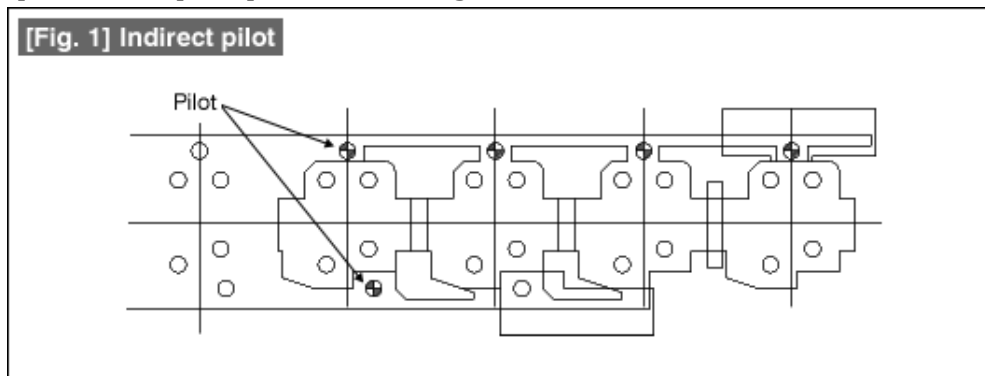
In outer cutting work, the cutting is done by moving (feeding) the material by the feed length (the feed pitch) using the side cut or a feeding device. At this time, any fluctuations in the feed pitch will have effect on the product. "Pilot" is used for the purpose of correcting the feed error immediately before carrying out the cutting.

A pilot is basically a round hole, and the error is corrected by inserting a shaft with a pointed tip (a pilot punch) inside this hole. There are two methods of using the hole. The method shown in Fig. 1 is one in which a hole in the product is directly used for correction, and this method is called a

direct pilot. Since a hole in the product is used, the shape will be one without any wastage. The drawback of this method is that the hole used for the pilot may get deformed. Care should be taken about this when the material is a soft material such as copper or pure aluminum, etc.



In order to avoid this problem, the form shown in Fig. 2 is one in which a special hole for the pilot is formed in the part that becomes scrap. This is called an indirect pilot. It is possible to determine freely the position and size of the pilot hole. A pilot punch is always inserted into the hole for the pilot immediately after the hole has been punched. If possible, if the pilot is inserted several times in succession, it is possible to reduce the load on each punch. There is a relationship between the diameter of the pilot hole and the diameter of the pilot punch. Although the positioning can be done most accurately when the pilot hole diameter is equal to the pilot punch diameter, the material will be picked up when the pilot punch is coming out of the hole.



Therefore, the relationship shown in Fig. 3 is used, that is, pilot hole diameter (D) is made greater than the pilot punch diameter (d). If the cut material plate thickness is assumed to be about 1mm, the difference between the two diameters should be about 0,02 when cutting high precision products, and about 0,04 in the case of ordinary precision products. This value is made small when the plate thickness of the material to be worked becomes smaller and is increased when the plate thickness increases.

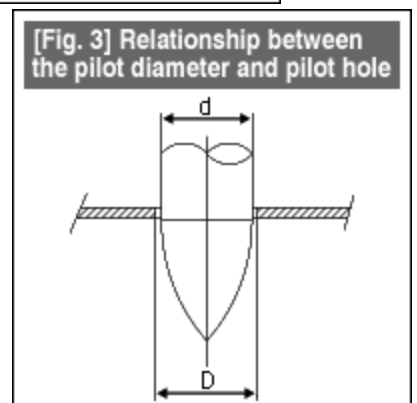
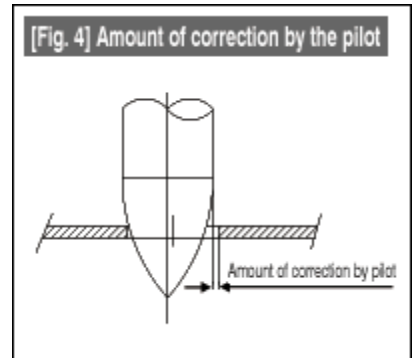
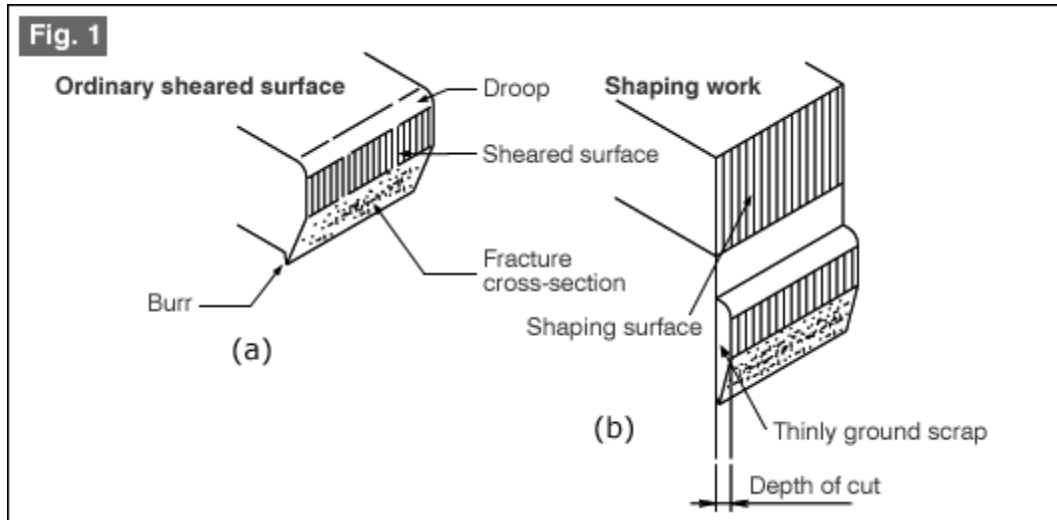


Figure 4 shows the amount of correction made by the pilot. The feed pitch error is corrected by the tip part of the pilot. The formed shape of the tip part can be the shape of a bullet or the shape of a taper. For the amount of correction, it is better that the diameter of the pilot punch is large, but it is important to achieve a balance with the plate thickness of the material. Assuming a plate thickness of 1mm and a pilot diameter of about 8mm, the amount of correction is in the range of about 0,3 to 0,5. If the amount of correction is large, the pilot punch gets worn out faster.



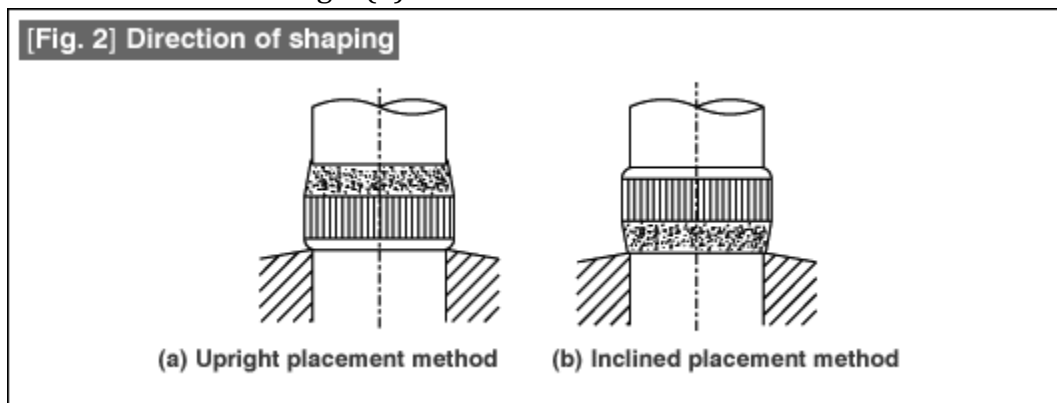
Shaping Work

In ordinary blanking work the cut end surface will be like that shown in Fig. 1(a). Some times it is required that this surface is a clean sheared surface (contour shape, or hole, or part of a shape). At such times, the cut end surface is cut slightly and finished in to a clean surface as shown in Fig. 1(b). This method of working is called "Shaping work".



The important item in shaping work is the size of the depth of cut shown in Fig. 1 (b). The size of the depth of cut that can be removed by one operation is about 5% to 10% of the material plate thickness. For example, a rough guide to the value of this depth of cut is about 5% in the case of soft steel, 8% to 10% in the case of hard steel, and about 10% in the case of brass. When one shaping work is not sufficient, a second or a third shaping may be done.

The direction of shaping can be the upright placement method shown in Fig. 2(a) or the inclined placement method shown in Fig. 2(b).



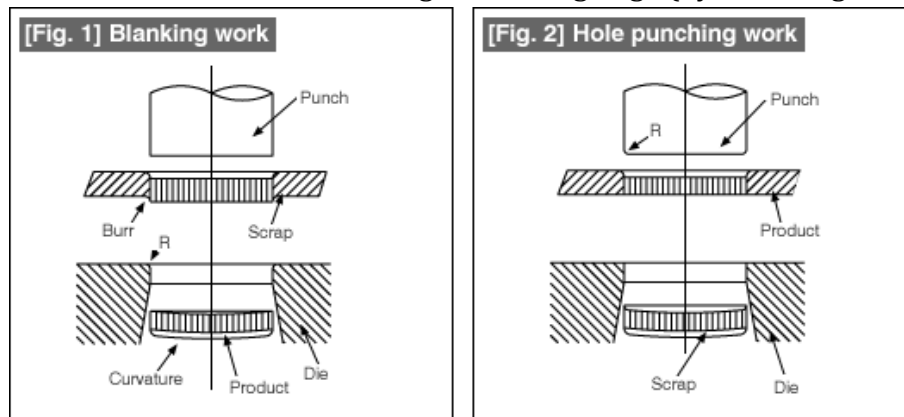
In the case of the upright placement method, the contact between the product and the die is uniform and the balance is good. In the inclined placement method, since the contact is made on the side of the fracture surface, the contact is unstable and there will be fluctuations in the way the grinding is done. Since shaping work is done in the next process step after the blanking operation is made, it basically increases the number of process steps. Further, even positioning is difficult. In addition, the problem in shaping is that the thinly ground scrap gets adhered to the die because of oil, etc., and is difficult to clean off, and hence it can cause scratches to be made on the product. In this manner, although this is a very well known process, it is used only rarely. Although this process step is included in progressive cutting works, if any mistake is made in the handling of the scrap, it can cause scratches on the products thereby causing the products to be discarded. When carrying out shaping operation in progressive blanking work, measures should be taken to make this scrap join with the scrap of ordinary blanking and remove them together.

Finishing Blanking Work

Finishing blanking work is the blanking work used for obtaining a smooth cutting cross-section surface. In the case of finishing blanking work, the clearance is made almost zero. In addition, the cutting edges of punches and dies are rounded so as to delay the generation of fracture surfaces, thereby preparing smooth cut end surface.

At the time of blanking work, the cutting edge of the die is rounded as shown in [Fig. 1]. In the case of hole punching work, on the other hand, the cutting edge of the punch is rounded.

Although basically rounding is done at the cutting edge, chamfering is also permissible. It is sufficient if the working force is distributed thereby delaying the generation of fracture surfaces. The key factors here are the clearance and blunting the cutting edge (by rounding or chamfering).

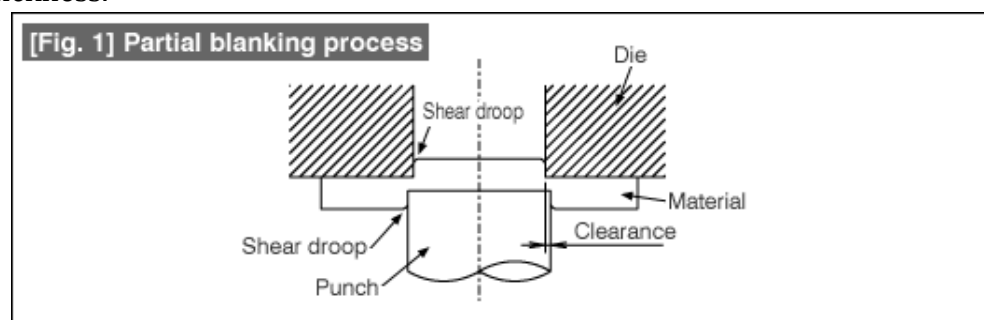


The size of rounding is about 0,2mm to 1,0mm rounding radius. When the rounding increased, although the appearance of fracture surface is delayed and a smooth cut end surface is obtained, but there will be more droop, curve, and burrs. Therefore, it is necessary to limit the rounding (chamfering) of the cutting edge to the minimum required amount. The relationship between rounding of the cutting edge and curve is almost a straight line relationship. When the rounding radius is changed from 0,5mm to 1,0mm, the curvature becomes almost twice larger. The stripping force increases as the rounding radius becomes smaller.

Blanking Work without Burrs on Both Surfaces

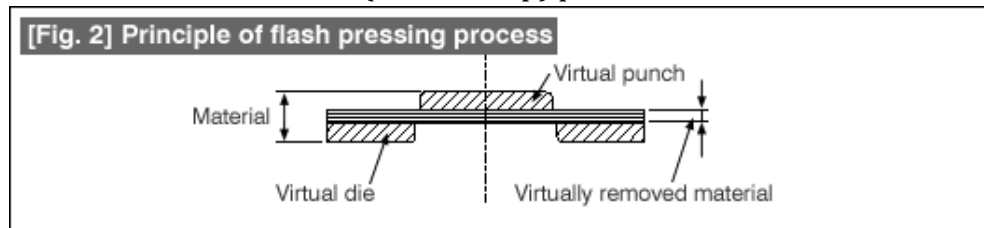
Blanking operations always result in generation of burrs. Because of that, burrs are very frequently removed by flattening the burrs. However, there are problems about Product Liability laws, and recently there is an increasing trend of removing burrs. One of the methods of eliminating burrs is given here. This method is generally called the flash pressing method.

In this method, to begin with partial blanking is done as shown in Fig. 1. Usually the punch is slightly larger than the die. This condition is called "negative clearance". By pushing the punch inside the material, the material is pushed inside the die and single sided shear droop is formed. The amount of pushing in by the punch at this time is very important, and should be 75% or more of the material plate thickness.

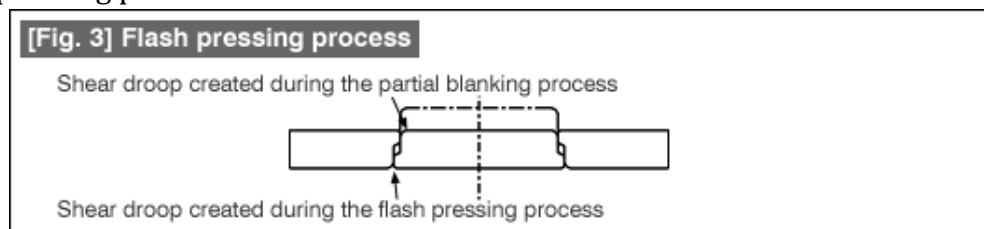


The next process is the flash pressing process. In the flash pressing processing although the

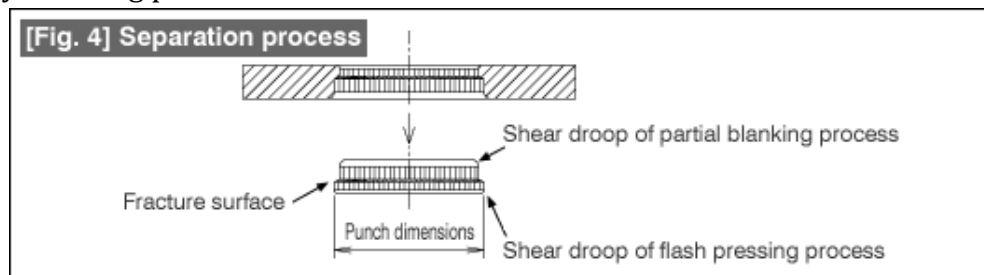
operation is very simple, its content is unique. This is explained in Fig. 2. The material is in the partially blanked condition. This condition is considered dividing it into three parts, namely, the virtual punch part, the virtual die part, and the part that is gripped between the virtual punch and the virtual die. The material in this part is blanked using the virtual punch and the die. In this process the material blanks itself the forms the die roll (shear droop) part.



The condition after flash pressing is shown in Fig. 3. The amount of pushing in the partial blanking process is the one that makes the flash pressing process successful. If this is shallow, the virtual punch and die are not effective. If this is too deep, the material gets cut before flash pressing. The reason for having this negative clearance is to make sure that the material does not get fused during the flash pressing process.



The shape after separation is shown in Fig. 4. Compare this shape carefully with that in Fig. 1. The finished dimensions, in terms of the external dimensions of the blanked product, will be almost the same as the punch dimensions in the partial blanking process. This is slightly different from the ordinary blanking process.



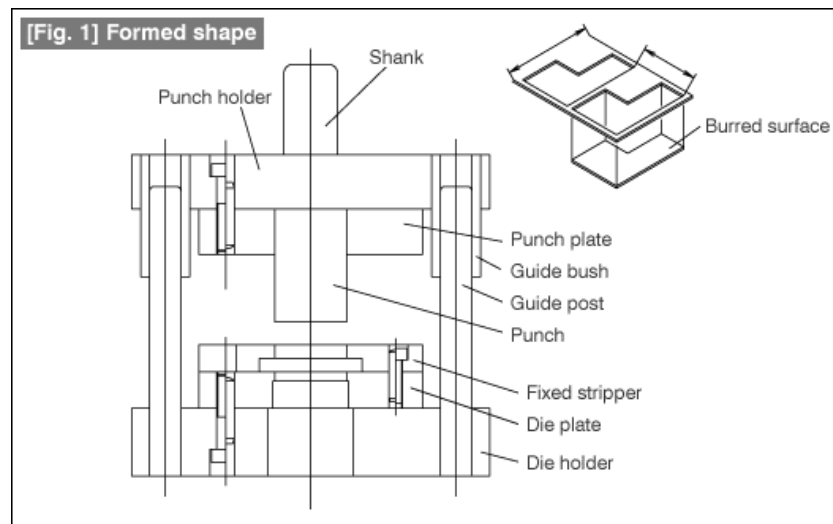
This method has not been tried for large products. Try out this process for small products.

BASICS OF DIE STRUCTURE

Structure of Blanking Dies

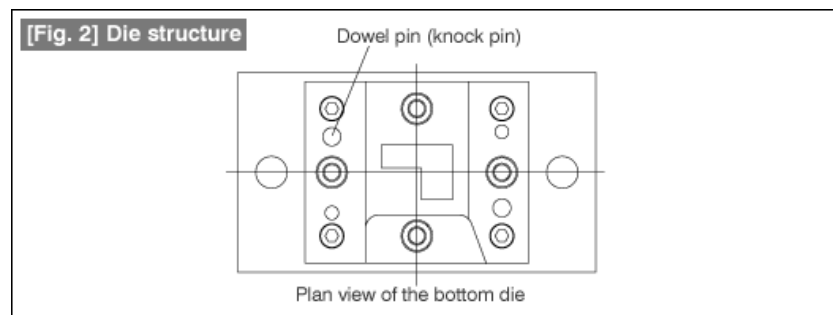
A blanking process is that of forming contour shapes as is shown in Fig. 1. The contour shape may become a product by itself, or some times may become a blank for bending or drawing operations. Normally, in the blanking process, the product passes through the die and falls down. A die of this type of structure is called a blanking die.

In a blanking die, the punch and the die are prepared to match with the shape of the product. The punch is made smaller than the die by the amount of the blanking clearance. When the material is processed, blanking chaff gets adhered to the punch. The stripper is the part used for the purpose of removing this blanking chaff from the punch. Since it is sufficient for the stripper to merely remove the blanking chaff from the punch, there is no problem even if the stripper is fixed on the side of the die plate. A stripper of this form is called a "fixed stripper".



Since this is a blanking die using a fixed stripper, it is called a blanking die of the fixed stripper structure. Since the material passes in between the fixed stripper and the die plate, a suitable gap is provided between them. Although there is no rule about this, but a guideline for the size of this gap is about 5 to 10 times the material plate thickness. Further, in this gap part, the material is guided along the width direction of the material.

Although a form is shown in Fig. 2 in which the punch is studded in the punch plate, if the cross section of the punch is large, the punch may also be affixed directly to the punch holder. On the other hand, if the punch is small and a thick material is being blanked, a punch packing plate may be placed between the punch plate and the punch holder. There can be many variations even in the basic structure.

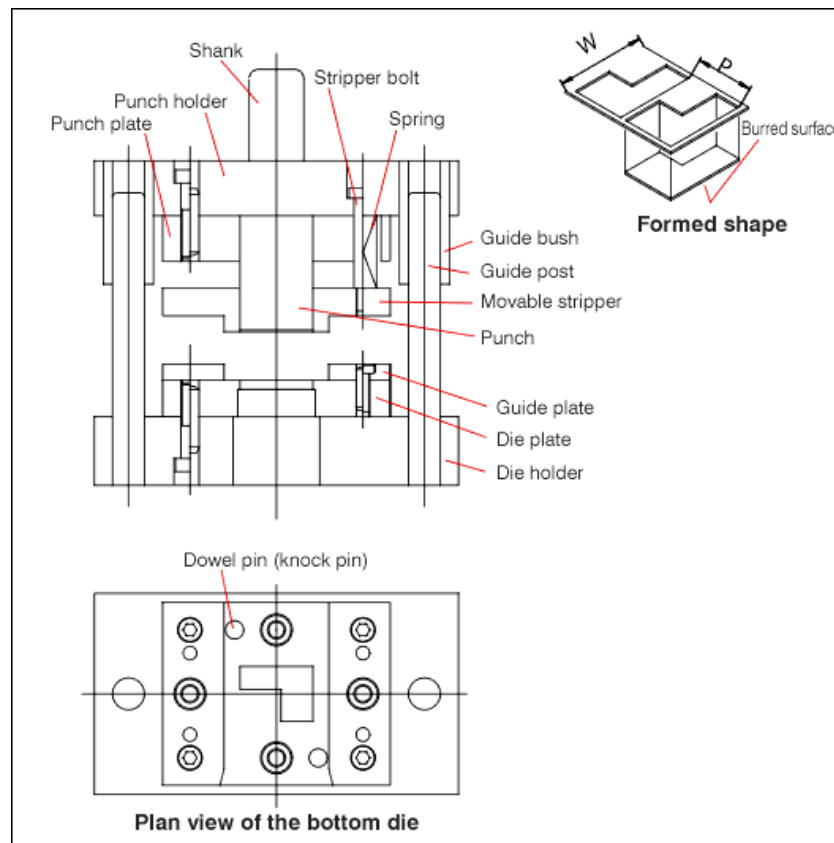


The purpose of blanking work is the same as that of a die of the fixed stripper structure. In the fixed stripper structure, since the fixed stripper is covering the die plate, some people say they do not like it because they cannot see the condition during working. Further, if a thick plate is blanked, gradually it may get warped making it difficult to carry out the work. Because of this, a movable stripper may be used because it is possible to press down the material. A blanking die of this type of structure is called a "movable stripper structure blanking die".

Compared to the fixed stripper structure, in the movable stripper structure, there are additionally the stripper bolt, spring, and the guide plate. Because of this, the cost will increase to some extent relative to the fixed stripper structure.

If a simple die is required, it is also possible to substitute the movable stripper by tying a urethane spring or rubber around the periphery of the punch. This is used very frequently in the case of small quantity production such as prototyping, etc.

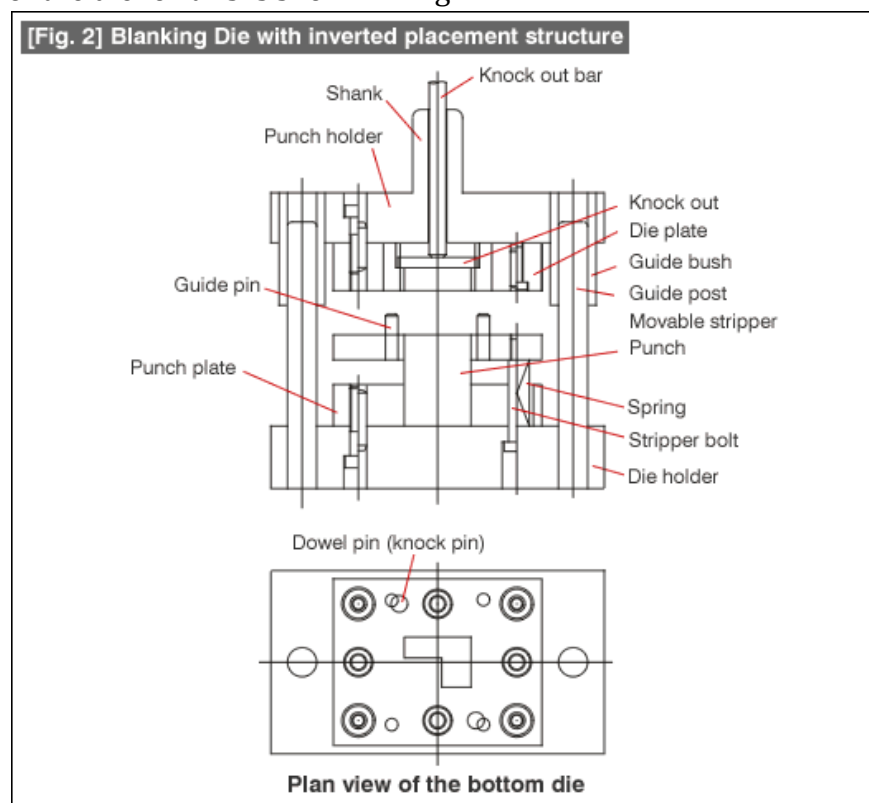
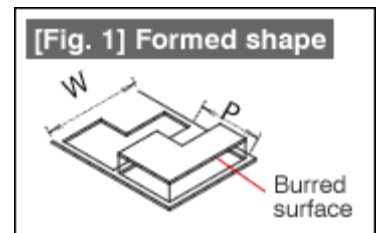
The product gets bent to some extent in blanking work. This is due to the effect of the bending moment that acts on the material at the time of blanking. This cannot be eliminated in ordinary work. Although there are some people who use the movable stripper structure with the purpose of improving this bending, but that is wrong. The bending becomes somewhat larger in the case of the movable stripper structure.



The blanking chaff sticking to the punch is removed from the punch by the force of the spring of the stripper. The size of this force need only be about 3 to 5% of the blanking force when a standard clearance is used. This force is called "stripping force" or "chaff removing force". The stripping force can be made larger when the clearance is smaller, and on the contrary, it can be made smaller as the clearance becomes larger.

This is a blanking work of a special form. As is shown in Fig. 1, the formation is done by pushing from below to above.

The structure of the die for this is shown in Fig. 2.



The product gets bent to some extent during blanking work. While this is due to the forces associated with the blanking operation and cannot be avoided, it is of course desirable that a flat product is obtained. This inverted placement structure was conceived as a countermeasure against the product getting bent.

The feature of the inverted placement structure is that the punch is placed as the bottom die and the die is placed as the top die. The blanked product enters the die. It will be necessary to discharge the product that has entered the die. The part for doing this is called the knock out. The knock out is linked to the pressing machine via the knock out bar.

The relationship between the blanking work and the knock out operation is as follows. The material is blanked near the bottom dead point of the pressing machine, and the product goes into the die. The die rises as it is, and near the top dead point of the pressing machine, the knock out bar of the die gets hit by the knock out part (called the knock out bar) of the pressing machine, the linked knock out gets pressed, and the product is discharged (ejected) from the die. A very common method of pushing away the discharged product is to blow it off using compressed air.

Using this type of structure for preparing flat products is because it is possible to reduce or suppress the bending that is caused during the blanking operation because the material is pressed down by the knock out. In the structure shown in Fig. 2, since the knock out has only penetrated into the die, the effect is small as a countermeasure against bending. In order to get much stronger effect, a spring is placed behind the knock out so that the knock out strongly presses against the material. In this case, since the product inside the die is pushed out due to the force of the spring, it does not matter even if there is no knock out bar in the die. The product will be pushed back into the scrap. The product is then recovered by removing it from the scrap.

The method of moving the product that has once been blanked after pushing it back into the material in this manner is called a "push back method".

Since in the form of installing a spring behind the knock out inside the die, the material is pushed from a direction opposite to the direction of movement of the punch, this form is called the material reverse pressing (or simply reverse pressing). Reverse pressing is not for only the inverted placement structure, but even in a structure in which the punch is above and the die is below (this structure is called the upright placement structure), the pressing member that presses in a direction opposite to the direction of movement of the punch is called a reverse pressing member.

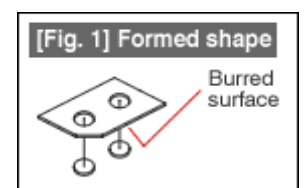
Structure of Hole Punching Dies

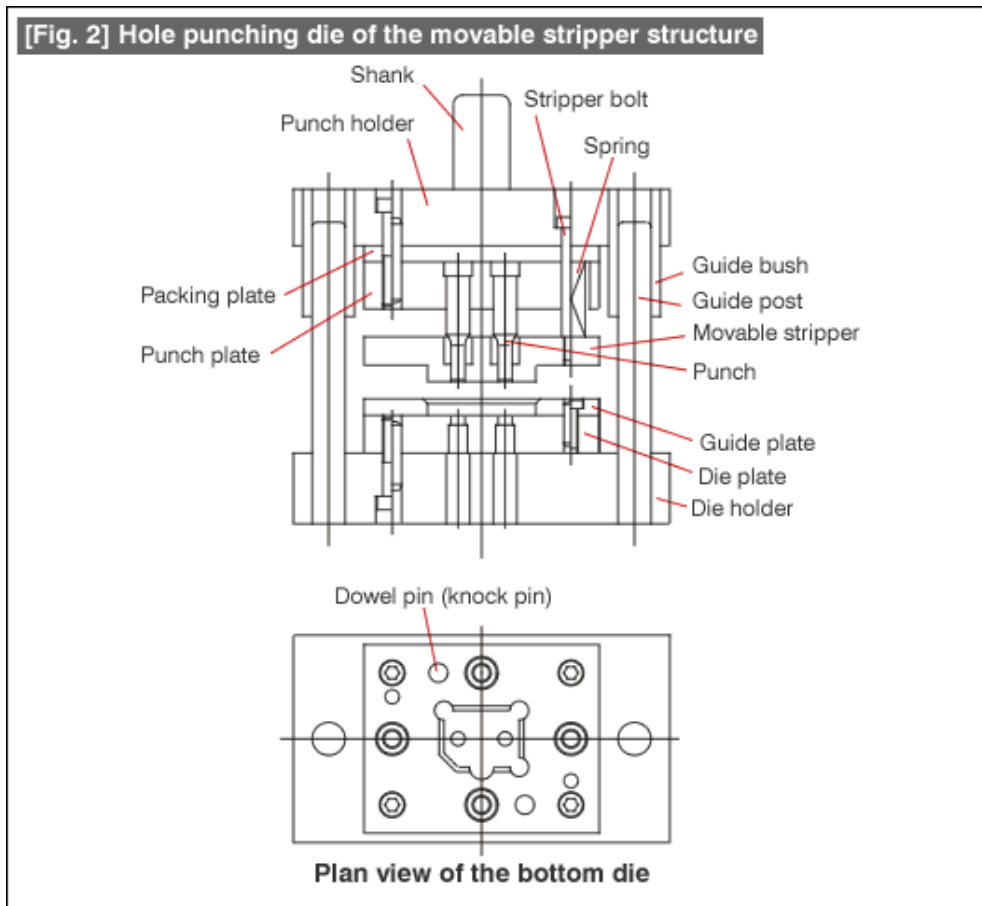
Hole Punching Die of the Movable Stripper Structure

In hole punching work, the operation is made after the material is placed on a die. The scrap of hole punching falls down as is shown in Fig. 1. In other words, the scrap passes through the die and falls down.

The material above the die tries to jump up when pressed by the punch. If the material is not kept pressed, it is likely that the flatness of the product becomes poor. In order to ensure the flatness of the product, the work should be carried out while pressing down the material. The movable stripper structure shown in Fig. 2 is a die structure that satisfies this condition.

The condition during working will be explained below. In the movable stripper structure, the material above the die is kept pressed down and fixed by the stripper and then the hole punching operation is performed. This prevents deformation of the material due to the forces during the hole punching operation. Although the product can get deformed when the punch that has fully penetrated the material is withdrawn (which is called stripping), there is no need to worry about this because the pressing is being done by a movable stripper.





The movable stripper is expected to have two functions, that of pressing down the material and of stripping. Here, we will be concerned about the strength of stripping by the movable stripper. If only stripping is considered, a force of about 5% of the hole punching force will be sufficient. The force of pressing down the material should be as strong as possible. However, generally speaking, very often a force up to about 30% of the hole punching force is set for this force.

Since the formed product remains on the die, recovering the product will have to be done either by an operator using work tools, etc, or by blowing off the product using compressed air.

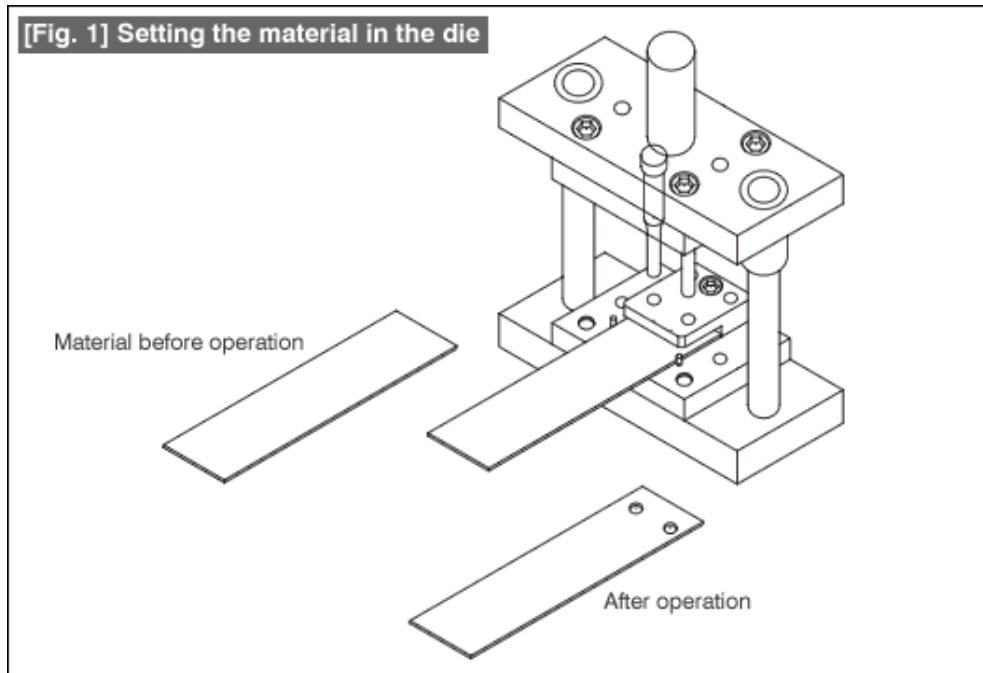
In the case of a thin punch, for the purpose of preventing the punch from breaking and to improve the relationship between the punch and the die, the tip of the punch is also guided by the movable stripper. This form is called the "punch guiding by stripper".

The drawback of the movable stripper structure is that the material can get scratched because it is being pressed by the stripper. It is necessary to carry out the work while taking care about penetration of dirt or dust from the outside, and about undulations, etc., in the die surface and in the stripper surface.

For the sake of reference, during hole punching work, the dimensions of the hole punching punch are the same as the dimensions of the product. The dimensions of the hole punching die are set to be larger than the dimensions of the hole punching punch by the amount of the clearance.

Hole Punching Die of the Fixed Stripper Structure

In the case of a product that does not require high accuracy in hole punching work, very often the fixed stripper structure is used because it offers ease of operation. For example, when a hole is to be punched at an end of a long product as is shown in Fig. 1, it becomes easy to do the work if a fixed stripper structure die is used. As can be understood from the figure, it is easy to the work because it is sufficient to insert the material inside the stripper and carry out the work when the material butts against the end. However, if the gap between the stripper and the die is large, although setting the material inside the die becomes easy, the punch gets fanned during stripping and becomes susceptible to breaking. It is better keep the gap small.



Since there is no pressing down of the material during hole punching, deformations such as warping can occur easily in the material. This is not suitable for punching holes close to the outer shape.

Apart from the above methods of use, this is also used frequently for the hole punching of bent products or drawn products. In such formed products, since the periphery of the hole to be punched is quite strong, very often there is no need to keep the material pressed down.

Hole punching need not be done only in flat surfaces, but sometimes it is necessary to punch holes in curved surfaces. In such situations, even the deformation of the area surrounding the hole is small, and very often it is sufficient to take care only about stripping and in a large number of cases the fixed stripper structure is quite satisfactory.

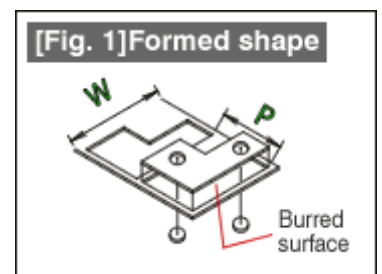
Although the basis of hole punching operation is punching the hole while keeping the material pressed down, depending on the conditions, there are products in which there is no problem even if the material is not kept pressed down and a simple structure can be used. Care should be taken because the easy of preparing the die and cost change depending on your judgment and decision.

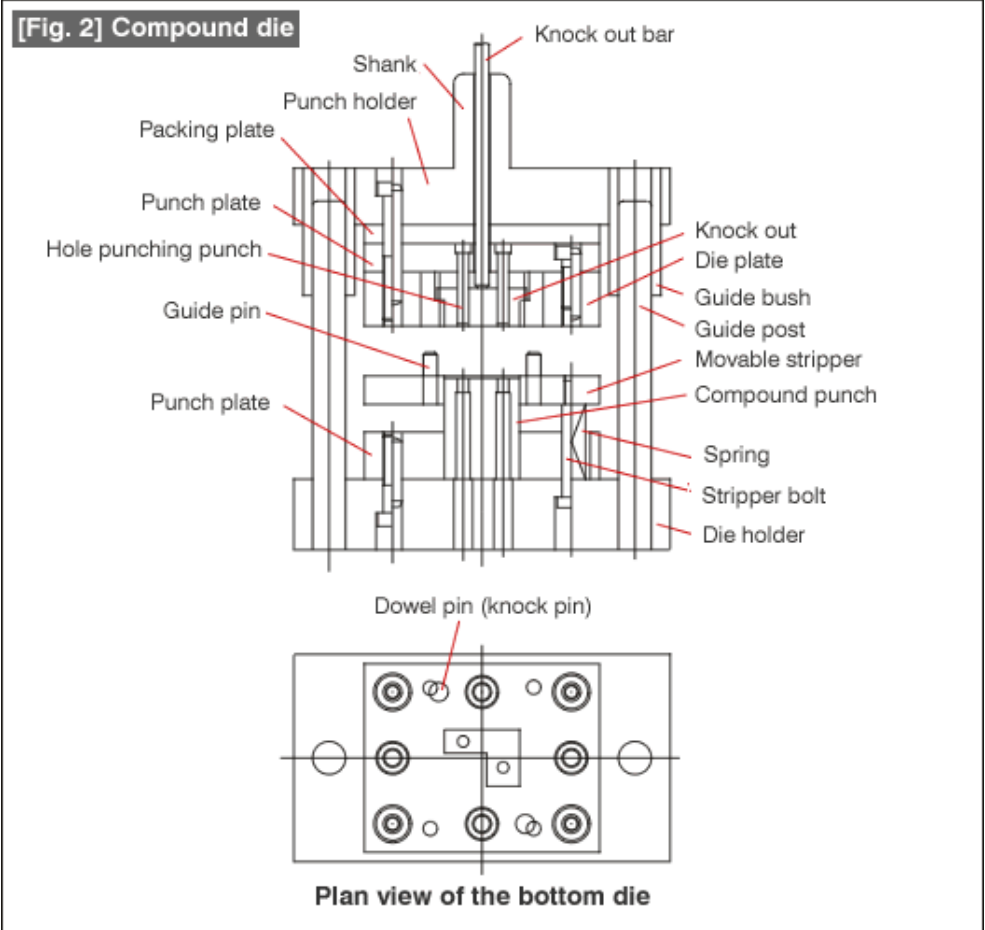
Structure of Compound Dies

Compound blanking operation is that of carrying out forming outer shape and hole punching simultaneously. This operation is called "compound processing". Furthermore, this type of work is also called "combined processing." As shown in Fig. 1, the forming the outer shape is carried out upwards from below and hole punching is performed downwards from above.

This can be said to be a combination of an inverted placement structure outer shape forming die that forms the outer shape and a movable stripper structure die which punches the holes (this has already been discussed in a previous course as a method of preparing compound die structures).

The basic structure of a compound die is shown in Fig. 2.





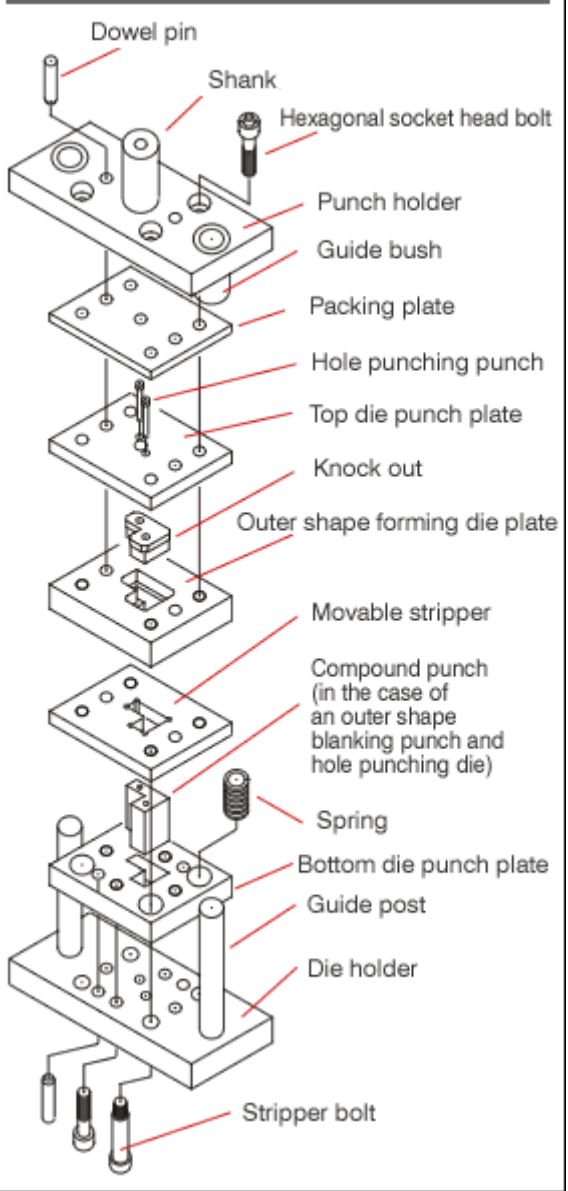
The features of compound blanking operation are – (1) It is possible to reduce the number of processing steps; (2) Since the accuracy of the relationship between outer shape and holes is determined by the die, the accuracy of the product becomes better; (3) The flatness is good because the work is done while keeping the material pressed by the knock outs and the punches; (4) The directions of the burrs of holes and outer shape are the same, etc.

On the contrary, since the structure becomes complex, there is the drawback that the number of steps of preparing the die becomes large. For the sake of reference, an exploded view drawing of a compound die is shown in Fig. 3. It is obvious that the structure is quite complex. In this figure, the knock out and compound punch are compound parts arising out of combined processing operations. The knock out has the functions of ejecting the product and of a hole punching stripper. The compound punch is a combination of a punch for outer shape blanking and a die for hole punching. These two parts will have almost the same shape as that of the product. Therefore, the die does not function if these two products become weak and break.

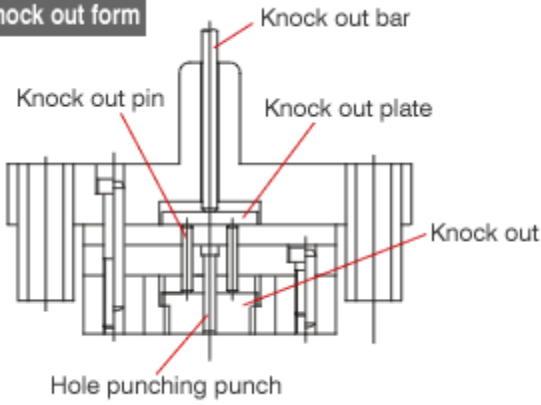
In compound blanking, the formed product is discharged into the die in the top die. Very often the method of recovering the discharged product by blowing it out using compressed air (air blowing off) is used. However, this air blowing off cannot be said to be efficient, and can be considered to be a disadvantage of compound blanking.

Although the discharge of the product from the die is done by the knock out, because of the hole punching punch it cannot be formed in the mode of Fig. 2, but very often it will have a structure of the form shown in Fig. 4. It can even be said that the form of Fig. 4 is the more standard one.

[Fig. 3] Exploded view drawing of a compound die



[Fig. 4] Change of the knock out form

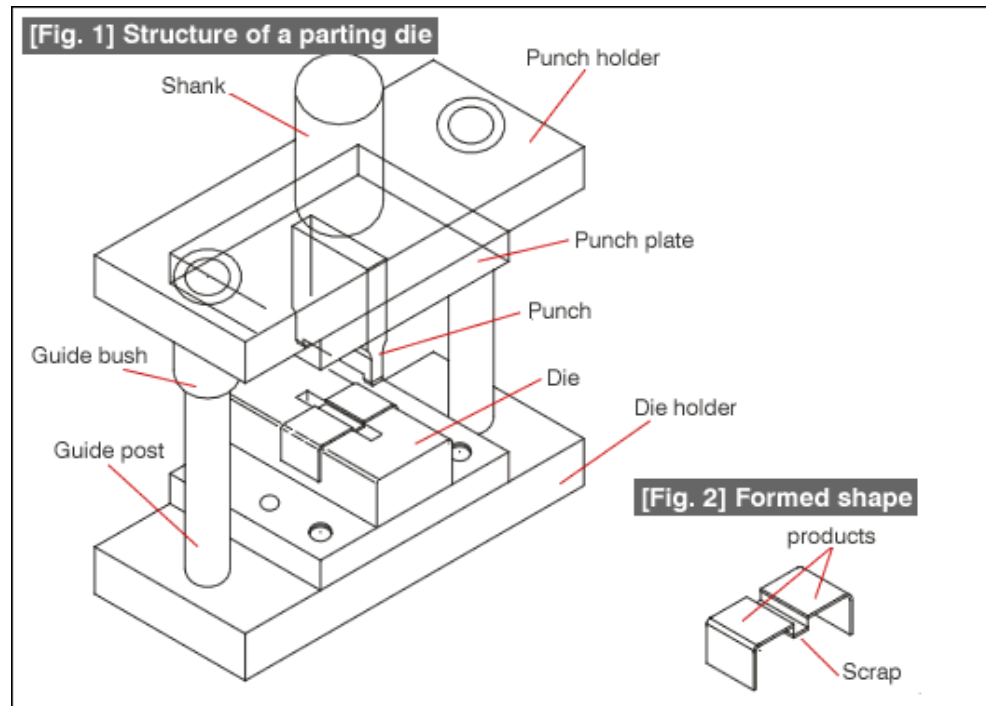


Parting Die

In parting work, the material is sheared and separated using a punch having a certain width. Very often blanks are also prepared from sheet material or coil material by parting. Since the shearing is done using a punch with a certain width, the directions of burrs after parting will be the same at the left and at the right (if shearing is done by cutting off without generating any scrap, the directions of the burrs at the right and at the left will be opposite to each other). In addition, quite often a

product that is bent or drawn is parted thereby getting two products.

Figure 1 shows the structure of a parting die used for such a purpose. Fig. 2 shows the conditions during operation.



By carrying out parting work it is possible to prepare products that are left and right symmetrical, or to prepare two products in the case of a non-directional product (of a shape shown by the example in this figure), and hence it is possible to increase the productivity.

Looking from a different point of view, in order to achieve a balance in the operation capacity of metal forming work, it is also possible to carry out left and right symmetrical formation work inevitably and then carry out parting work.

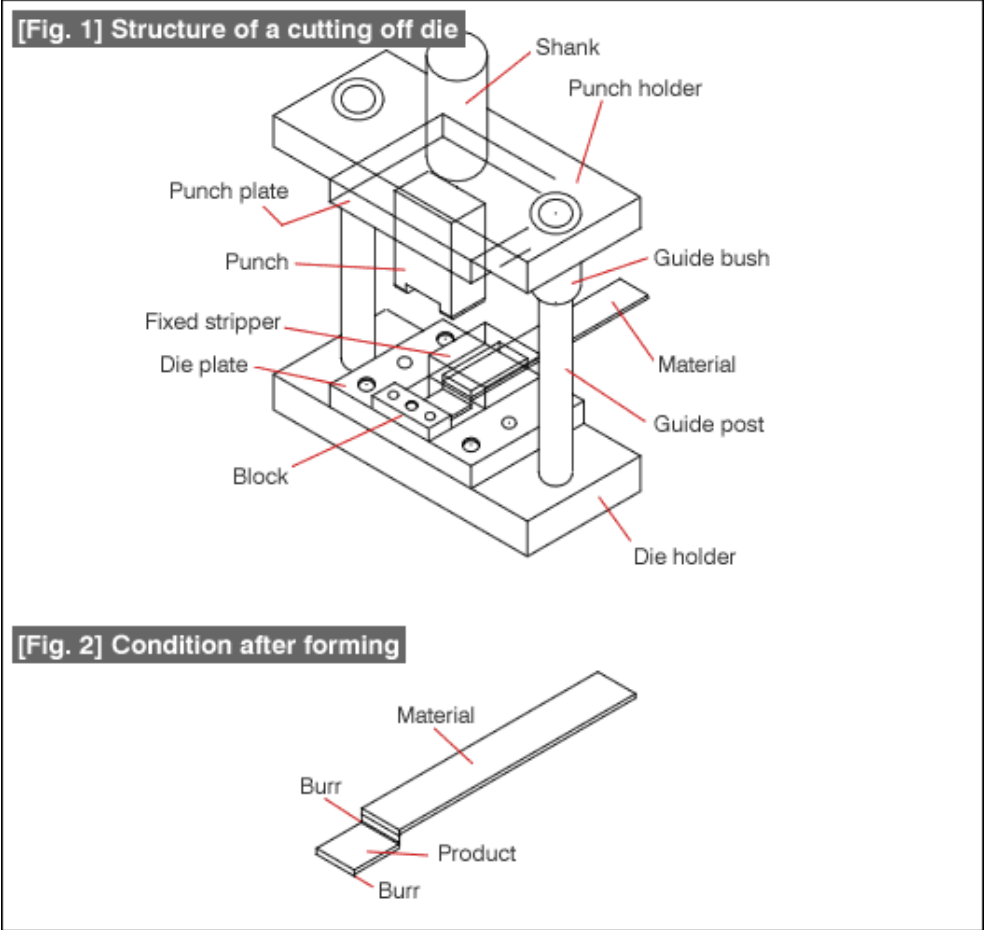
Although the shape shown in the example in the figure is a simple one, in practice, very often a very complex formed product is parted. In this kind of work, very often even the die has a curved surface to match with the shape of the product.

In parting work, since the product is divided into two products due to parting, there is no possibility of the formed material sticking to the punch, and hence there is the feature that there is little problem if there is no stripper. Depending on the product, as soon as the parting is done, the two products fly off to the left and right due to the sideward force during operation. This not only makes it difficult to collect the products but also can be dangerous and hence care will have to be taken. In order to prevent the products from flying off, it is safe to have a structure in which the products are pressed down by a light and simple stripper. When the pressing down by the stripper is removed, since the product after working get divided into two part and move simply to the left and right, it is possible to collect the products easily and even the operability of the press becomes relatively better.

Cutting Off Die

Cutting off work is a method of blanking work in which the material is cut by shearing into two parts without generating any scrap. If this method is used, the rate of utilization of the material (yield) can be increased to the maximum possible extent.

The basic structure of a cutting off die is shown in Fig. 1. The cutting is done in the condition in which the material is passed through the tunnel part of a fixed stripper and has butted against a block. This work is shown in Fig. 2.



Since the burrs at the left and at the right after cutting are in opposite directions, they remain as they are in the products (see Fig. 2). This is the first problem. Another problem comes because the cutting off is done along a single line. The material on the die jumps up due to the bending moment generated during the operation, and on the contrary the tip of the material of the cut part falls down. Since the cutting off is not done with the flat condition maintained, the cut edge surface becomes inclined. This is the second problem.

There are no countermeasures possible for the different directions of the burrs.

As a countermeasure for the cutting edge surface becoming inclined, it is essential to set the cutting clearance smaller than normal. Even when the clearance is small, if the punch moves away because of being pushed by a lateral force during working, the clearance becomes large and the problem only gets worse. It is necessary to take measures to prevent the punch from moving away by providing a back up heel or a back up block so that the punch does not move away.

As a positive measure to prevent the inclination of the material during cutting off, it is important to provide a material pressing member inside the die (inverted pressing member) thereby gripping the material between the punch and the inverted pressing member thereby ensuring that the material does not get inclined during cutting off. In addition to putting an inverted pressing member on the die side, even changing the stripper from a fixed stripper to a movable stripper is a good countermeasure. However, this increases the cost.

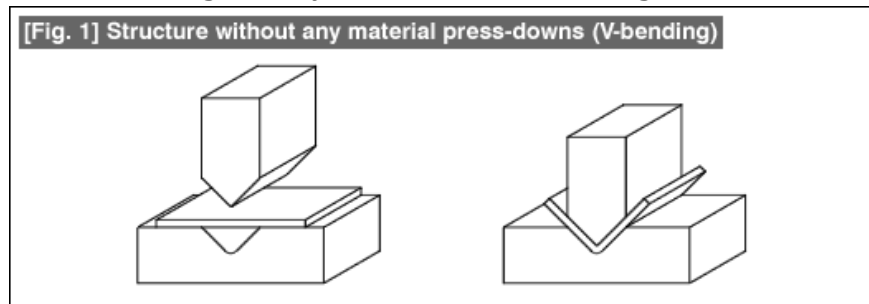
Although the cutting off operation appears simple, it is quite difficult when the work has to be done neatly. Although the operating force becomes balanced if the cutting is done with a certain width such as in parting, since the cutting is made on one side, there is the problem that the operating force becomes unbalanced. It is necessary to consider this aspect at the time of designing the structure.

Basics of Bending Die Structures

The largest shape in press formed products can be said to be bent products. The basic structure of dies for bent products will be explained below.

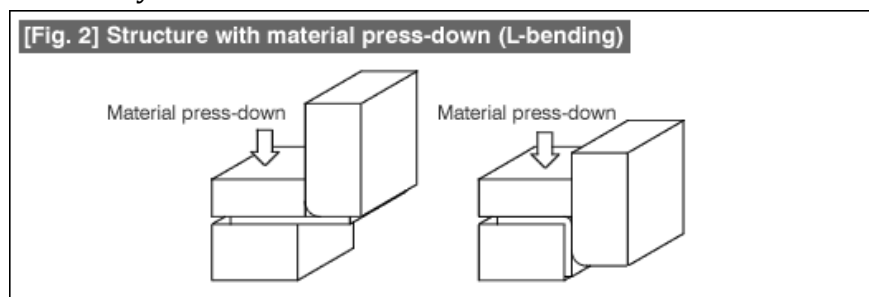
Bottoming bending (V bending)

This is a structure of forming a shape by pushing a punch towards a material held at two pivots. See Fig. 1. This is the simplest bending structure. The bending angle changes depending on the Stroke of the punch. The bending method of this form is called "free bending". In the case of free bending the die does not have to have a V-shape as shown in Fig. 1. By preparing the punch and die to have the shape that is to be formed as shown in Fig. 1 and transferring the shape of the punch and die to the material by pressing the material between the punch and the die thereby preparing the desired shape is called "bottoming bending". Since the typical shape made using this method of forming is the shape of the letter V, generally this is called V-bending.



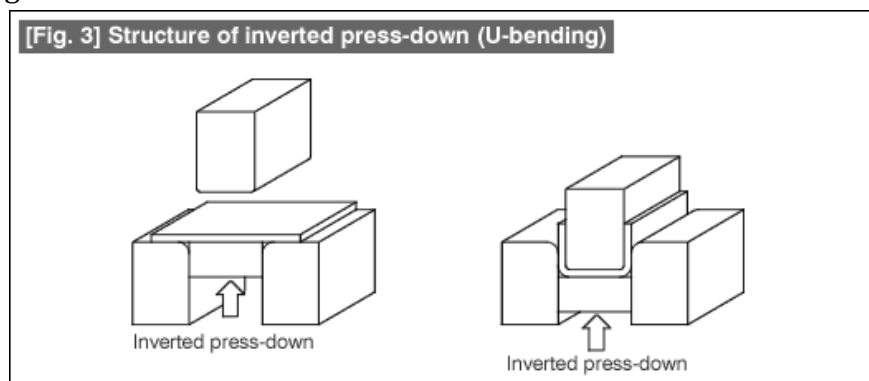
Press-down bending (L-bending)

This is the method of forming shown in Fig. 2. The bending is done after holding the material on the die using press-downs that press the material so that the material does not get shifted. The feature of this method is that the material press-down and the punch operate from the same direction. Since the material is pulled in the direction of the punch during formation, sufficient pressing area and force will be necessary.



Inverted press-down bending (U-bending)

This is the method of forming shown in Fig. 3. An inverted press-down is incorporated into the die, and the material is formed by pressing the material using the punch and the inverted press-down. Since both ends of the material are bent, it is not necessary to worry about the material being pulled as in L-bending.

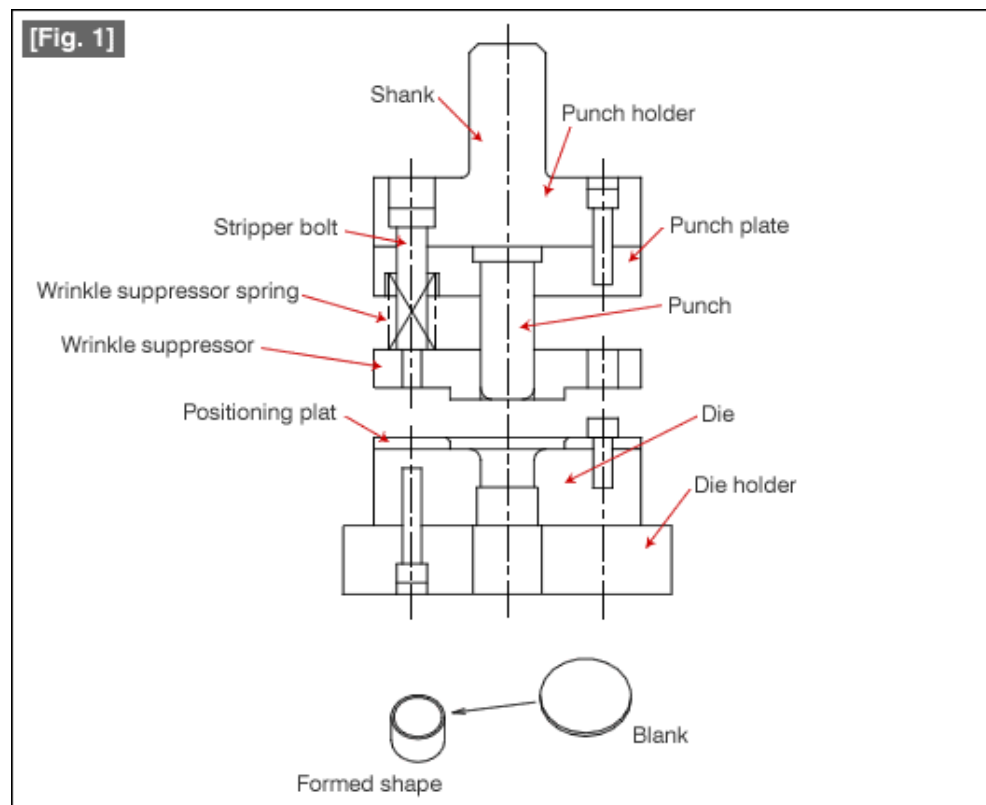


The above three methods are the basic structures of bending. Very often the bending is also done from a direction opposite to the bending directions shown in Fig. 1, Fig. 2, and Fig. 3. The bending of different bend product shapes is carried out by devising techniques so as to make the bending according to these basic forms.

Structure of Drawing Dies

First Drawing Dies for Drawing and Dropping

The most important parts of a die for drawing are the punch, the die, and the wrinkle suppressor. When drawing a cylindrical shape without a flange from a blank, a die of the drawing and dropping structure such as the one shown in Fig. 1 is used. The material to be formed is placed on the positioning plate, and after that material is drawn by the punch, the product is made to pass through the die and fall down. Even the die structure is simple and easy to prepare, and the die structure can be said to be one offering efficient press operation. The drawback is that the bottom part gets bent and it is difficult to make it flat.

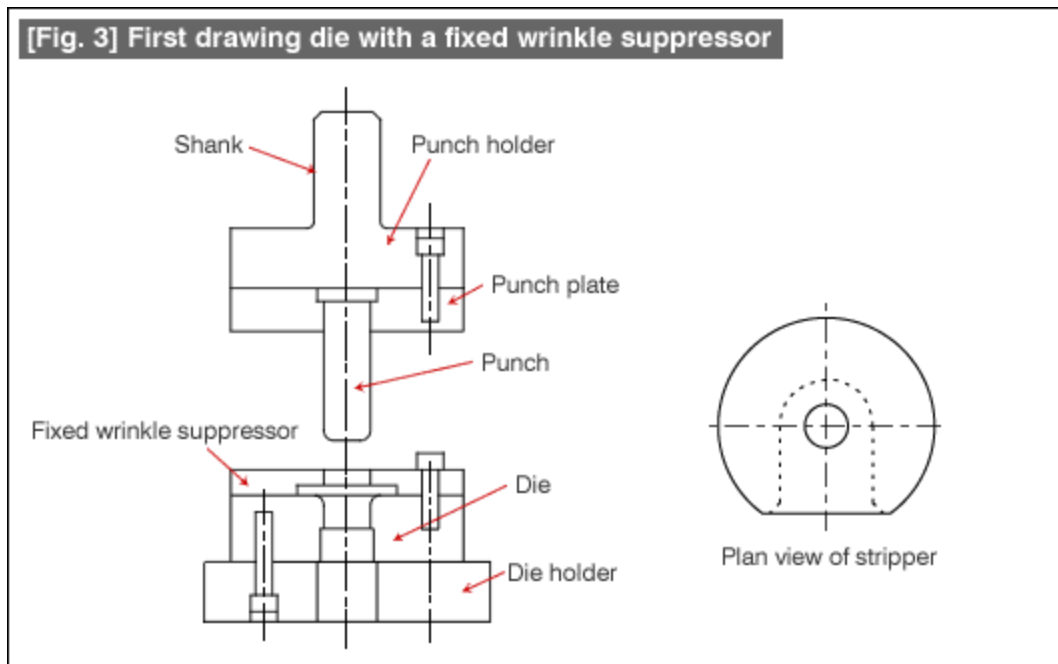
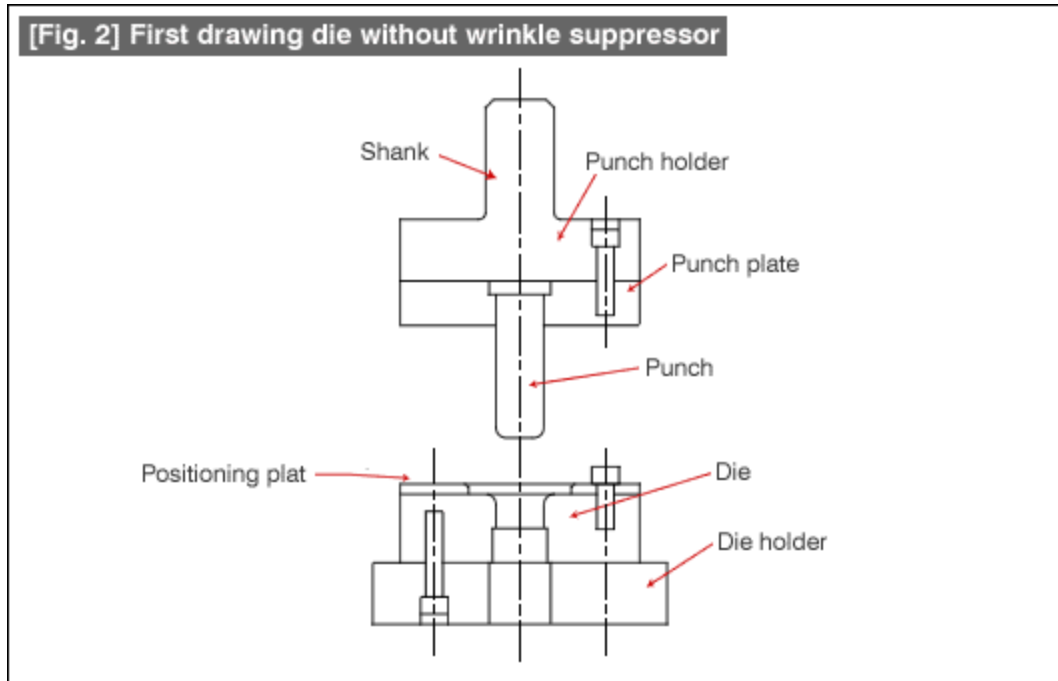


The wrinkle suppressor in cylindrical drawing is used for the purpose of preventing the generation of wrinkles because of the material getting buckled due to the compression in the circumferential direction during drawing of the blank. The generation of wrinkles can be known roughly from the value of the material thickness divided into the diameter of the blank (expressed as a % value, and called the relative plate thickness). When the relative plate thickness is 3 or more with the drawing ratio (m) being about 0,6, it is possible to draw even without a wrinkle suppressor. As is shown in Fig. 2, the structure of the die can also be much simpler.

The purpose of the wrinkle suppressor is to suppress the buckling of the material. It is sufficient to prepare a gap so that the material to be drawn can move, and also wrinkles are not formed, and hence there is also a die structure using a fixed stripper as shown in Fig. 3.

Although this structure is easy to prepare compared to the structure of Fig. 1 using a spring, it is difficult to carry out manual press operation. This is used for simple type die for small volume production when used for manual operations. For mass production, the suitable structure is one in which automatic forming is done using a pusher feeder (an apparatus that carries out automatic

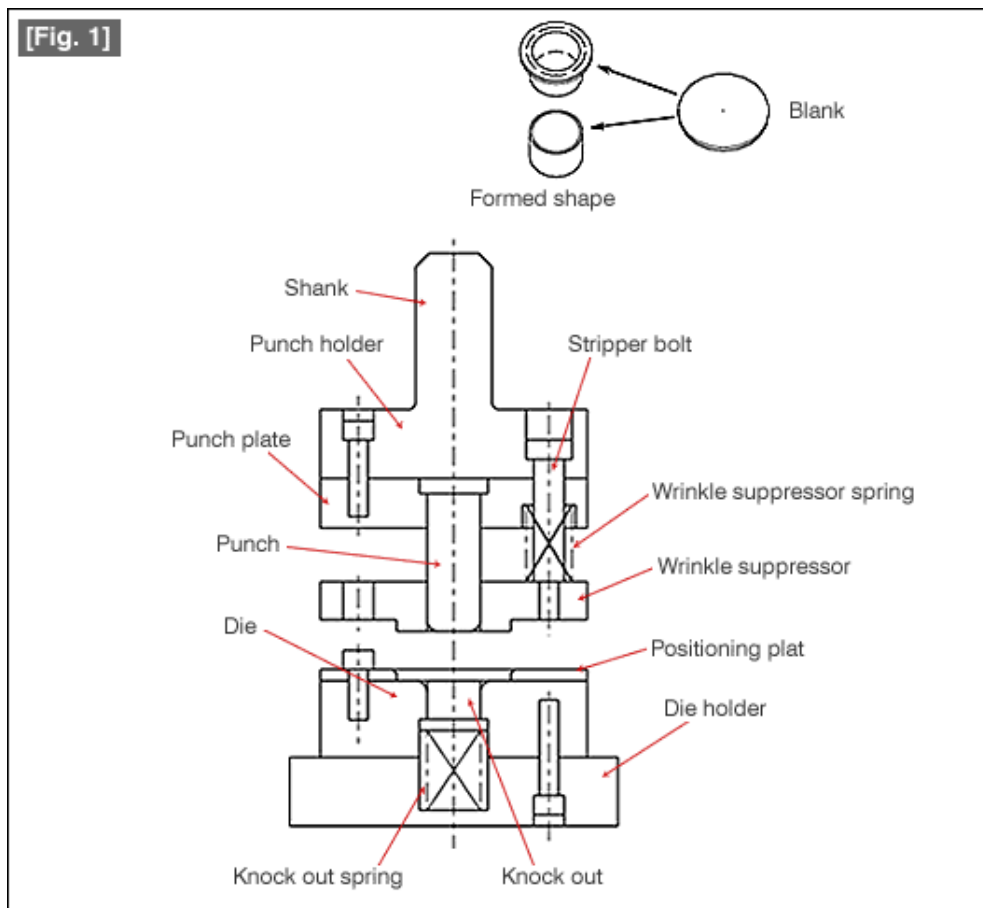
forming by inserting into the die one sheet at a time from a pile of blanks that are pushed out by a plate shaped part carrying out reciprocating movement). Since quite a large force acts on the wrinkle suppressor, it will get warped if it is too thin. It is necessary to design it with a slightly larger thickness.



Although movable type wrinkle suppressors are very common, depending on the conditions, it may not even be necessary. The structure of a die should not be determined shortsightedly and in haste, but should be determined checking even the forming conditions and the method of working, etc.

First Drawing Dies for Downward Drawing

This is a structure in which a knock out is incorporated in a die of the drawing and dropping type structure with movable wrinkle suppressor. This structure is shown in Fig. 1



This structure can be used for both drawing of cylindrical shapes with flanges and drawing of cylindrical shapes without flanges from blanks. In addition, since the forming is done while gripping the material between the punch and the knock out, the flatness of the bottom of the drawing object is quite good. The knock out has the two functions of pressing down the material and of ejecting the product.

The drawback of this structure is that it is not suitable for deep drawing. The reason for this is that there is some restriction on the length of the spring that can be incorporated. Considering the top die, the punch becomes longer in proportional to the depth of drawing. At the same time, it is necessary to make even the spring for the wrinkle suppressor longer. If the length of the spring is determined from the amount of deflection of the spring, a longer space than the punch may be required, and hence the top die becomes large thereby it becomes difficult or impossible to realize the structure because of the balance relationship with the bottom die or because of the die height,

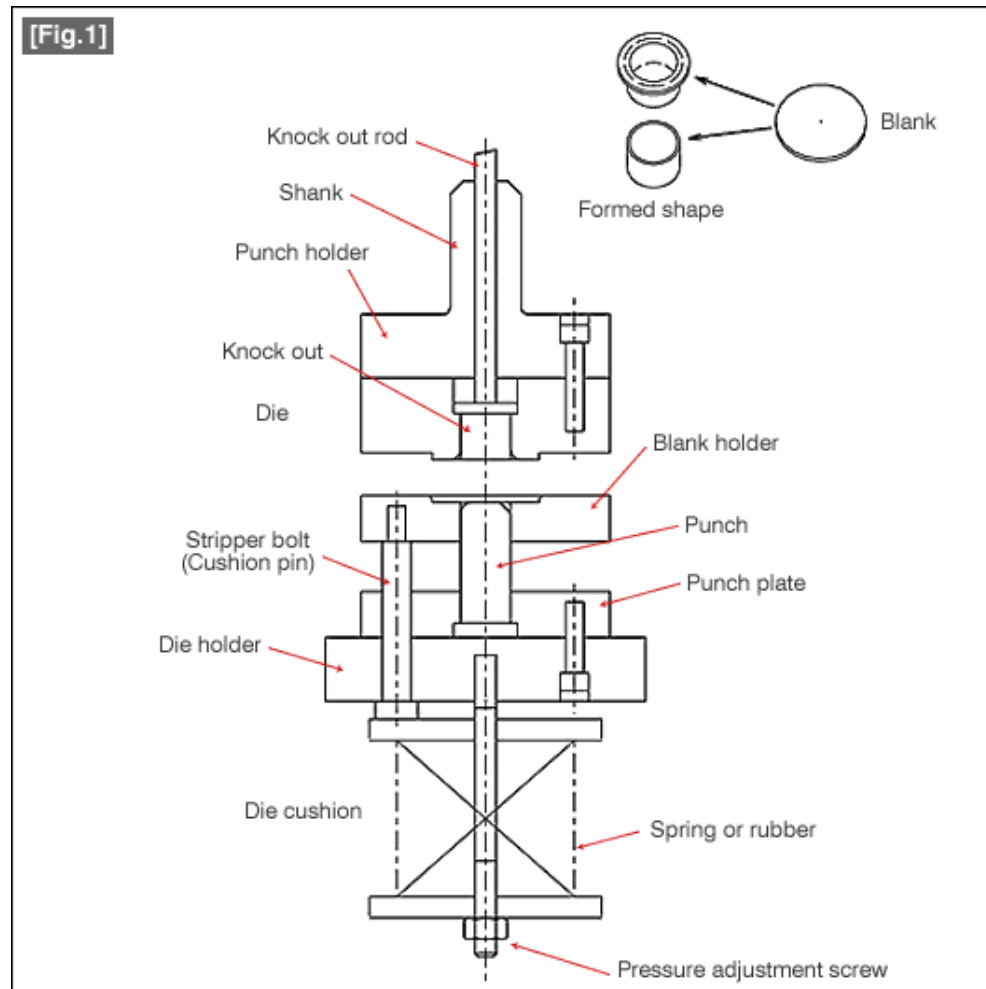
The same can be said of the knock out spring of the bottom die.

Because of the spring space, this is a structure that is used frequently for relatively shallow drawing operations.

When this die is seen from the point of view of press operations, this structure cannot be said to have ease of operation. In specific terms, the material is inserted in the positioning plate in the lower die. The drawing is done when the upper die comes down. Although the formed product is ejected from the die in the condition in which it is gripped between the knock out and the wrinkle suppressor of the top die, since the product is being pressed down by the wrinkle suppressor, the product will remain on the die. This product is removed by the operator and the next material is inserted inside the die. Since the operator will have to carry out the two operations of inserting the material into the die and of taking out the product from inside the die, the efficiency of operation goes down compared to merely inserting the material inside the die which is then drawn and dropped.

First Drawing Dies for Upward Drawing

This is a drawing die structure in which the placement of punch and die is inverted. This die structure is shown in Fig. 1.

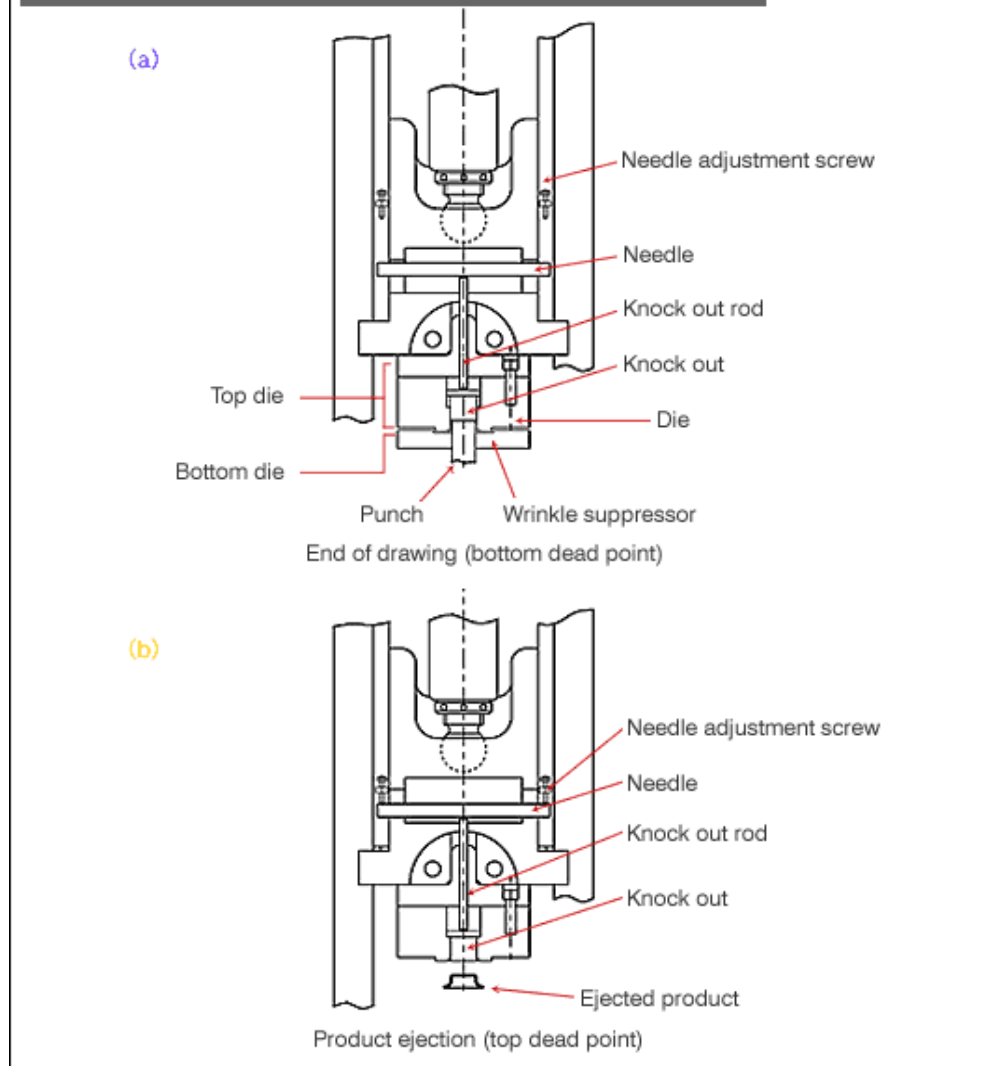


This die structure is used extremely frequently for drawing operations. The wrinkle suppressor is very often called the blank holder. This is because the blank positioning part has been prepared in the wrinkle suppressor. The material to be formed is placed on the blank holder, the drawing is done upwards from below, and the product enters the die. The product that has entered the die is ejected from the die by the knock out at the top dead point, and is blown away to outside the die by compressed air, etc.

The method of knocking out is shown in Fig. 2

The state at the bottom dead point after completion of drawing is shown in Fig. 2(a). The product that has been drawn by the punch of the bottom die is present inside the die. The knock out is pushed up by the product. Along with the knock out, the knock out rod and the needle of the press machine are pushed up together. From this condition, although the slide of the press machine rises towards the top dead point, the product that has entered the die remains as it is in the die. After rising to near the top dead point, the needle hits against the needle adjustment screw. When this happens, the needle is lowered and lowers the knock out via the knock out rod, and ejects the product to outside the die. Fig. 2(b) shows the condition when the product ejection has been completed. The fearsome thing in this knock out structure is that of adjusting the needle. If the needle adjustment screw is lowered too much by mistake, the knock out rod will get bent. In the worst case, the top die gets detached from the slide and falls down thereby leading to accidents. When the knock out is not used or before adjusting the knock out, the needle adjustment screw should always be unscrewed up to the topmost position.

[Fig.2] Relationship between the press machine and the die
Ejecting the product in upward drawing



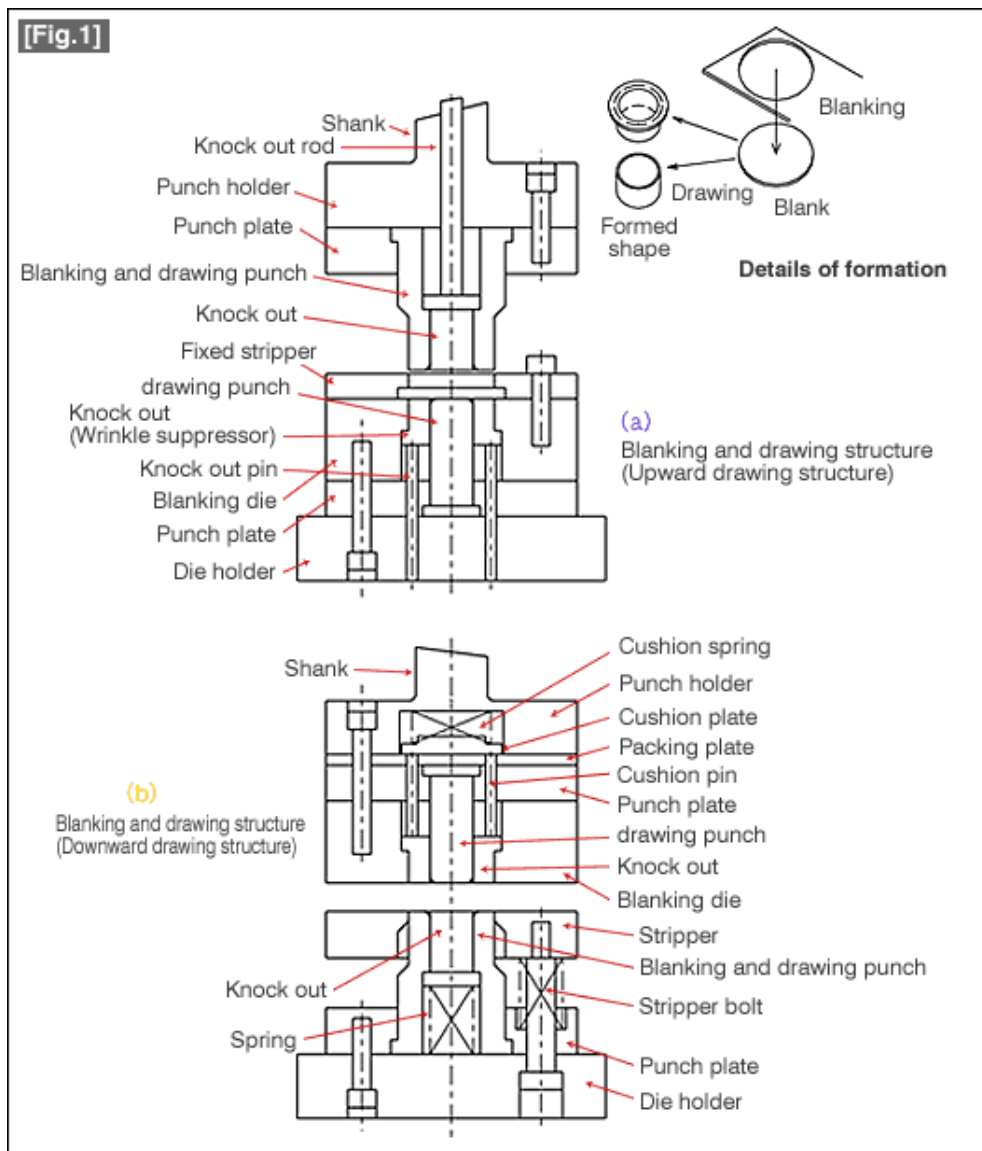
Returning to Fig. 1 let us pay attention to the die cushion in the bottom die. (This figure is showing a small die. In a large die, the die cushion will become an accessory apparatus of the press machine.) The die cushion is extending downwards after passing through the bolster hole of the press machine. Therefore, a considerably long spring can be used. This implies that it is possible to carry out the forming of even a considerably long drawn product. This makes it possible to form difficult products that can not be formed using downward drawing. Since it is sufficient to merely place the blank on the blank holder, the operability of press operation is much better than that of downward drawing. This can be used for forming shapes from blanks even when the product has a flange as well as when the product does not have a flange.

Blanking and Drawing Dies

A blanking and drawing die is a compound die that combines blank punching and first drawing.

The upward drawing structure is shown in Fig. (a).

While a fixed stripper structure has been shown in this figure, it is also possible to have a movable stripper structure in which the stripper is provided in the top die. The content of forming is shown in the figure marked "formed shape". The blank is punched using the blanking and drawing punch (compound part: this is the punch for blanking as well as the die for drawing), and subsequently, drawing is done by the continuing stroke. The drawn product is ejected from the top die by the knock out mechanism near the top dead point.



The knock out in the bottom die has the function of making sure that the product does not stick to the punch and of wrinkle suppression.

The downward drawing structure is shown in Fig. (b). This is not suitable for longer product drawing because of the spring space.

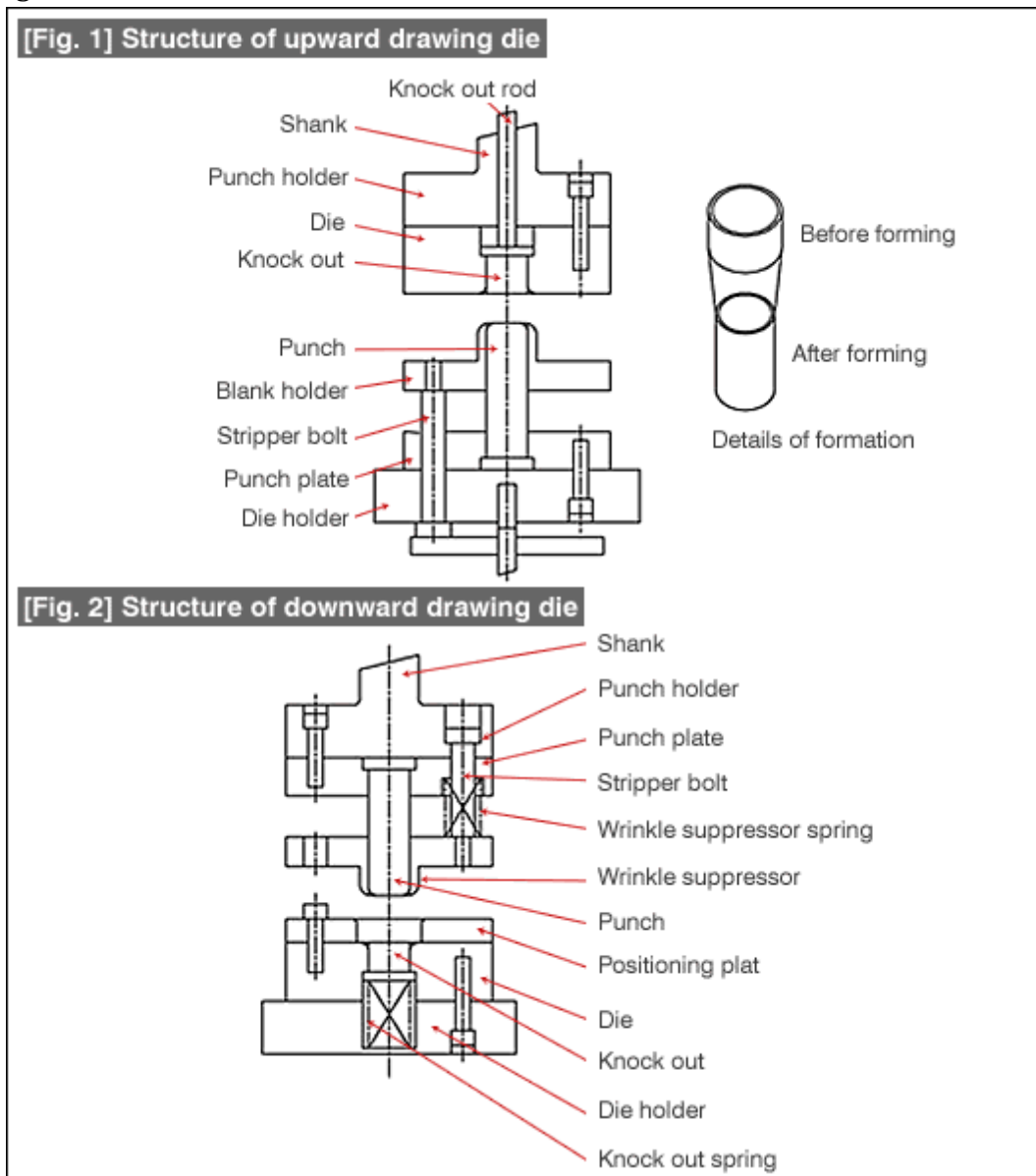
In the case of shallow drawing, it is possible to make this a drawing and dropping structure by removing the knock out and spring in the bottom die and opening a hole in the die holder for letting the product pass through it.

The drawback of the blanking and drawing structure is in maintenance. Maintenance will have to be carried out when burrs start appearing because of the cutting part of blanking is worn out or damaged. Although the damaged part is ground again and the cutting edge is created again, since even the rounded part of the drawing die is ground, it will be necessary to reconstruct the rounded part of the die. Every time maintenance is carried out, if the reconstruction of the die is not made with the rounding of the same shape, there will be changes in the drawing thereby causing defects in drawing. In addition, since the structure is weak, if any mistake is made in the press operation, the die breaks immediately. This is also another drawback.

Although this type of compound structure has drawbacks, its attraction is that the process can be made short. If an upward drawing type blanking and drawing structure is used, it is possible to carry out compound forming operation of blanking → drawing → hole punching.

Redrawing Die

In drawing work, there is a limit to the extent to which drawing can be done in one operation. Therefore, the desired diameter is obtained by repeating drawing several times. Such repeated drawing is called "redrawing". A die that is used for redrawing is called a "redrawing die". Since the drawing diameter difference is large in the step next to first drawing, a die with a structure shown in Fig. 1 or in Fig. 2 is used.



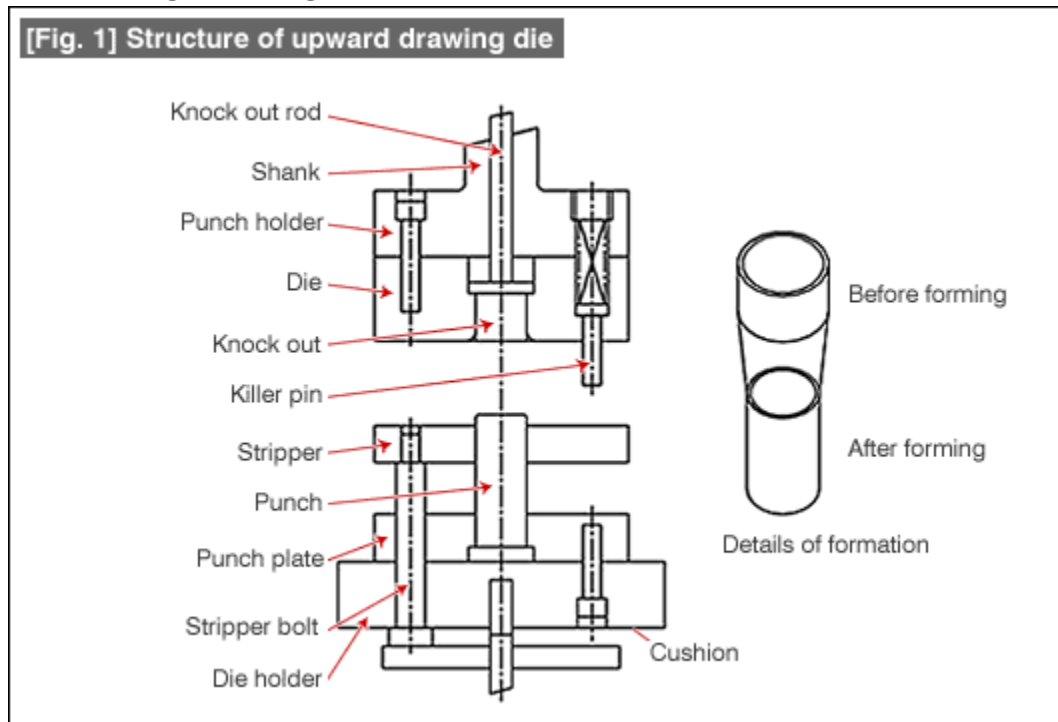
The product to be formed from now on is formed after placing a guide (inner diameter guide) in the gap between the punch and the inner diameter difference part of the drawn product by the blank holder (wrinkle suppressor in the case of a downward drawing die). Although wrinkles appear in the flange part during first drawing, in redrawing in which the difference between the diameters before and after drawing is large, wrinkles appear as vertical wrinkles in the side wall part. The inner diameter guide supports so that the side wall part does not buckle.

Next the relationship between the inner diameter guide and the rounded part of the die is explained here. The material of the product is gripped between the inner diameter guide and the rounded part of the die, slides over the inner diameter guide, moves to the rounded part of the die, and the drawing is done as the product moves to the interior of the die. At this time, the pressing force on the material held between the inner diameter guide and the rounded part of the die is determined either by the pressure of the die cushion or by the pressure of the spring. If this force is too strong, the deformation resistance becomes large causing breakage defects of the product or

breakage of the inner diameter guide. If this force is too weak, it will lead to wrinkles. It is desirable to maintain a fixed gap between the inner diameter guide and the rounded part of the die. To do this, techniques are used such as placing a pin in the die, etc., and also a stopper is provided so that the gap between the inner diameter guide and the rounded part of the die is fixed.

This can be said to be the basic structure of a redrawing die.

Even redrawing work when carried out several times, cause the diameter reduction ratio to become small. Because of this, although the inner diameter guide becomes weak and easily breakable and hence can no longer be used, there is no problem because there is no fear of buckling of the drawn side wall part because of the small diameter reduction ratio. These types of redrawing die structures are shown in Fig. 1 and Fig. 2.

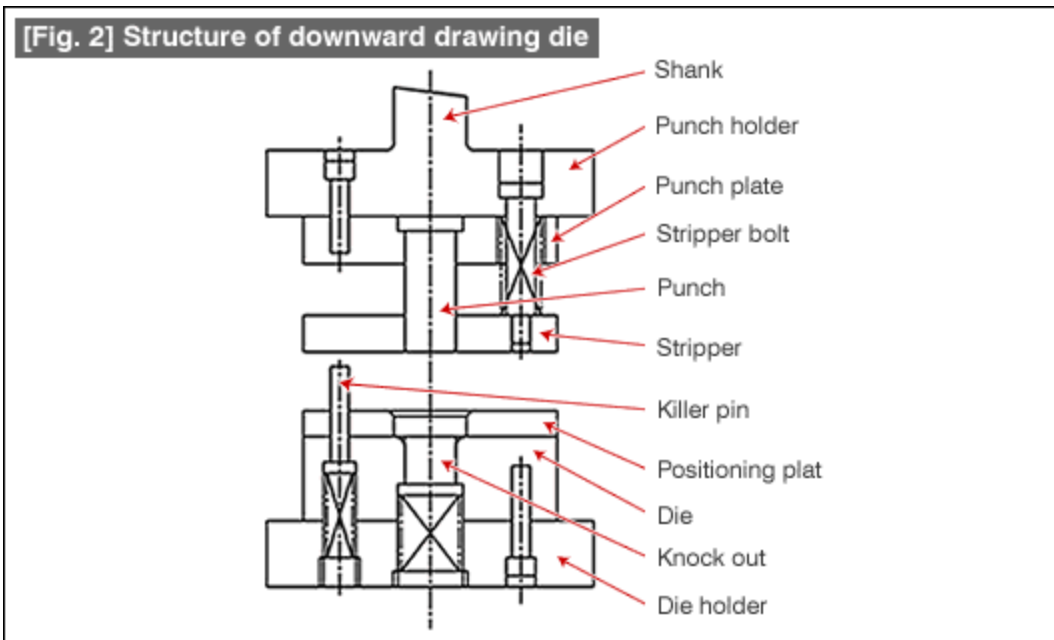


The structure of Fig. 1 is suitable for redrawing of products with a flange. The flange part of the product goes on top of the stripper, and the inner diameter of the product is guided by the tip of the punch that is projecting beyond the stripper.

The structure shown in Fig. 2 is structure that is suitable for redrawing of products without a flange. In the case of a product without a flange, the edge of drawing does not become flat but becomes wavy. Because of this, if the drawn edge part of the product is placed downwards, the product becomes slant. Becoming slant is a problem in drawing work. Therefore, drawing the material so that the bottom part of the drawn product is at the bottom causes the drawing process to become stable.

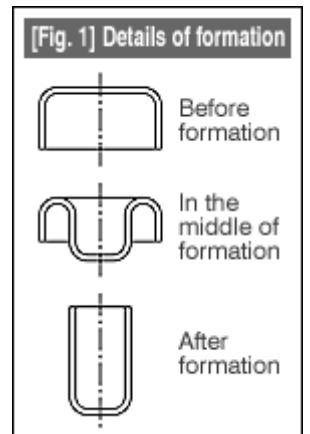
The feature of this redrawing die structure is in the killer pin. The killer pin presses down the stripper according to the timing of drawing, and makes sure that the product is not strongly gripped between the die and the stripper. If there is no killer pin, to begin with, the product is held between the stripper and the die, and the drawing is started thereafter. If this form is used, the plate thickness will not become uniform in the side wall part, and becomes the cause of generation of cracks in the bottom of the drawn product.

The killer pin is held by a spring. At the end of drawing, the spring of the killer pin contracts so that the stripper comes into contact with the die or the positioning plate.

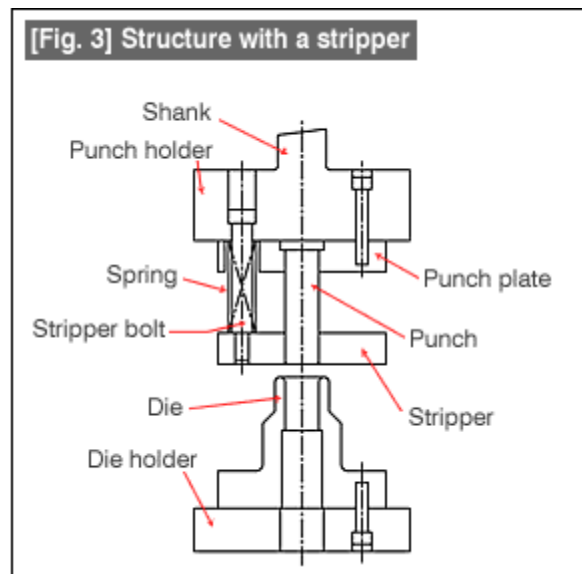
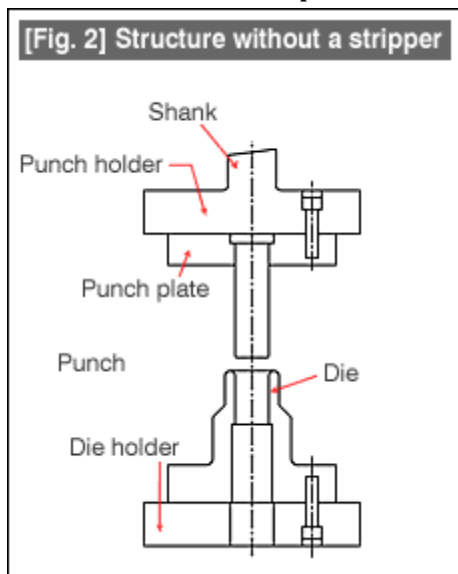


Reverse Redrawing Dies

Reverse redrawing is explained using Fig. 1 "Details of formation". The condition before formation is prepared by ordinary drawing. This shape is drawn so that the outside becomes the inside as is shown by the figure of "In the middle of formation". The product after forming is such that the inside of the shape before forming has become the outside. By doing this, the material of the product is made to move by a substantial amount, the stress of drawing changes, and it is possible to obtain larger reduction ratio than normal drawing.

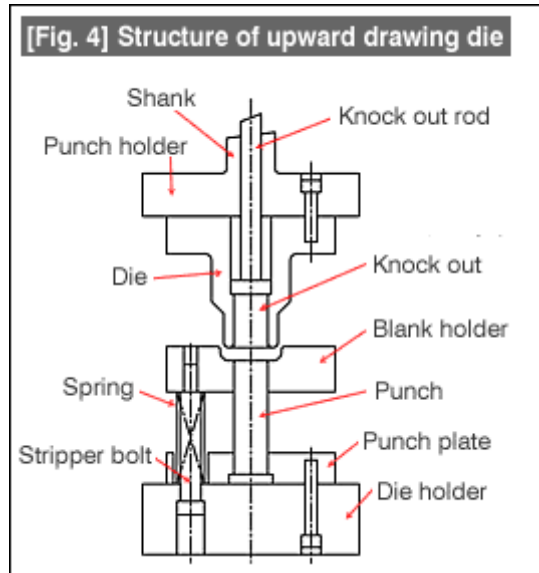


The structure of the drawing die will be as shown in Figure 2 to Fig. 4. The shape of the die is common to all the structures. This looks very weak. However, the inner diameter of the product to be drawn gets added to the external shape of the die, and in the process of drawing, the product moves so as to tighten the die and becomes a resistance to the force during drawing that tries to open the die outwards, and hence since a balance is achieved, breakage of the die is not common. It is better that the straight part of the die interior is as short as possible.



Whether or not a stripper is necessary is determined by the relationship between the drawing diameter and the material plate thickness. If the material plate thickness is small compared to the drawing diameter, the structure becomes one like that shown in Fig. 4. This is because genera-

tion of wrinkles is suppressed at the part where the material makes U turn.

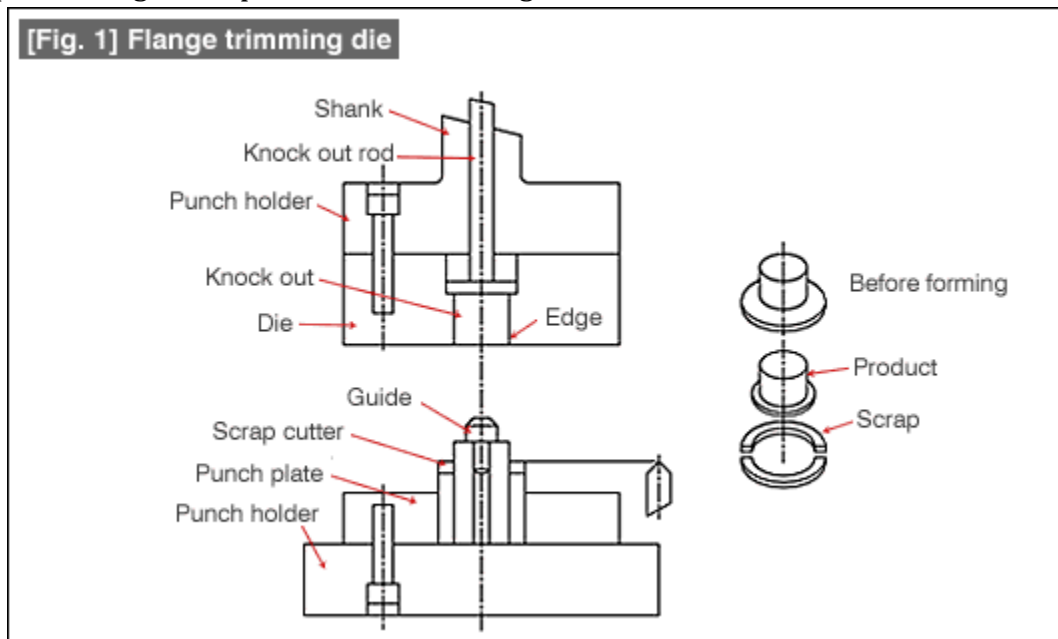


is the ease of operation of press formation work. This is because it is difficult to use for transfer forming of progressive forming depending on the details of the drawing work (work of stopping in the middle without inverting completely is a different case). Since single process formation is done frequently because of this, the ease of operation is judged to be poor.

Draw Trimming Dies

In drawing work the material gets deformed due to the anisotropy of the material. For example, when a circular drawing is made from a circular blank, the blank does not become round but becomes a shape that is closer to a rectangle. An ear is generated when forming a drawn shape without a flange, and the edge becomes wavy. "Trimming" is the operation of cutting off the parts that have deviated from the shape as described above thereby making the shape correct.

A typical die structure for trimming is shown in Fig. 1. An inverted placement structure is being used. The positioning of the product is done using the internal diameter.

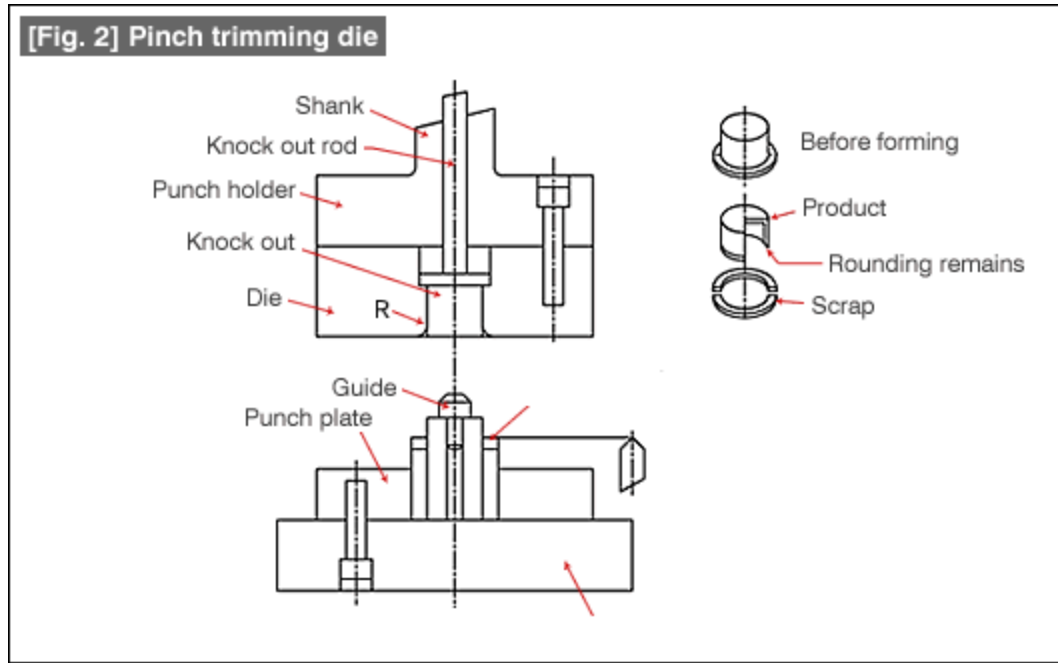


The same clearance between the punch and the die as well as the shape of the cutting edge as in normal blanking work are used as they are in this case also.

The trimming is done by the top die, and the product enters inside the top die. The product inside the die rises above the top die and is knocked out near the top dead point, and is thus ejected from the die. The knock out in Fig. 1 touches the bottom of the drawn product. In the case of a product with a large flange, there is the possibility that the flange is warped at the time of ejecting.

In the case of a product with a large flange, the knock out is made to escape according to the diameter of drawing, and the ejecting is done at the flange part.

One of the methods of trimming products without flanges is shown in Fig. 2. This method is called "pinch trimming". In pinch trimming, a rounding close to the rounding radius of the flange is provided. The tip of the punch is an edge. The clearance is made zero or close to zero. The trimming is done by pushing the product into the die. Basically, no step is formed in the outer periphery (if a clearance is provided, a step corresponding to the size of the clearance will be formed). Rounding remains inside the product. When the cut edge has to be made neat, although cutting is made horizontally using a cam, etc., the structure of the die becomes complex.



The scrap of trimming has the shape of a ring, and this remains on the outer periphery of the punch. If it is left as it is, it will not be possible to take it out of the die. This problem is solved by a scrap cutter. A part with the shape of the letter V hits against the scrap. While the scrap is pushed down during the subsequent trimming operations, at that time, the scrap is cut by the V-shape and gets detached from the punch. At least two scrap cutters should be provided, and their number is increased as the shape of the product becomes large so that the scrap is cut into smaller pieces thereby making it easy to handle it.

RELATIONSHIP BETWEEN PRESS MACHINE AND DIE

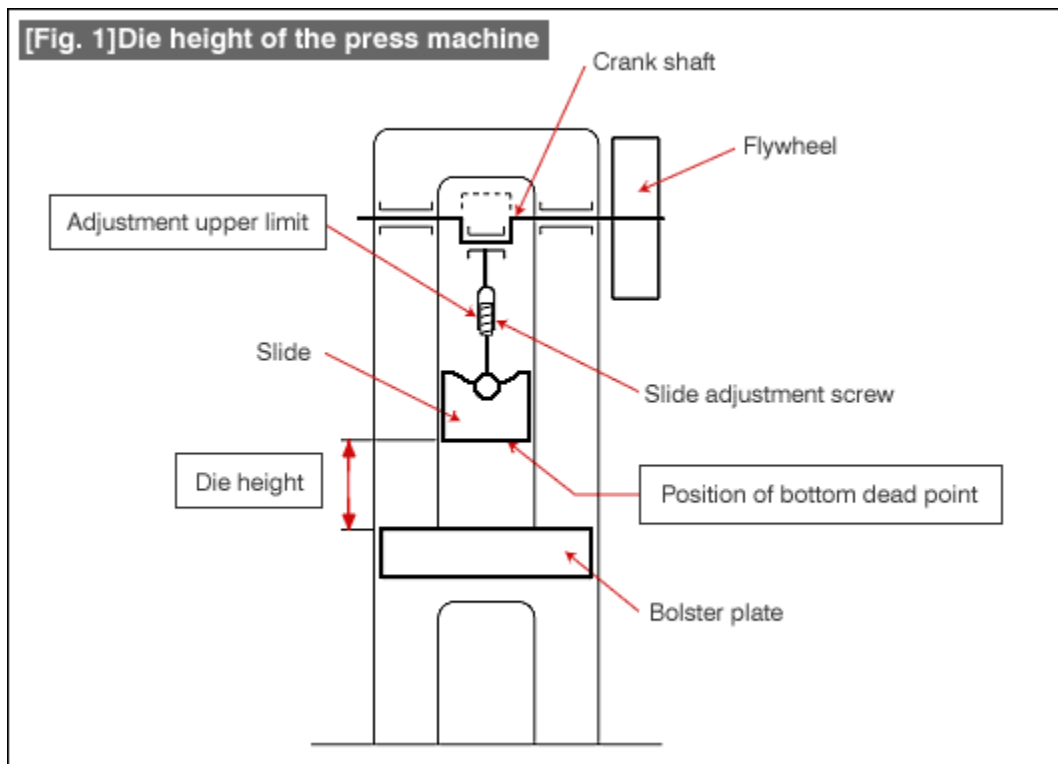
Die Height

There are two types of die heights, namely, die height of the press machine and the die height.

Die height has restrictions related to the height of installing the die. The primary height of the die is that of the press machine, and the secondary height of the die is of the die.

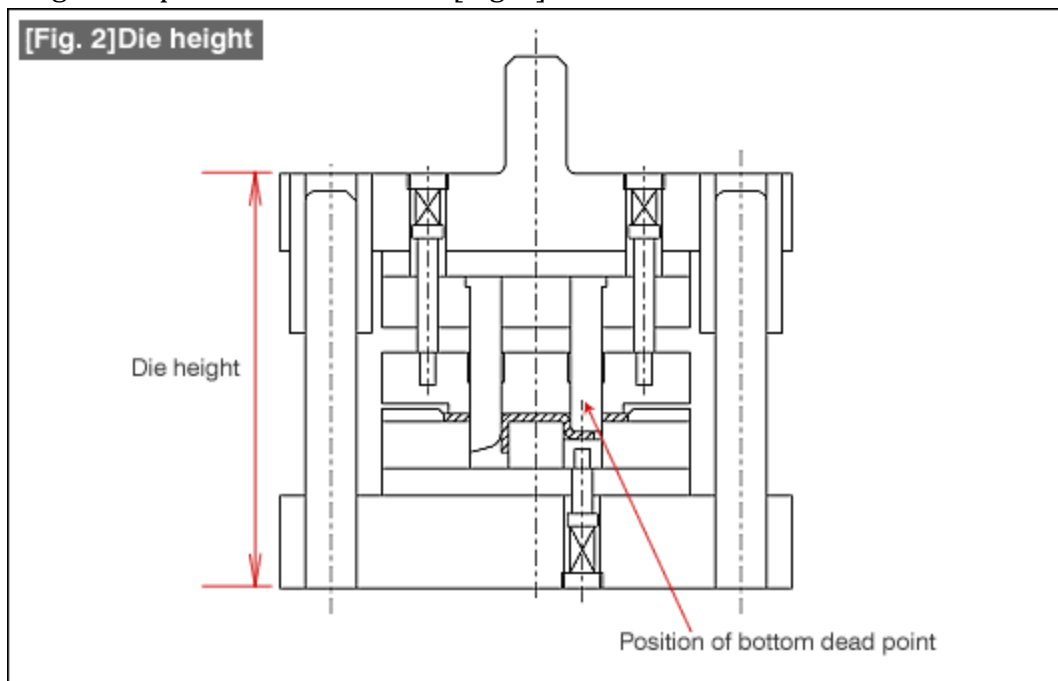
The die height of the press machine is shown in [Fig. 1].

In the condition in which the slide adjustment screw is raised to the upper limit and the slide stroke is lowered to the bottom dead point, the distance from the top surface of the bolster plate to the bottom surface of the slide is the die height of the press machine. In this press machine, it is not possible to install a die with a die height more than this height. If the die has a die height smaller than this height, it is possible to adjust using the height adjustment screw. In the case of a die with a low die height that is outside the adjustment range of the slide adjustment screw, a plate for height adjustment (called a parallel block) is placed above or below the die and then the die is installed.



If the die height varies, it will be necessary to rotate the adjustment screw of the press machine several times, and the time taken for replacing the die becomes long. Therefore, as far as possible, it is better to make uniform the height for all dies that are used by installing in the same press machine, thereby making the amount of adjustment small.

The die height of a press die is shown in [Fig. 2].

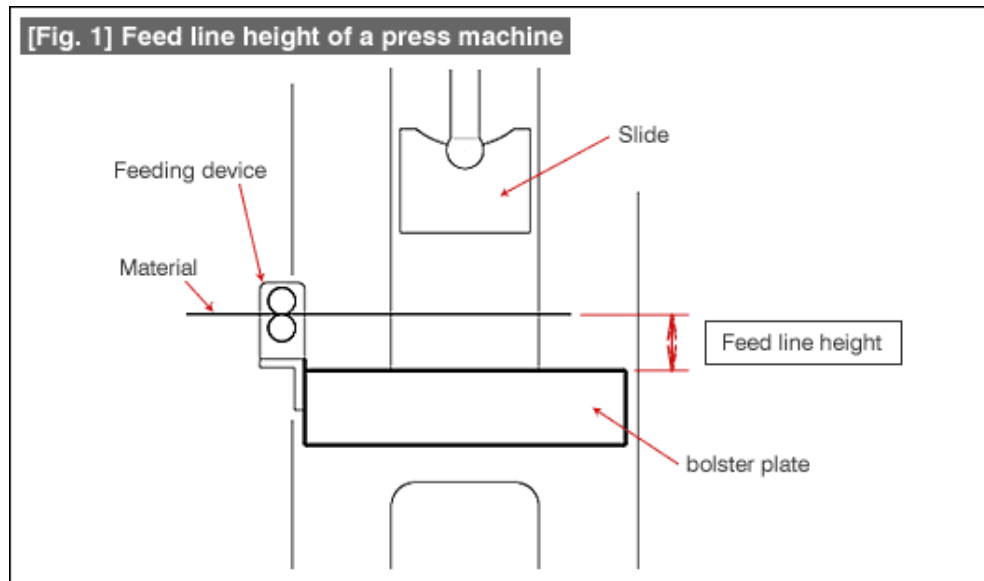


The die height is the height from the bottom surface of the die holder to the top surface of the punch holder in the condition at the bottom dead point when the punch and the die have mated together and the operation has been completed. In the case of a die with a structure in which the punch can penetrate the die to any extent, such as in the case of a blanking die, the depth of penetration of the punch should be decided and the height at that time is taken as the die height.

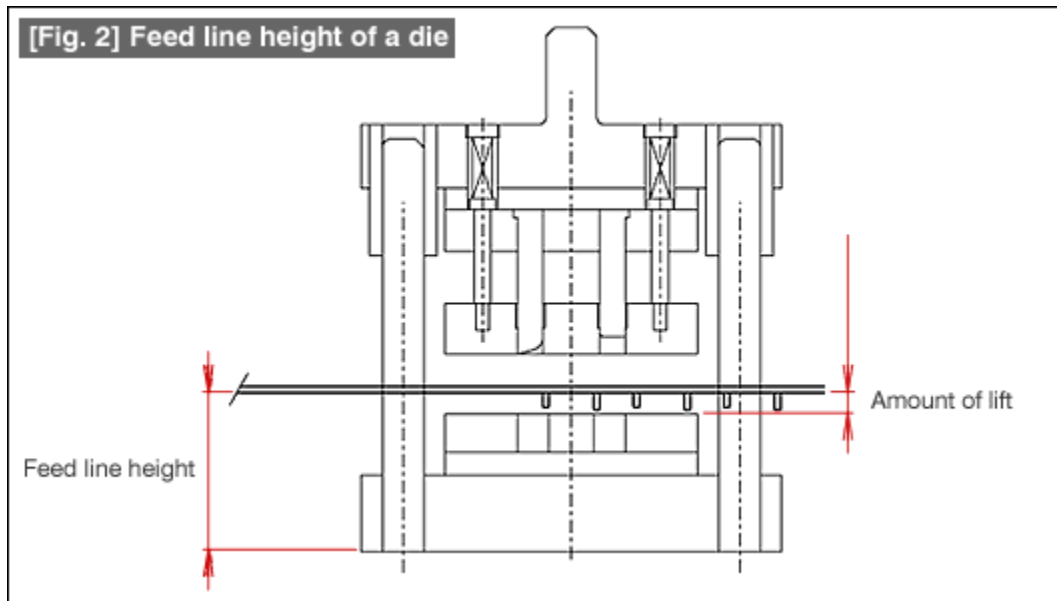
There are some people who call the die height of a press machine "shut height". The shut height is the distance from the bed surface (bolster surface) to the bottom surface of the slide under the same conditions as for the die height.

Feed Line Height and Amount of Lift

The feed line height of the material is the height from the bolster plate surface to the movement position of the material, as is shown in Fig. 1. This may also be referred to as "feed level" or "path line". In the case of a press die for carrying out automatic forming using a material feeding device, it is necessary to make both the die height and the feed line height match with the press machine.



The feed line height of a press die is shown in Fig. 2. This is the distance from the top surface of the bolster plate (bottom surface of the die holder) to the position to which the material has been lifted up from the die surface.



The feed line height of a press die is shown in Fig. 2. This is the distance from the top surface of the bolster plate (bottom surface of the die holder) to the position to which the material has been lifted up from the die surface.

Lifting up occurs unavoidably in the forming of products that includes forming operations such as bending, etc. The forming of the product is done after pressing the material down from the lifted up state down to the die surface. At this time, if the amount of lift is large the inclination of the material becomes large causing defects in forming. At the time of designing the die care should be taken to ensure that the amount of lift is as small as possible.

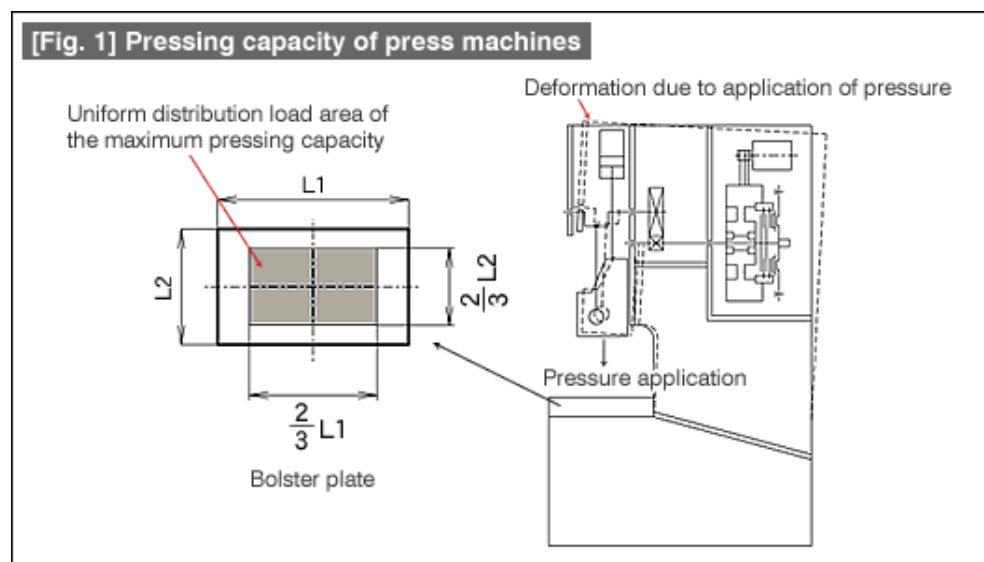
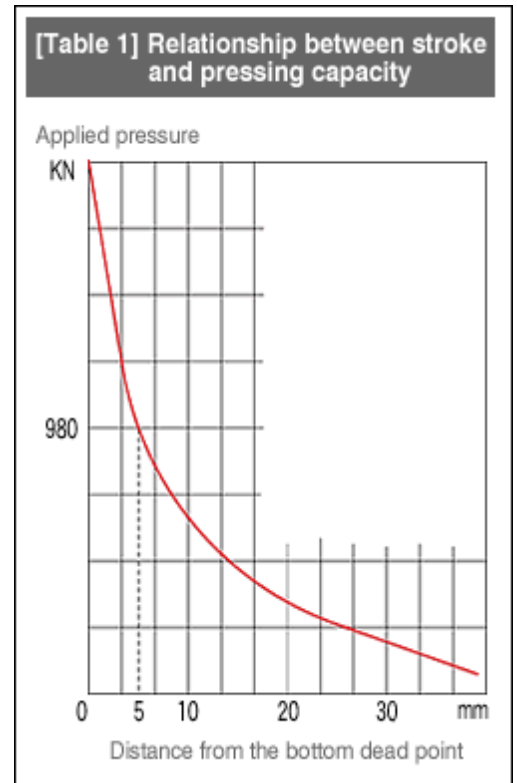
If the amount of lift has become large unavoidably, the position of the feed line height of the press machine is set to the position of about half the amount of lift. By doing so, the material tilts

slightly upward at the time of feeding the material. At the time of forming the product, the material is pressed down by the top die, the material that has tilted upward first becomes flat (when equal to the feed line height of the press machine), and then starts tilting downward from that state and comes into contact with the die surface. Compared to the normal setting of the feed line height, it is possible to make the tilt small of the material during product forming, and it is also possible to reduce defects in forming.

Pressing Capacity of Press Machine

In the crank press which is used most widely in press forming, there is the pressing capacity (capacity to apply pressure) which is an indicator of the capacity of the press machine. Pressing capacity is the maximum pressure that the press machine can generate safely. As shown in Table 1 in the case of a crank press, the pressure generated changes depending on the stroke position of the slide. Therefore the pressing capacity indicates the pressure at a determined position above the bottom dead point. In the example shown in Table 1, it can be seen that a pressure of 980kN (980 kilo Newtons = 100 tons) is being obtained at a position of 5 mm above the bottom dead point.

While it is wrongly thought that the press machine is hard and does not get deformed even when the applied pressure is acting, even within the permissible range of the pressure applying capacity, the frame and the bolster plate of the press machine become elastically deformed as shown in Fig. 1. Even when there is deformation of the frame etc., safety is guaranteed if the load is less than the pressure applying capacity.



The pressure called pressing capacity assumes that uniformly distributed load is active on a predetermined region in the area of the bolster plate as shown in Fig. 1. Even within the permissible range of the pressing capacity it is not good to make a concentrated force act on a narrow region.

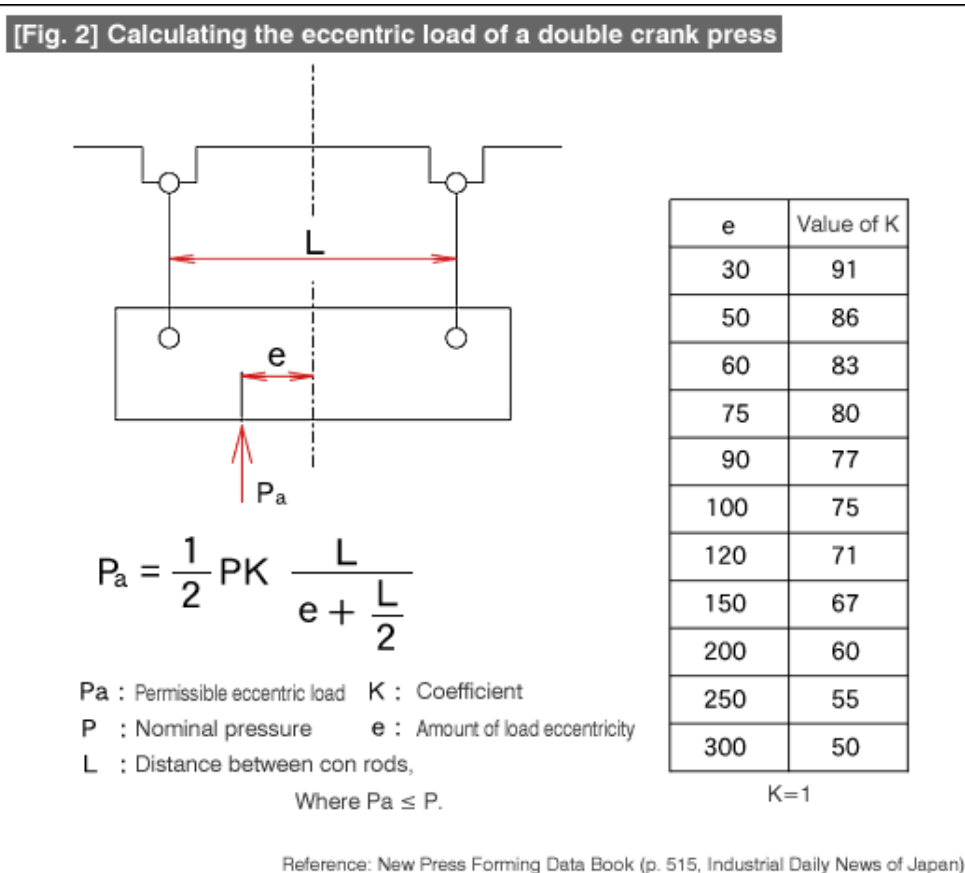
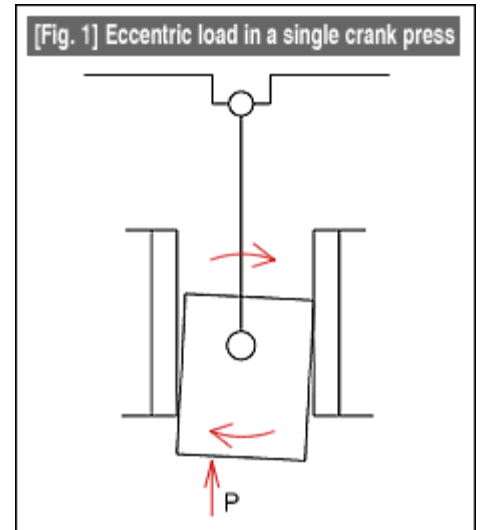
From the aspect of life of the die, if work is done at the maximum pressing capacity, the life of the die becomes shorter due to the effects of deformations of the frame and the bolster plate of

the press machine. When the life of the die is considered, it is necessary to carry out the work while having some leeway with respect to the pressing capacity. In general, it is considered good for the life of the die to carry out work at pressures up to 60 to 70% of the pressing capacity.

Eccentric Load on Press Machine

(the center of the forming force when the die is working) matches with the center of the slide of the press machine. However, due to the restrictions of the product shape or due to the forming method, etc., in a large number of cases it may be difficult to make the center of the die match with the center of the load. In the dies for progressive formation, it can be assumed that all the centers of dies are shifted from the center of the load. When such a die is installed in a press machine, an eccentric load will be applied because the center of the press machine and the load center are shifted with respect to each other.

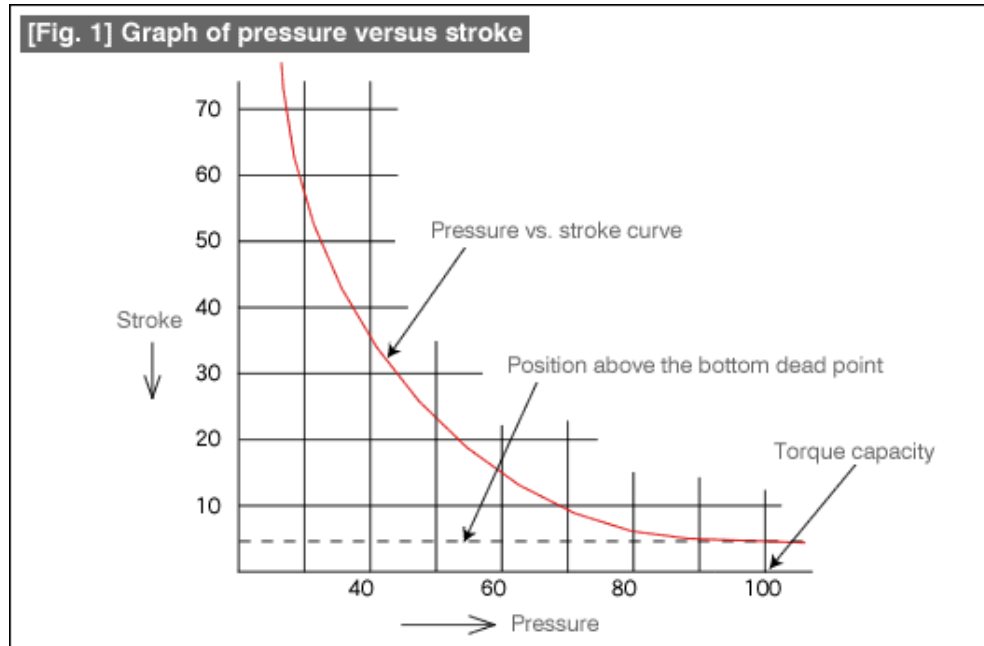
In a single crank press machine (one point press), the slide becomes tilted as is shown in Fig. 1, and the parallelism between the bolster plate and the slide gets disturbed. This inclination is proportional to the magnitude of the load. Naturally, even the life of the die is affected. In a single crank press machine, there are no rules about the relationship between the eccentricity and the load. It is necessary to take measures such as making the eccentricity small by changing the method of installing the die, or to use a press machine with a large capacity.



In the case of a double crank press machine (two points), the effect will be smaller compared to a single crank press machine. In the case of formation of products demanding accuracy, one of the reasons why the use of a double crank press machine is better than the use of a single crank press machine is the relationship with this eccentric load. The method of obtaining the permissible eccentric load of a double crank press machine is shown in Fig. 2.

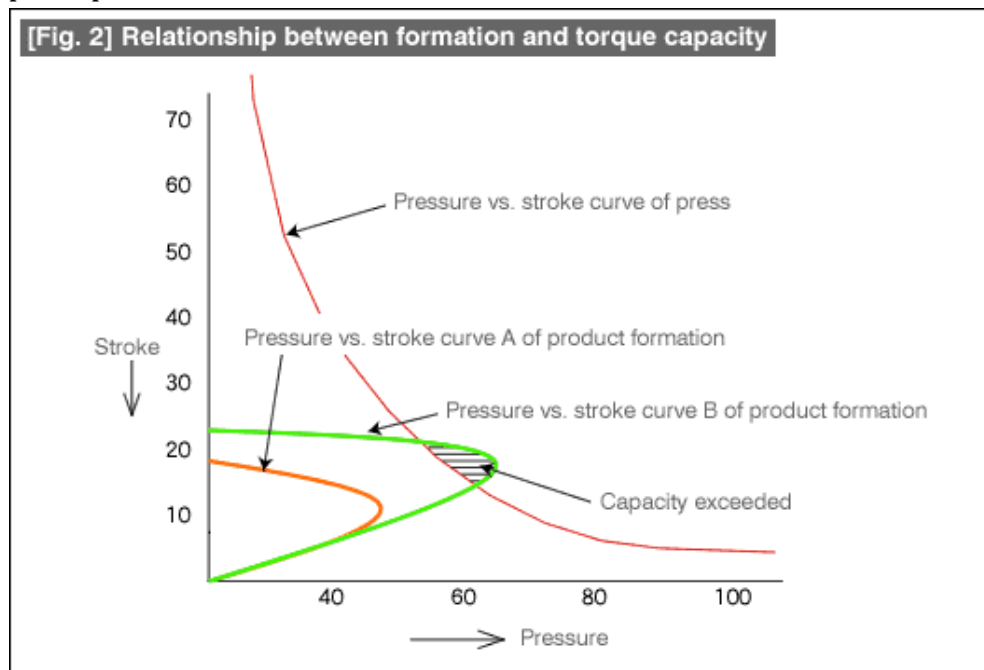
Torque Capacity of Press Machine

In machine presses such as crank presses, etc., the pressure generated changes depending on the position of the stroke. This point is a big difference from fluid presses such as hydraulic presses in which the pressing force does not change at any position of the stroke. Fig. 1 shows a graph of pressure versus stroke of a crank press.



This indicates that the pressure generated becomes higher as the stroke position of the slide gets closer to the bottom dead point. Theoretically, it is possible to get infinite pressure. In the indication of the capacity of a press machine, the position of the bottom dead point is determined, and the capacity is indicated. This is called "Torque Capacity".

In press formation, the formation starts from a certain position above the bottom dead point, and ends at the bottom dead point. The change in the forming force between the starting point of product formation until the completion of formation is called "the curve of pressure of product formation versus stroke". Fig. 2 shows the pressure versus stroke curves for the product and the press machine superimposed on each other.



Two curves A and B have been shown for product formation. The product formation curve A is inside the curve for the press machine. If the condition is like this, it indicates that there is no

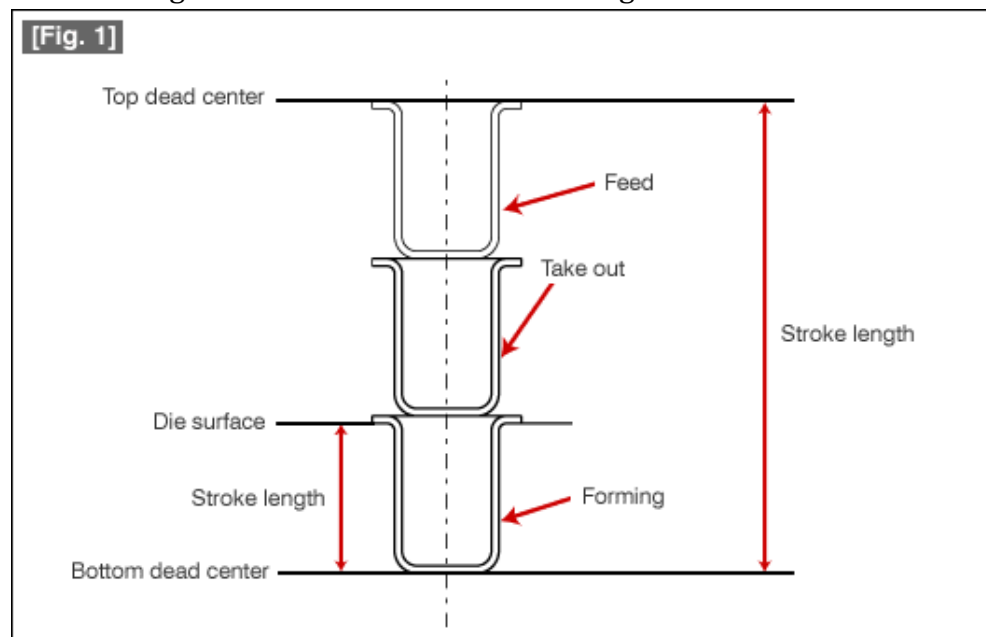
problem in press formation. However, the product formation curve B is intersecting the curve for the press machine. The part indicated by "Capacity exceeded" in the figure indicates that the torque capacity of the press machine has been exceeded. Since the possibility increases of abnormality occurring in the movement transmission parts such as the crank shaft, etc., of the press machine, it will be necessary to use a press machine with a higher capacity.

In actual practice, since it is difficult to know the pressure versus stroke curve of the product formation, the formation will have to be made by judging based the maximum formation pressure. While the maximum formation pressure occurs a little after starting the formation, it should be confirmed that the pressure generated by the press machine at the formation starting position is exceeding the product formation force. If this is done, it is possible to carry out the work with some leeway in the capacity. It is necessary to take particular care in drawing operations because very often the formation starting point comes above.

Stroke Length of Press Machines

The stroke length of a press machine is selected depending on the details of the job at hand. In blanking formation, the stroke length is short being on the order of 10 to 80mm. In bending or drawing work, it is necessary to select the stroke length taking care about the formed height of the product.

An example of drawing work is described below. See Fig. 1 below.



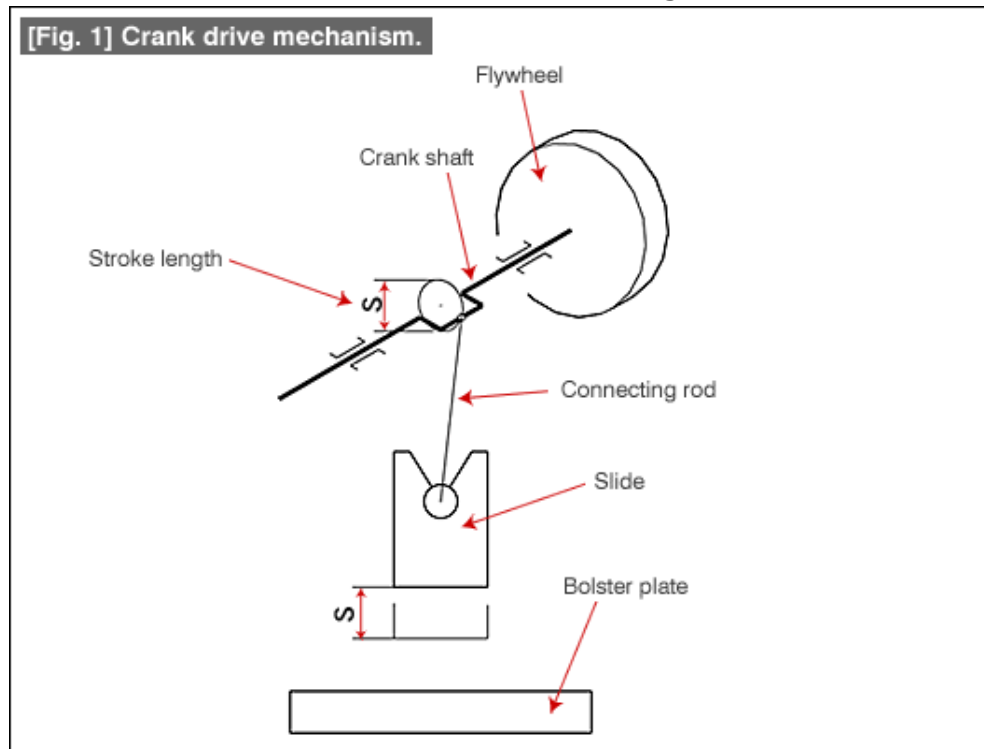
The drawing formation starts at the die surface and ends at the bottom dead center. The bottom drawn part of a completely formed product comes above the die surface making it easier to take it out. In addition, unless there is some additional margin, the working becomes difficult. Therefore, in manual operations, a stroke length of more than 2.5 times the product height becomes necessary. When carrying out automatic forming, since time is required for material movement, a stroke length of more than three times the product height can be said to be a safe stroke length. However, caution should be exercised because too long a stroke length decreases the working efficiency. With a short stroke, there are the problems that it is difficult to see inside the die and that it is difficult to take out the product, which also reduces the work efficiency and is dangerous at the same time.

In the relationship with the number of strokes per minute (*spm*), there is an inversely proportional relationship between *spm* and stroke length. When *spm* becomes large, the inertial energy of the slide becomes large, which affects the vibrations, noise, and machine rigidity. Because of this,

the stroke is made shorter thereby avoiding these effects. It can also be said that a limit is placed on *spm* by the stroke length. In a high speed press exceeding 600 *spm*, the stroke length is about 10 to 30mm. When the stroke length exceeds 200mm, in most cases *spm* will be less than 50.

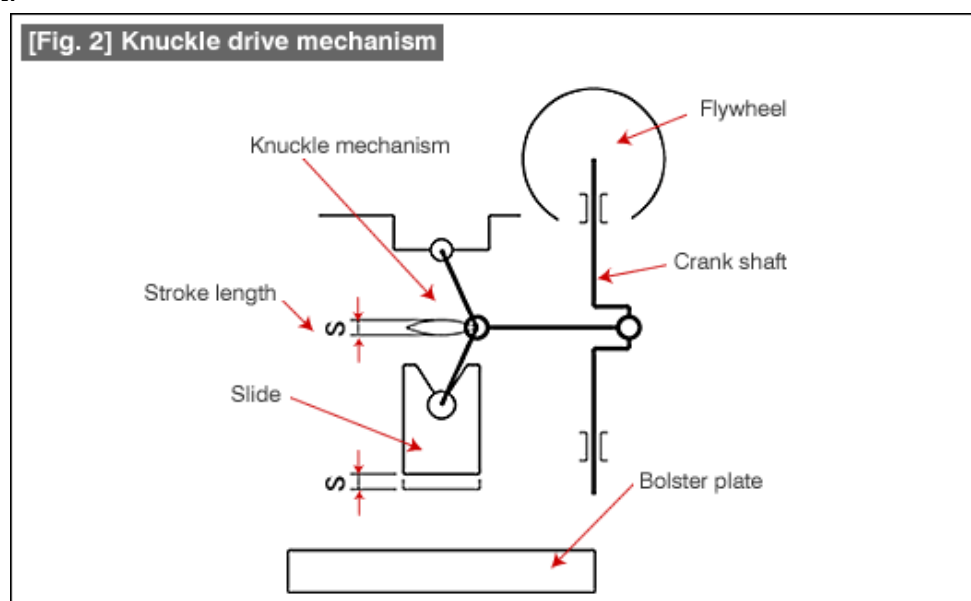
Drive Mechanisms of Press Machines

The crank type press machines (crank presses) that are used most frequently among all types of press machines have a structure such as that shown in Fig. 1.



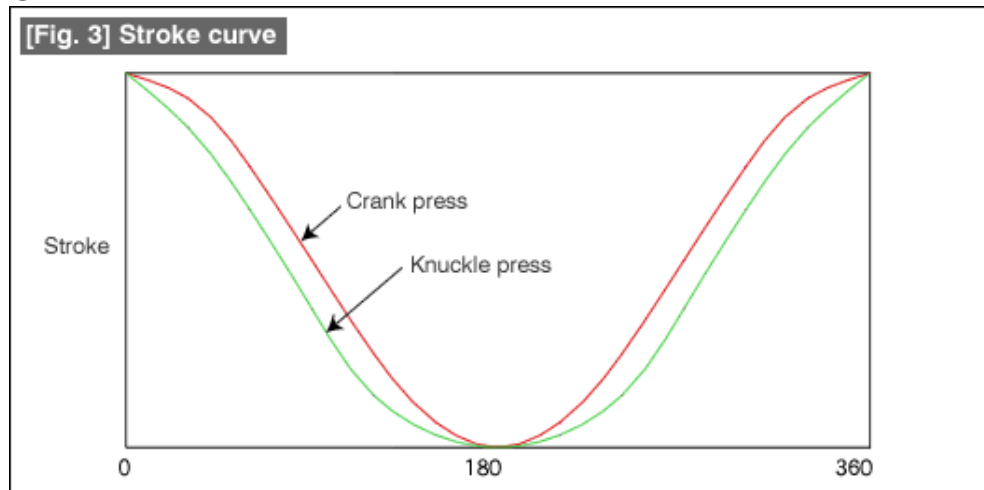
The structure of this type is simple and this type is used widely because it is easy to manufacture. There is a form called eccentric shaft among crank shafts, but recently there is no particular preference being given to any shape of the shaft (because the completeness of the press machine becomes high and since it is possible to confirm that the required functions are being satisfied by checking the specifications).

Another typical mechanism is the knuckle mechanism in a press machine. This type of structure is shown in Fig. 2. This is a machine in which the slide is being driven by adding a link to the crank mechanism.



The reason why press machines are manufactured by changing the mechanism is the stroke

curve shown in Fig. 3.



In a crank press, as soon as the slide reaches the bottom dead center, the returning step is started immediately. In press forming, if there is a slight pressing time at the bottom dead center, there is the characteristic that the formed shape becomes stable. Modifications are made to the drive mechanism in order to exploit this characteristic. The stroke curve of the knuckle mechanism in Fig. 3 becomes more gradual near the bottom dead center compared the stroke curve of the crank mechanism, from which it can be seen that the pressing time is longer than in the case of the crank press. It can be said that this mechanism is one that was prepared for obtaining this forming curve.

Because of this characteristic of the knuckle press is used frequently in the case of forming that includes crushing or when countermeasures are to be taken against spring back of bending, etc. Its disadvantages are that it is difficult to prepare long strokes, and that, since the number of joints becomes large, the overall gap is likely to become large, etc. However, high precision modified press machines of this type are being manufactured at present.

Apart from the above, there is also a type called link press. This type is prepared with the intention of obtaining gradual movement at the bottom dead center and fast returning. In addition, by changing the mechanical details, there are machines in which changes have been made in the motor. This type is called a servo motor press. The press machine of the mechanical type assumes a constant rotation of the crank shaft within one stroke. If it is possible to change the rotation of the shaft, it will be possible to prepare any stroke curve freely. Perhaps the manufacturing of molds may become somewhat easier.

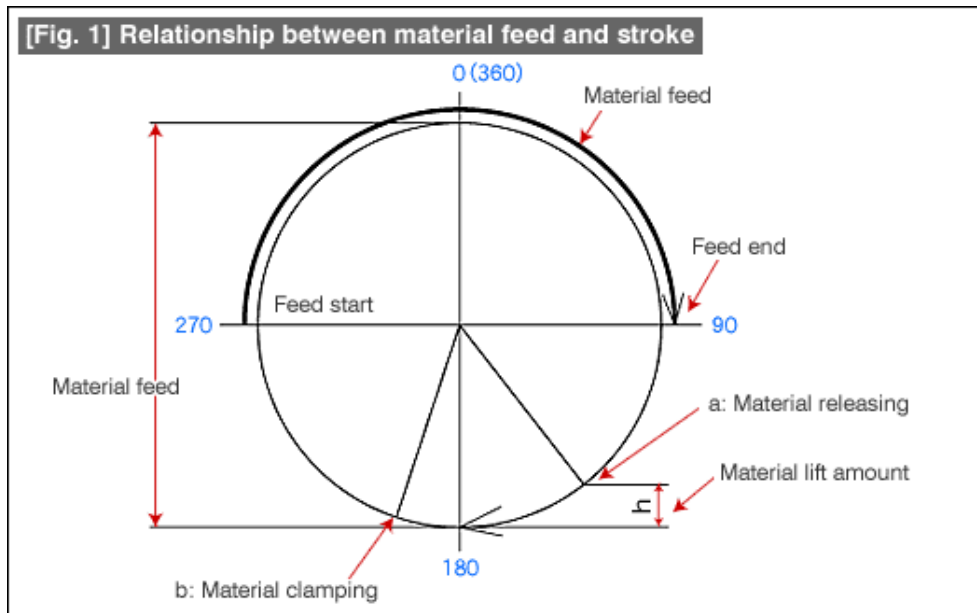
Relationship Between Material Feeding Device and Press Stroke

Figure 1 shows the relationship between the material feed and the stroke in a press machine.

The slide of the press machine starts moving down from the top dead center (0°) and reaches the bottom dead center (180°). Material feed is started from the mid point (270°) of the return process, and completes the feeding at the mid point (90°) of the lowering process (typical timing). The feeding device not only does this kind of simple movement, but also carries out a little more complex movement.

Some feeding error occurs during material feeding. This feeding error does not become a problem if it is a product that is finished in one stroke such as a blanking operation. However, during successive forming, a product gets completed only after several strokes. In such forming, feed errors are not permissible and corrections become necessary. This role is played in a mold by a pilot. A pilot moves the material finely by entering into the pilot holes made in the material thereby correcting the feed errors. If the feeding device is clamping the material at this time, the pilot can-

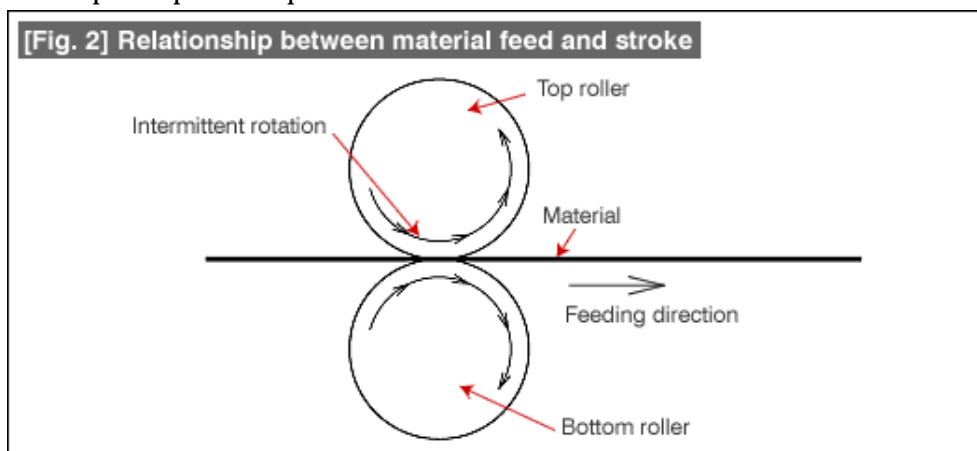
not move the material and correct the error.



It is necessary that the feeding device releases the material at timings matching with the movement of the pilot. This movement is called "material releasing". Usually, material releasing is matched with the position at which the material is lifted in the die (material lifting position). The end of material releasing (material clamping) is done after the slide has passed the bottom dead center.

There are two typical forms of material feeding devices, namely, roll feeder and gripper feeder.

Fig. 2 shows the principles of operation of a roll feeder.



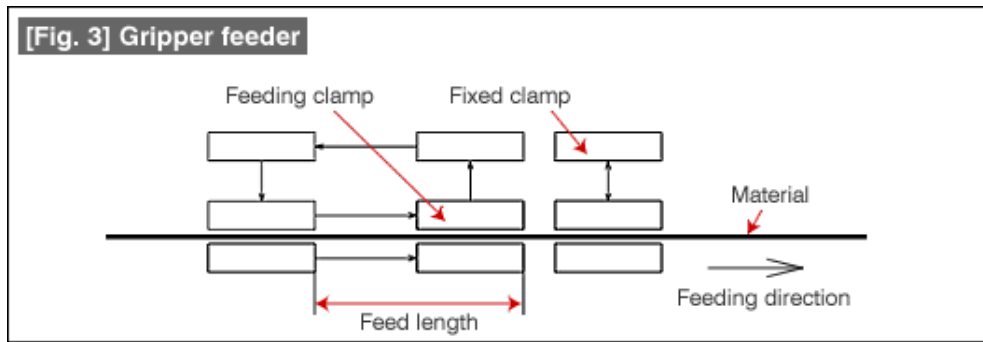
This feeder is made up of a top roller and a bottom roller. The rollers feed the material by intermittently rotating by a distance equal to the feed length.

Unidirectional clutches, various types of cam mechanisms, and servo motors, etc., are used as the means for carrying out intermittent rotation.

Usually, the bottom roller is fixed, and the top roller is pressing against the bottom roller by the force of a spring, etc. For material releasing, the top roller is pushed up using a lever, etc.

Fig. 3 shows the principles of operation of a gripper feeder.

This feeder has two clamps, namely, a feeding clamp and a fixed clamp. As can be understood from the figure, the feeding clamp repeats the operations of opening >> returning >> closing >> feeding. The fixed clamp goes into the open state when the feeding clamp is carrying out the feeding operation and will be in the closed state during all other operations of the feeding clamp. Next, at the time of material releasing, both the feeding clamp and the fixed clamp carry out the opening and closing operation simultaneously.



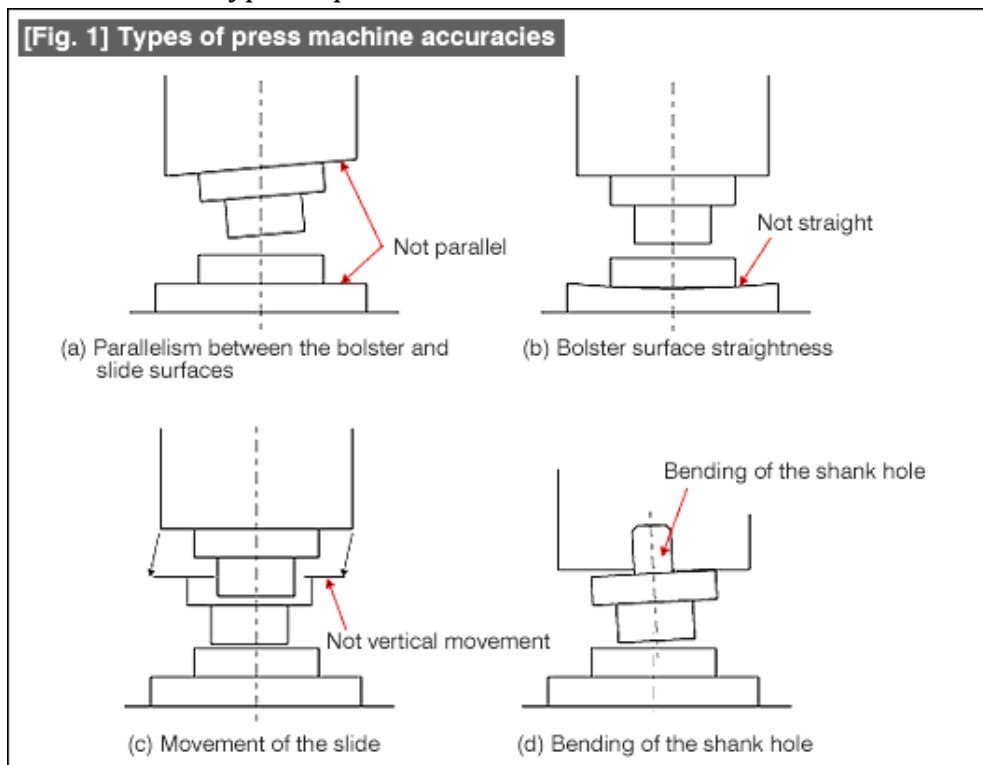
The movements of the gripper feeder can be operated using air by switching some valves, or can be carried out using some mechanisms such as cams, etc.

During the operations of material feeding, the position of releasing the material changes depending on the amount of material lift. It is necessary to adjust the timing of releasing to match with those changes.

Accuracy of Press Machines

The accuracy of press machines not only has adverse effects on the press formed products, but also shortens the life of the dies. The accuracy of press machines is of two types, namely, static accuracy which is the accuracy in the state in which no load is applied, and the dynamic accuracy which is the accuracy in the condition in which the products are being formed. Dynamic accuracy has not been stipulated in JIS. Therefore, the accuracy used at the time of purchasing a press machine is only the static accuracy. Dynamic accuracy is original to the manufacturer and there are fine differences between different manufacturers. The main static accuracies are the following.

Fig. 1 shows the different types of press machine accuracies.



Parallelism between the bolster and slide surfaces

This is the parallelism between the top surface of the bolster plate and the bottom surface of the slide. Even if the slide is carrying out truly vertical movement, if the parallelism of this part is poor, it not only affects the bending angle and the suppression of wrinkles in drawing, but also reduces the life of the die.

Straightness of the bolster surface

Since the bottom surface of the bottom die and the surface of the bolster plate are not in close contact, the pressing at the bottom dead center does not stabilize.

Defective movement of the slide

Although the slide is only expected to carry out vertical movement, sometimes, it may move at an inclination or can move in the form of the letter 8 in the vertical direction. If such movements are made, the wearing of the guide post is speeded up. Of course, the product quality is also affected.

Bending of the shank hole

In a small die, although sometimes the top die is installed using the shank hole of the slide, if the hole is not drilled vertically in the bottom surface of the slide, the die will be installed at an angle leading to the same problems as in (a) above.

Overall gap

Various parts are moving in order to make the slide move up and down. There are very small gaps between the moving parts. This gap changes when a pressure is applied thereby causing the bottom dead center to be disturbed. When no pressure is applied, the parts become relaxed returning the gaps to the original larger values and hence large movements can be made. Such a deformation is called the overall gap. The amount of displacement is investigated when the slide is pushed up with a force equal to 5% of the nominal force. This JIS standard is shown in Fig. 2.

[Fig. 2] Overall gaps of press machines

Static accuracy according to JIS B 6402

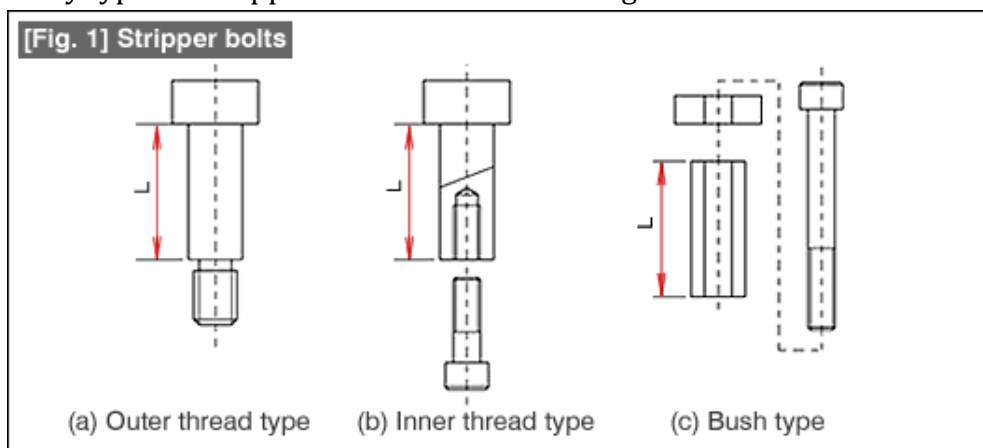
Tolerance value of overall gap (Unit: mm)		
Grade	Crank type	Crankless type
Special grade	$0.1 + \frac{2\sqrt{P}}{100}$	$0.4 + \frac{6\sqrt{P}}{100}$
First grade	$0.2 + \frac{3\sqrt{P}}{100}$	$0.8 + \frac{8\sqrt{P}}{100}$
Second grade	$0.4 + \frac{4\sqrt{P}}{100}$	$1.6 + \frac{10\sqrt{P}}{100}$
Third grade	$0.8 + \frac{8\sqrt{P}}{100}$	$3.2 + \frac{12\sqrt{P}}{100}$

Applied pressure is $p/20$, where p is the nominal capacity of the press (tf)

METHOD OF USING STANDARD COMPONENTS

Method of Using Stripper Bolt

There are many types of stripper bolts as is shown in Fig. 1.



The shapes shown here are the basic shapes, and considering fine applications, standard components have been finely subdivided thereby widening the available choice. A stripper bolt retains the part by the length of the shaft (L) and makes the component movable. Because of this method of use, it is also called a hanging bolt, shoulder bolt, etc. Since the method of use of a stripper retention of a die with the movable stripper structure is very well known, the name stripper bolt has come into standard use.

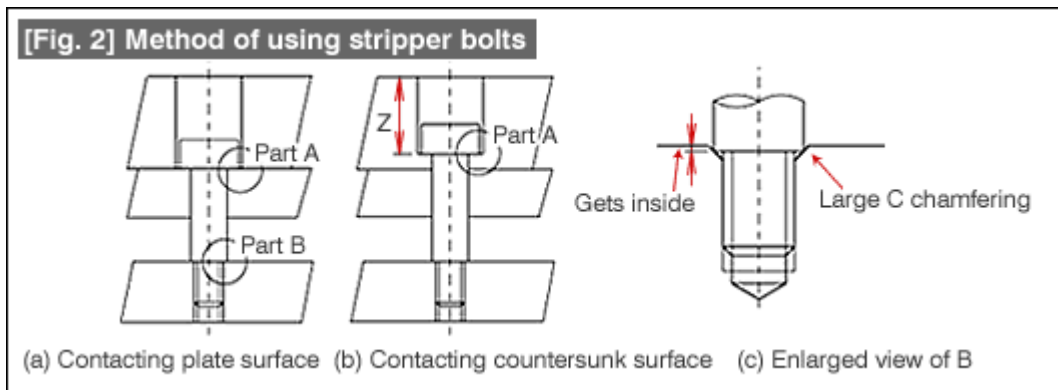
Shaft length (L)

Several stripper bolts are used for a movable stripper. If there are any fluctuations in the shaft length (L) at that time, while the head of a short bolt is contacting the head part seating surface the others will not be contacting, and hence the stripper becomes inclined thereby causing breakage of the stripper bolt. The stripper bolts used for the same part should ideally have small variations in the shaft lengths but are of the same shaft length. This is particularly important in dies for forming thin plates.

Method of using stripper bolts

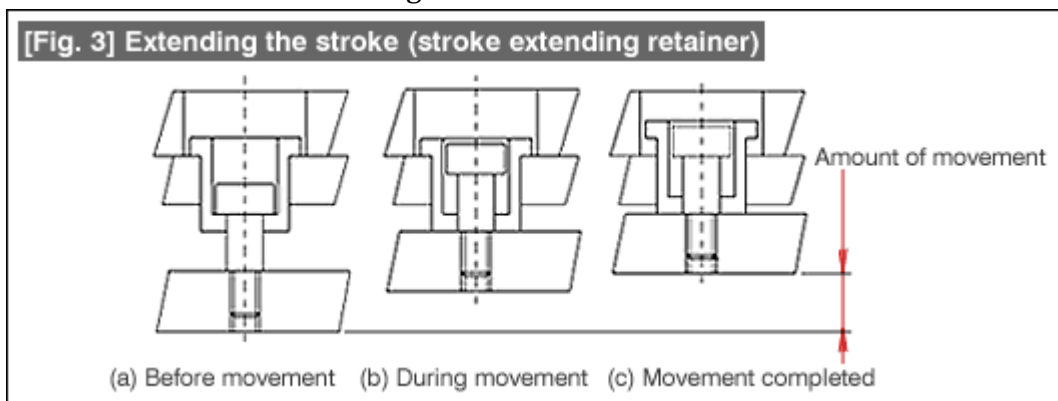
Figs. 2(a) and 2(b) show the methods of using stripper bolts.

The method of use shown in (a) is good. Although the form in (b) is such that the seating surface is at the bottom of the countersunk surface, it is difficult to machine accurately the Z dimension at the time of forming the countersunk, and hence fluctuations will be present. These fluctuations will have the same effect as when there are fluctuations in the shaft length. Figure (c) shows the precautions when using stripper bolts of the outer thread type. If the chamfering of the tapped part is too large, as is shown in the figure, the end part of the shaft gets into the chamfering part. Further, care should be taken because breakage of the stripper bolt may be caused if the tap for attaching the stripper bolt has been machined with an inclination.



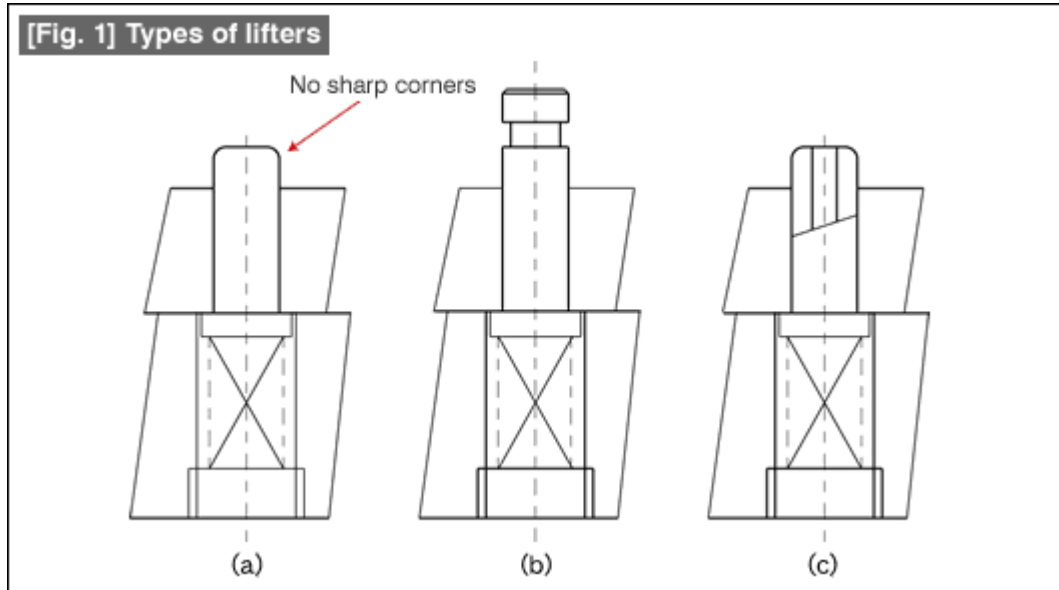
Special method of use

Depending on the die, sometimes there is no space at the top and at the bottom, but a need for making the amount of stripper movement large. In such situations, the usual method of using stripper bolts is not good. Fig. 3 shows an example of obtaining a long stroke in a narrow space by using in combination with a stroke extending retainer.



Method of Using Lifters and Guide Lifters

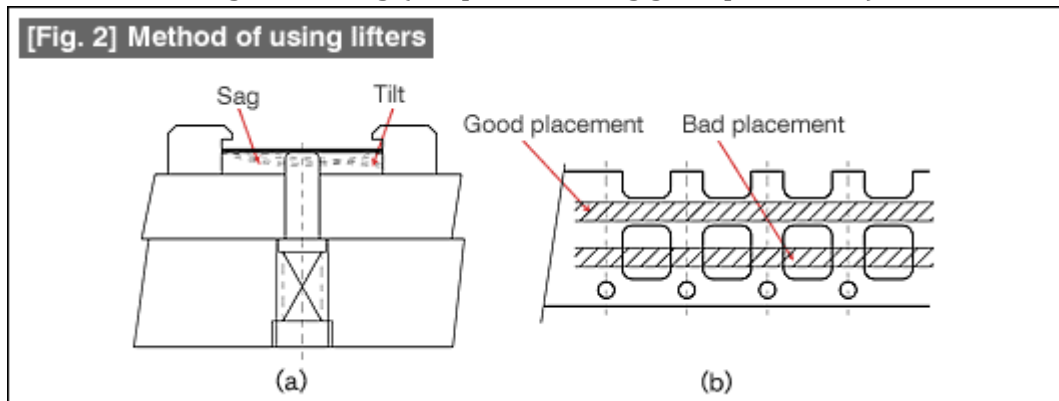
Figure 1 shows the types of lifters. A lifter is a component for supporting the material inside the die so that it does not sag or tilt. A lifter can be of the round type or of the square type.



Method of using lifters

Sharp corners are not allowed in the surfaces of lifters that come into contact with the material and these parts should be rounded (see Fig. 1). This is to make sure that no scratches are formed on the material.

In the dies for successive feeding, very often it is necessary to make the material in the die float above the surface of the die. This is for feeding the material. This is also commonly true for transfer dies, dies for robot machining. Lifters are placed in a balanced manner so that the material does not sag or get tilted as shown in Fig. 2(a). The precaution in the placement of lifters in a mold for successive feeding is shown in Fig. 2(b). The lifters are placed and fixed so that they do not interfere with the material during its feeding (the part showing good placement).



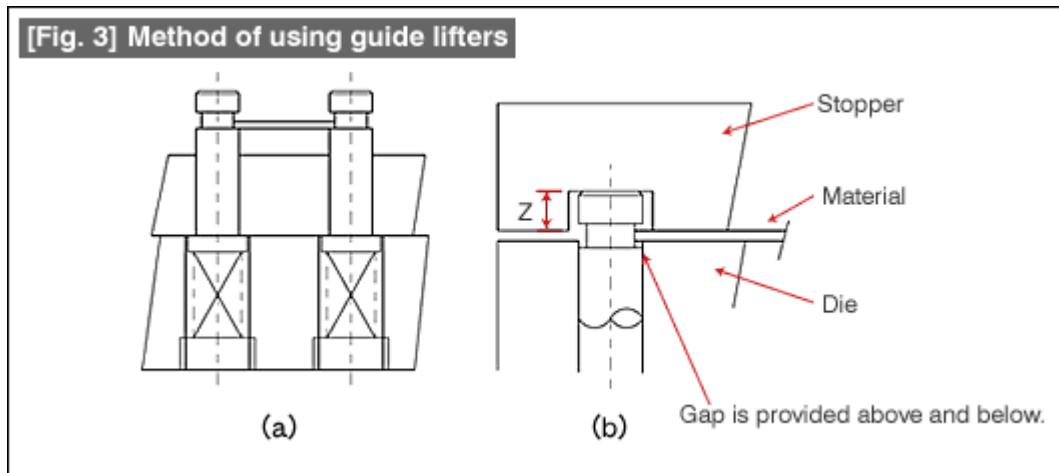
Method of using guide lifters

As is shown in Fig. 3(a), guide lifters are components that carry out the functions of both a material guide along the width direction and a lifter. The basic principle is to place them so that there is no sag in the material.

Fig. 3(b) shows the relationship in the up and down directions. When the material is on the die surface, guide gaps of the guide lifter are provided above and below the material as is shown in the figure. If care is not taken about this, the guide lifter can cause crescent shaped scratches or deformations in the material. Sometimes, the material may also be cut in the shape of a crescent moon.

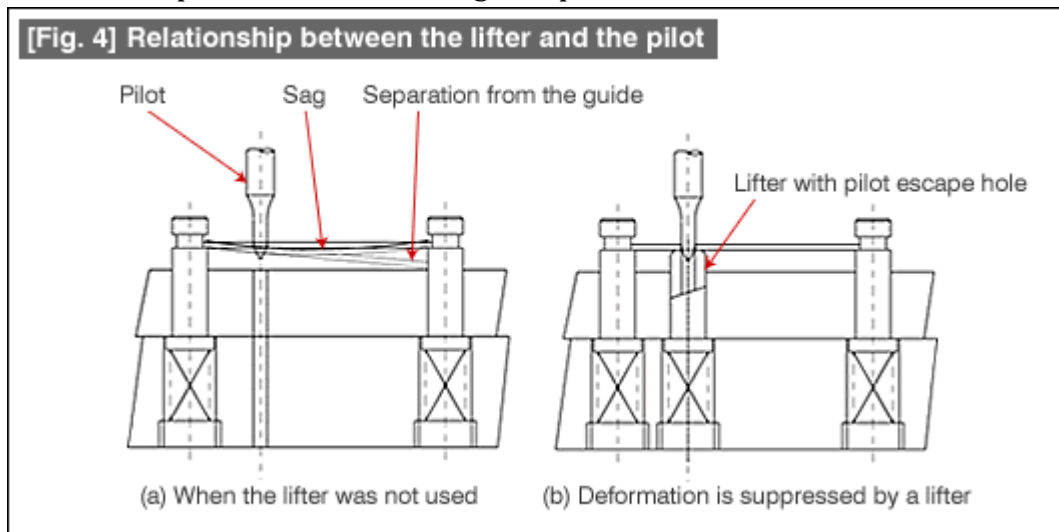
The pressing down of the guide lifter is made at the head part of the lifter. Measures should

be taken so that there are no fluctuations in the depth Z machined in the stopper. Take care so that the pushing direction is not tilted because this can cause breakage of the head of the guide lifter.



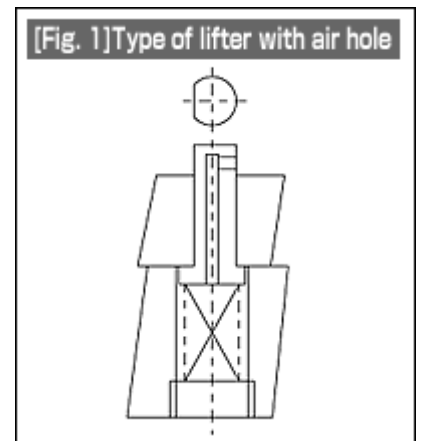
Relationship between lifters and pilots

When forming thin plates, if a pilot enters in the lifted condition as is shown in Fig. 4(a), it causes various problems such as the material sagging or becoming tilted, thereby it can dislodge from the guide lifter, etc. As a countermeasure for this, there are lifters with escape holes for pilots. The material becomes stable because it is supported from below when a pilot enters the material. It is good to use this as far as possible while forming thin plates.

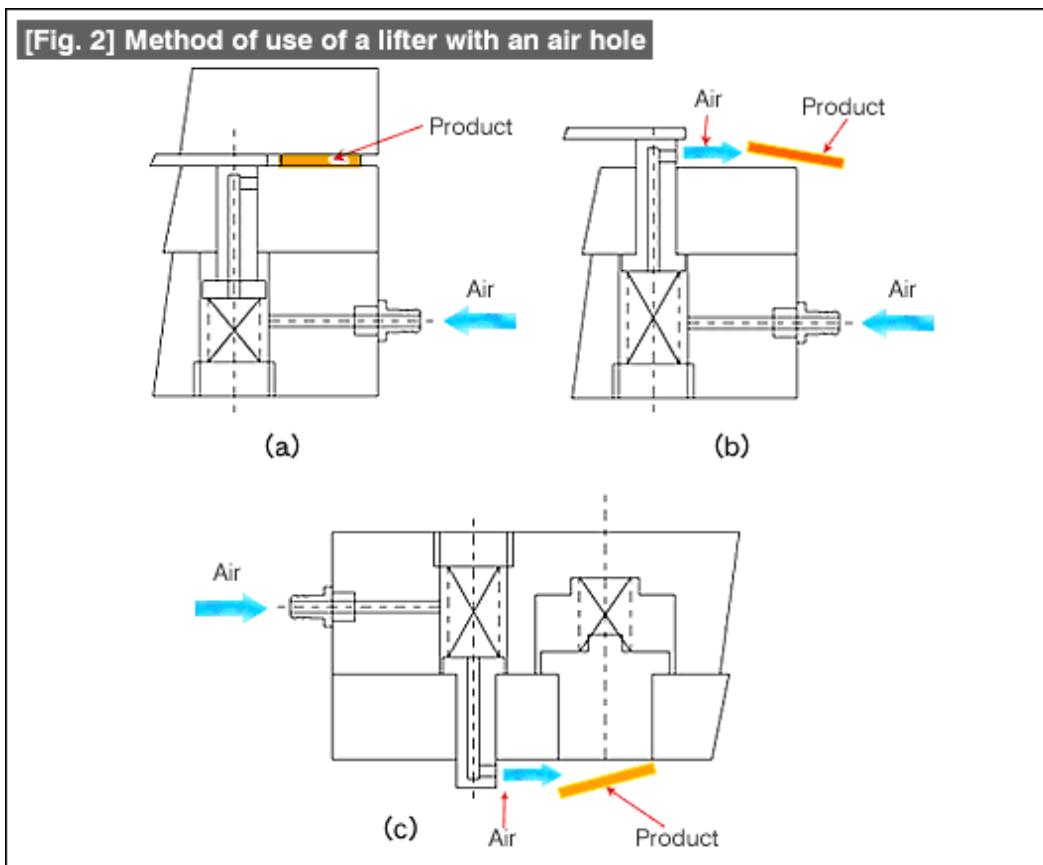


Method of Using Lifters with Air Holes

Fig. 1 shows a lifter with an air hole. This is a component obtained by providing an air hole in and a measure to stop the rotation of an ordinary lifter.



Figs. 2(a) and 2(b) show the conditions of use.



Air is fed from outside to the lifter part. When the die is at the bottom dead center, the air hole is closed automatically since the lifter is pushed up, and hence air does not come out [Fig. 2(a)]. When the top die rises from the bottom dead center, air is blown out from the air hole, and the product that has been cut and separated is blown off [Fig. 2(b)]. At this time, the stopper is still rising. The ejected air flows between the die and the stopper. Because of this, the flow stabilizes and even the blowing off of the product becomes stable.

Although the flow of the air blowing from outside near the top dead center gets dispersed and the flying off of the product is not stable, the above method not only avoids this drawback but also shortens the time required for setting up the die.

Fig. 2 shows the method of use as an air blow in a blanking die or an upward drawing die. Although the name "lifter" gives the impression that it is used in a bottom die, this is a method of use considering it as an air nozzle. Since air is blown near the product, the flying off of the product becomes stable. As was explained above, it becomes unnecessary to set up a separate air nozzle for the product, and the setting up time becomes shorter.

Knock Pin (Dowel Pin)

A knock pin is also called by other names such as a dowel pin. This is used for positioning die components.

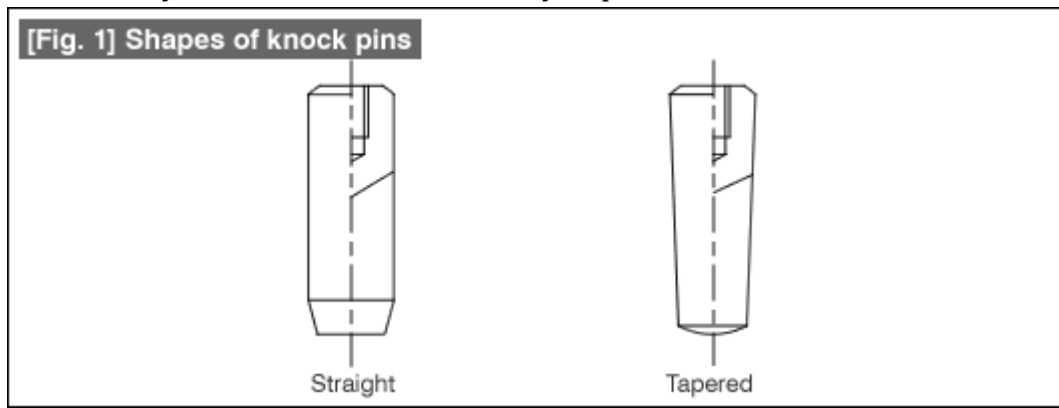
A knock pin can be of the straight type or can be of the tapered type as is shown in Fig. 1.

Each of these come in tapped types also. According to JIS, this is called a dowel pin for press dies (B 5062, only straight type). According to JIS, apart from this, there is a parallel pin (B 1354) and a tapered pin (B 1352) for machines, but their accuracies are far inferior to those of the pins for dies and molds.

The accuracy of the diameter and the hardness of the material are the important requirements of a knock pin.

A knock pin is used by lightly pushing it in a hole. The retention force of a pin inserted in a hole by press fitting is generated by the surface pressure due to elastic deformation and friction.

Therefore, when using a knock pin, the relationship between the accuracy of the diameter of the knock pin and the accuracy of the hole diameter is very important.



While the hole diameter will be slightly smaller than the knock pin diameter for the pin to be push fitted inside the hole, there will be changes in the retention force and driving in force between the raw material and the tempered material unless the hole diameter is changed. The hole diameter is made smaller by about $10\mu\text{m}$ in the case of a raw material and by about $5\mu\text{m}$ in the case of a tempered material.

The basic method of using a knock pin is, as shown in Fig. 2, driving in two knock pins in a plate thereby making sure that there is no position shift. For increasing the accuracy, it is better to make their positions as far as possible.

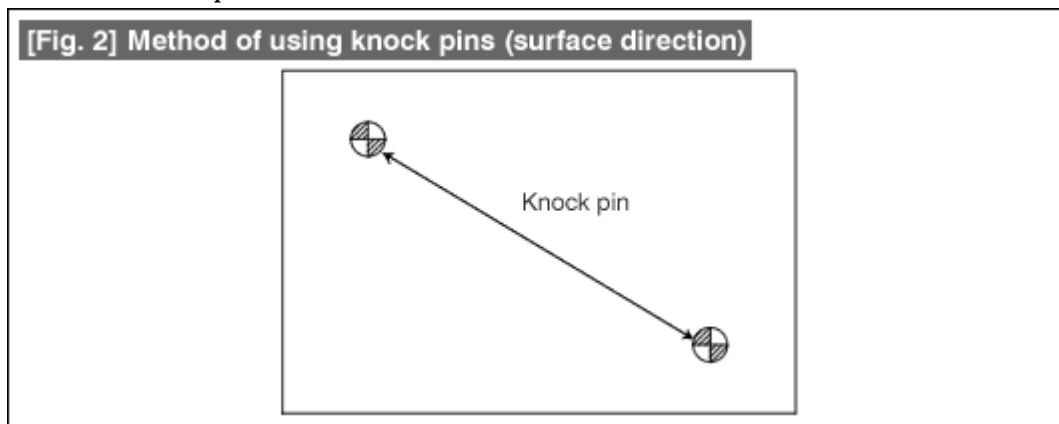
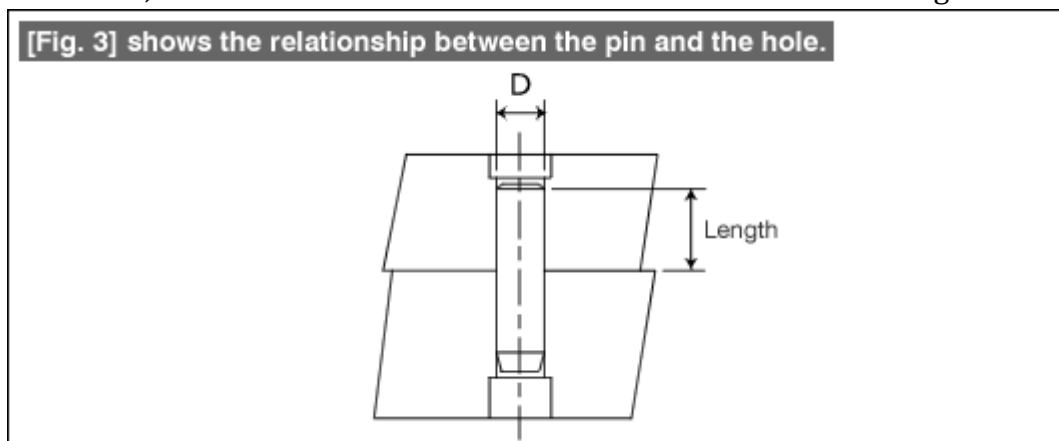
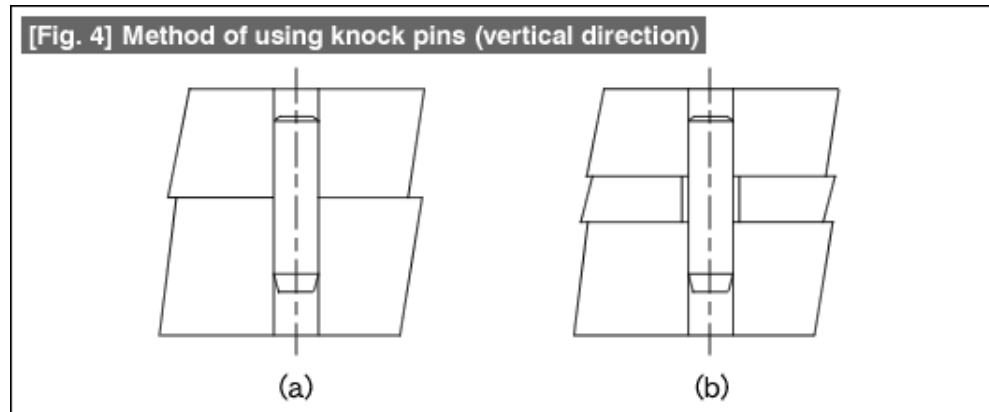


Fig. 3 shows the relationship between the pin and the hole.

A guideline for the relationship between the hole diameter and depth is that the length of the pin retaining part is about twice the diameter, the minimum length being about the same as the diameter, and the maximum being about three times the diameter. If the hole depth is shallower than the pin diameter, the positioning accuracy becomes poor, and if the depth becomes larger than three times the diameter, it becomes difficult to machine the hole while maintaining the accuracy



The conventional method of using knock pins is to position two components as shown in Fig. 4(a). However, as shown in Fig. 4(b), although it is possible to use it by passing through three plates, the hole in the middle plate is left free as a dummy hole. Since in this form the middle part of the knock pin is not supported, the accuracy of positioning decreases. Therefore, passing a knock pin through four or more plates should be avoided because of accuracy considerations.



Usually, although the straight type is used more often as the method of using knock pins, the tapered type knock pins is also used. Caution should be exercised because there is the danger of their becoming loose due to vibrations or shock.

Further, the method of using in which the pressure applied from the side surface is taken by the knock pins is not the proper method of using knock pins, and there is enough reason to think that it cannot serve the purpose sufficiently.

The method of determining the diameter of the knock pin is based on the size of the clamping screws used along with it. The size used normally is either the same as that of the screws or is a slightly larger diameter.

Clamping Screws (Hexagonal Bolts with Holes)

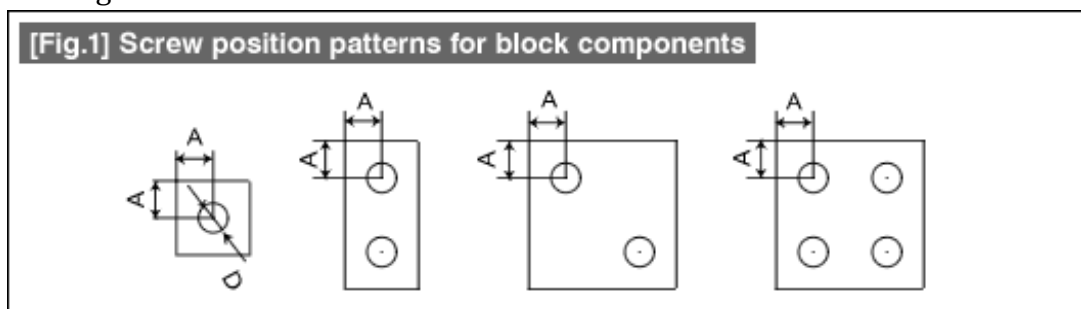
In press dies, for some unknown reason, hexagonal bolts with holes (JIS B 1176) are used as the clamping screws. Hexagonal head bolts and countersunk screws were being used in the olden days, but naturally over time, these have become the standard components. For the descriptions of the detailed standards of hexagonal headed bolts with holes, see the JIS standards or the technical data part of the Misumi catalog "Face".

Unfortunately, there are no documents that clearly describe the method of using clamping screws. Because of this, the designers of dies are forced to worry that they do not this but cannot go and ask for such simple information. Take heart, because everybody is in the same situation in the beginning. One gradually comes to know the method of use.

Coming to the point, the methods of using clamping screws can be divided broadly into two methods, that of plate components and block components.

Clamping screws of block components (nested, punch, etc.)

There are a large number of methods of using clamping screws in the case of block components as shown in Fig. 1.

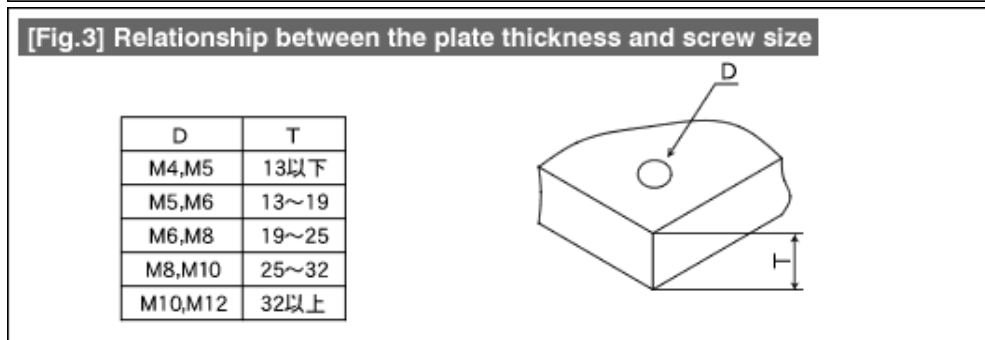
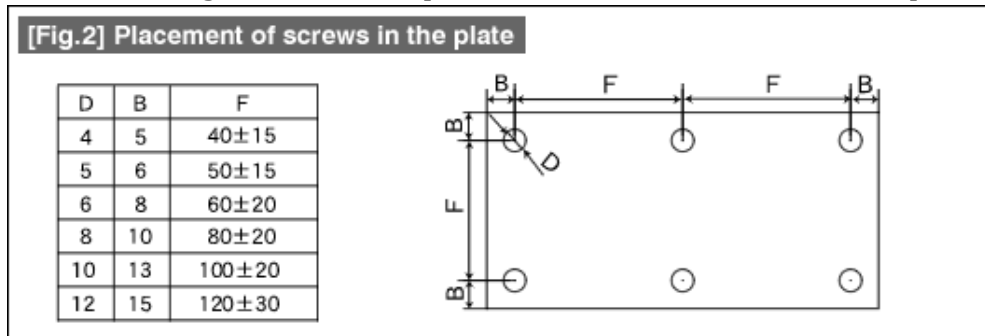


Taking the minimum value of the dimension A in the figure as the screw diameter (D), the thickest screw that can be used is selected from the size of the block (screw breaking countermeasure).

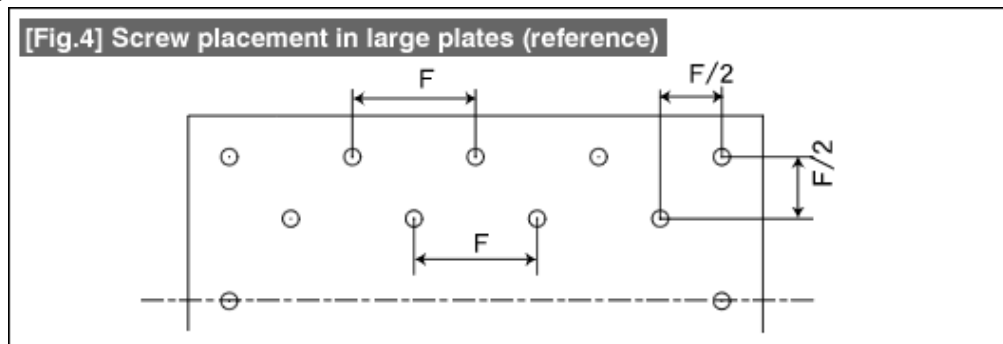
When there are large and small blocks present simultaneously in a die, if the screw size is determined individually for each block, there will be a mix of thick and thin screws, which makes it inconvenient during assembly and disassembly of the die, and hence it is recommended to use screws of the same size.

Clamping screws of plate components

In the case of plate components, as is shown in Fig. 2, the screw size is determined considering the combination of the relationships among the dimension B from the edge of the plate, the pitch F of the screws, and the plate thickness shown in Fig. 3. It is easier to understand if attention is paid to the dimension W of the plate, the dimension B is made about twice the smallest value, and the decision is made considering the relationship between the dimension F and the plate thickness.



When the plate becomes big, it becomes insufficient to place the screws only near the periphery. In such situations, determine the placement of screws inside the plate such as in the example shown in Fig. 4.



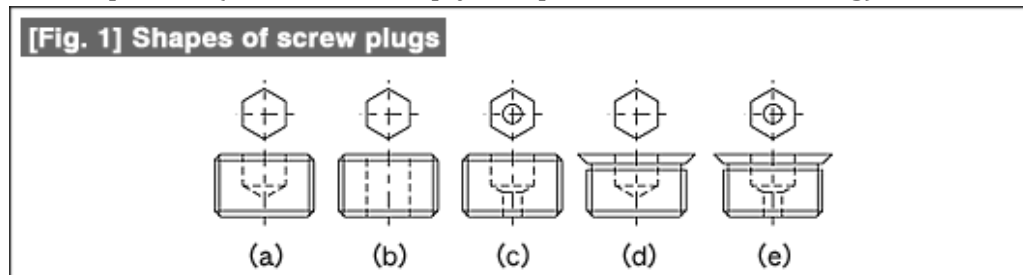
Screw diameter and tap depth

There is a certain depth of penetration of the screw for every screw diameter at which there is no problem in the clamping. This is related to the depth up to which thread tapping is done. In general, the tap depth is taken to be about 1.5 to 2.5 times the screw diameter, the minimum depth of insertion of the screw is taken to be about the same as the screw diameter, and about two times the screw diameter when the screw is inserted deeper. Unless there is some special problem, it can be taken to be a standard of clamping if the depth is more than 1.5 times the diameter of the screw.

Plug

Screw plugs have been unified to have coarse thread pitch for sizes of M8 or less and a pitch of 1.5mm for M10 or more. This is for the purpose of making it easy to understand the relationship between the screw diameter and the spring when the screw plug is used as a cap screw for a spring, and also because, when the screw pitch becomes large in proportion to the screw diameter, it is also necessary to make the thickness of the screw plug larger in proportion to the screw diameter. If the screw pitch is the same, it is possible to make the thickness uniform. The screw plug standard has been prepared from this point of view.

There are five types of screw plugs used in dies as shown in Fig. 1. A screw plug is operated using a hexagonal bar spanner (referred to simply as 'spanner' in the following).

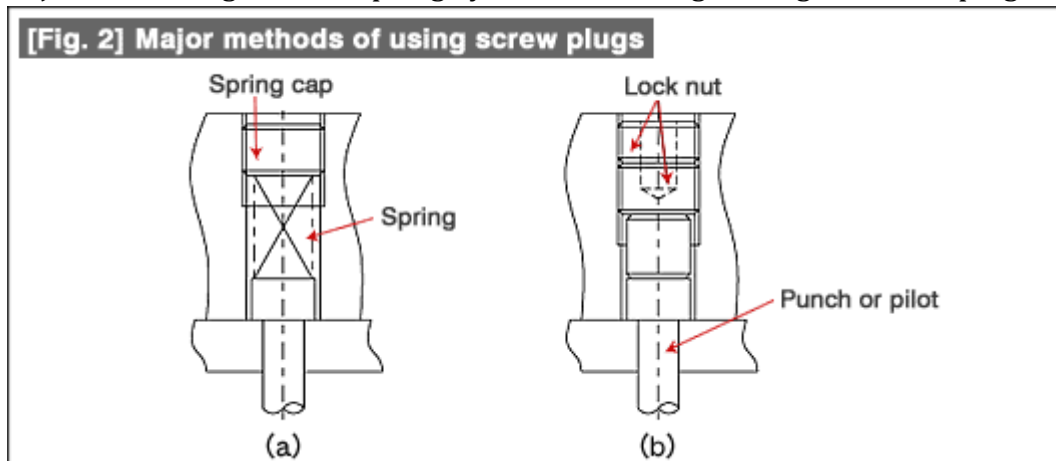


The basic shape is the one shown in (a) in which the spanner hole is not penetrating. The shape (b) has a penetrating spanner hole. The shape (c) is the basic shape with a penetrating round hole provided at the end of the spanner hole.

The shapes (d) and (e) are with a flange, and the two are different in the type of spanner hole.

The method of using a screw plug is shown in Fig. 2.

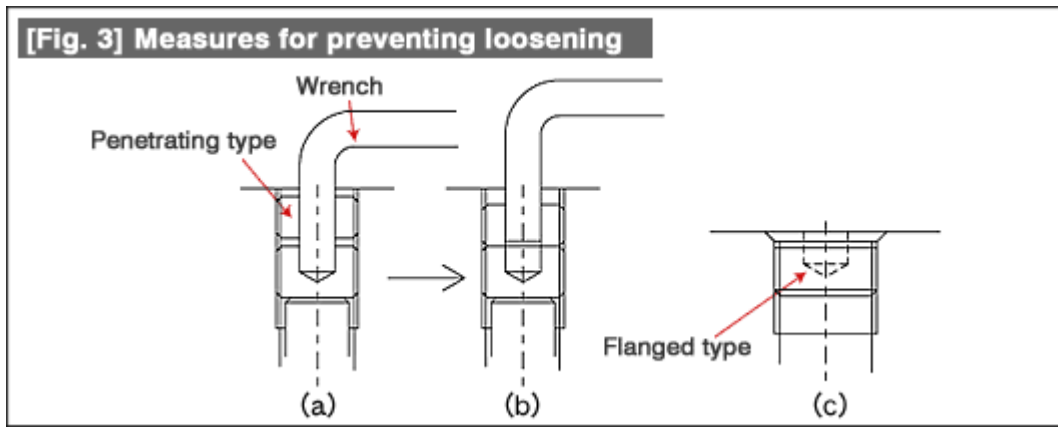
The method of use as a cap screw of a spring is shown in (a). This is the method of use when it is desired to adjust the strength of the spring by the extent of tightening the screw plug.



Care should be taken while using this method to make sure that the spring is compressed at all times. If the spring is not compressed, it shakes inside the hole, and consequently there is the danger that the screw plug becomes loose.

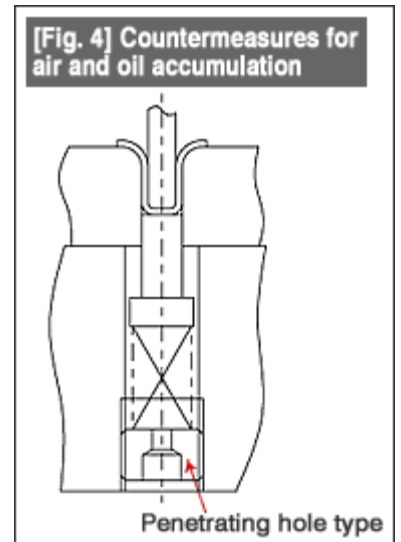
The method of use as a lock nut is shown in (b). A lock nut is a method of using the opposing forces of two screws to prevent the screws from becoming loose. The method of use is shown Fig. 3(a) and (b). An ordinary screw plug and one with a penetrating spanner hole are combined together.

To lock a lock nut, first the spanner is inserted and operated as shown in Fig. 3(a) until the nuts are tightened. After that, the spanner is lifted up as shown in Fig. 3(b) and only the screw plug with a penetrating spanner hole is tightened thereby preventing them from becoming loose. The screw plug with a penetrating spanner hole was developed for use as a lock nut.



Another method of preventing loosening is the flanged type screw plug. Elastic deformation occurs when the flange surface is strongly pressed against the hole. This is a type of screw plug in which loosening is prevented using this force.

Figure 4 shows a shape that occurs frequently in dies. This figure shows an example of a step in a drawing operation. Drawing oil is used in a drawing operation. The drawing oil enters the hole of the spring by passing through the gap of the die. If it does not have an escape path, it gets collected at the bottom leading to accidents (the accumulated oil cannot be seen from outside). As a countermeasure for this, there is the method of using a screw plug for a lock nut, and the method of using the penetrating hole type shown in Fig. 1(c). Fig. 1(c) is the type prepared for the purpose of removing air or oil.



Coil Springs

What are expected of springs in dies are load and deflection as shown in Fig. 1. For a coil spring (referred to merely as a spring in the following) that supports the lifter spring used in a die, not much load is necessary, but a certain amount of deflection is required. The load is the main requirement in a movable stripper. Sometimes, both load and deflection may be the necessary requirements.

The items required of springs can be many. In order to meet those requirements, springs with various spring constants (in a spring, the force obtained when the deflection is 1mm is called the spring constant) such as springs in which a large deflection is obtained, springs in which extremely strong forces are obtained, and springs in between these. It has become very convenient for die manufacturing. However, load and deflection are inversely proportional to each other, and it can also be said that it is difficult to satisfy requirements of both load and deflection.

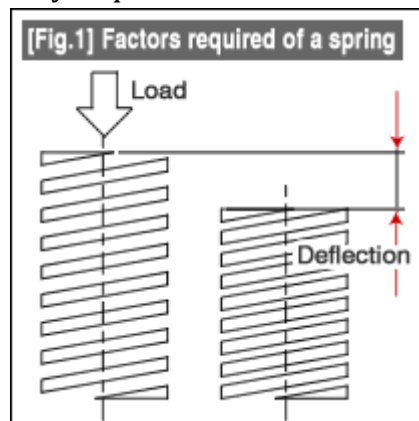
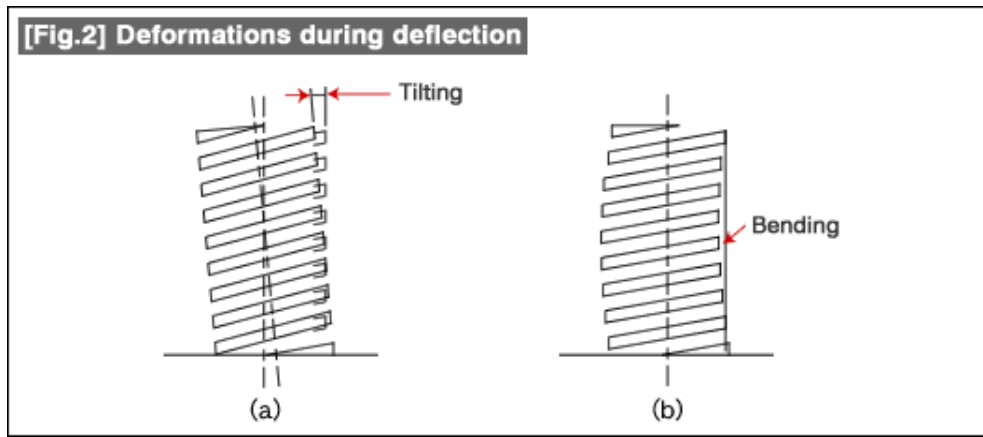
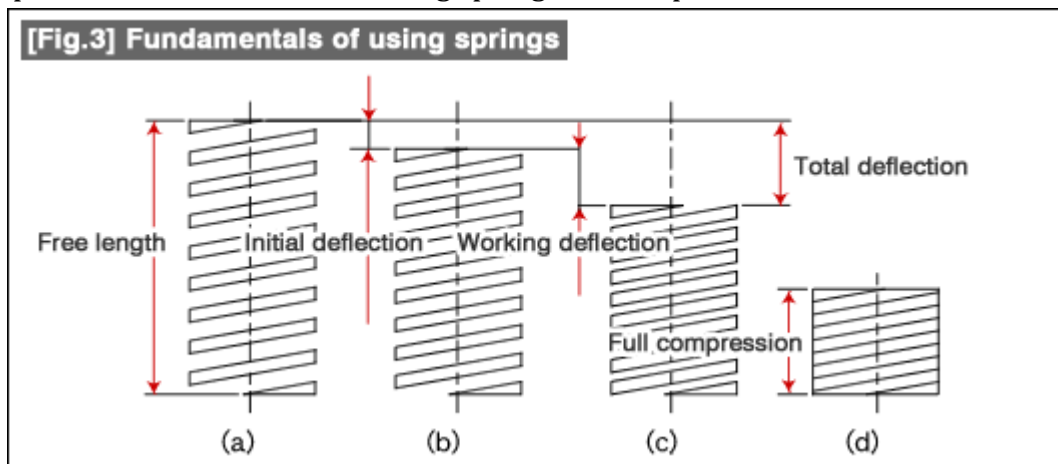


Fig. 2 shows the precautions in using springs.



If there is any tilting of the spring as shown in Fig. 2(a), the outer periphery of the spring rubs against the side wall of the hole which reduces the life of the spring. The cause of tilting can be that the processing of the end surface of the spring is bad, or the seating surface of the hole in which the spring is inserted is not good. A spring easily tends to get tilted if placed in a hole that has merely been drilled. Fig. 2(b) shows the phenomenon that occurs in which the spring bends when compressed. This is a problem that can occur easily in springs with large free lengths. Similar to tilting, this also reduces the life of the spring.

Fig. 3 explains the basic method of using springs for compression.



The length of the spring before it is deflected is called the free length (Fig. 3(a)). A spring is not used at its free length. It is compressed at least by 1 to 2mm.

When a prescribed load is required, the amount of deflection is obtained from the relationship with the spring constant, and the spring is compressed from its free length by the amount of this deflection. This amount of deflection is called the "initial deflection" (Fig. 3(b))

The material is pressed using the load obtained from the initial deflection, and the operations of punching or bending are carried out. The spring is further compressed by the punching or bending operation and goes into the state shown in Fig. 3(c). The amount of deflection at this time is called the "working deflection".

The sum of initial deflection and working deflection is the total deflection. The maximum total deflection is the deflection when the spring is in the fully compressed state shown in Fig. 3(d). If the spring is completely compressed, compression force is applied on the spring material itself, and this drastically decreases the spring life. Therefore, normally a spring is not used in this manner. Even though the spring is not fully compressed, the life gets decreased if the amount of deflection exceeds 30% of the free length. Normally, using at a total amount of deflection of 20% of the free length is good for the life of the spring.

The major methods of using coil springs (hereafter referred to merely as springs) are explained here. Fig. a to Fig. f show the major methods of using springs.

Fig. a is a method of using a spring when the amount of movement of the stripper is small. The spring is placed behind the stripper bolt. There is no undue stress because the spring pushes along the same axis. Since it is not possible to use a long spring, it is not possible to obtain a large deflection.

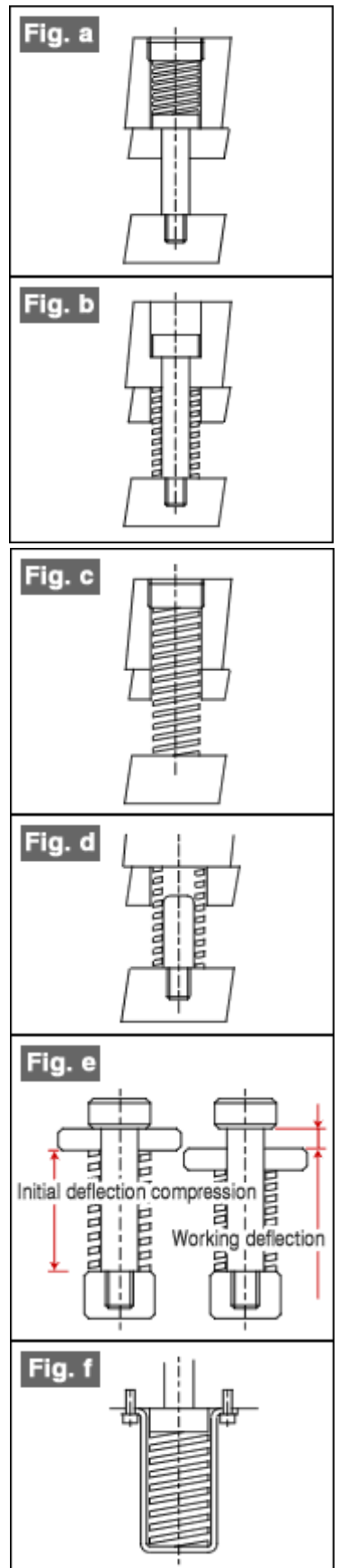
Fig. b is a method of using a spring in which it is placed in the shaft part of the stripper bolt. It is possible to obtain a larger deflection than in the method shown in Fig. a. This method is suitable for the operations of bending, etc. In this method, the deflection of the spring is made by turning the stripper bolt. Therefore, turning the stripper bolt becomes heavy due to the load of the spring. This is a drawback of this method of using springs.

Fig. c is a method of using a spring by providing a hold dedicated to the spring. This is suitable for drawing operations that require large amounts of deflection. It is possible to use the longest springs.

Fig. d shows a countermeasure for preventing tilting or bending of springs. A spring for a normal die is prepared so that it can be guided using the internal diameter. This figure shows one example and there are various other shapes.

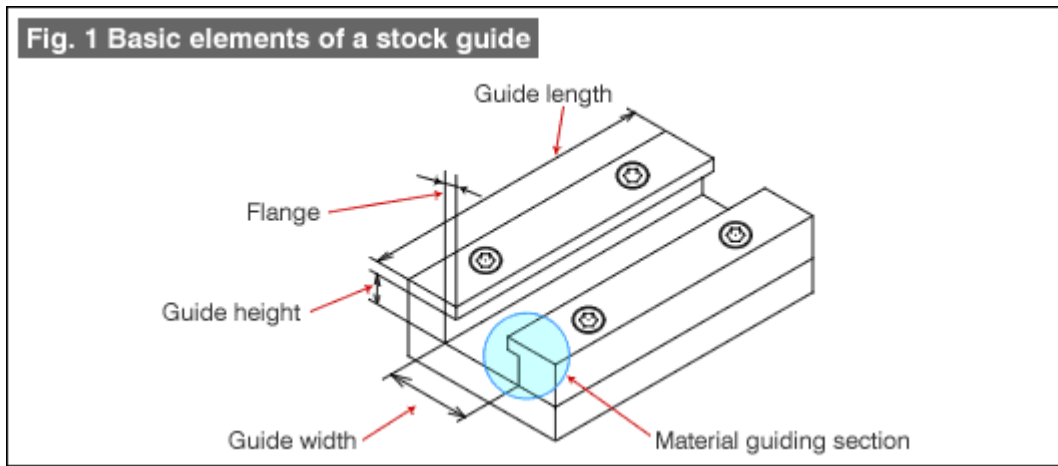
Fig. e shows a method of use in which the spring is set in the initial deflection state. In the case of an ordinary spring, the setting of the initial pressure is set again by tightening the screw plug, etc., every time a die is disassembled and assembled again. This takes considerable time and labor. The method of use (e) is selected in order to solve this problem. This is given as the flange for the spring unit (WUNT) in the catalog "Face".

Fig. f is the method of use when the spring cannot be placed completely inside the die. The spring is placed inside an auxiliary case and is set in the form shown in the figure. In this method of using a spring, it is possible to use considerably long springs. This is given in the catalog "Face" as the spring case unit (SPRC).



Stock Guide

The basic elements of a stock guide ("Material guide unit" in the Misumi standards) are shown in Fig. 1.

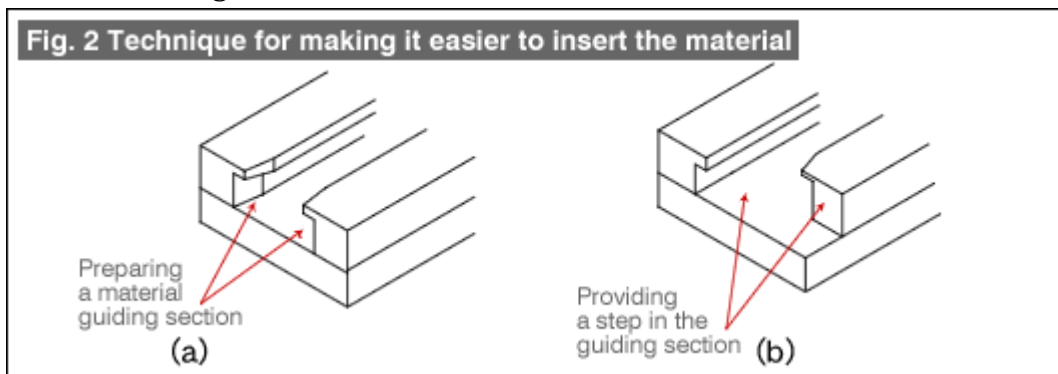


The width part of the guide is the part that keeps pressed the width of the material. This is determined considering the variations (tolerances) in the material width. Another factor is the horizontal bending (camber) of the material. This occurs due to the relationship with the length of the guide. The length of the guide should at least be equal to the width of the material, and if possible it should desirably be nearly twice the width of the material. The expected role of the guide, at the time of inserting the material inside the die for the first time, is to ensure that every time the material can be inserted in the die without clashing in the same state. Whether or not this condition is satisfied is determined by the guide width and the guide length.

The guide height varies depending on the content of press operation of the product. In other words, the amount of lift of the material during product forming determines the guide height. The guide height is determined to match with the amount of lift.

In the state of Fig. 1, it is very difficult for the material to enter the guide. As a countermeasure for this, a material guiding section is provided at the entrance to the guide as shown in Fig. 2.

The form shown in Fig. 2(a) is an extremely obvious shape of an escape. Although there is no problem when the material width and plate thickness are of an easy-to-handle size, if the material becomes wider or the plate becomes thicker, which is a state referred to commonly that the material is oversized, working becomes difficult with the shape of (a). If a step is provided in the guide as shown in Fig. 2(b), it is possible to place the material first on the bottom plate of the guide and then to insert it in the width of the guide, and hence the work becomes easier.

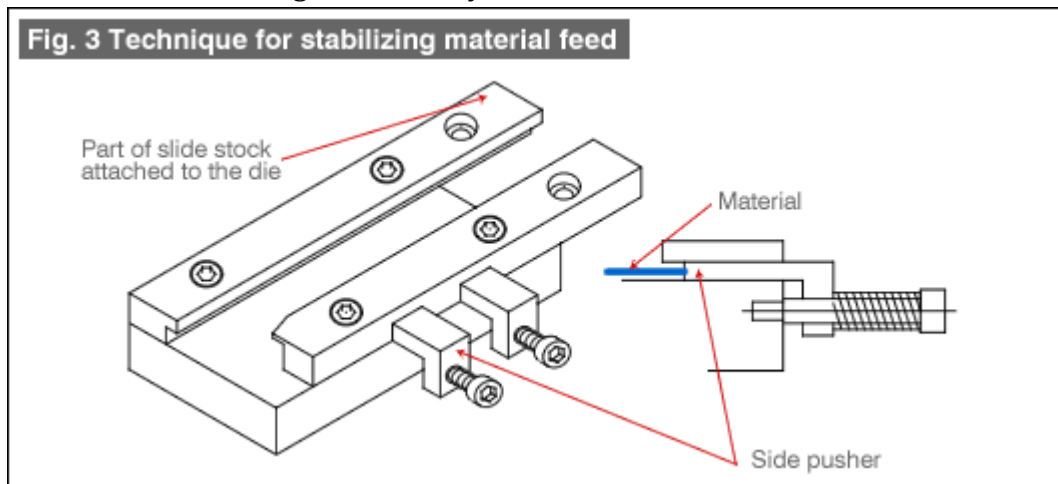


In Fig. 3, using a side pusher (called a "stock guide set" in the Misumi standards), the material is pushed to one side, thereby restricting the material from moving due to the variations within the tolerance of the material width.

This method is particularly effective in the case of continuous feed using a single sided carrier. If the material is pushed too strongly, it can obstruct the material feeding operation. In addition, it is also necessary to take measures to reduce the contact resistance of the receiving surface opposite to the side of the material facing the side pusher (such as making it point contact, etc.).

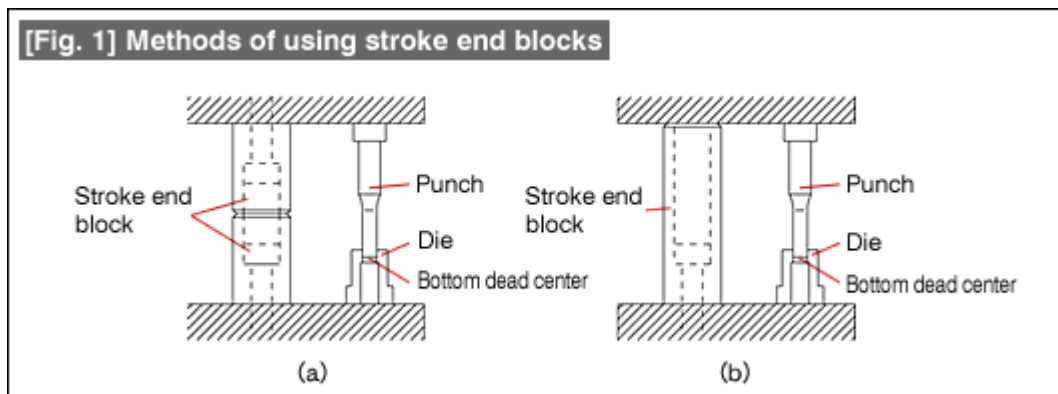
Although very often the stock guide is installed on the die set, the alignment straightness can

sometimes be disturbed. By attaching the part for installing to the die with the shape shown in Fig. 3, it is possible to maintain the straightness easily.



Stroke End Block (Height Block)

Stroke end blocks are used in forms shown in Figs. 1(a) and (b). The form (a) is used more often.



Although a stroke end block is a component for determining the bottom dead center of the die, it is not enough to decide once. Depending on the die, there are structures in which the die height changes due to regrinding. In such dies, it is necessary to adjust again in such situations.

A stroke end block is not used in one shot type dies, but is used very often in continuous feed type dies. The position of placing a stroke end block is very often the die set part on the outside of the plate constituting the die such as the die plate, etc. There is the danger of getting one's finger pinched due to carelessness during adjustment after setting up. This has been considered in the form shown in Fig. 1(b).

Caution about this matter is necessary when using a stroke end block of the form of Fig. 1(a).

The following are the two methods of using stroke end blocks.

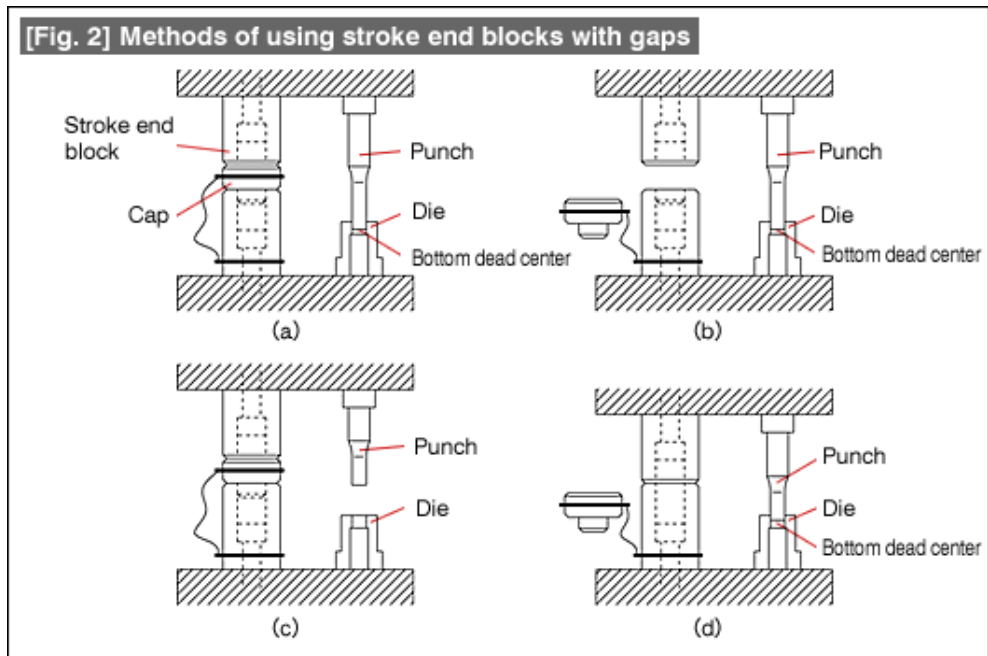
1. Method of using for the purpose of determining the bottom dead center during setting up

This is the method of determining the bottom dead center by adjusting using the slide adjuster so that the stroke end block touches lightly.

2. Method of using for the purpose of suppressing fluctuations of the bottom dead center while carrying out press operations

This is the method of using for stabilizing the dynamic accuracy by always making the stroke end block butt after determining the bottom dead center using the slide adjuster. The press machine will be damaged if the butting is weak.

The stroke end block can be of the integral type (shown in Fig. 1) or can be of the type with a gap. Some methods of using the stroke end block with a gap for the purpose described in 1 above are shown in Figs. 2(a) and 2(b).



Once the setting up is complete, since the role of the stroke end block is finished, so that the fingers are not caught in that part, in this method the cap is removed thereby creating a gap and thus achieving safety.

The methods of using shown in Figs. 2(c) and 2(d) are those in which a cap used to create a gap between the top die and the bottom die during storage, and during use of the dies, a stroke end block is made to butt thereby stabilizing the bottom dead center.

The method of using two pieces as shown in (a) is suitable for only determining the bottom dead center. In a method of use for stabilizing the bottom dead center, it is better to use four pieces as shown in (b).

When using multiple stroke end blocks, as far as possible, the height should be adjusted to be identical by carrying out simultaneous grinding.

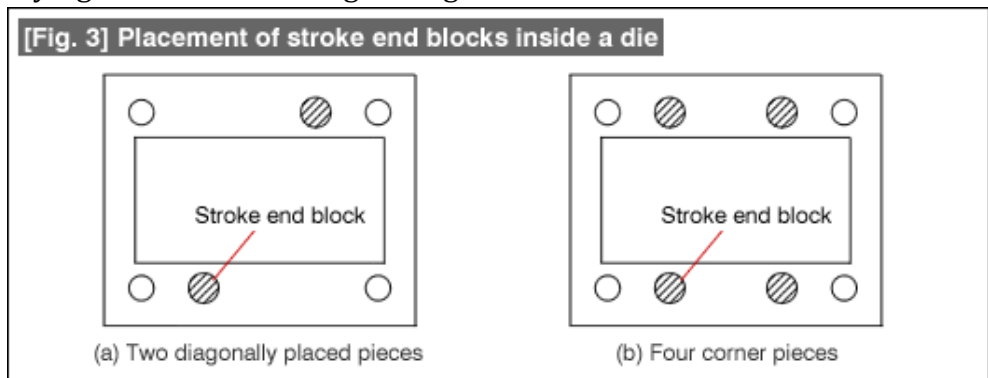


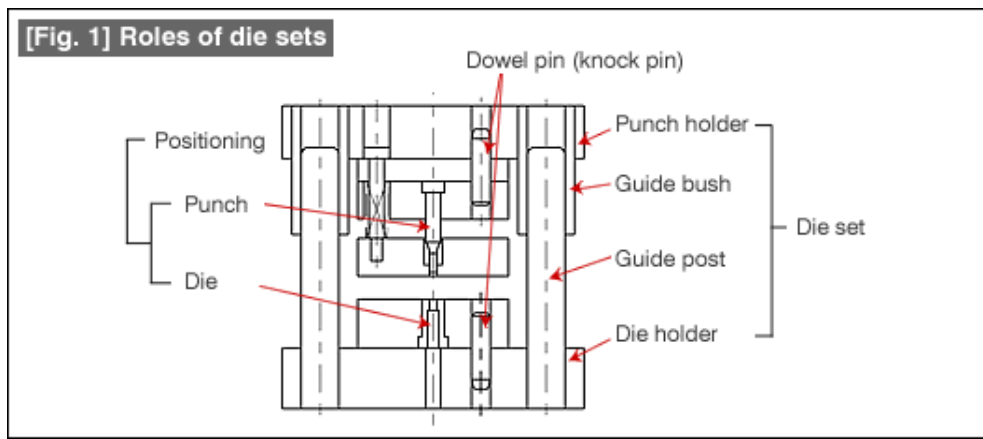
Fig. 3 Placement of stroke end blocks inside a die

Die Sets

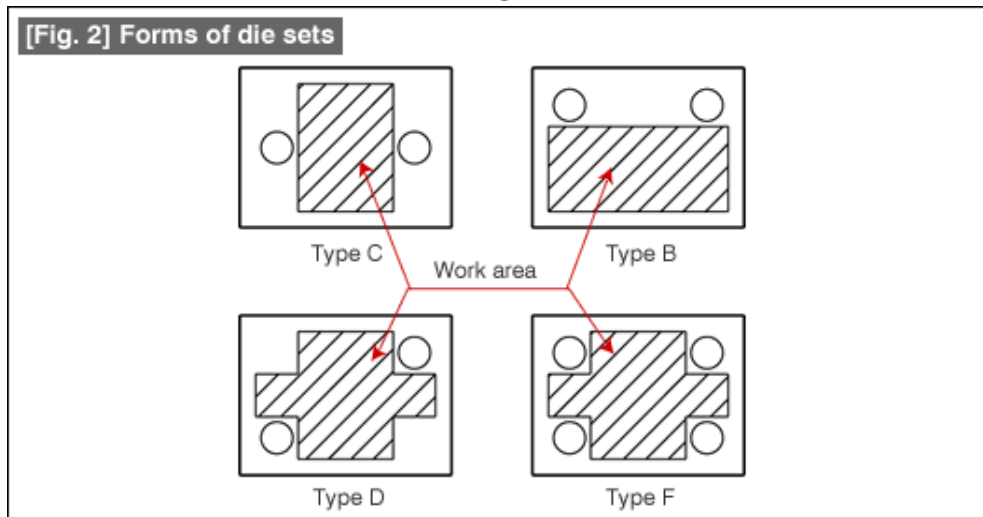
Die sets are used for maintaining correct relationship between the top die and the bottom die as shown in Fig. 1.

A die set is a unit component constituted from a punch holder, a die holder, a guide post, and a guide bush.

If we consider the relationship between the punch and the die when the top die is taken to be a punch and the bottom die is taken to be a die, the relationship between the punch and the die is maintained by being conveyed by the dowel pin (knock pin) to the guide of the die set (see Fig. 1).



There are four forms of die sets as shown in Fig. 2.



Type C (center post) is suitable when the center of gravity of the die is at the center, and work can be done at its front and back. This type is used frequently for one shot forming such as blanking, hole punching, bending, etc.

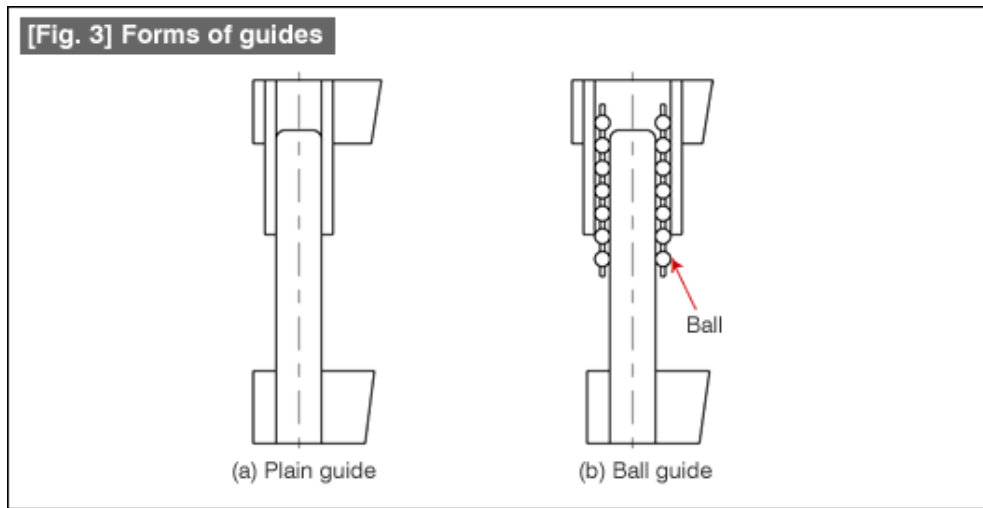
Since the left, right, and front are free in the case of the type B (back post), this is a die set with a structure that is easy to use in one shot operations. In addition, in robot operations, since there is no obstruction to the passage of the feed bar or the arm, etc., this type is used frequently for such dies. The drawback of this is that since heavy parts are supported only on one side, the front tends to droop which can be a problem in terms of accuracy.

Type D (diagonal post) is a structure that is used frequently in automated types such as continuous feeding type dies that are relatively small.

Type F (four posts) offers the highest reliability of the accuracy of dies because the guides are placed on four corners. On the other hand, since the posts can become obstructions, the ease of working is decreased in dies for one shot type production, Therefore, this type can be said to be suitable for continuous feed type dies.

The forms of guides shown in Fig. 3 are the main ones.

Although plain guides or ball guides are used in small die sets, mostly ball guides are used in large die sets because of the force required for operation. This trend is due to the desire to make the movements smooth with weak forces.

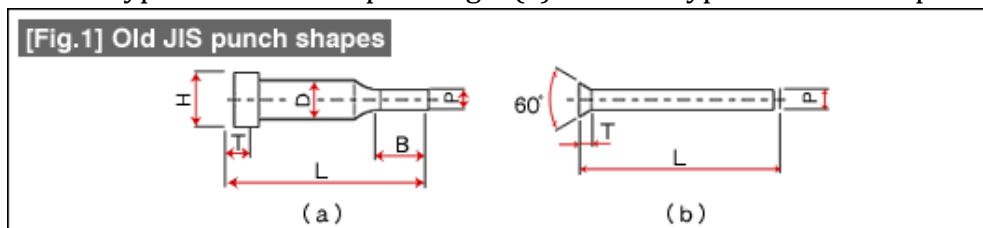


Plain guides are superior in terms of accuracy. Ball guides are weak against pressure from the side. Recently, roller type guides have also appeared because of the desire to make smooth movements and also to have rigidity.

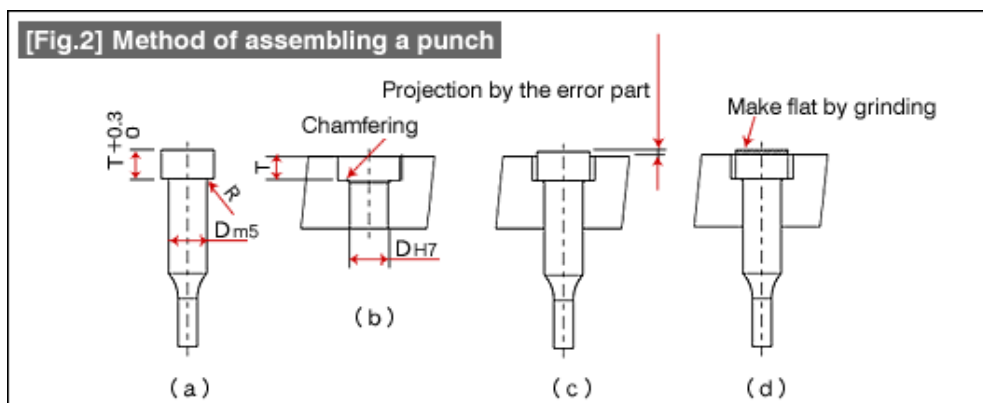
Round Punches

In JIS standards, round punches are classified as "dies" among "tools" of the category S. The JIS number is B5009. Although initially the name was "round punch for press dies", it has been changed at present to "punch with flange for press dies".

Initially in JIS a total of three types were determined as the standard types from the shapes shown in Fig. 1 with two types from the shape of Fig. 1(a) and one type from the shape of Fig. 1(b).



One type from Fig. 2(a) has all its dimensions determined, with the round tip diameter ranging from 1,0mm to 4,0mm in steps of 0,1mm, and those with higher diameters were standardized up to 24mm with suitable intervals between them. These were the first standardized round punches. Because of the low degree of freedom during use, they have been deleted from the current JIS standards. Another standard is one in which it is possible to select freely the tool tip dimensions with a certain width relative to the shank diameter of the round punch. This is the base for the shoulder punches of Misumi. In the standards of shoulder punches, it is possible to select more types than in JIS.

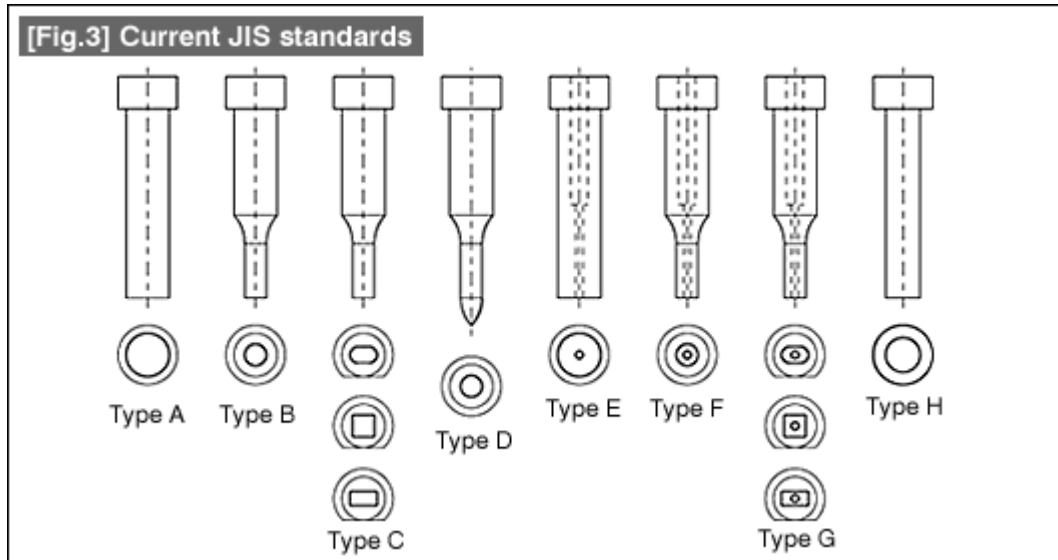


Even in the standards of the type from Fig. 2(b) all the dimensions have been determined, and there were standards of diameter from 0,1mm to 4.9mm in steps of 0,1mm. At present, these have been deleted from the standards. Misumi has standards as mini straight punches.

Tolerance in the positive direction has been determined for the thickness (T) of the flange part of Fig. 2(a). Although initially this was $+0,3/0$, at present, it has been changed to $+0,25/0$. The explanation why the flange part is the press tolerance is given

Although countersinking is made in the formation of the hole in which the punch enters as shown in Fig. 2(b), countersinking is a procedure that is relatively poor in accuracy. Since it is difficult to eliminate the gap between the punch and the hole, always the assembly should be made so that the flange part of the punch projects up, and after that, as a rule, in the assembled state, the projecting part should be made flat by grinding. (This method of assembling was common when this standard was prepared.) This thinking is still being carried on.

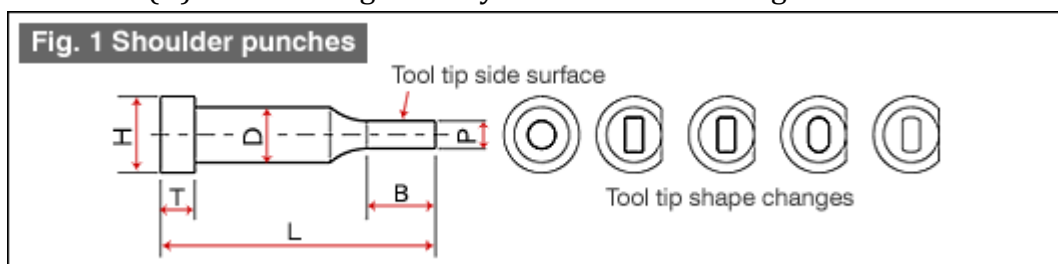
The current JIS standards are of the types shown in Fig. 3.



The number of types has increased, and it appears that it is possible to meet a variety of applications. In addition, although matching with ISO has been implemented, because of that there appears to be some part that is difficult to use. This is the overall length of the punch.

The earlier length standards were 40, 50, and 60, but gradually lengths matching with the standards have come into use, for example, the lengths of 56, 63, and 71, and the lengths 50, 60, and 70 are not present. In the actual practice the previous overall lengths are still being used, and it is convenient because it is possible to specify the length freely.

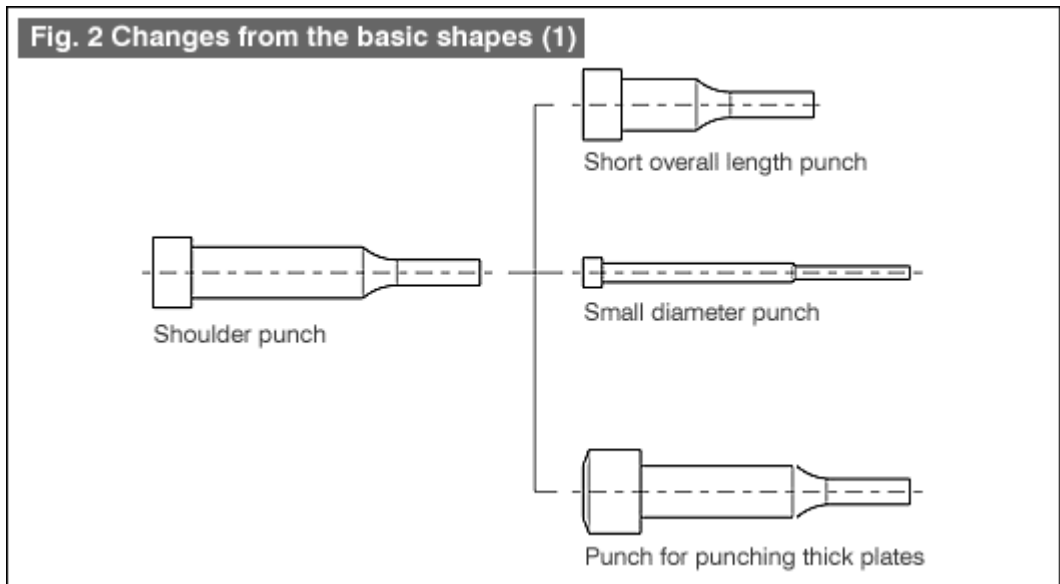
In the case of the shoulder punches shown in Fig. 1, the standard is such that the parts other than the shank diameter (D) can be changed freely within a certain range.



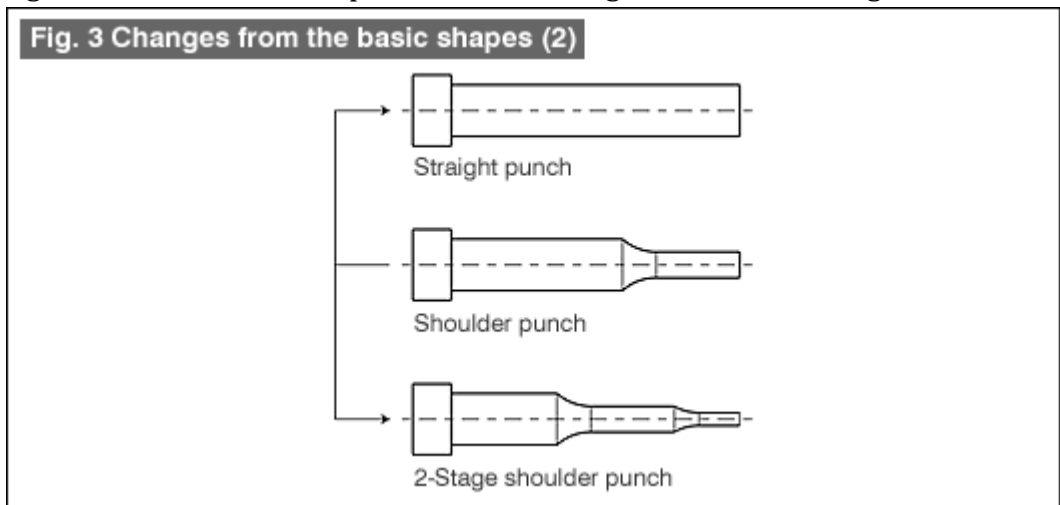
Even the tool tip shapes can be many. The materials are SKD11 equivalent, SKH51 and powder high speed steel, ultra hard alloys, and it is possible to select the lapping finish of the tool tip part, TiCN and DICOAT processing as the surface coating. It is possible to select low cost components for small quantity production to long life components.

The changes shown in Fig. 2 are available for meeting different applications.

- Items with shortened overall lengths so that they can enter narrow parts inside dies
- Small diameter punches that can work in close proximity to small diameter holes in a narrow range.
- Punches made strong against breakages considering the punching of thick plates.

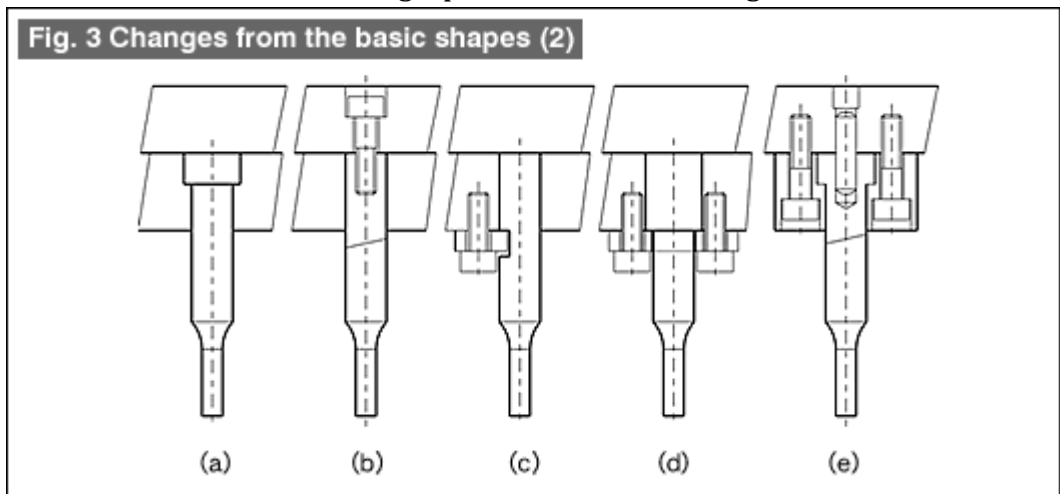


The changes related to the tool tip diameter and length are shown in Fig. 3.



There should be no problem even if the tool tip diameter and the shank diameter are the same, and such a punch is the straight punch. On the other hand, since even shoulder punches cannot be used because the diameter is small, the number of stages has been increased and the strength is maintained in the 2-stage punch.

The variations in the method of fixing a punch are shown in Fig. 4.



In addition to the methods of fixing using flanges, screws, and keys, there is a method using a type with a positioning knock as shown in Fig. 4(e). When an attempt is being made to fix an independent punch to a certain part, it is common to think of embedding the punch inside a small block, and installing that block using a knock pin and screws. At this time, the punch positioning accuracy

is dependent on the accuracies of the punch hole in the block and knock hole. If the punch and the knock pin are not embedded, it is possible to insert that knock pin directly inside the knock pin hole of the plate, and the accuracy of positioning the punch increases. Since it is sufficient for the block to have only the role of preventing the punch from coming out, a knock hole becomes unnecessary, and it is sufficient to have only holes for the fixing screws.

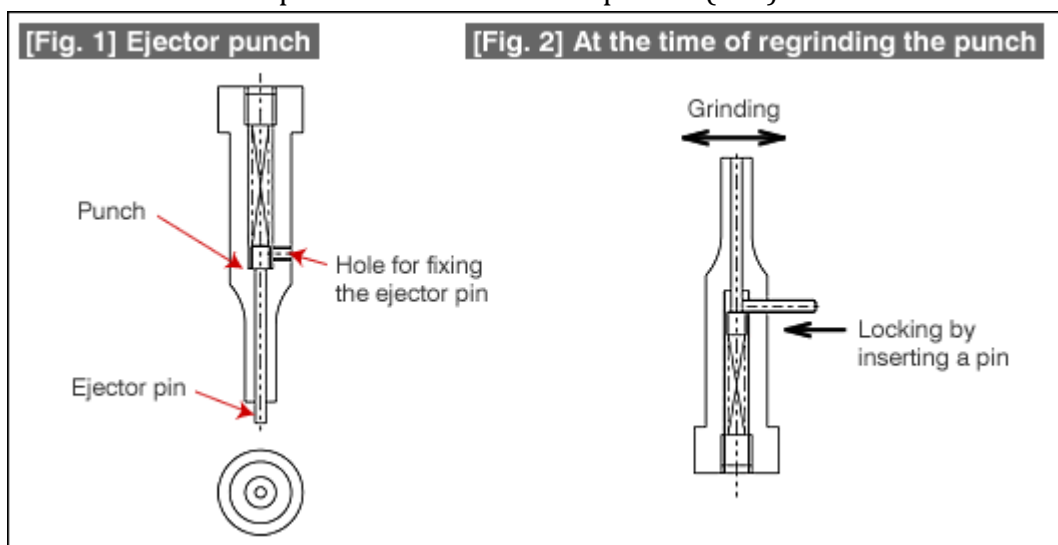
As described above, round punches have to be used appropriately by making modifications according to the application and purpose of use.

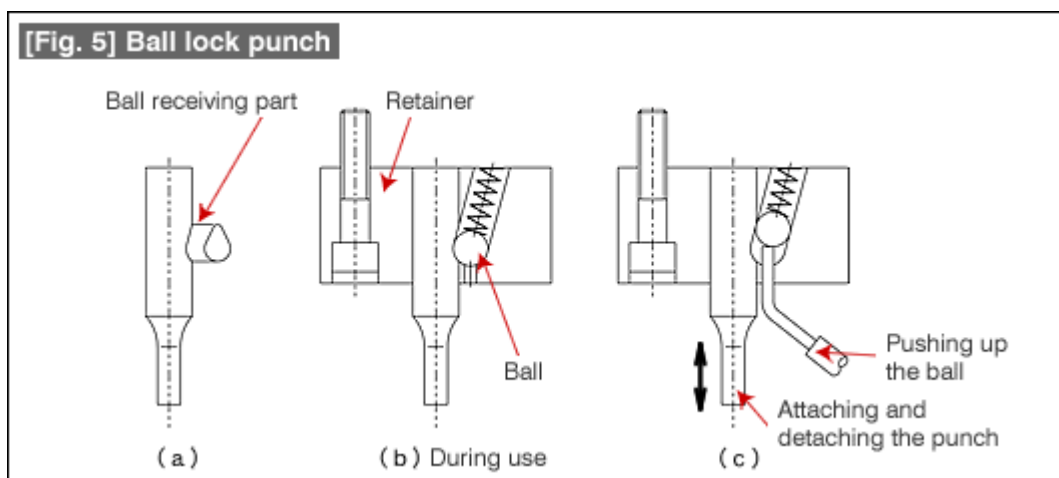
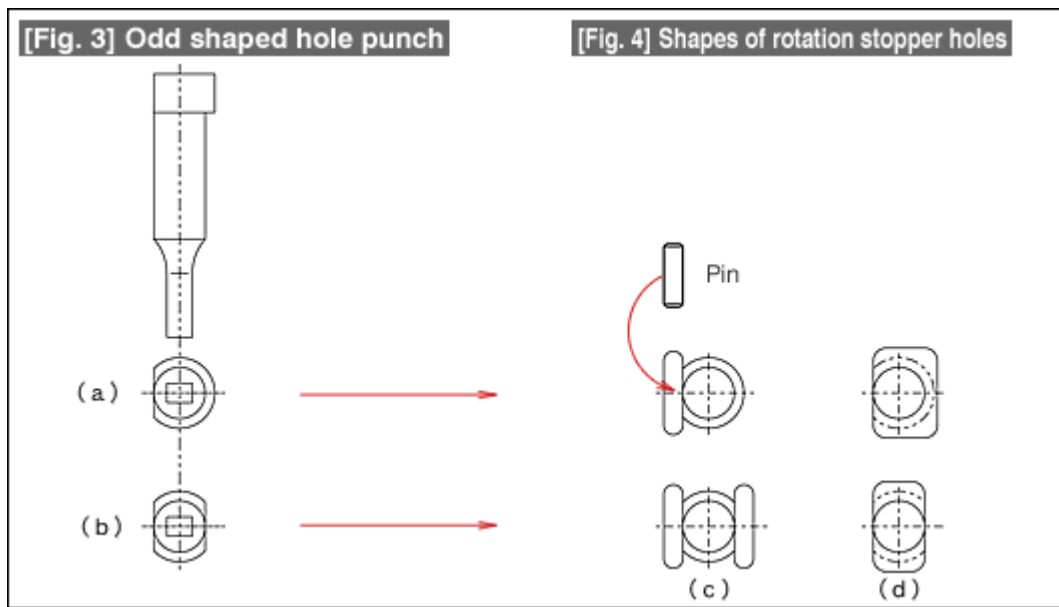
It is also possible to use a shoulder punch by carrying out additional machining. However, if standard components are used as they are while cleverly utilizing various standards, it is possible to reduce the cost and to shorten the time required.

In round hole blanking operation, there is the problem of slug pulling. The easiest method of countermeasure for this is forcibly pushing down the slug that is trying to come up. A punch prepared for this purpose is the ejector punch shown in Fig. 1 (Ejector punch in Misumi). Although using the punch is good as a countermeasure against slug pulling, the ejector pin becomes an obstruction while regrinding the punch. Disassembling and removing the ejector pin is very cumbersome. As a countermeasure for this, a hole has been opened at the side of the punch. As shown in Fig. 2, if a pin is inserted in the side hole with the pin pushed down, the ejector pin will remain in the pulled in condition, and hence grinding becomes easy.

A round punch is used for forming shapes other a round shape. This method is used for the purpose of hole punching of punch plates easy. However, since the orientation will be important if the shape is not round, a rotation stopper will be necessary as shown in Fig. 3. The shapes of rotation stoppers are shown in Fig. 4. The shape (e) can be said to be the basic shape of a rotation stopper. A groove is machined using an end mill, and a pin is inserted in it to make it into a rotation stopper. Adjustments can be made by handling the pin. The shape (d) is one in which the rotation stopper is formed directly using an end mill. The accuracy of the rotation stopper is determined by the accuracy of machining the hole. Although positioning using a rotation stopper looks simple, it is actually quite difficult.

As a special method of using a round punch, there is the ball lock punch. This is a punch in which the attaching and detaching of the punch can be made with one touch. This is a punch having a groove on the side surface of the punch in which a steel spheres (ball) has been inserted.





See Fig. 5(a). This punch is used as shown in Fig. 5(b). The punch is set using a dedicated holder called a retainer with a ball held by a spring incorporated in it. When a tensile force acts on the punch, the ball enters into the groove of the ball receiving part of the punch thereby preventing the punch from getting detached. When wanting to detach the punch due to the wear, etc., if a pin is inserted in the hole in the retainer and the ball is pushed up, the punch can be detached easily. The background of creating this kind of structure is that, during the hole punching operations of large components of cars, etc., since it is difficult to take down a large die from the press machine for re-grinding the punch, etc., the punch replacement has been made possible in the condition in which the die has been installed in the press machine.

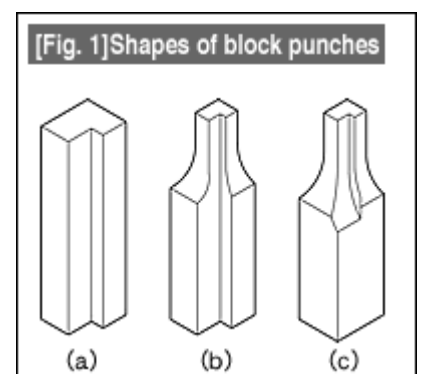
Block Punches

In shapes other than round, the part that is embedded into the punch plate (the shank part) is most often made square or odd shaped. A typical shape of a block punch is shown in Fig. 1.

Fig. (a) is of the straight type. This is the type with the punch cross-section being large and is a type that is easy to produce.

Fig. (b) is one with a small punch cross-section, and is a type used when the strength is not enough in a straight type. The size is still the one in which it is possible to give considerations to machining the punch making straight the parts that are difficult to machine.

Fig. (c) is the shape when the punch cross-section is small and priority is given to the punch



strength. This is the shape that makes the punch machining most difficult. As long as there are no problems, it is good to design to the shape of (a).

The above discussion is about common block punches. Since presupposes standardization, as shown in Fig. 2, the block punches are limited to shanks parts that are square and tool tips that are either square or oval shaped.

Among block punches it is also possible to make those that work only at one side (edge cutting punches or L-shape bending punches, etc.). In such cases, a sideward force acts on the punch. Countermeasures for this are necessary in the punches. Fig. 3 shows examples of countermeasures against sideward forces.

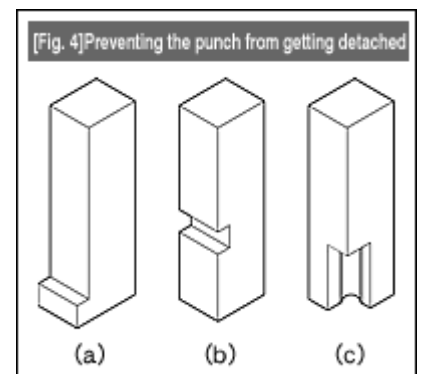
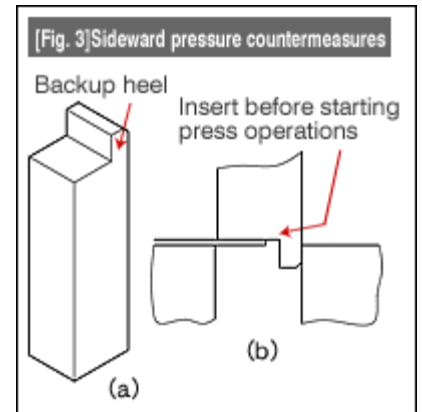
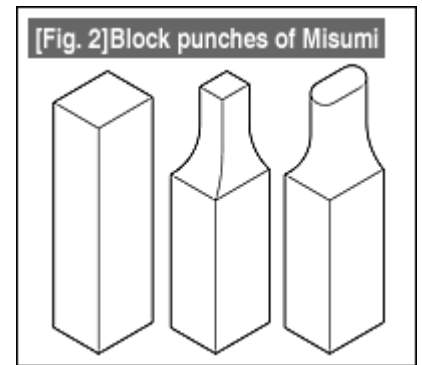
A projecting part is prepared in the cutting edge part of the punch. This projecting part is called the back up heel (or simply, heel). Before starting the press forming operations, the heel part is inserted in the die, receives the sideward force during operation, and prevents changes in the clearance, etc. As a countermeasure against sideward force, there is also the method of making the die side projecting relative to the normal shape of the punch.

The major methods for preventing a block punch from getting detached are shown in Fig. 4.

Fig. (a) is a flange stopper. In the figure, although a flange is shown only on one side, it is also possible to have flanges on two or three sides. The design of providing a flange on all four sides is very rare as being making the machining of the flange very tedious.

Fig. (b) is a key stopper. Very often the key groove is provided on one side or on two opposite sides. Although the machining of a key groove is easier than the machining of a flange, since it affects the strength of the punch, it is necessary to exercise caution while paying attention to the size of the punch.

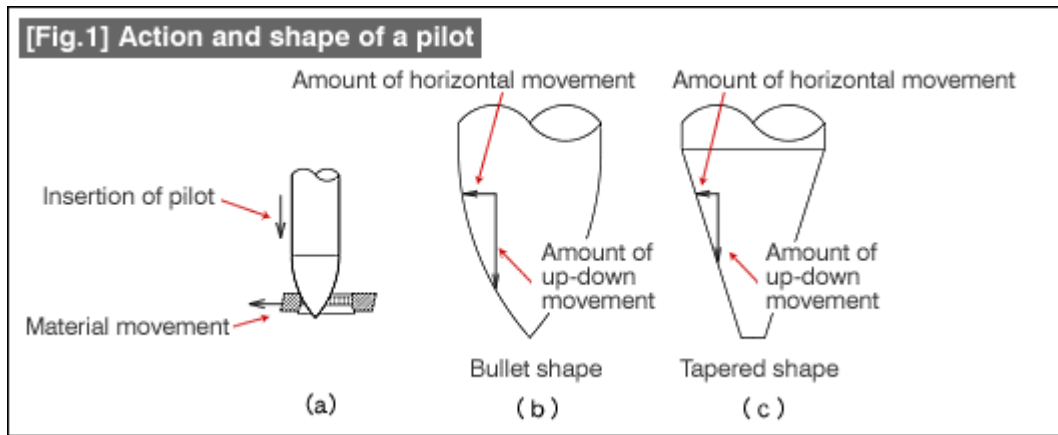
Fig. (c) is a screw stopper. This is used very frequently in punches prepared by wire cutting. Apart from the punch detaching prevention methods shown here, there are also other methods with some special techniques adopted. In a single die, as far as possible, the form of punch detaching prevention is made the same, thereby making it easy to assemble and disassemble the punch.



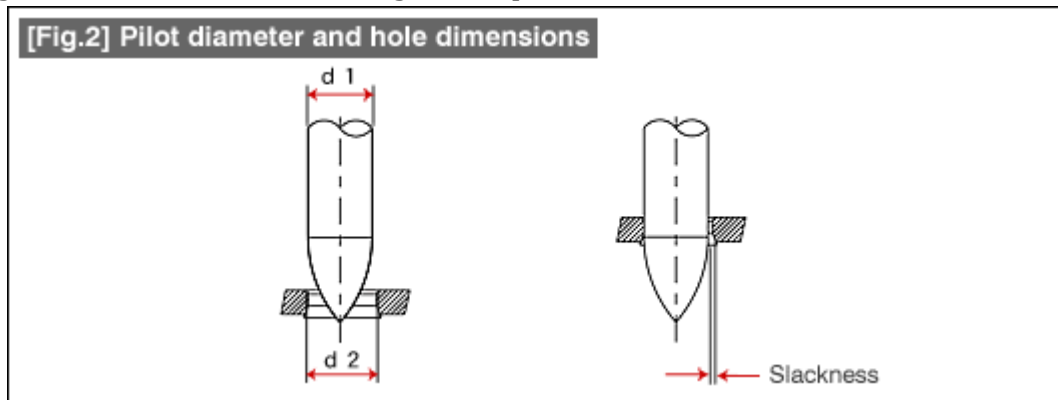
Pilot

As shown in Fig. 1(a), the pilot carries out the final positioning of the material inside a die. Although the material is fed into a die by human hand or by a feeding device, there is always some error in feeding. It is required that this error is corrected to the extent that it does not affect the product. The correction of the position of the material is made by sliding the material along the inclined surface of the pilot. The shape of the inclined surface can be the bullet shape shown (b) or the tapered shape shown in (c). In the bullet shape, the amount of horizontal movement changes with respect to the amount of up-down movement. In the tapered shape, the amount of movement is always fixed. Earlier it was said that the tapered shape is good for precision machining, but at present no distinction is being made between the two shapes. In the case of precision products or when the plate is thin or is made of a soft material, the horizontal movement with respect to the up-down movement is made small, and there is the trend of making the horizontal movement larger as

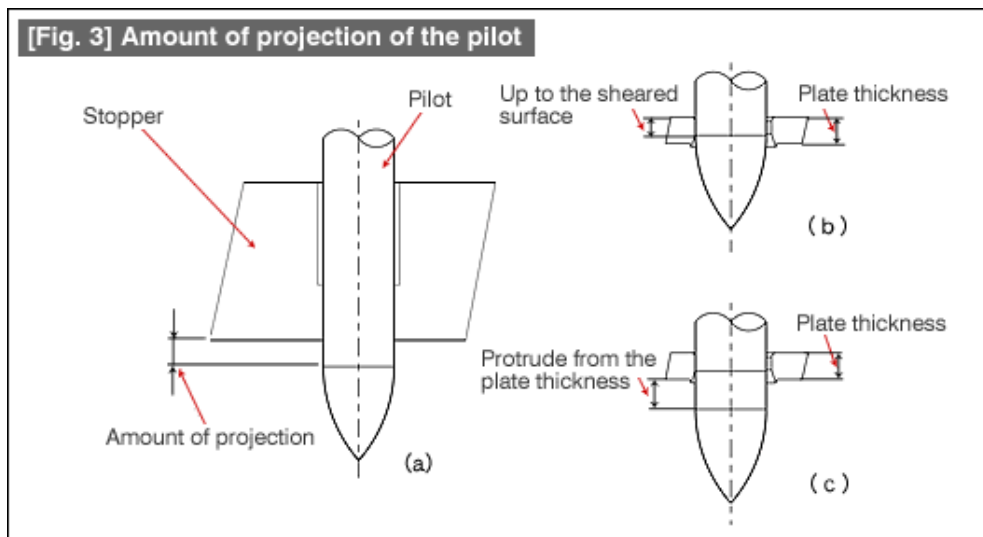
the plate thickness increases. The inclined surface against which the material slides is finished clean and smooth thereby reducing the sliding resistance.



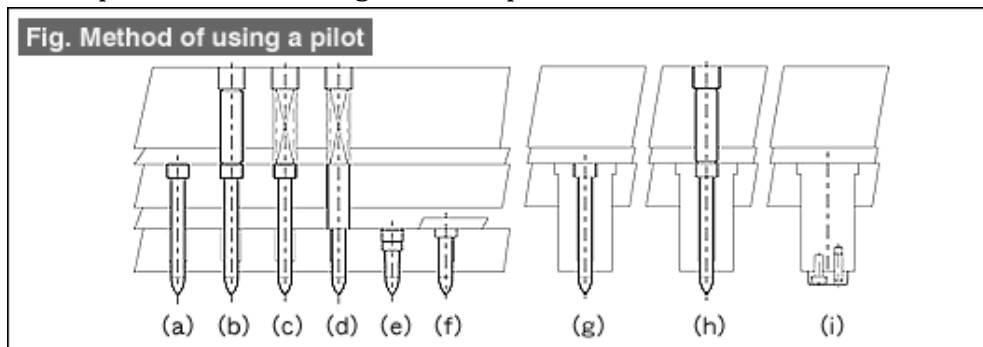
While usually a pilot is inserted in a hole for the pilot, care should be taken about the relationship between the pilot diameter and the hole shown in Fig. 2(a). Although the positioning accuracy becomes better as the "slackness" shown in Fig. 2(b) is small, if there is no slackness, the material will be lifted up when the pilot is being removed from the material. The relationship between the pilot diameter and the hole is determined considering the relationship between the accuracy of positioning and the problem of material being lifted up. Even in the case of precision products, the slackness (difference between the diameters) is about 0,01mm which is about 0,02 to 0,04mm in ordinary situations (when the plate thickness is roughly 1mm). Although the slackness appears as an error, when there are a number of pilots inside the mold, they interfere with each other increasing the accuracy. However, if the number of pilots is too large, the mutual interference becomes tight becoming a cause of the material being lifted up.



The pilot has to move before machining. Therefore, a form is used in a movable stripper structure in which the pilot projects from the stripper surface. If the length that is projecting is too much, it will become a cause for the material to be lifted up. See Fig. 3(a). While the amount of projection is determined considering the material plate thickness, it is desirable to make it as short as possible. The thinking is as follows. The blanking surface of the hole in which the pilot enters is constituted as "droop - sheared surface - fracture surface". The reliable surface is the sheared surface. The function is achieved if the pilot acts on the sheared surface part. If the plate thickness of the material is sufficient, there will be no problems even if the amount of projection of the pilot is made short as shown in Fig. 3(b). However, if the material plate thickness becomes small, if the form of Fig. (b) is used, the method fails unless the component accuracy of the pilot is very high. In view of this, as shown in Fig. (c), the amount of projection is made more than the material plate thickness. By making the amount of projection larger, it is possible to make rough the machining accuracy of the pilot. The problem of the material being lifted up will be present even if the amount of projection is made large, and hence a compromise has to be found.



The different shapes shown in the figure are explained below.



a) This is the basic method of use. This is a form that is a modification of the basic method of use of a round punch. The tip of the pilot is proportional to the amount variable movement of the movable stripper. It is cumbersome to remove the pilot at the time of carrying out maintenance of the die.

b) The function is the same as the basic method. The feature is that considerations have been given to the maintenance of the die and disassembling has been made easy.

c) The material will be pierced by the pilot if wrong punching is done in the basic form. The die may break because of this. As a countermeasure for that, a spring is provided behind the pilot, and when a wrong punching is made and a large load acts on the pilot, the spring gets compressed thereby avoiding the material being pierced. If the spring is weak, it gets compressed even during the normal state and hence the positioning accuracy may become poor. It is necessary to take care about these aspects.

d) In the basic method, the pilot punch is fixed to the punch plate. As a consequence, the penetration of the pilot into the die becomes deeper. If the penetration into the die becomes deep, the pilot will be scratching the material for a long time, and this may cause deformation of the pilot hole or pulling up of the material. This is a structure which avoids this phenomenon and also avoids the pilot piercing of the material when a wrong punching is made. The feature is that the stepped part of the pilot butts against the stripper surface. The precautions about the spring are the same as in the structure of (c).

e) This is the basic form of a pilot fixed to the stripper. By fixing to the stripper, it is possible to maintain the amount of projection of the pilot at a fixed value. The fixing is done by a press screw. Since the screw can easily become loose, although it is better to use two screws, the disadvantage is that it is difficult to provide two screws because of space limitations.

f) Although this is a pilot fixed to the stripper, this is a structure in which it is pressed from the back using a stripper packing. This structure has been made easier to prepare than the struc-

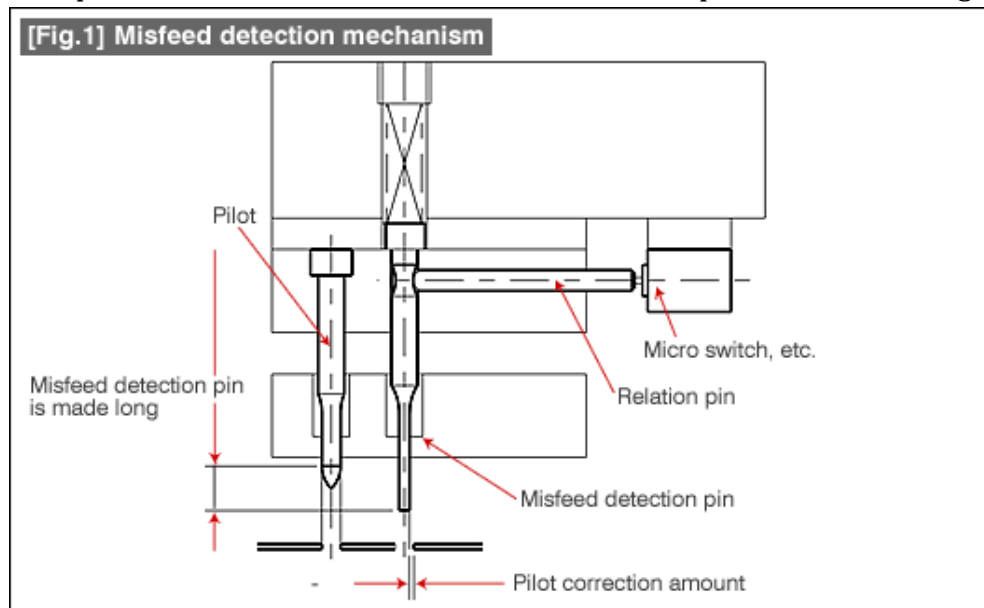
ture (e).

g) Although this is a pilot fixed to the punch, this is a structure in which the attaching and detaching of the pilot has been made easy in order to make it easy to carry out regrinding of the punch.

h) In a large punch, this is a structure in which the fixing on the punch is done using bolts and knock pins (dowel pins). The key points are that care needs to be taken about falling off of the knock pin and taking measures to make it easy to remove the knock pin at the time or detaching the pilot.

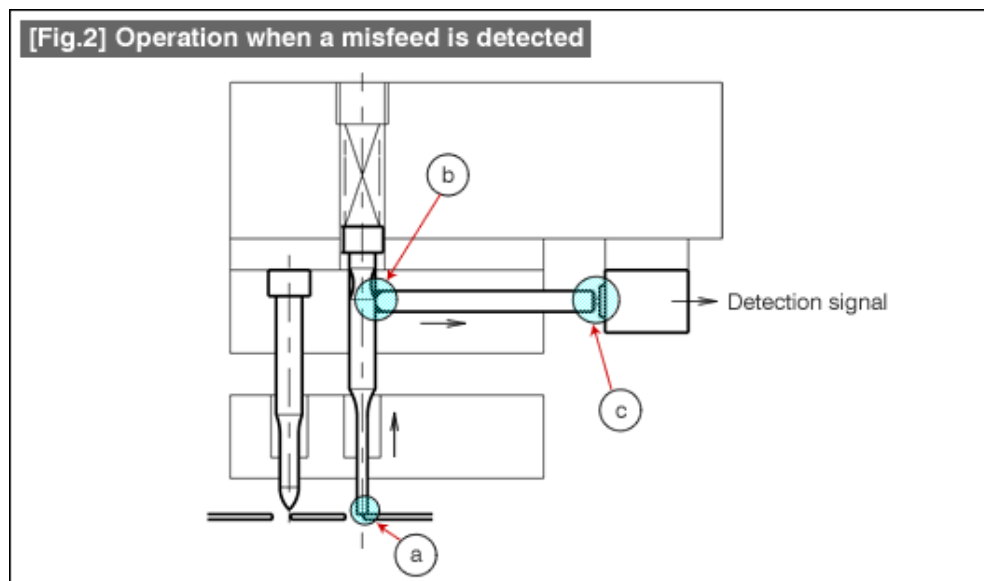
Misfeed Detection Unit

The relationship between the misfeed detection unit and the pilot is shown in Fig. 1.



The misfeed detection is made to operate in the state in which the pilot cannot correct the position of the fed material. Therefore, since it is made to act earlier than the pilot, it has to be made longer and thinner than the pilot (within the correction amount of the pilot). The general form of a misfeed detection unit is constituted from a misfeed detection pin, a relation pin, and a micro switch, etc.

Fig. 2 shows the state in which a misfeed has been detected.



The operation is made in the following sequence

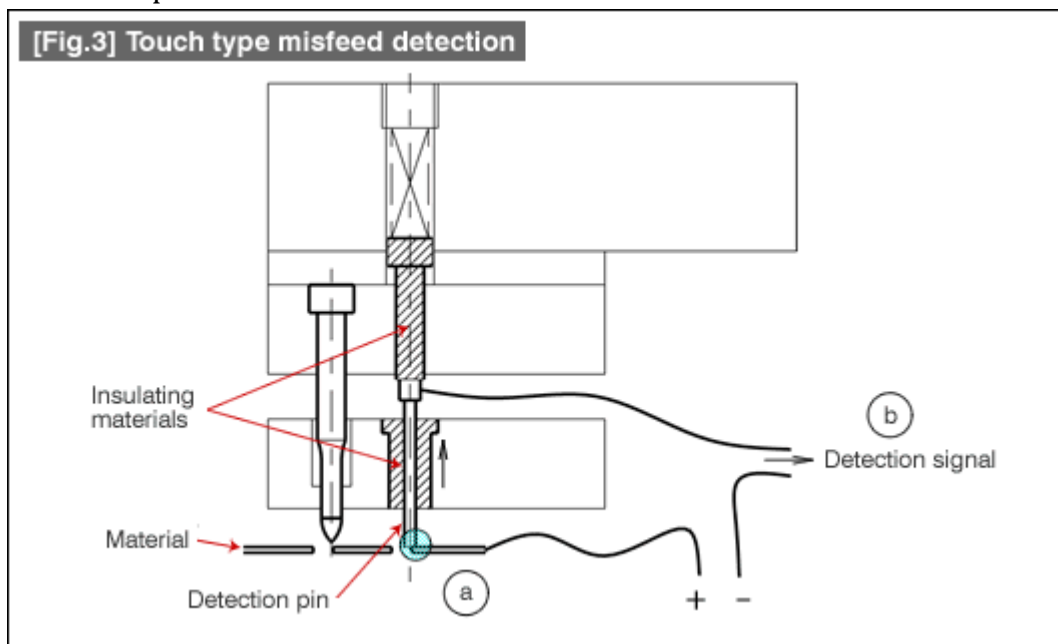
a) The misfeed detection pin climbs over the edge of the pilot hole of the shifted material.

b) The misfeed detection pin is pushed up.

c) The relation pin set in the groove of the misfeed detection pin is pushed sideways and presses a micro switch, etc., outputs the detection signal, which stops the press machine.

After detecting a misfeed, although it is good that the press machine is stopped before the pilot contacts the material, in order to do that, it is necessary that the misfeed detection pin is considerably longer than the pilot. The conditions are very often difficult to realize, and it is often assumed that the machine stops after making one wrong press operation. In the case of a high speed press machine, even if a sudden stop is made, the machine stops after making two or three wrong press operations. In the method of misfeed detection explained using Fig. 1 and Fig. 2, there is some play in the movements of the misfeed detection pin, the relation pin, and the micro switch, etc. Since there is a delay in the detection time corresponding to this play in the movement, the stopping of the press machine becomes late, and the wrong press operations become more.

The mechanism in Fig. 3 has been made to operate electrically considering the problem of delay in the mechanical operations.

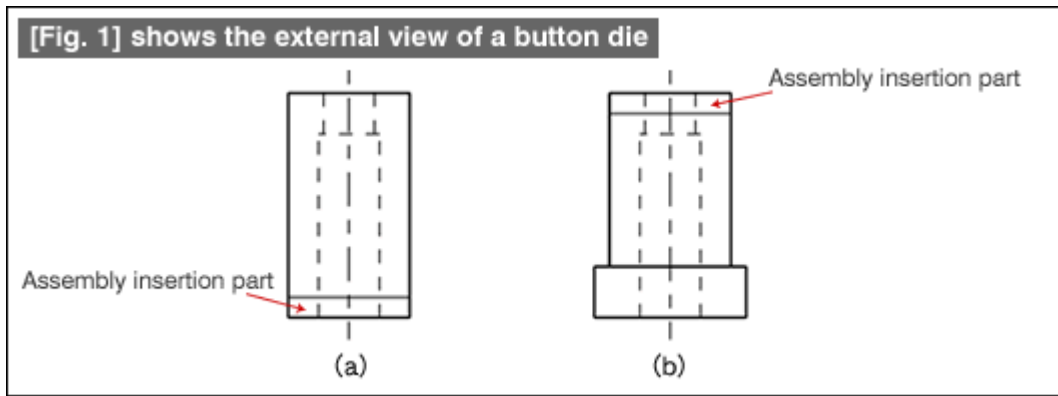


The example shown in the figure is merely one of the possible examples, and a form with many modifications is used. The principle of operation is that the detection pin is maintained in the insulated state, and a small current is passed between the material and the detection pin. Under normal conditions, no current flows because the detection pin enters the pilot hole without touching the material. If the pilot hole gets shifted as shown in Fig. 3(a) and contacts the detection pin, a current flows, and a detection signal is output stopping the press machine. Faster operation can be obtained compared to Fig. 1. The drawback is that the electrical lead wire of the detection pin is moving all the time during press operation. As a consequence of this, the lead wire is likely to get cut somewhere. If this happens, even if the detection pin detects an abnormality, the press machine cannot be stopped. Periodical checks cannot be avoided.

Button Die

A button die is used as a part inserted in a die plate (nested). It is used as an insert in a non-tempered die plate, and is used to make the preparation of the die easy, or to make the die maintenance easy, or to obtain a long life.

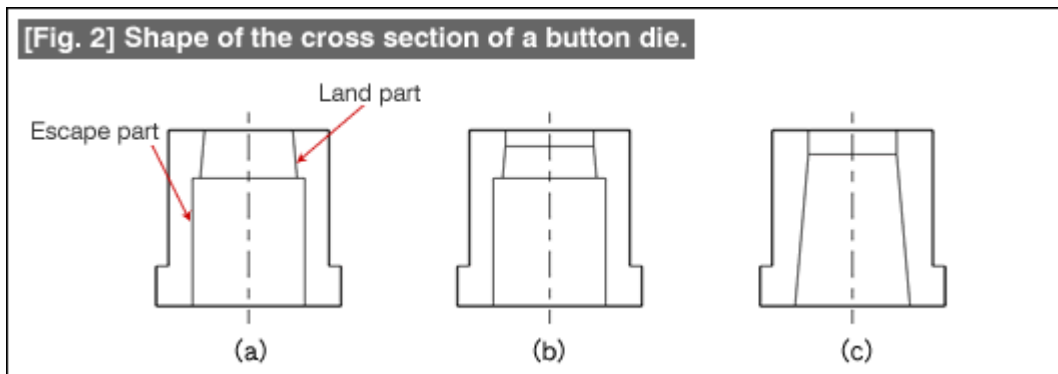
Fig. 1 shows the external view of a button die.



Straight type (a) is one that is used by lightly pressing inside the plate. An assembly insertion part has been provided in the part thereby making its assembly easy.

The type (b) is one with a flange. This shape can be said to be the standard type. The materials available for button dies are SKD11, SKH51, powder high speed steel, ultra hard alloys, etc.

Fig. 2 shows the cross section of the hole of a button die.



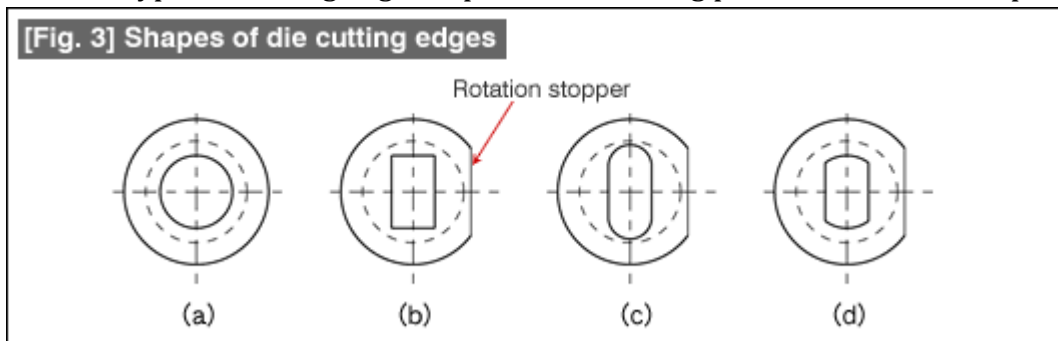
The hole is constituted from a land part (cutting edge part) and an escape part. There are three basic types of the hole cross sections as shown in the figure.

(a) is a type with a land part having a taper. This is a shape considering the passage of the blanked material. The drawback is that the hole becomes slightly larger every time the die is re-ground.

(b) is a type considering the drawback of the type (a), and the part necessary for regrinding has been made straight, and this is the type in which there is no change in the hole dimensions due to regrinding.

(c) is a type in which the part below the land part is not made to escape in a big way, and that part is escaped entirely by a taper. This is used relatively frequently for small diameter holes. This can be said to be a type in which some considerations have been given to scrap clogging. This is also called an angular button die.

Fig. 3 shows the types of cutting edge shapes that are being provided as standard parts.

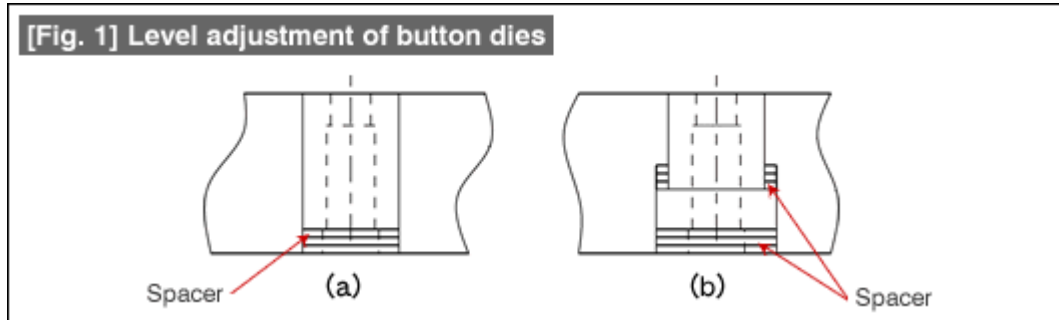


Since the orientation of the hole is present in the types (b) to (d), there is no need for a rotation stopper. It is possible to specify in detail the different dimensions, the method of preparing the rotation stopper, etc. It is also possible to make changes in the details related to the cross section,

and it is possible to make the shape most suitable for the pressed material and the plate thickness.

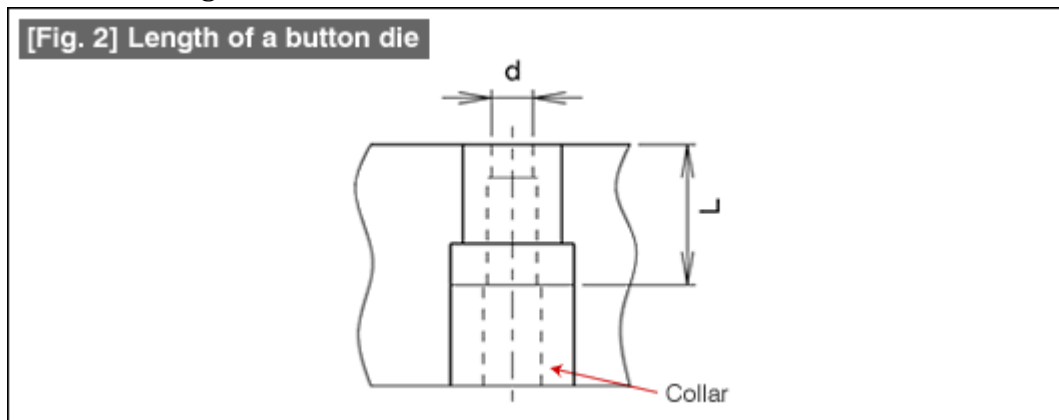
Punches and button dies have been standardized and made available at low costs, and hence it can be said that die preparation has become quite easy. Punches and button dies can be said to be parts in which the effect of standardization has been brought out in a big way.

Dies are reground when the cutting edge part is worn out (increase in the number of burrs) thereby regenerating the cutting edge. The methods of regrinding a die are – the method of grinding the entire plate and the method of grinding only the insert part. In the method of grinding the entire plate, although the plate becomes thin every time it is ground, there is no particular problem because even the insert parts such as button dies change at the same level. In the method of grinding only the insert parts, it is necessary to adjust the level to which the grinding is made. If this adjustment is not good, undulations appear in the plate surface, and this will affect the product quality. Therefore, as shown in Fig. 1, it is made easy to carry out adjustment of the level of the button dies.



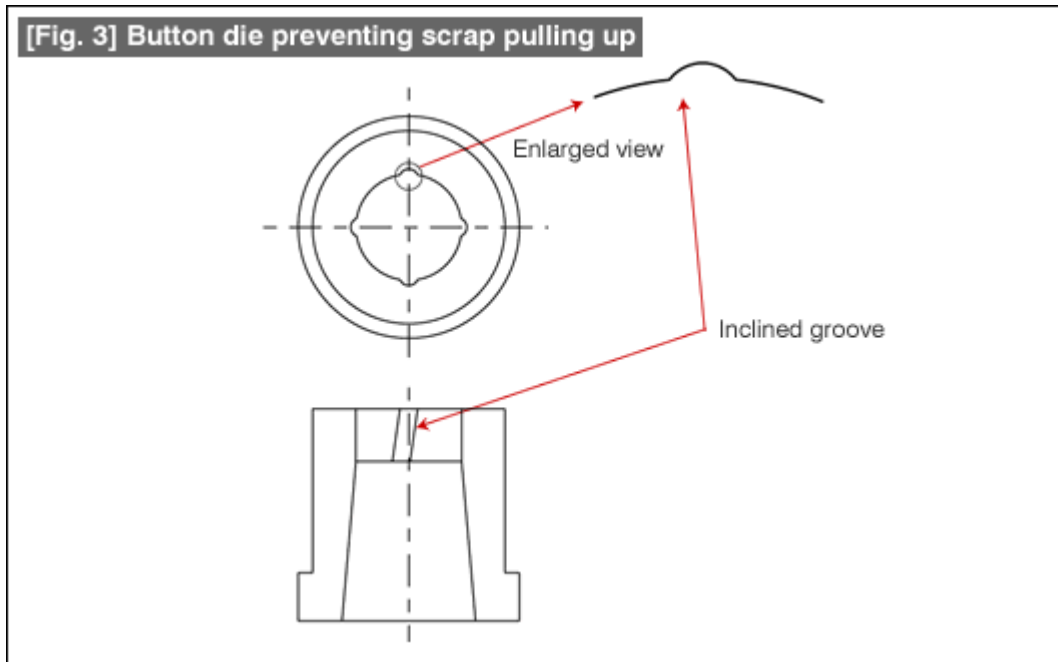
In a button die without a flange as in (a), there is no particular problem because it is possible to adjust by placing a spacer to the extent of grinding. In a button die with a flange as in (b), it is necessary to place a spacer above the flange. While the number of spacers increases as the number regrindings increases, it is not good when they become too many. The spacers should be only up to about 3 to 4, and when their number becomes large, their thicknesses are increased so that their number does not increase.

Next, we discuss the relationship between the hole diameter (d) and the height (L) of the button die. When the dimension L becomes too long compared to the hole diameter, it becomes easy for scrap clogging to occur. Since this problem is particularly easy to occur in the case of small hole diameters, it is good to make it as short as possible. Considering the relationship with other machinings, the plate becomes thick and the length of the button die becomes too long compared to the hole diameter. When it is felt that the balance between the hole diameter and the length of the button die is poor, it may be good to adjust the length of the button die by placing a collar behind the button die as shown in Fig. 2.



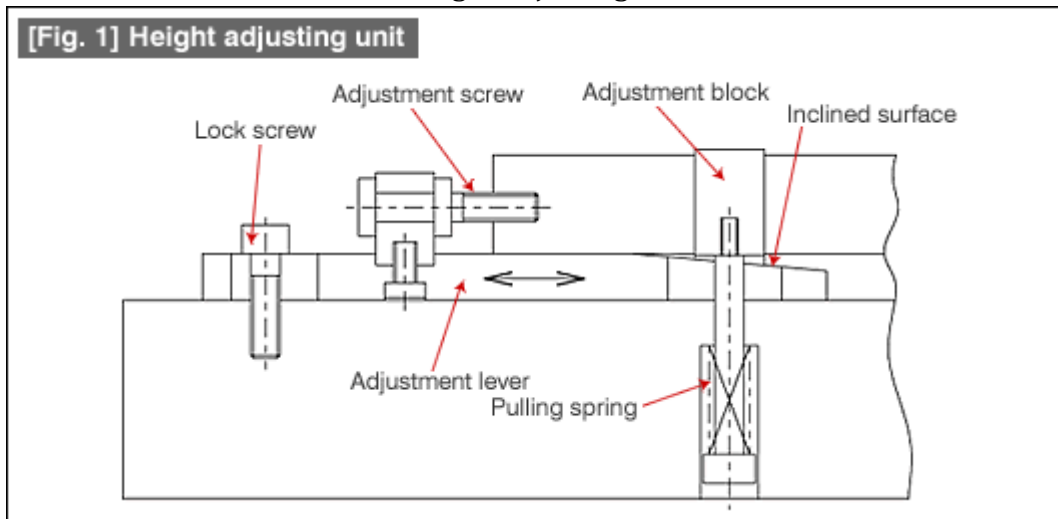
In hole punching using a button die, very often the hole shape is simple, and there is the trend of easy pulling up of scrap. As a countermeasure, there is a button die that prevents pulling up of scrap. This structure is shown in Fig. 3.

In hole punching operations, there is no effect on the operation even if there is slight change in the clearance of the straight part or curved part shape. Further, shape of the hole punching is that of the punch and the shape of the punched part is that of the die. The scrap pulling up preventing button die is one that has utilized this principle. The clearance is widened at a part of the die and a groove is prepared. This groove is made to be inclined. Many such grooves are prepared. The blanked shape is that of the die cutting edge shape. The blanking scrap moves vertically. Therefore, the projected shape of the inclined groove is a shape that climbs over the inclined groove, and hence increases the biting of the die. This biting force prevents the pulling up of the scrap. However, the effect is small in the case of hard materials such as SK materials or in the case of very thin materials.



Height Adjusting Unit

Figure 1 shows the condition when a height adjusting unit has been attached to a die.



An adjustment lever and an adjustment screw have been integrated in this unit. The adjustment screw has been affixed to a plate in which the adjustment block is present. When adjustment screw is rotated, the adjustment lever moves to the front or back. The front end of the adjustment lever is an inclined surface, and the adjustment block is on that inclined surface. The adjustment block is supported by a pulling spring so that it is kept pushed against the inclined surface.

When the adjustment lever is moved to the front or back the adjustment block moves up or

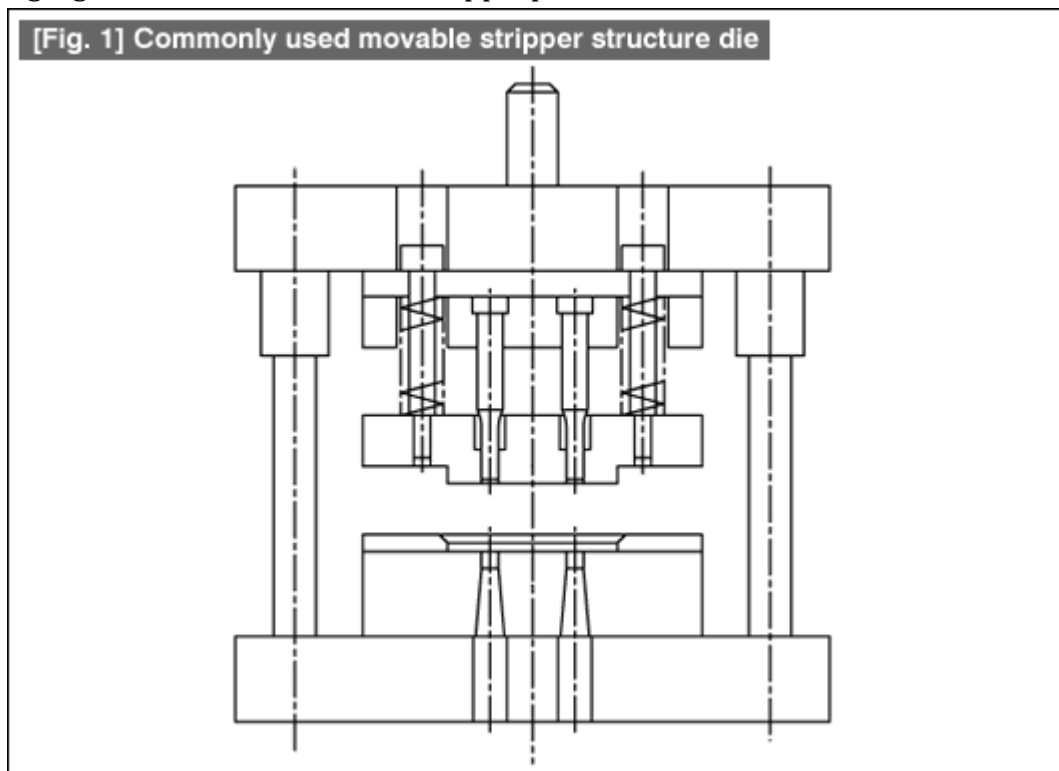
down. This amount of movement is related to the tangent of the angle of the inclined surface. It goes without saying that it is possible to make finer adjustments as the angle of the inclined surface is made smaller. When the adjustment has been finalized, it is necessary to directly fix the adjustment lever by a lock screw. In addition, the groove of the plate in which the adjustment lever enters should have no play, and the adjustment lever should have entered in it completely.

The adjustment mechanism is very frequently used for managing the camber associated with product formation, or warping of the surface, or the depth at the time of marking by punching. It is good if there are as few adjustment parts as possible in a die. However, there are inevitable situations, and the adjustment mechanism is used as a countermeasure. The method of adjusting differs slightly depending on the person making the adjustment. It is necessary to prepare measurement jigs or limit samples, and to take measures so that there will be no differences in the results depending on the individual making the adjustment.

Stripper Guide

Role of a Stripper Guide

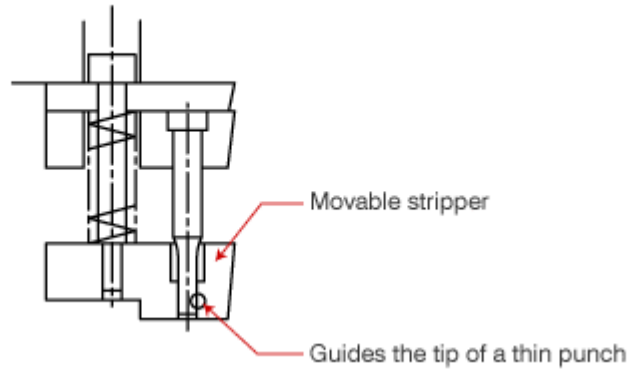
As shown in Fig. 1, the position adjustment of the relationship between the punch and the die is made using a guide for the die set and an appropriate clearance is maintained between them.



A die set makes it easy to establish the relationship between the punch and the die, and also makes it easy to install the die in press machine. Compared to the age in which die sets were not used, dies have brought in great changes. In a die with the movable stripper structure shown in Fig. 1, the material is kept pressed by the stripper and the pressing is done so that it does not get deformed.

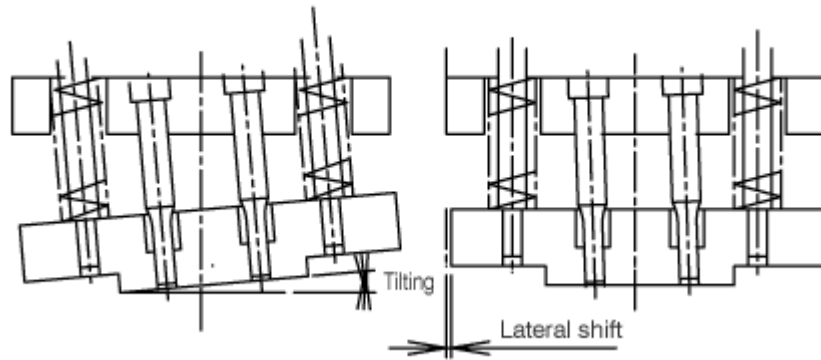
The die structure is used very often in product formation applications that require relatively accurate shapes. In accurate formation, very often the formed shape becomes finely detailed, and since even the punch shape becomes weak, one would desire to strengthen the punch. As an idea for strengthening the punch, as is shown in Fig. 2, a lot of people thought that it becomes difficult for the punch to break if the weak tip of the punch is guided by the stripper and they have implemented this structure.

[Fig. 2] Stripper guiding the punch



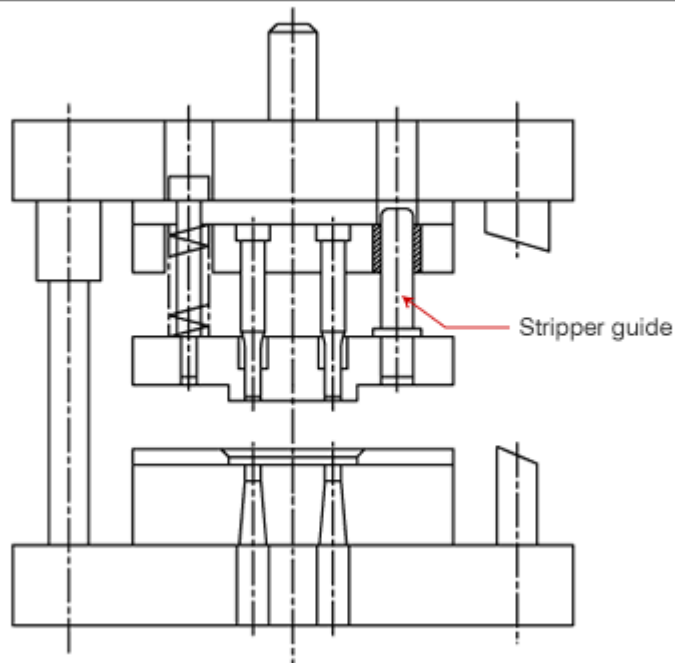
However, in the structure of Fig. 1, there is a movement of the stripper as shown in Fig. 3, and the stripper damages the punch that it is guiding.

[Fig. 3] Tilting and lateral shift of the stripper



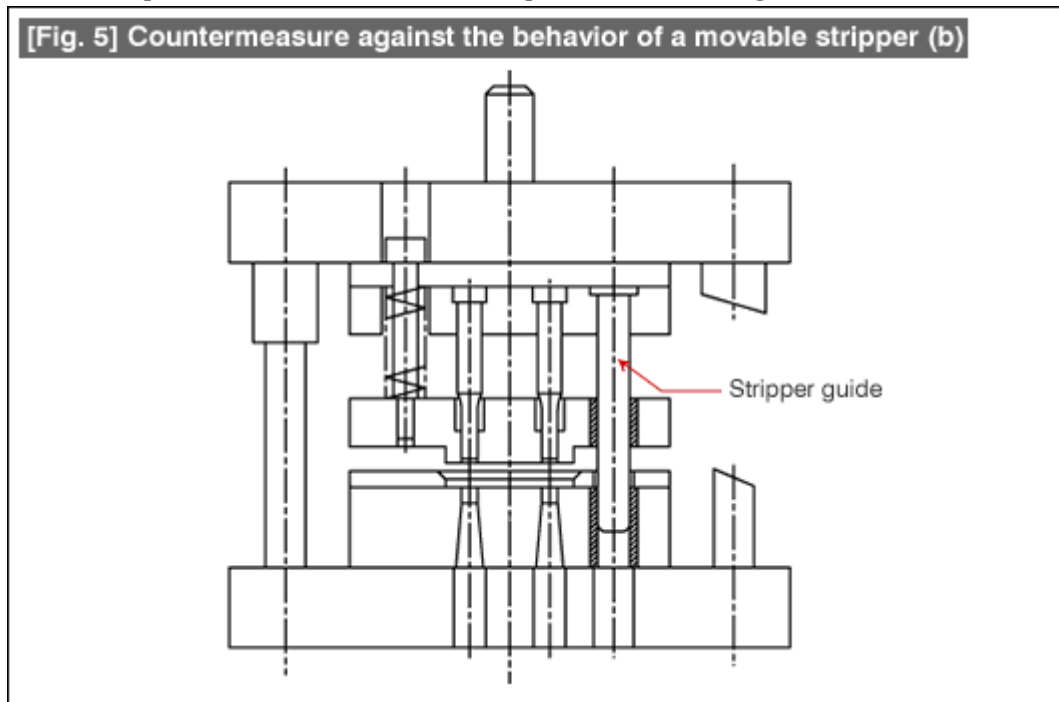
Since the original function of the stripper is to peel off the material that has got adhered to the punch, although there was no problem even if did some slightly strange movement, but in order to guide the tip of the punch, it is necessary that the stripper maintains horizontality and only carries out up and down movement, a stripper guide was placed between the stripper and the punch plate as shown in Fig. 4.

[Fig. 4] Countermeasure against the behavior of a movable stripper (a)



The relationship between the top mold and the bottom mold is maintained by the guide post bush of the die set, and since the stripper guide only restricts the behavior of the stripper it is also

called a "sub-guide". When one starts using the stripper guide, the die life gets extended compared to the conventional dies, stable press operation is obtained, and in addition, by making the stripper guide penetrate up to the die as shown in Fig. 5, the accuracy of the die becomes better, and this has become the mainstream punch and die structure for precision forming.

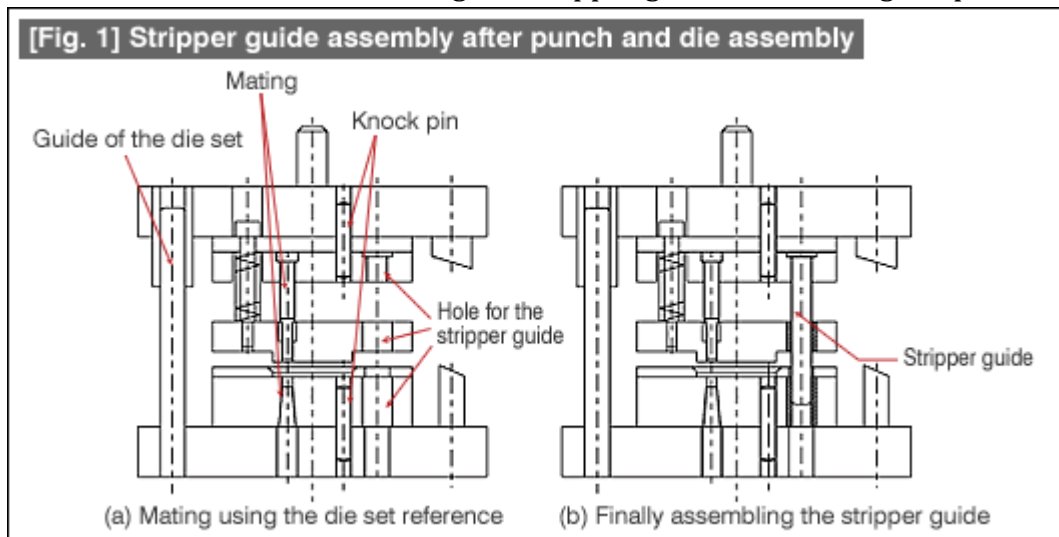


A stripper guide is said to have the following roles.

1. Restricting the behavior of the stripper in order for the stripper to guide the punch.
2. Heightening the dynamic accuracy of the punch and die.
3. Making the assembly of the punch and die easy.
4. Making the maintenance easy, etc.

However, these can change depending on the method of assembling the stripper guide. Some examples of these are shown in Fig. 1 and Fig. 2.

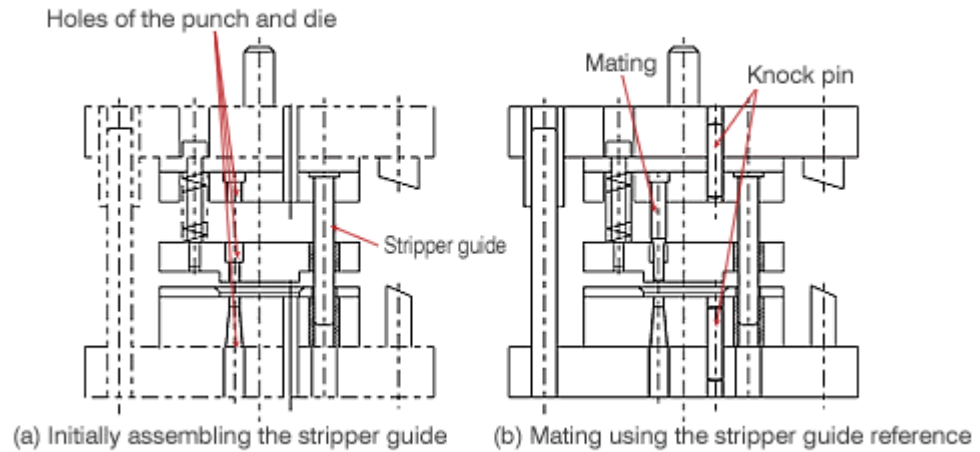
Figure 1 shows the method of assembling the stripper guide after mating the punch and die.



This can be said to be the form used initially when stripper guides were started to be used. In the times when it was not possible to carry out high precision plate machining, after mating the die and the punch cutting edges, the bush is fixed using Devcon (adhesive). This is effective for behavior of the stripper, dynamic accuracy, and ease of maintenance.

The form shown in Fig. 2 may be said to be the form of punch and die assembly in recent times.

[Fig. 2] Stripper guide assembly before punch and die assembly



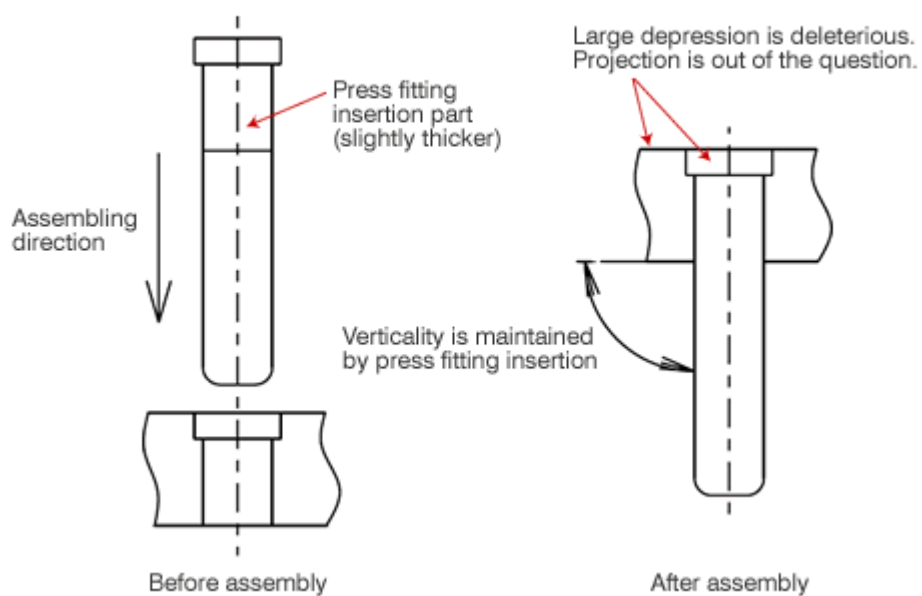
The plate is machined to a high accuracy, initially the stripper guide post and the bush are made to stand on the plate, and the punch and die are mated taking the stripper guide as the reference. At this time, it is possible to mate the punch and die even if the plate has not been assembled inside the die set. Assembling in the die set is also carried out after mating the punch and die. All the roles of the guide indicated above are included in this method. However, there will be differences in the accuracy depending on the method of assembling the guide bush and the post. Techniques will become necessary matching with the required accuracy. For example, this is the difference due to selecting the method of fixing the bush either the press fitting method or the adhesive fixing method, etc. The reason that there are a large number of types of stripper guides among the standard parts is probably the result of pursuing parts to suit the quality expected from the punches and dies.

It is dangerous to judge the function of the stripper guide from its finished form, and it is necessary to consider from the method of assembling the stripper guide post and bush.

Shapes and Features of Stripper Guides

The stripper guide posts come in various shapes. Fig. 1 shows what can be said the basic type with a head (with a flange). This can also be said to be the basic shape of a post.

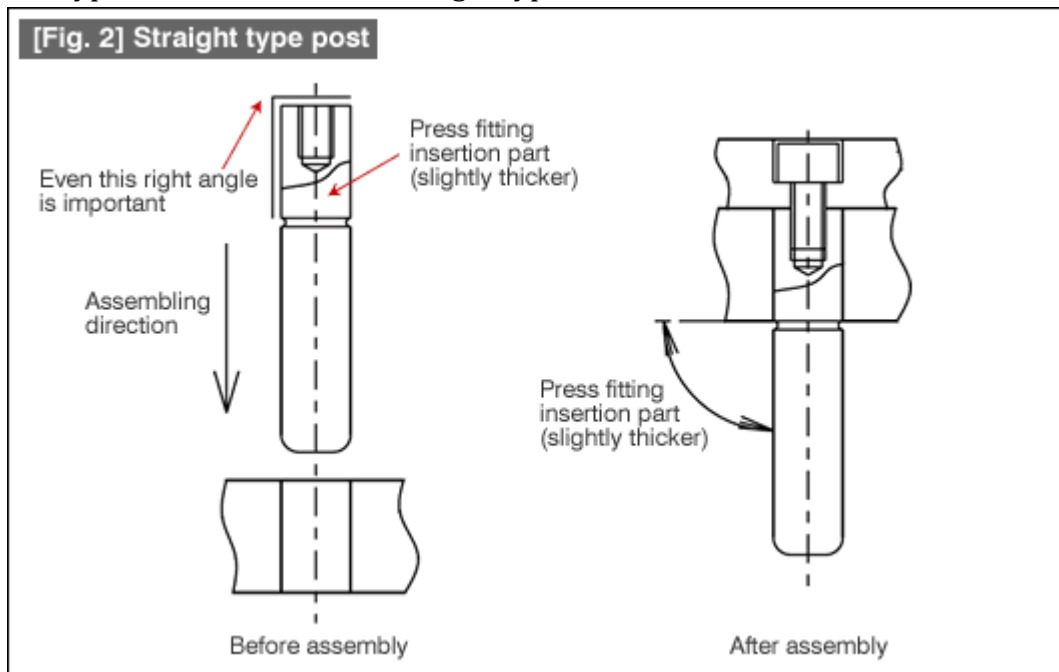
[Fig. 1] Type of post with a head



The position and verticality are maintained by press fitting insertion of the post into the plate. Detaching is prevented by the flange part. Although the flange part sinks inside the counter-

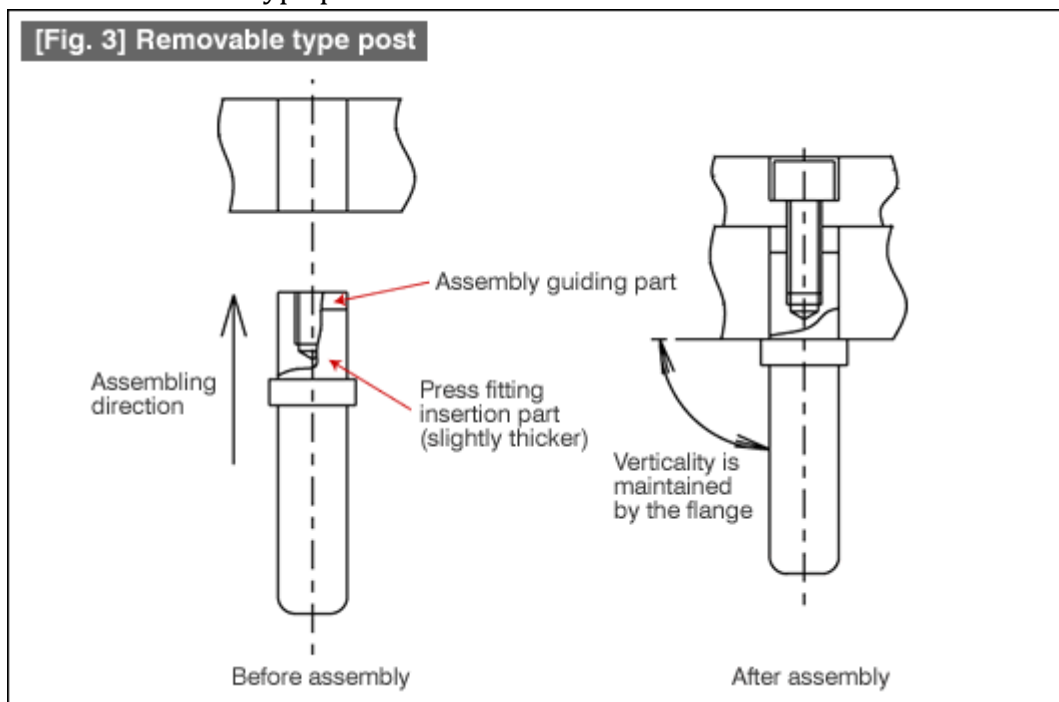
sinking hole in the plate, the ideal condition is that the end surface of the post and the surface of the plate are in the same plane. However, there will be some deviations from this ideal condition in actual practice. If the depression of the post inside the hole is too much, the post will move in the up / down direction and hence the verticality will be poor. This may also cause breakage of the flange part.

Fig. 2 is the type which is called the straight type.



Detaching is prevented by a screw. Similar to the post with a flange, even in the case of this post, the verticality and position are maintained by press fitting insertion. In the press fitting inserted condition, as shown in the figure, detaching is prevented by fixing using a bolt. At this time, if the press fitting insertion part of the post and the end surface of the post are not at a right angle, a tilting force acts on the post when the post is pulled by the bolt, and this can cause the verticality of the post to be disturbed.

Fig. 3 shows a removable type post.



The position of the post is maintained by the press fitting insertion part. The verticality is maintained by the flange part. The functions are slightly different for the above two types. Because

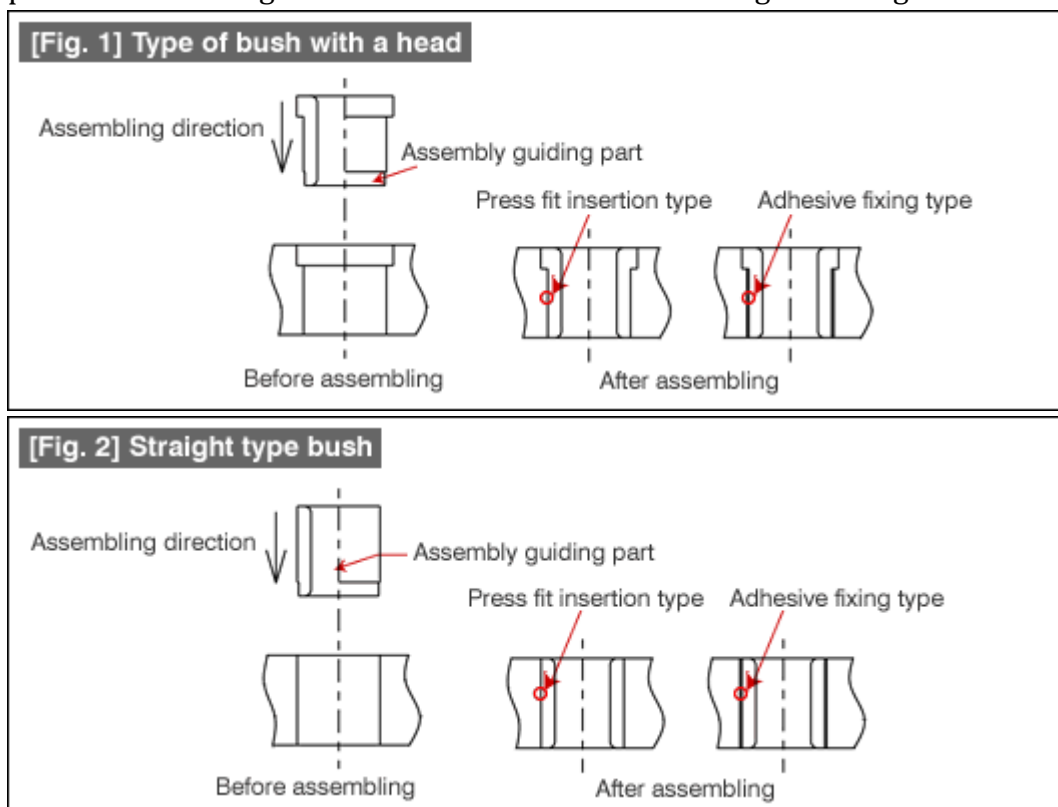
of this, it is also possible even if the press fitting insertion part is short. Detaching of the post is prevented by a bolt. The removable type post has the purpose of making the detaching and attaching of the post easy at the time of maintenance of the punch and die, thereby making the work easy, or else to make easy the grinding or replacement of the post. In order to make detaching easy, it is a common method to make the press fitting insertion light.

These posts are fixed to the punch plate, and the common form is one in which bushes are plated in the stripper plate and die plate. In recent years, there have also appeared some forms in which the post is fixed to the stripper plate and bushes are provided in the punch plate and die plate.

Shapes and Features of Stripper Guide Bushes

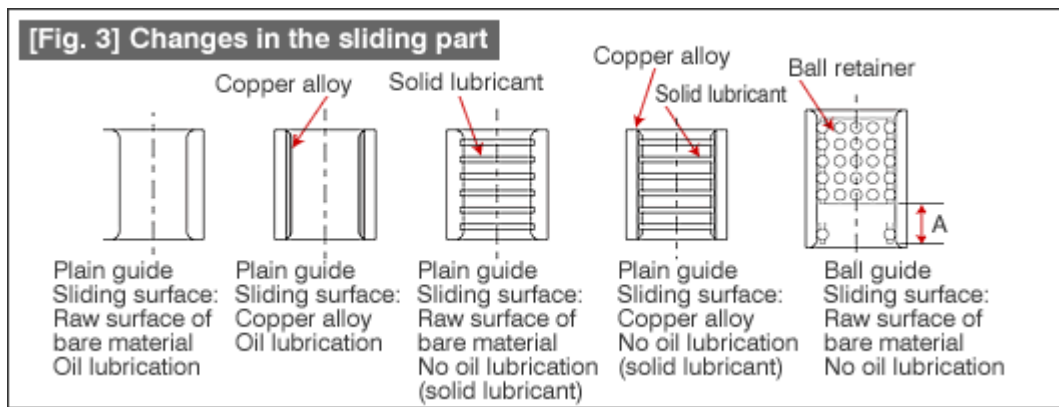
Stripper guide bushes can be divided into two types based on their external appearance. These are the type with a head (with a flange) and the straight type. Further, the changes in the sliding part are also included in the classification into types. In addition, as the method of assembly, there is the press fit insertion method and the adhesive fixing method. The adhesive fixing type can be further divided into the Loctite adhesive and the Devcon adhesive types. Devcon adhesive fixing has become considerably rare, and Loctite adhesive fixing has become the mainstream method. There are some difficulties with the press fit insertion method. When the degree of tightening in press fit insertion becomes large, distortion appears in the internal diameter of the bush after press fit insertion and can cause fusing, etc. On the other hand, the degree of tightening is made extremely small (light mating), and accuracy is increased by assembling with a force equivalent to that of pressing with the fingers. In this case, the machining of the hole becomes difficult.

The shapes and assembling methods of bushes are shown in Fig. 1 and Fig. 2.



In the press fit insertion type of the straight type, the guide diameter becomes distorted if the press fit insertion is made strongly, and the bush can easily get detached if the press fit insertion is made lightly, and hence their use is less frequent. In the adhesive fixing method, there are bushes in which a groove is formed on the outer periphery of the bush, thereby making it easier for the adhesive material to enter.

Fig. 3 shows the changes in the sliding part.



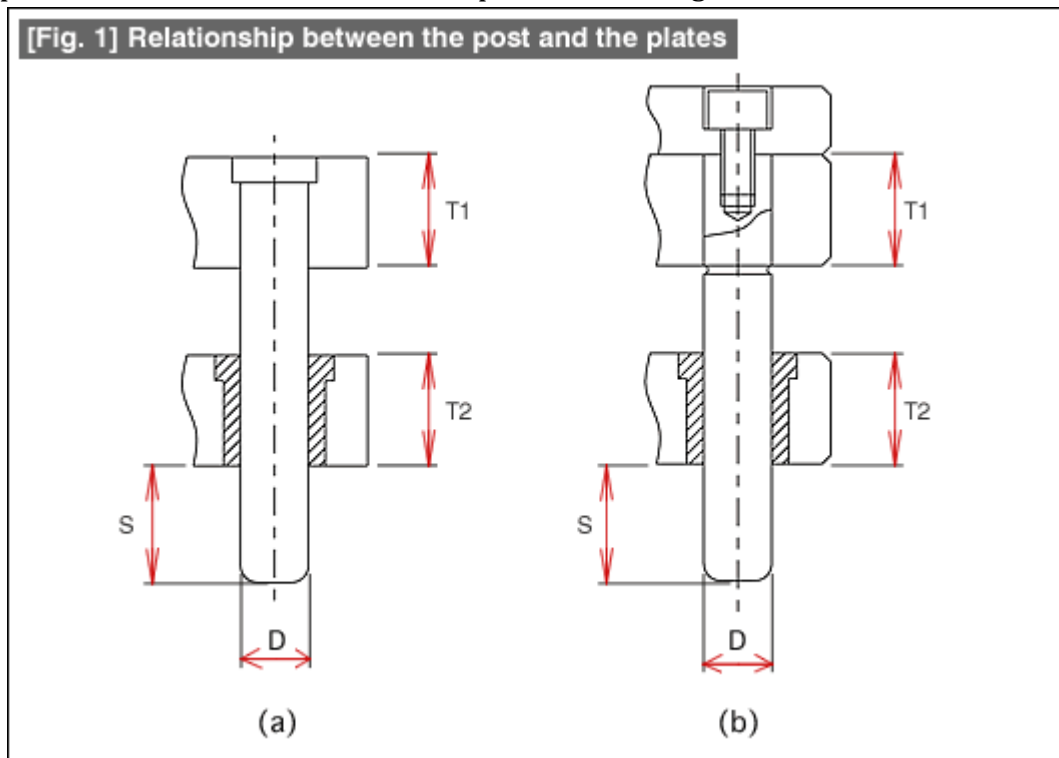
The basic type is a plain guide with the raw surface of the bare material (bearing steel is used very frequently) is used as it is as the sliding surface. As a countermeasure for fusing, there are some types in which the sliding surface has been coated with a copper alloy.

The above is used with oil lubrication. When oil is not acceptable, a solid lubricant (molybdenum sulfide) is embedded in the sliding surface and the bush is used without any oil lubrication. This type wears out rather quickly compared to the oil lubricated type. The movement of the plain guide is rather sluggish (heavy), and since fusing can occur in such types of guides, there are types in which balls are placed between the post and the bush with the balls in rotating contact with the post and the bush. Although the movement becomes smooth and light, this becomes weak against eccentric loads. The container that supports the balls is called a retainer, and the retainer moved by about a half of the stroke (the part indicated by A in Fig. 3).

As has been described above, the combination conditions of bushes are many and although a bush is a part with a simple shape, one may find it difficult to make the selection.

Method of Using a Stripper Guide Post

By the stripper guide post penetrating through the plates, the mutual relationship between the plates is restricted, and hence the relationship is maintained. It is desirable that the maintained relationship does not change even when the punch and die set is operating, and is maintained in the initial state. Because of this, it is necessary to take care about the relationship between the plates and the guide post. Their dimensional relationship is shown in Fig. 1.



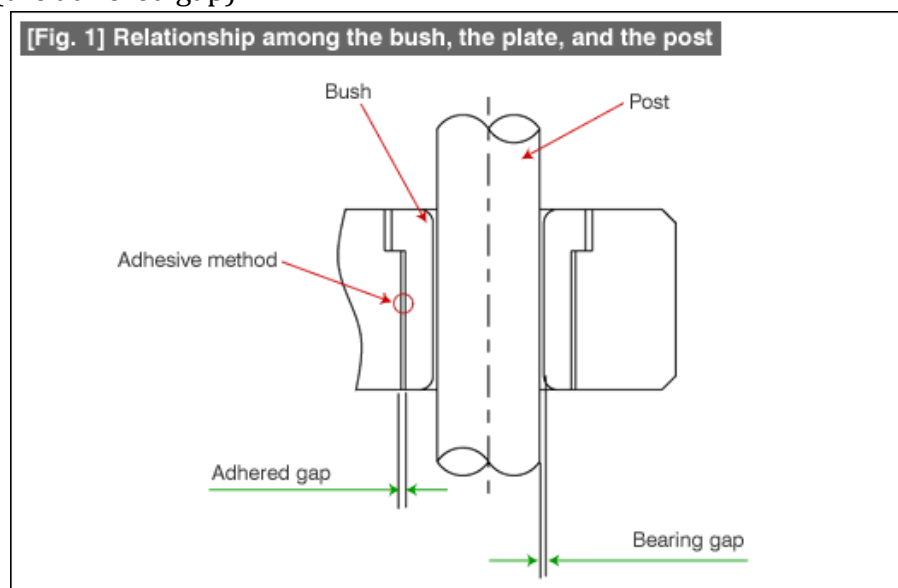
While (a) is a flange stopping type post and (b) is a screw type post, both are the same. In the

relationship between the post and the plates, the minimum value of the plate thicknesses (T1 and T2) relative to the post diameter (D) is that they are equal ($D = T$), and usually the plate is made thicker than the post diameter. Although the maximum thickness is about 3 times the diameter of the post, usually the plates are not made this thick. The figure of "3 times" is a guideline so that it is possible to drill the hole economically and accurately. The relationship between the hole diameter and the depth is not only a problem with guide posts, but is the same with the holes for knock pins (dowel pins), etc. Deep holes requiring accuracy become harder to drill and are not good. There is also not much meaning in terms of accuracy.

One other problem is that of by how much is the tip of the post to be made longer than the plate. Usually, the post enters inside the hole in the die plate, thereby creating the relationship between the top mold and the bottom mold. At this time, the question is how deep should the post enter in order to maintain accuracy. Although there are some dies in which the post has been made quite small because the post can easily bite into the hole, this can be a method of use that ruins the function of the inner guide. It is good if the length of protrusion from the plate is as long as possible, and a guideline for this length is about 1.5 to 2 times the diameter of the post. In the case of a press machine with a short stroke length, it is good to make the length long enough so that the inner guide does not come out of the die plate even at the top dead point of the press machine. The purpose of making this long is to make it strong against eccentric loads. The above discussion is given assuming that there are four posts, and the effect becomes still higher when the number of posts is increased to, say, six or eight posts.

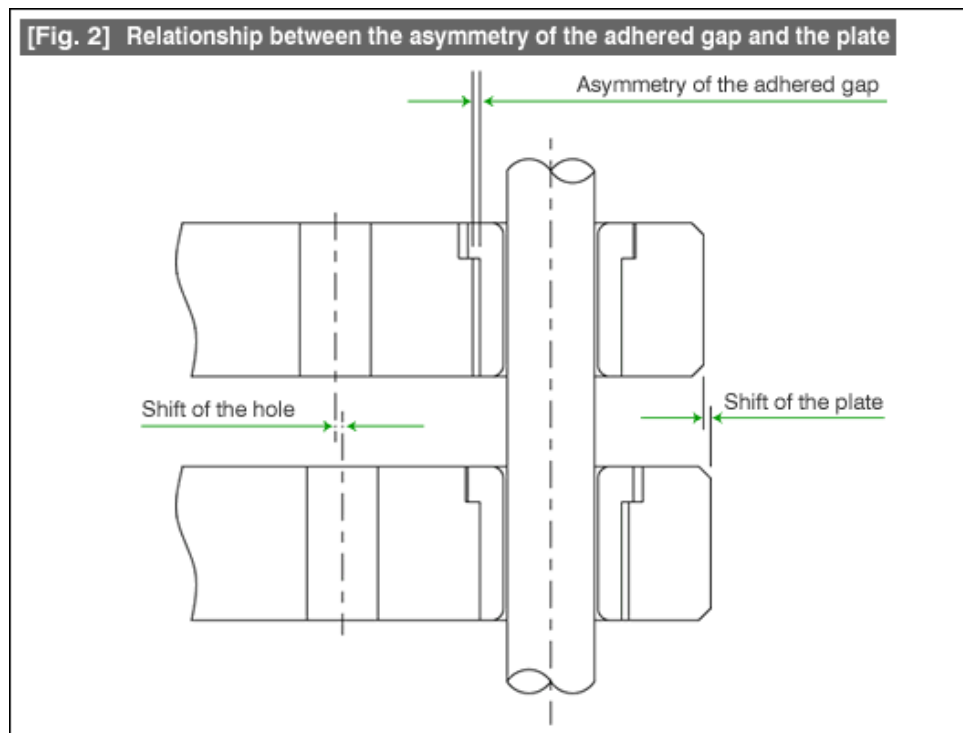
Method of Using a Stripper Guide Bush

When using stripper guide bushes, it is necessary to take care about the two gaps shown in Fig. 1. These are the gap between the post and the bush (the bearing gap) and the gap between the bush and the plate (the adhered gap).



The bearing gap changed basically based on the viscosity of the lubricating oil, or on whether it is a no oil lubrication type. When used over a long time, this gap becomes wider due to wear. Periodic replacement is necessary in order to maintain the accuracy. This gap directly affects the accuracy of the relationship between the top mold and the bottom mold. In the blanking of thin plate materials, this means that this directly affects the blanking clearance. If this gap is made unduly small, it can cause fusing problems.

The adhered gap is very frequently determined by the characteristics of the adhesive material used. In an adhered type bush, very often the assembly is made taking the post as the reference. The assembled condition is as shown in Fig. 2.

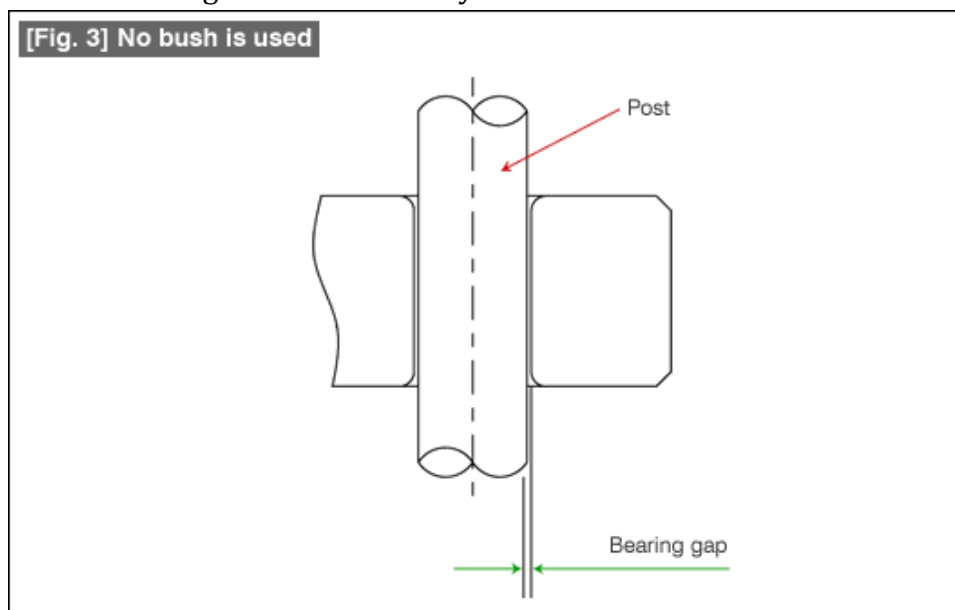


It is not certain that the adhered gap is uniform with respect to the bush. It is very common that the gap is large in some places and small in other places. Therefore, there will be shifts between two plates. Since the shift is also linked to the holes in the plates, there will even be a shift in the relationship hole of the two plates. When a penetrating part (a punch, etc.) enters this hole, it cannot maintain verticality and gets pushed to one side, thereby making the mold accuracy and life poor. Care should be taken about the relationship between the mold parts and the plate hole and the relationship with the estimated amount of shift of adhered gap with the blanking clearance, etc., and it is necessary to take measures regarding the method of assembling the bush and the mold.

Although extremely good results can be obtained when used correctly, the structure of the inner guide can get damaged when used wrongly. A major part of the problem is that of gap management. This point should be understood well, and techniques should be used in the method of use that match with the punch and die accuracy.

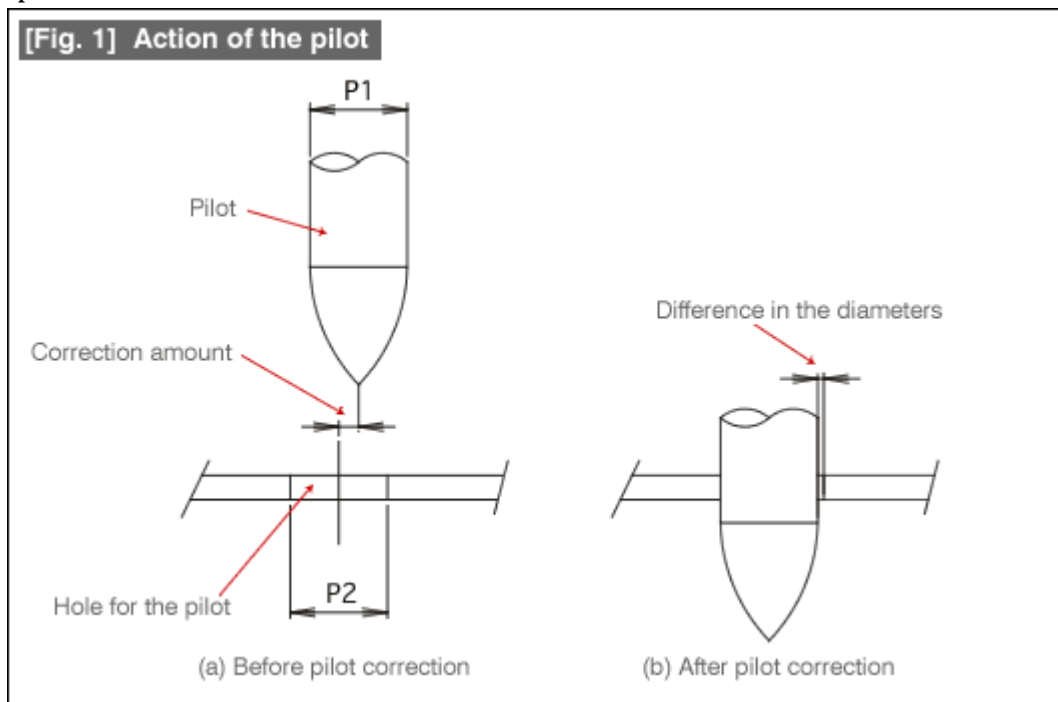
When the production volume is small but accuracy is needed, the technique shown in Fig. 3 is also used in the punches and dies.

Although this decreases the cost, it decreases the number of gaps to be managed by one, and it can be used to aim at increasing the mold accuracy.



Relationship Among Material: Material Guide – Pilot

Pilots are used for the purpose of correcting to the proper state the material position before carrying out the press operation (see also, Pilot (1) of No. 95). In general, as is shown in Fig. 1, the pilot is pushed inside the hole thereby correct the shift. At that time, the amount of shift between the center of the pilot and the center of the hole is called the correction amount. The correction amount is proportional to the material thickness and the pilot diameter. The minimum actual dimension of the pilot diameter is about 1mm diameter.



The pilot diameter and the hole should not be of the same dimensions. This is because if they are the same, the pilot will pull up the material after piloting it to the correct position. In general, (see Fig. 1(a)) the pilot diameter (P1) is made at least 0,01mm smaller than the hole diameter (P2). When the plate thickness of the material is about 1mm, the diameter is made about 0,02 to 0,04mm smaller. This difference in the diameters becomes the positioning accuracy. As shown in Fig. 1(b), the pilot will be in a condition in which it butts against the hole and will never be at the center of the hole, and the difference in the diameters appears as a shift. This becomes the limiting accuracy of the product. However, it is very rare that only one pilot is used and since many pilots are used, these pilots interfere with each other and the error will be smaller than when one pilot is considered. However, if the number of pilots is made too large, due to the effect of the mold machining errors, etc., the material pulling up becomes frequency thereby causing problems.

The details related to material positioning are shown in Fig. 2.

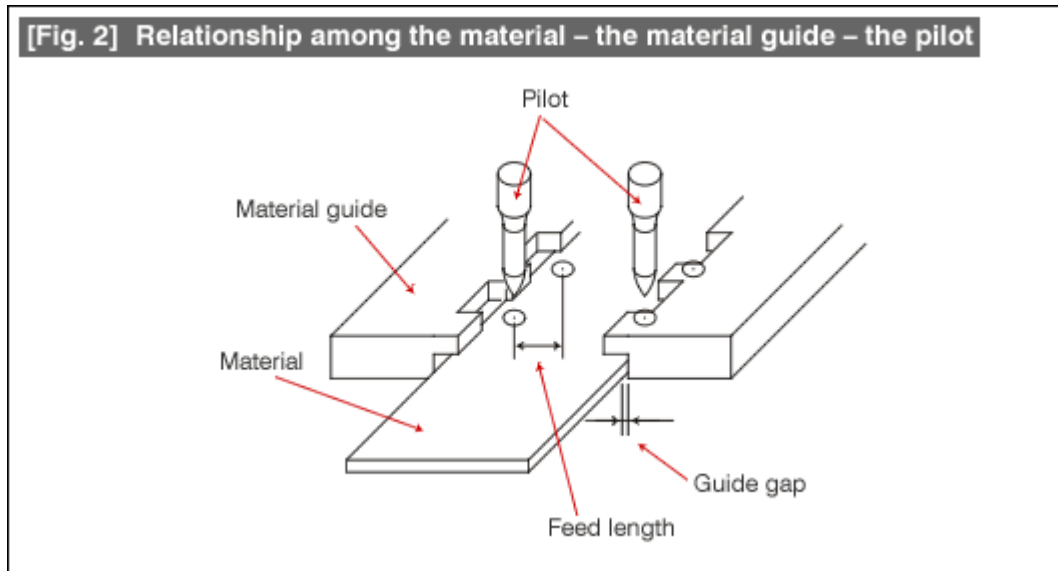
The material is initially guided by the material guide. At this time, the relationship between the material guide and the material, that is, the guide gap is determined predicting the width tolerance, the sideward bending, etc., of the material. Even in the worst condition, it is ensured that the material passes through inside the guide. The guide accuracy at this time cannot be said to be in a state in which the product accuracy can be satisfied.

The feed length is set to the prescribed length in the feeding device, and the material is fed accordingly. The fluctuations in the feed length at this time are mainly the accuracy of the feeding device, and these fluctuations need not be within the product accuracy.

The role of the pilot is to correct the material which is in such a state to a state in which the product accuracy can be satisfied.

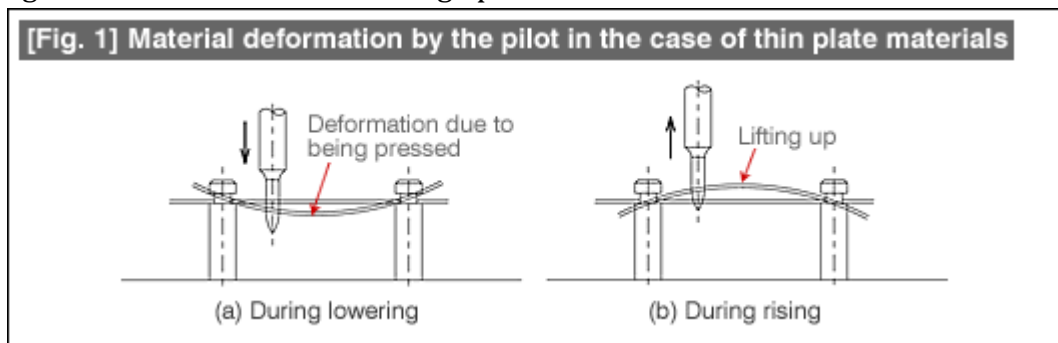
The material guide is a primary guide that supports the material within the range of the cor-

rection amount of the pilot, and thereafter the pilot takes over and can also be called a secondary guide for satisfying the product accuracy.



Countermeasures against Thin Plate Material Deformations and Material Pulling Up

In continuous press operation, the material is lifted slightly up from the die surface and moved. Lifting up the material from the die surface is called "Lift up". The pilot provided in the top mold moves down and inserts the pilot in the material that is in the lifted up state. If the material has sufficient thickness, because of the strength of the material, it is possible for the pilot to enter the material without deforming the material. However, since instability is caused if the positions of the guide lifter and the pilot hole are separated far apart, the positions of the pilot hole and the guide lifter should be as close to each other as possible, thereby making the material deformation small. If the material becomes thin, even if the guide lifter is made to come close, the material gets deformed by being pressed by the pilot as shown in Fig. 1(a). If this happens, since the pilot does not enter into the hole properly, it can lead to wrong punching. Even if it does enter properly, as shown in Fig. 1(b), the material will be lifted up by the pilot during the returning operation after punching, and again this can cause more wrong operations.

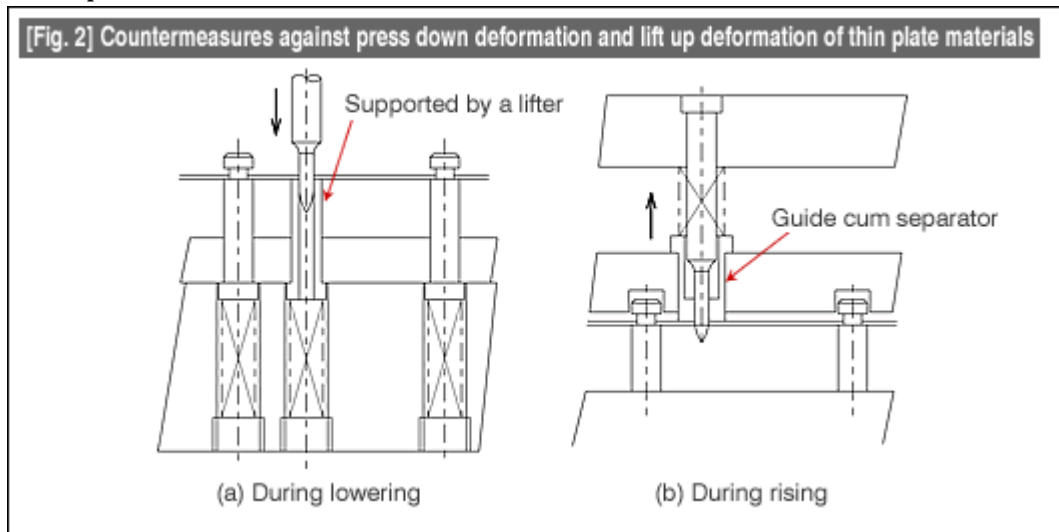


As a basic countermeasure against these problems, the surface of the pilot is polished well and the contact resistance is made low. A fundamental countermeasure is to strengthen the weak parts. A concrete example of this is shown in Fig. 2.

Fig. 2(a) is a measure of supporting from below due to being pushed down from above. A lifter is also used as a lifting up part. While a normal lifter functions for lifting up, if a hole is provided in the lifter and the tip of the pilot is made to enter in it, it becomes possible to use a lifter below a pilot, and since the material is supported without getting bent, it becomes possible to pilot the material in a stable manner. Such a lifter is called a "lifter with hole below the pilot".

Fig. 2(b) is a measure for preventing the lifting up of the material in the returning process.

The pilot guide is placed inside the stripper. This guide is supported by a spring. In a normal pilot, a straight part should be coming out from the stripper surface. While the positioning is done using this part, even the lifting up of the material is done using this part. The pilot guide incorporated into the stripper is made movable (spring supported), and the tip of the guide is lowered to the guide part of the tip of the pilot.



By doing this, it is possible to prevent lifting up of the material. If the guide is lowered to the tip of the pilot, there will be problems at the time that the pilot enters the hole. Therefore, the spring supporting the pilot guide is made extremely weak. If this form is used in combination with the lifter with a hole below the pilot, the result will be perfect.

It is also important to change the surrounding conditions of a pilot to match the conditions of use.

Urethane Spring

The method of using a urethane spring of providing it on the punch of a simple mold and using it as a substitute for a stripper as is shown in Fig. 1 is relatively frequent.

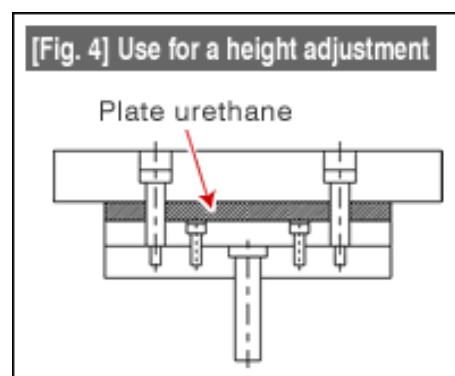
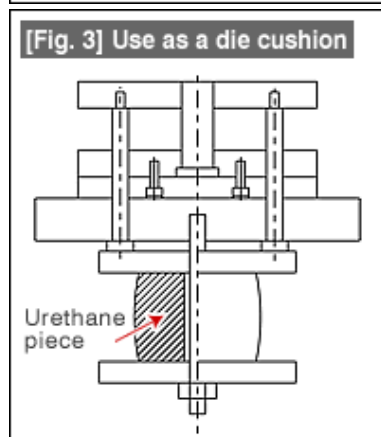
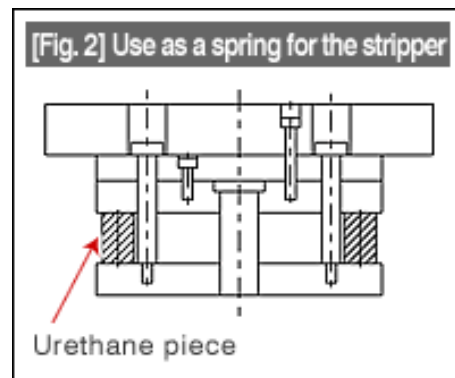
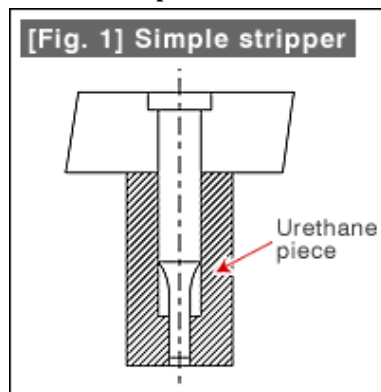


Fig. 2 is the form of using a urethane piece as a spring for the stripper.

Fig. 3 is a method of use as a die cushion in drawing or bending operations. The urethane pieces used in the above forms are mainly pieces cut from a long round shaped material.

Fig. 4 is a special method of use, and the urethane piece is used by gripping it between the plates. This method of use is adopted when wanting to absorb the variations of the bottom dead point. A plate shaped urethane piece is used in this method. A large amount of compression cannot be obtained.

Urethane pieces can be classified broadly into two types. One type is that in the state of ordinary rubber (ordinary urethane), and the other is what is called the porous type. Porous type has the shape of a sponge.

When ordinary urethane is compressed and deformed, heat is generated due to internal friction. If this heat is accumulated inside, the pressure characteristics change, and the pressure generated decreases from the initially set pressure. This is a point that has to be paid attention to in using urethane. The amount of heat generated is proportional to the amount of compression (deflection) and the speed of compression. In the case of ordinary urethane, the limit to the deflection is about 20% of the free length of the urethane spring. At this time, the limit to the speed (spm) of the press machine is about 100spm. As the speed (spm) is increased, the amount of deflection of the urethane spring should be made smaller. For example, the limit to the amount of deflection will be about 14% at a press machine speed of 200spm.

When the porous type is compressed, the internal air bubbles get deformed and the spring gets deflected. Since the deformation of the material inside the urethane spring is small, the heat generation is small compared to ordinary urethane, and hence since even the heat accumulation is small, it is possible to increase the amount of deflection. It is possible to increase the amount of deflection to about 35% at 100spm. However, the generated pressure is small compared to ordinary urethane. This type is used when a large deflection is required.

Even when a urethane spring is being used within the specifications, it gets deteriorated and break by developing cracks. It is necessary to replace early.

FUNDAMENTALS OF STEEL MATERIALS FOR DIES

Properties of Steel Materials (Wear Resistance)

Steel materials for dies and punches are required to have various properties. To start with, let us understand them.

Wear resistance

According to JIS, wear is described as "the phenomenon of metal surfaces that are moving relative to each other getting worn out due to the surfaces scratching each other or due to metallic adhesion". Wear resistance can be said to be the property in which such a phenomenon is difficult to occur.

Factor affecting wear resistance

1) Effect of hardness

A big factor affecting wear resistance is "hardness". In general, the wear resistance increases as the material becomes harder. The wear resistance shows a big change bordering a Rockwell hardness value of around 40HRC. The amount of wear is larger below 40HRC, and the wear is small above that hardness value. However, it is not correct to assume that making the material hard by tempering it, because it is better that the internal residual stress in the steel material is low in addition to higher hardness of the material. This is the reason why tempering and annealing are done together.

2) Effects of the constituents

One of the main constituents of steel materials is carbon (C). Tempering becomes easy as the amount of carbon increases. If the amount of carbon exceeds 0,6%, the tempered hardness becomes almost constant. Although when the hardness becomes constant, the wear resistance does not become stable at that point, but the wear resistance increases further as the carbon content increases. In addition, the wear resistance increase as the elements such as W, Cr, V, Mo, etc., are added to the steel material.

The amounts of addition of these constituents increase in the sequence of – carbon tool steel (SK), special tool steel (SKS), and die steel (SKD). Compare the constituents by checking the JIS standards, for example, and then you will know the difference.

3) Effect of the structure of the material

When a steel material is tempered, iron (Fe) and carbon (C) bond together and the material changes into a martensite. This martensite is effective for wear resistance. However, in high carbon steel or high alloy tool steel (SKD, etc.), not all the material is converted into martensite by tempering and annealing, and about 20 to 30% of the material remains as austenite. This residual austenite is not good for wear resistance.

As a method of converting the residual austenite into martensite, there is the sub-zero processing. In sub-zero processing, by cooling the steel material up to -60 to -80°C, the residual austenite is converted into martensite.

Properties of Steel Materials (Shock Resistance)

Machining forces act on the punches and dies (tools) used in press molds. These machining forces are very close to shocks. Let us now consider the punch and die materials and shock.

Toughness

Tools are expected to maintain their shapes for a very long time so that a large production can be made. This is that "the tool does not wear out and maintains the initial shape for a long time". Hardness has an important role in the wear of the tool.

When the properties of the material are considered, "hard" gives one the image that it resists wear, and "brittle" gives one the image that the material does not get deformed when a force acts on it but it just crumbles.

Also, "soft" gives us the impression that the material can get worn out easily and that it can extend easily (ductility). This is not a desirable property in a tool.

There is one more property of being difficult to get deformed or broken when subjected to a force. While this property is somewhat difficult to understand, this is described as "being tough". This is called "toughness". According to the glossary in JIS, toughness is described as "the degree of being tenacious and difficult to be broken by shock".

The key to the shock resistance of tool steel is the toughness possessed by the material.

Hardening and annealing

It is not true to say that a material becomes tough when it is made soft, and if thermal refining (hardening and tempering) is done, the material goes into a state of being hard and strong against shock compared to an untreated material. Thermal refining is the operation of carrying out tempering at a relatively high temperature (more than 400°C) after hardening. Care should be taken about the difference in the temperature compared to that of ordinary annealing (around 200°C). There is something that needs to be paid attention to in tempering. It is temper brittleness. This is the reduction in the strength against shock due to tempering. Temper brittleness appears at some temperatures. It is the "low temperature temper brittleness" that appears around 300°C, the "primary temper brittleness" that appears around 500°C, and the "secondary temper brittleness" that

appears at still higher temperatures.

Properties of Steel Materials (Fatigue Resistance)

Repetitive load acts on the parts such as punches, etc., in press forming operations. Repeated load becomes the cause of fatigue failure. Fatigue failure can be linked to fatigue strength.

The causes related to fatigue strength are the following:

1. Hardness after thermal refining (after obtaining a hardness of about 45HRC)
2. Eliminating sharp corners (rounding or chamfering)
3. Making the surface smooth.

Relationship with tensile strength

The fatigue strength is almost directly proportional to the tensile strength of the material. There is a difference between hardened material and raw material. The fatigue strength is about 50% of the tensile strength in the case of the raw (unhardened) material, and is about 45% in the case of the hardened material. This fact is not dependent on the material itself.

Relationship with hardness

Even regarding the hardness of the material, the fatigue strength is higher for a harder material. The fatigue strength becomes the highest for a material that has been thermally refined to a hardness of 45HRC.

Surface condition

Even if the tensile strength and the hardness are suitable, the fatigue strength decreases if the surface condition of the parts such as punches, etc., is bad. It is better to finish the surface to as good a state as possible.

Shape

In the case of a shape with depressions and projections, the corners of depressions should not be made square but should be rounded. The effect is larger as the radius of curvature R is made larger.

Residual compressive stress

Fatigue failure is generated from the surface of a part. Therefore, it is possible to increase the fatigue strength by making the surface (surface layer) hard and, in addition, if a residual compressive stress is present. It is very effective to carry out shot peening treatment of the surface in which the material surface is hit with steel ball or glass beads at a high speed.

Steel Materials Used in Dies (Unhardened Materials)

Among the materials constituting dies, these are the materials that are mainly the materials that form the structure.

Rolled steels for ordinary structures (SS materials)

This is a material used most commonly as the base material for molds, punches, and dies. The very frequently used type is SS400. This is usually referred to as the SS material.

The number in the material name SS400 indicates the tensile strength. SS400 has a tensile strength of 400 to 510N/mm².

Since this is a soft material with tenacity, and there is also the opinion that it is difficult to process because during hole drilling the cutting chips (cut pieces) connect to each other in the form of a long spiral.

Carbon steel for machine structures (SC materials)

These materials are also used in a manner similar to SS materials. The SC materials come in varieties from S10C to S58C. The number here expresses the amount of carbon (C) contained in the steel material. The amount of carbon ranges from 0,08% to 0,61%. When the amount of carbon ex-

ceeds 0,61%, the material then becomes carbon tool steel (SK materials).

The interesting fact about this material is that its mechanical properties have not been indicated. Only some reference values are given. The reason for this is that the tensile strength stipulated in JIS is the test result for a material of 25mm diameter. This is a consideration for the fact that the conditions change in the case of large structures.

Various materials were being used earlier in the standards. For example, they were S35C, S45C, S50C, S55C, etc. At present, due to standardization of plates, it has been standardized to use either S50C or S55C. The reason why the steels with larger numbers have remained is that the materials with more carbon content are stronger.

From the point of view of ease of machining, these materials are considered to be easy to use since the cutting chips do not become long as in the case of SS materials and the handling of scrap becomes easier. This is due to the difference in the carbon content. In the case of SS materials, there is no specification of the amount of carbon content (extremely small).

Steel Materials Used in Dies (Tool Steels)

These are materials constituting molds and are the materials used in the main parts mainly of punches, dies, strippers, and packing plates, etc.

(1) Carbon steels for tools (SK materials)

The amount of carbon content of SK materials is 0,6 to 1.5%. The SK materials are available in various types, from Type 1 to Type 7. SK1 has a carbon content ratio of 1.3 to 1.5% while SK7 has a carbon content ratio of 0,6 to 0,7%. The carbon content ratio of the material decreases from SK1 to SK7. By the way, when the carbon content ratio becomes less than or equal to 0,6%, the material becomes a material for machine structures (SC material).

In press dies, SK3 and SK5 are used very often.

The method of their use in press dies is for punches and dies for small production volumes.

Since the hardness of SK materials is weak towards heat, even after sufficient hardening, it is not possible to expect long life when used for items that generate machining heat such as in press blanking operations. Because of this, rather than using these materials for punches and dies, it is very common to use these materials as supplementary part such as packing plates, etc.

(2) Alloy tool steels (SKS, SKD)

Alloy tool steels are SK materials whose characteristics have been modified by adding special elements such as tungsten (W), chromium (Cr), molybdenum (Mo), and vanadium (V), etc.

SKS Materials

SKS3 is used in press molds. These are materials obtained by adding Cr and W to SK materials. The amount of deformation due to hardening is about 1/2 of that of SK materials. Although at present deformation due to heat treatment is no longer of any concern since their machining is done by wire cutting electric discharge machining after hardening, this was of great concern earlier.

These materials are used in the punches and dies for medium to small production volumes. Apart from that, these materials are also used in strippers or punch plates that require hardening.

SKD Materials

These materials are called die steels. These are materials obtained by adding Cr, Mo, and V to SK materials. The material SKD11 is used very frequently in press molds. These materials can also be said to be the mainstream materials for punches and dies. These materials are used in the molds for medium to large production volumes. The deformation due to heat treatment is still smaller than the SKS materials.

The deformation is small during wire cutting electric discharge machining, and ease of machining is also a reason why these materials have become the mainstream materials for molds.

Since the deformation during wire cutting electric discharge machining is still smaller when high temperature tempering is done (at about 500 to 550 °C) rather than the normal tempering (about 180 to 200 °C), high temperature tempering has come to be used more often. However, since the hardness decreases (to about 58HRC), there was also the drawback that the tool life becomes poor. Manufacturers of steel materials are developing materials in which a hardness of 60HRC can be maintained even after high temperature tempering. However, since the heat treatment conditions of these materials have changed finely, unless care is taken, the expected heat treatment characteristics may not be obtained.

Steel Materials Used in Dies (High Speed Tool Steels)

High speed tool steels are frequently abbreviated in Japanese as "Hice". The symbol for these materials is SKH.

High speed tool steels can be based on Tungsten (W) or on Molybdenum (Mo). These are specified in JIS G 4403.

About 18% of tungsten is added in tungsten-based high speed tool steels, and they do not contain any molybdenum. These steels come in the types of SKH2, SKH3, SKH4, and SKH10. Since steels of this series have high wear resistance, they are used very frequently in cutting tools, etc.

About 5% of molybdenum and about 6% of tungsten are added in molybdenum – based high speed tool steels. These steels come in the nine types of SKH51 to SKH59.

Since steels of this series have a high toughness, they are ideally suitable for press dies that are subject to shock. SKH51 (old symbol SKH9) is the type used most frequently.

The tempered hardness of high speed steels is more than 63 HRC. The tempered hardness of the die steel SKD11 is about 62 HRC. High speed steel is used very frequently for small diameter punches, etc., in which case the wear resistance and toughness of die steels are somewhat insufficient.

Powdered high speed tool steel

Similar to the method of manufacturing ordinary tool steel, high speed tool steel is manufactured by solidifying molten material.

A uniform and fine structure of powdered high speed tool steel is prepared by first finely powdering the molten material, and solidifying that powder. By doing this, the wear resistance, toughness, and fatigue resistance all are increased. A sintered hardness of about 64 to 70 HRC is obtained.

These steels are used when using high speed die steels are not satisfactory. JIS has standardized powdered high speed tool steel in SKH40 (molybdenum based). A large number of manufacturers use originally developed steels.

Steel Materials Used in Dies (Pre-hardened Steel, Cast Iron, and Others)

Below we introduce materials including non-steel materials.

Pre-hardened steel

These are mold materials developed for plastic molding and used for dies of presses. These have not been stipulated in JIS standards, and the materials used are those developed under the brand names of the manufacturers. These materials have reasonable hardness and can be machined. The material properties are adjusted to obtain a hardness of about 40 HRC, and precipitation hardened types (see note [*]) are used.

Pre-hardened steel is used frequently for punches and dies for blanking or bending in the case of low volume production. In the case of large volume production, pre-hardened steel is used for punch plates, backing plates, etc. This material is commonly used because it can be machined

and is convenient because it can be used as is without heat treatment.

* Precipitation hardening:

This is hardening caused by the precipitation of certain constituents when a supersaturated solid solution is heated to an appropriate temperature.

Flame hardened steel

Flame hardened steel is used for dies for the blanking, drawing, or bending of automobile components. This is a material in which surface hardening can be done easily by flame hardening.

Normally, while it is necessary to harden (total hardening) the die to the necessary hardness after it has been machined, this step can be simplified in the case of flame hardened steel, and although the strength is lower than the steels that require total hardening, it is used widely in the case of some specific applications since the time required for preparing dies can be shortened.

Aluminum bronze

Aluminum bronze is a copper-based alloy. It can withstand high press pressures, has superior wear resistance, and high galling resistance. This material is also called HZ alloy (Hitachi Shipbuilding), AMPCO metal (USA). This is used frequently in the dies for drawing or for forming hard to form materials such as SUS or titanium, etc.

Cast iron

Cast iron is used very frequently for die sets, or the dies forming medium to large sized products, or the dies for drawing, etc.

4-1. Gray cast iron (JIS G 5501)

This is also called ordinary cast iron, has excellent casting properties, and is used frequently for die sets, holders, and punches and dies of medium sized products.

The JIS symbol is FC, and its types have been stipulated from FC100 to FC350 with the number increasing in steps of 50. Among these, FC200, FC250, and FC300 are being used for dies.

4-2. Spherical graphite cast iron (JIS G 5502)

This is also called ductile cast iron, and is used when the strength of gray cast iron is considered insufficient. In gray cast iron, carbon precipitates inside the form of flakes inside a matrix of ferrite or pearlite. In contrast, magnesium has been added to the melt so as to make the precipitated carbon have the shape of spherical nodules. By making the precipitated carbon have a spherical shape, this material has achieved a high strength close to that of steel, and also has excellent ductility, rigidity, and wear resistance.

The JIS symbol is FCD, and its types have been stipulated from FCD350 to FCD800. Among these, FCD450, FCD500, and FCD600 are being used for dies.

Cemented Carbides Used in Dies

Cemented carbides used in press dies are alloys of tungsten carbide (WC) and cobalt (Co). The main constituent of the material is tungsten carbide, and cobalt has the role of a binder (adhesive material). The amount of cobalt is in the range of 5 to 25%.

The hardness of cemented carbide decreases as the amount of cobalt increases.

This material has been stipulated into the types of V10, V20, V30, V40, V50, and V60 in the standard 019 of the Japan Cemented Carbide Tool Manufacturer's Association.

V10 has about 5% cobalt, V30 has about 12%, and V60 about 25%.

The hardness is 89 HRA or more in the case of V10, 87 HRA or more in the case of V30, and 78 HRA or more in the case of V60. By the way, 85 HRA is converted to 67 HRC.

Apart from the amount of cobalt, the hardness is also related to the size of WC particles. The hardness increases as the particle size becomes smaller. The particle size of ordinary cemented carbide is about 2.5 to 1.5 μm . Ultra fine particles have diameters in the range of 0,7 to 0,5 μm .

When the material has ultra fine particles, it is possible to enhance the properties of both wear resistance and brittleness.

Cemented carbide is a hard material but is also brittle. The material property is selected considering the balance between hardness and brittleness according to the intended application. V30 and V40 are about the standard for press dies.

In the case of blanking dies and punches, V30 is used for punches and V40 is used for dies. For bending and drawing, a slightly harder V30 and V20 are used giving priority to wear resistance. A softer V50 and V60 are used in compression forming in order to prevent breakage.

Even if the selection of the material is appropriate, if the surface roughness is bad, it may not be possible to satisfy the expected life even in the case of cemented carbide. Reducing the surface roughness by lapping is a very frequently used countermeasure in the case of cutting blades. However, when machining copper, nickel, and pure iron, the wear of cemented carbide may be fast. The reason for this is that the affinity between the cobalt present in cemented carbide and copper or nickel causes the wearing of the cemented carbide to progress faster.

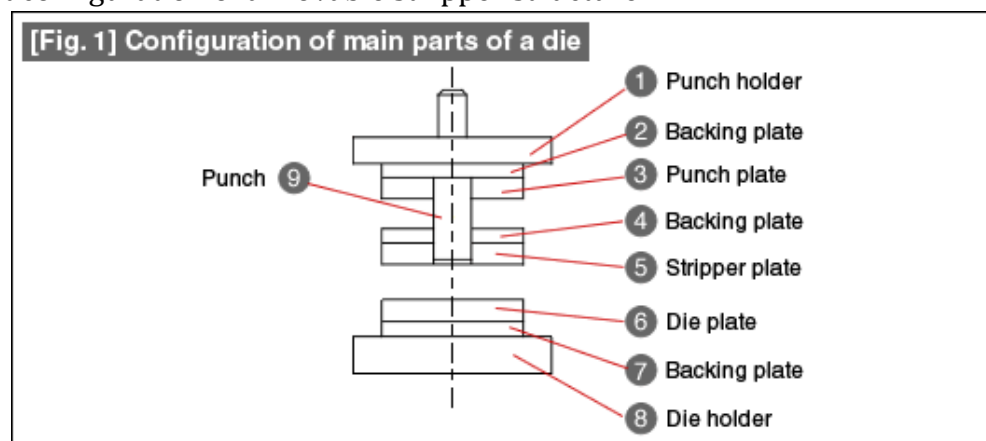
Although cemented carbide appears to be hard and versatile, caution should be exercised because it may not meet the expectations depending on how it is used.

Although the standards of the Japan Cemented Carbide Tool Manufacturer's Association were used for the above explanations, the code used can be different for different manufacturers. Use the standards of JCCMA to compare and select the appropriate material.

Materials for the Main Parts of Dies

The die materials used for the main parts of medium-sized and large-sized dies are described here.

Although there are several types of die structures, explanations are given here are based on the widely used movable stripper structure. The plate configuration of the die shown in Fig. 1 shows the largest configuration of a movable stripper structure.



Holder SS400, S50C (S55C), FC250, SKS3, and A7075

The punch and die holder are not only for fixing the die to the press machine but also for supporting the rigidity of the die. They also have the role of adjusting the die height and providing the space for springs, etc.

Usually, the materials used are SS400 or S50C. There is no big difference between the two. Among cast iron types, FC250 is used. This is the material used when cast iron die sets are used. When high rigidity is required for purposes such as high volume production, etc., SKS3 is used after heat treatment (to a hardness of about 56 HRC). When low weight is required, the aluminum alloy A7075 may be used.

Backing plate SK3, SK5, SKS3, and S50C

Backing plates are used at three locations in a die. They are used for the purpose of backing

up so as to prevent components such as small diameter punches, etc., from getting too deep inside the holder due to the force of press operation. Apart from that, backing plates are used for preventing the parts from getting detached (stripper backing plate) and for adjusting the height of the die.

For backing up, an SK material is used after heat treatment (to a hardness of about 56 HRC). The SKS material is used when high rigidity is required. Materials such as S50C, which is used without heat treatment, is used for backing up or preventing the detachment of parts such as a large-sized punch with a large pressure receiving area, or for adjusting the height.

Punch plate SS400, S50C (S55C), SKS3, SKD11, pre-hardened steel

A punch plate is used for the purpose of holding a small punch. Usually, SS400, S50C, etc. are used without heat treatment. In the case of dies for high volume production, pre-hardened steel having a certain amount of hardness, or heat treated SKS3 or SKD11 may also be used. The SK material is rarely used. When the machining tolerance of SKS3 is of concern, the material SKD11 may also be used which is a decision based on the wire cutting characteristics.

Stripper plate S50C, pre-hardened steel, SKS3, SKD11

While the main function of a stripper is to remove scrap, very frequently it is made to have important secondary functions of pressing the material or guiding the tip of the punch (punch guide).

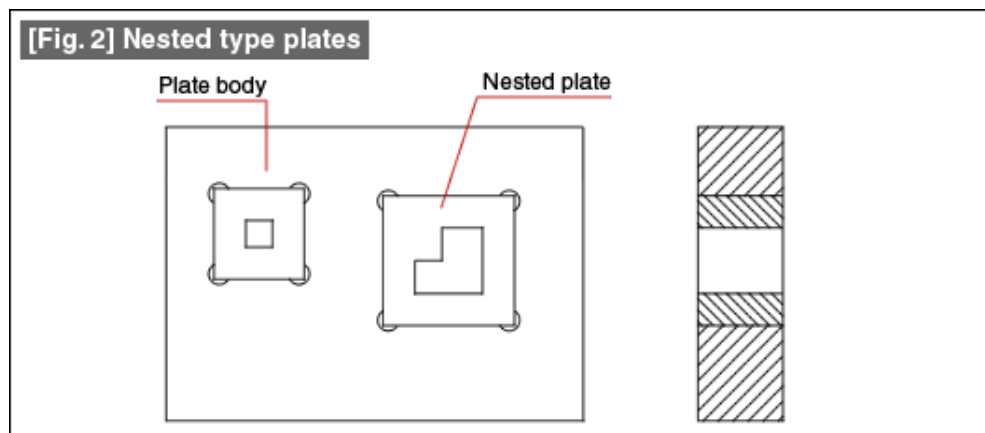
When removing scrap in small volume production is important, materials such as S50C or pre-hardened steel are used which do not require heat treatment. When materials without heat treatment are used, although they are made to have the functions of pressing the material and guiding the punch, the plate may get deformed when there is wrong punching. When a punch guide or a material pressing member is added, a material such as SKS3 or SKD11 is used after heat treatment.

Die plate SK materials, SKS3, SKD11

SK materials or SKS3 is used in dies for small volume production. The standard material used is SKD11. This trend has become established because preparation of dies using electric discharge wire cutting machines has become widespread.

Nested plates (see Fig. 2)

The descriptions given above assume single type plates. In dies, nested type (insert type) plates are used very often. Such plates are used for stripper plates or die plates. In the case of small volume production, materials such as S50C without heat treatment are sometimes used for the main plate. For medium or higher volume production, materials such as SKS3 or SKD11 are used after heat treatment.



The materials SKD11, SKH51, pre-hardened steel, and cemented carbide, etc. are used as the materials for nested plates. The selection of the material is based on ease of maintenance, accuracy, and operating life.

Punch

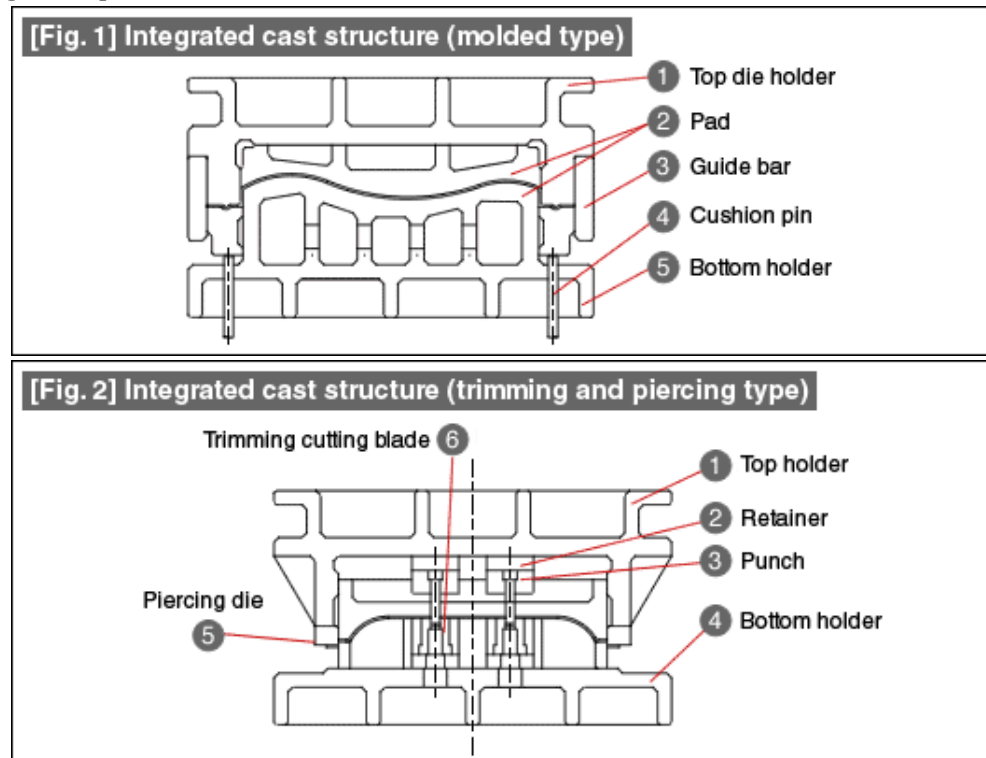
The materials used for punches are SKS3, SKD11, SKH51, powdered high speed tool steel,

cemented carbide, etc.

The standard material used is SKD11. SKS3 is sometimes used in the case of small volume production. SKH51 is used when the size is small, or when toughness is required. Powdered high speed tool steel or cemented carbide are used when wear resistance is required or for large volume production.

Dies with an integrated cast structure

Fig. 1 and Fig. 2 show dies with an integrated cast structure. Since the cast structure allows the preparation of a large shape as a single piece, it can be prepared more easily compared to the preparation using steel plates.



When the material to be formed is a thin plate and the production volume is low, and even in the case of blanking, bending, or drawing, the material frequently used for casting is the gray cast iron FC250 or FC300. This is used for all the die parts such as punches, dies, and pads, etc.

When the thickness of the material to be formed becomes higher, or when the production volume increases, or when the strength is of concern, a spherical graphite nodule cast iron such as FCD600 is used.

In the case of cast iron dies for blanking, SC450 or another material is welded to the cutting edge part. In the case of large volume production of the drawing type or shape forming type, SC450, etc. is used after flame hardening. When there is concern about using cast iron (gray cast iron, spherical graphite nodule cast iron) for the trimming type, etc., a material such as SC450 is used as it is.

FUNDAMENTALS OF PRESS DIE STRUCTURE DESIGN

Method of Using Screws

A die is constructed from many components which are held together with screws. Although screws are very common, the method of using them can be quite confusing. Here, we explain how to select the screw size based on the plate thickness and the dimensions from the end surfaces.

For information on the tightening force and torque of a bolt, refer to the descriptions given in the "Technical Data" which is an appendix to the Misumi catalog "Standard Components for Press Dies" and use that information for reference.

Here, we define screw as a hexagonal bolt with a hole.

Fig. 1 shows the relationship between the plate thickness and the screw. In general, there is a correlation between the plate thickness and the area, and it is assumed that a plate with an extraordinary large surface area relative to the thickness is not used.

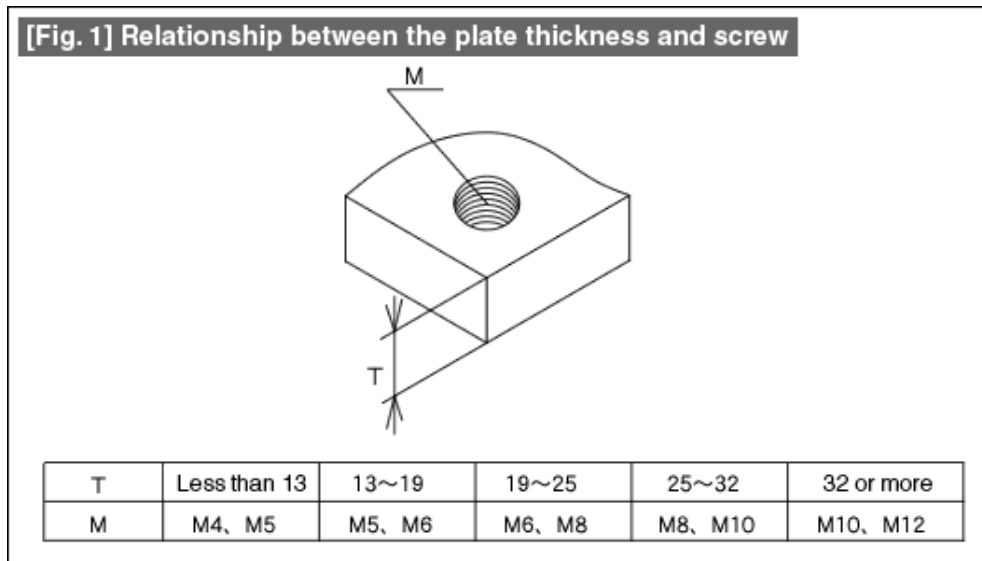
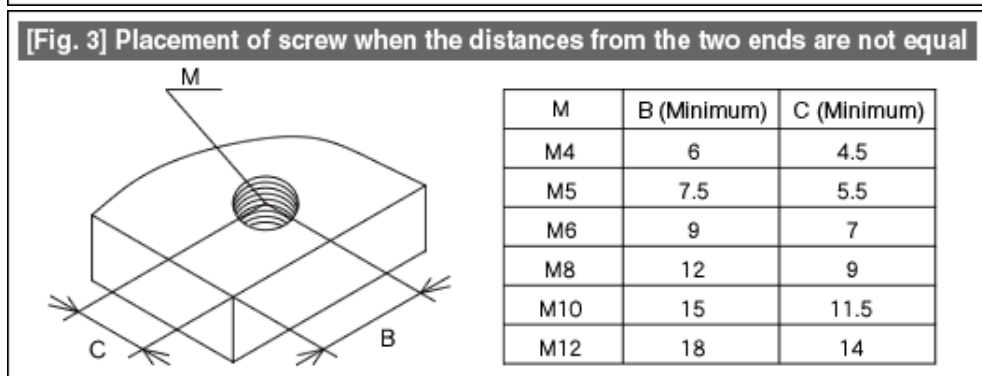
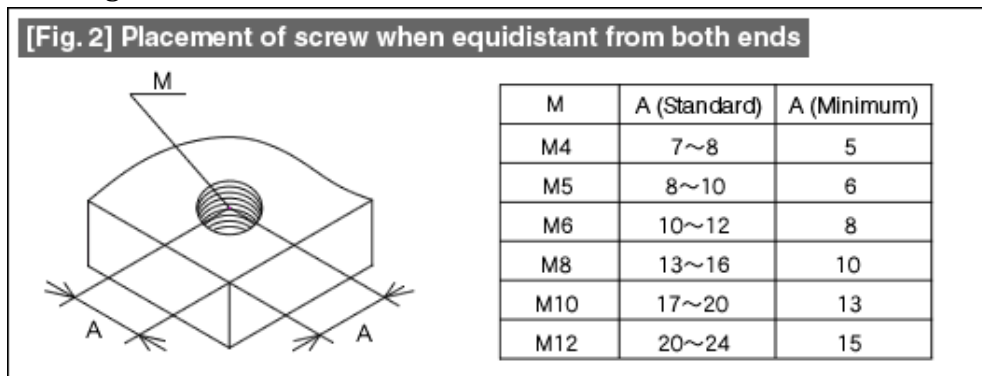


Fig. 2 and Fig. 3 show the dimensions from the end surface of the plate or block taking the screw size as the reference. Assume that the material is steel that is not hardened. For materials such as cast iron which is brittle or hardened steel which can break easily, it is better to use values larger than those of being shown.



When block size needs to be minimized, place a screw, used as a stopper and with sufficient strength, at distance equal to the screw diameter from the end surface.

This would be the minimum dimension of screw placement.

In ordinary dies, M3 screws are avoided because of problems in strength.

It is important to carefully consider screw placement when designing dies.

There is the problem of whether to make the screw size large and make the number of screws small, or to make the screw size small and make the number of screws large. See No. 285 regarding this problem.

After the screw size has been decided, we have to think what should be the spacing between screws.

Fig. 1 shows the relationship between the screw size and the screw spacing. Consider that the spacing is 10 times the screw size. Since there is no clear standard regarding the screw spacing, it is convenient in the case of parts like screws to take this as an easy to understand method. (Strictly speaking, the screw spacing will have to be determined taking into account the amount of plate deformation and the fastening force, etc., but since realistically this is difficult, the spacing is usually decided by intuition based on experience.)

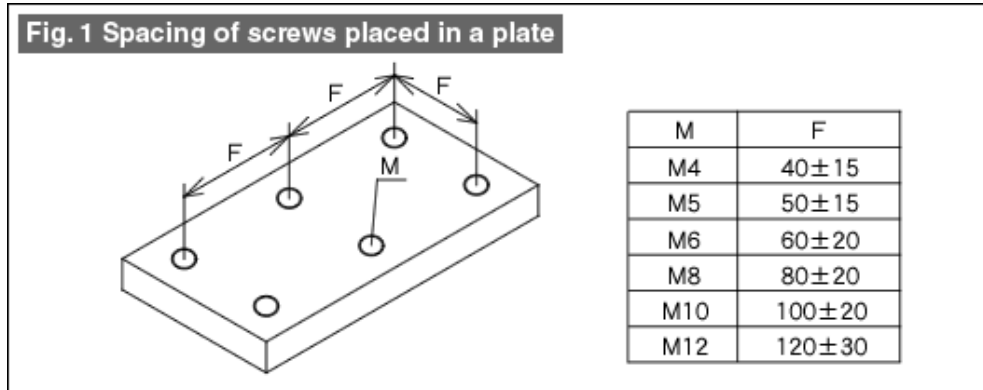
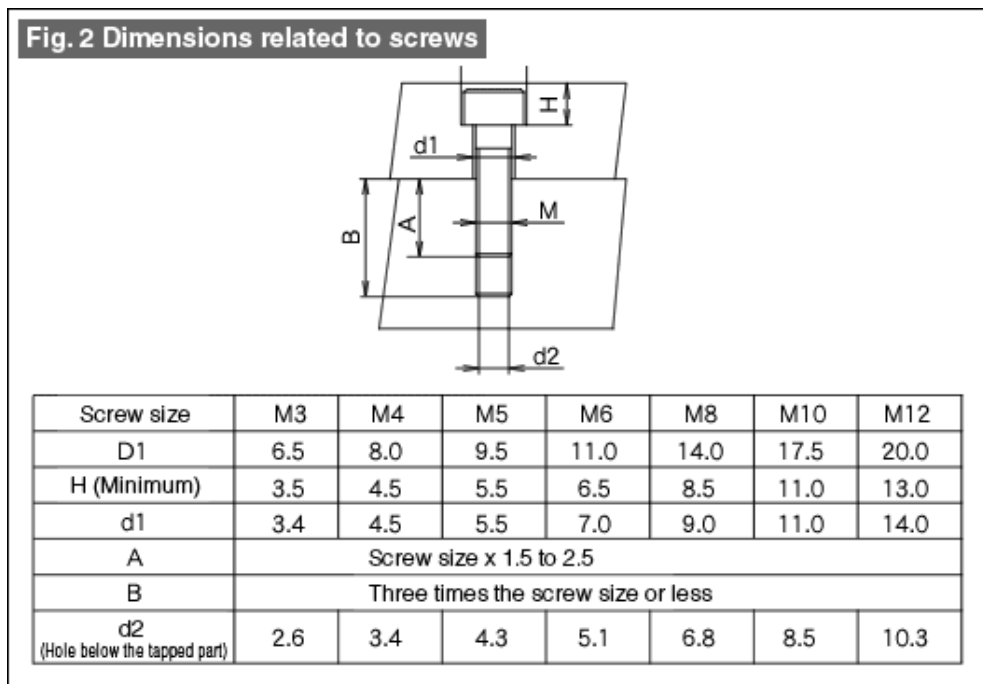


Fig. 2 shows the dimensions related to screws. Although these have been stipulated in JIS also, it is good to decide on your own company's standards. Consider that the following is one such example.



When tapping the holes in the plate, there are the problems of determining the dimensions of the hole below the tapped part and the depth of tapping. When a tapped part that is too deep is specified, the effect is not much but the machining becomes difficult. Determine the hole below the tap and the tap depth that is easy to machine the tap, and make the machining work economical.

Method of Using Dowel Pins

Dowel pins are used very frequently for the positioning of die components. A common method of using dowel pins is to determine the position by lightly pressure fitting a dowel pin in two components. Similar to screws, the diameter of the dowel pin is determined according to the size of the die component.

Fig. 1 shows the relationship between the plate thickness and the diameter of the dowel pin.

In general, there is a correlation between the plate thickness and the area, and it is assumed that a plate with a large end surface relative to the thickness is not used.

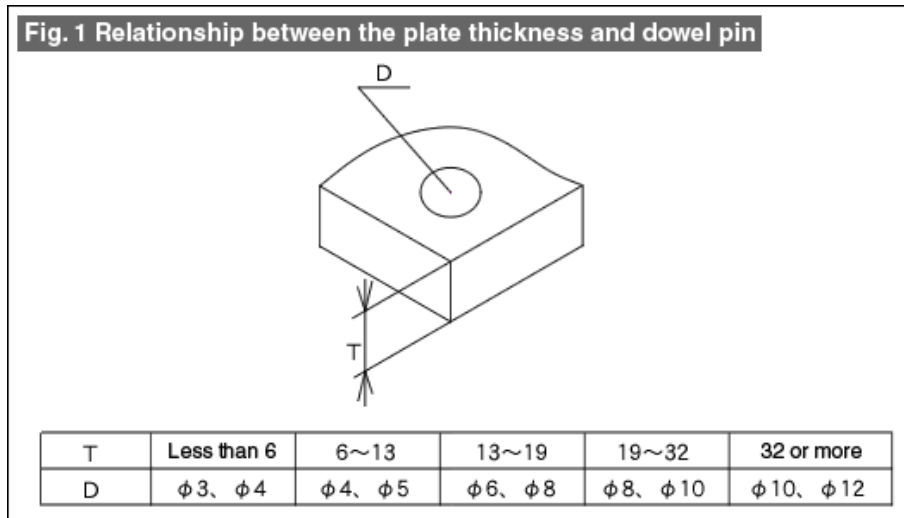
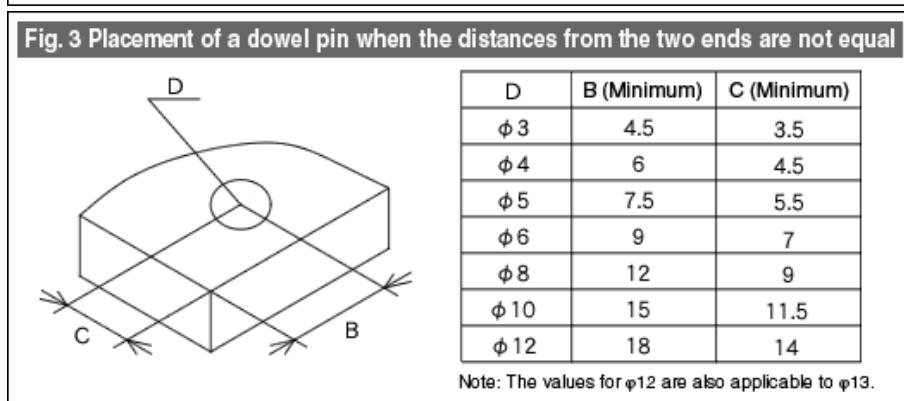
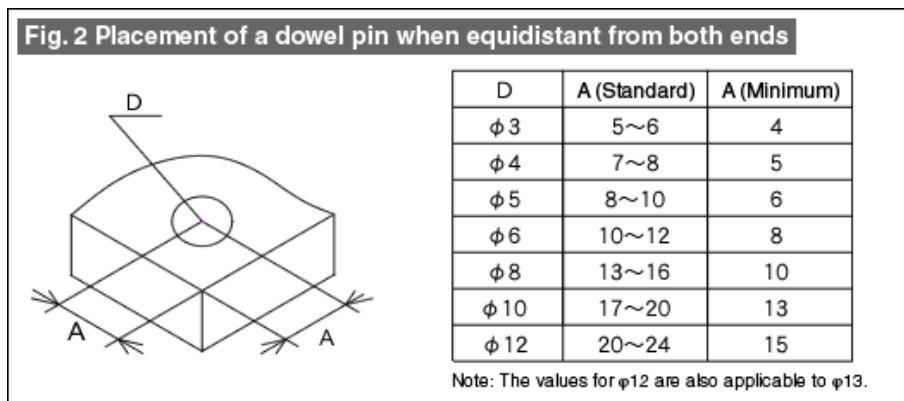


Fig. 2 and Fig. 3 show the dimensions from the end surface of the plate or block taking the dowel pin size as the reference. Although a dowel pin diameter of 12 mm has been shown in the table, there are dowel pins with a diameter of 13 mm also. These dowel pin diameters of 12 mm and 13 mm are created from the standard value of 12.5 mm. Which one of the two diameters to use is up to the liking of the user. Although recently the use of 13 mm is increasing, it is possible to use either of these two diameters.



The position of installing a component is determined by using two dowel pins. It is better that the two dowel pins are as far apart as possible. Let us explain referring to Fig. 1. One should be aware that there is always a machining error in the positions of the holes machined in the plates. Therefore, when one point is taken as the reference, assuming that the machining error is the same and comparing the case when the position of the other hole is near with the case when it is far, the effect of the error is large when the other hole is near. From this, the accuracy is better when the spacing between the dowel pins is large.

In addition, if the positions of the two dowel pins are symmetrical, it will be possible to fix

the part even if it has been reversed leading to the wrong installation of the component. In order to avoid such situations, always make it a point to ensure that the positions of the two holes are asymmetrical. Making it impossible to assemble in the reversed position is called fool-proofing.

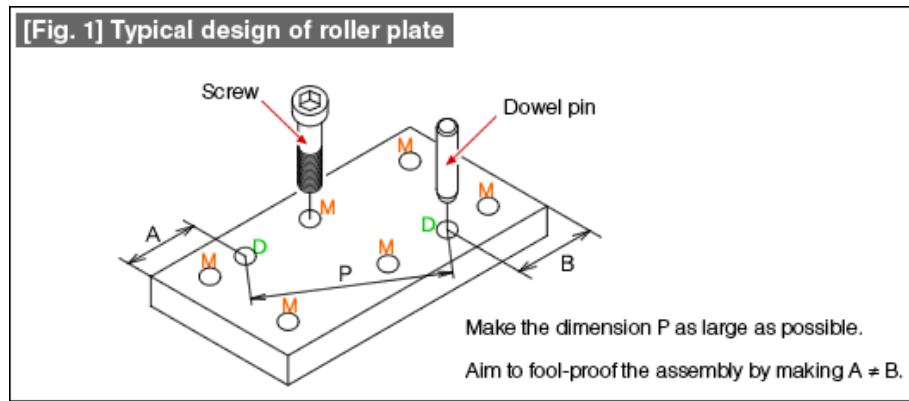
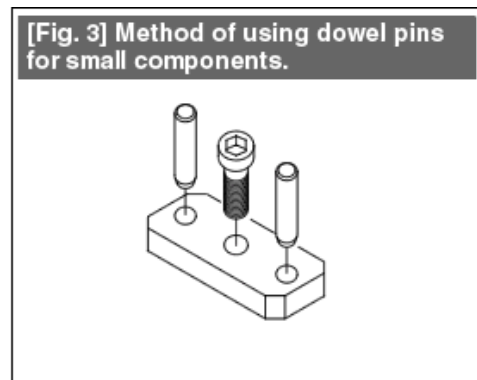
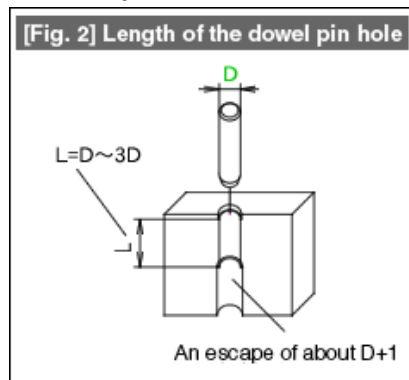
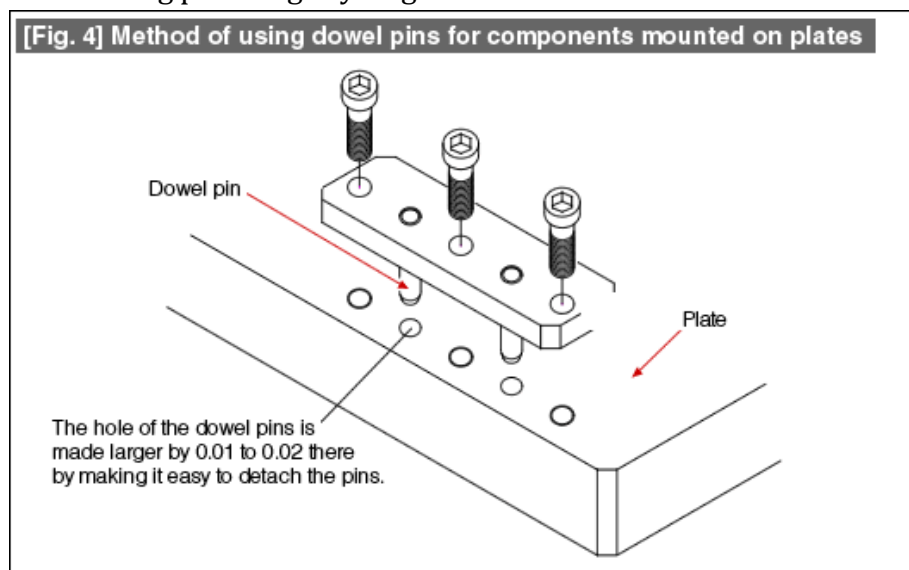


Fig. 2 shows the relationship between the dowel pin and the depth of the hole. When machining a dowel hole in a thick plate, etc., the limit is three times the diameter. A hole deeper than this is not desirable in terms of both accuracy and economy.

Fig. 3 shows the positioning of small components. The position is determined by two dowel pins, and the fixing is done by one screw.



In the case of components that are mounted on a plate such as a guide plate, the maintenance of dies becomes easy if they are made easy to disassemble as shown in Fig. 4. Since the function is not affected much even if components such as guide plates, etc., are shifted slightly, instead of removing the dowel pins by hitting, the design is made so that they can be detached easily by making the hole in the installing plate slightly larger.



Method of Selecting the Reference for Machining Plates

A reference is necessary for machining any item. Making the reference vague makes machin-

ing difficult, and the desired product may not be obtained. In the case of plates for constructing press dies, there are several methods of selecting the reference.

Although each of these methods has its own features, unless there is a unified reference, there will be a lot of confusion in the machine shop, and sometimes this can cause problems in assembling the dies. The types of machining references are shown in Fig. 1. Their features are described below.

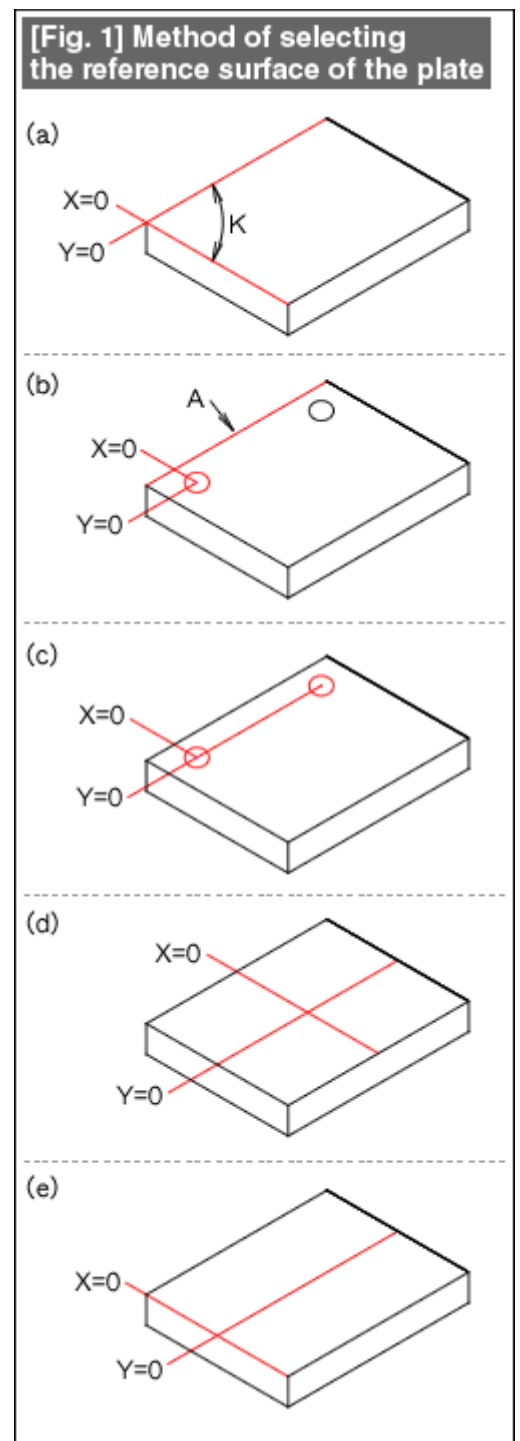
Fig. 1(a): Double surface reference. This is the method in which a line parallel to the plate and a perpendicular line are obtained, and the machining is carried out taking the point of intersection between these two lines as the origin. When this origin is used, it is necessary to carry out surface grinding of the plate at two reference planes and to obtain a right angle between them, and the accuracy of these affects the machining accuracy of the plate.

At present, the machining of holes in the plate is done by determining the center by reading the graduations in the machine, and then machining the hole, but previously, marking was done taking two surfaces as the reference thereby obtaining the center of the hole, making a center mark using a center punch, and then machining the hole. The accuracy of the right angle between the two surfaces was reflected as it is in the hole position.

Fig. 1(b): Single surface-hole reference. A parallel line is obtained using one surface of the plate, and the machining is done taking the center of a hole as the reference. This method eliminates the tediousness of obtaining the right angle in the case of double surface reference. This is the method of selecting the reference which assumes that the machining is done after determining the positions of all the holes to be machined in the plate by the table movement of the machining center. Grinding is necessary on the surfaces used for obtaining parallelism. Sometimes, grinding is done on only two end surfaces.

Fig. 1(c): Two hole reference. The lines parallel to the plate are obtained using two holes, and the machining is done taking the center of one hole as the origin. It does not matter what the shape of the peripheral surface of the plate is. For example, it can also be a cut surface as it is.

Fig. 1(d): Double centerline reference. There are two methods of using this reference. In the method of obtaining the coordinates position by marking, obtaining right angles between the four surfaces of the plate is necessary. A short line is marked at a position thought to be the center of the plate. Next, the same thing is done on the reverse surface by turning the plate upside down (this is called "flipping" in workshop jargon). As a result, if the two short marking lines match, that point becomes the center, and if they do not match, the operation is repeated aiming at the center of the shift between the two lines. Finally, the center is obtained. The reference positions of the X- and Y-axes are obtained by repeating this after rotating by 90°, and machining the hole is



done by obtaining the position of the hole taking the point of intersection between the two as the origin. In this method, the errors in the width and length of the plate are distributed between the ends of the plate.

In the other method, a right angle is obtained between two surfaces, and the X- and Y-axes are determined by shifting the coordinates to a position considered to be the center (1/2 of the nominal dimensions), and machining is done taking the point of intersection between the X- and Y-axes as the origin.

This method of selecting the reference is used frequently in single-step type fabrication.

Fig. 1(e): One surface and centerline reference. The method of obtaining the center of the Y-axis is the same as that in the two centerline reference method. The end surface is taken as the reference for the X-axis. In the successive feeding type, the material is machined by placing it at the center of the plate. This method of selecting the reference is being used because it is easy to get used to, since the method of placing the material and the shift of machining matches with the shift of dimensions in the direction of the X-axis.

Method of Expressing the Plates of the Top Die and Bottom Die

When expressing dies, the bottom die is expressed in the state in which it is viewed from above. This is the plan view in the drawing methods. The top die is very frequently expressed in the state in which it has been removed from the bottom die, turned upside down, and is viewed from above. This becomes the plan view in drawing methods. There are several methods of expressing the top die.

Fig. 1 is the method of expression when the top die is turned upside down in the front to back direction. This figure has been expressed using the double surface reference method. Although the dimensions do not change along the X-axis, the dimensions along the Y-axis are reversed from front to back. In the case of dies for successive feeding, this state can be said to be easy to understand because it matches with the movement of the material.

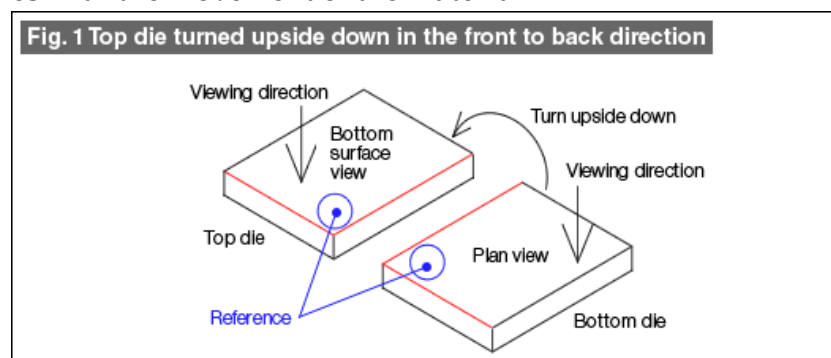
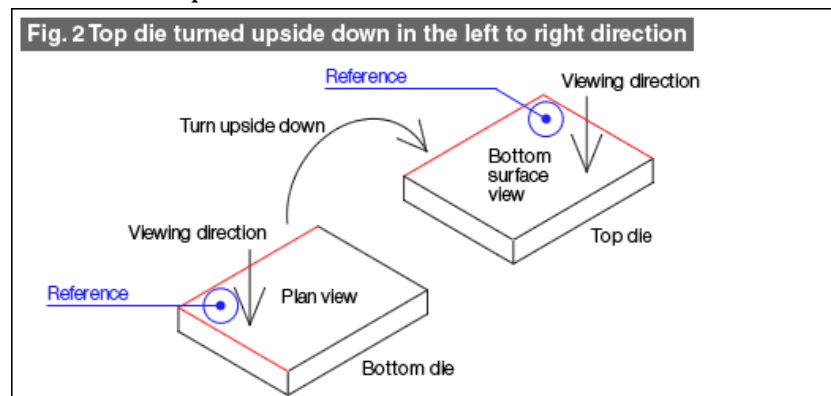
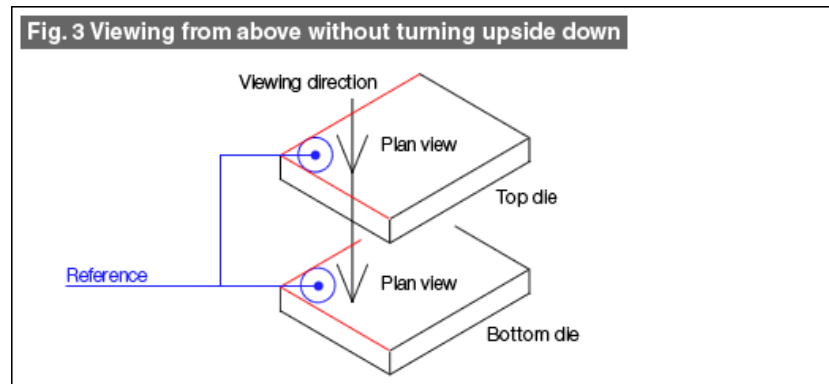


Fig. 2 is the method of expression when the top die is turned upside down in the left to right direction. Although the dimensions do not change along the Y-axis, the dimensions along the X-axis are symmetrical in the left – right manner. In the case of dies for successive feeding, it can be said that the relationship between the top die and the bottom die is difficult to understand.



Since the dies are shown in the opened state in the methods of expressing in Fig. 1 and Fig. 2, they are in the same state as an actual die, and can be said to be a view that makes it easy to understand the inside of the dies. However, at the time of machining the plates, there is a difference between the plan view state and the bottom surface view, and care will have to be taken while machining the plates. A method of expressing considering this aspect is the one shown in Fig. 3. This is a method that makes machining of the plates easy. The method of expressing the top die makes it difficult to understand the structure of the dies.

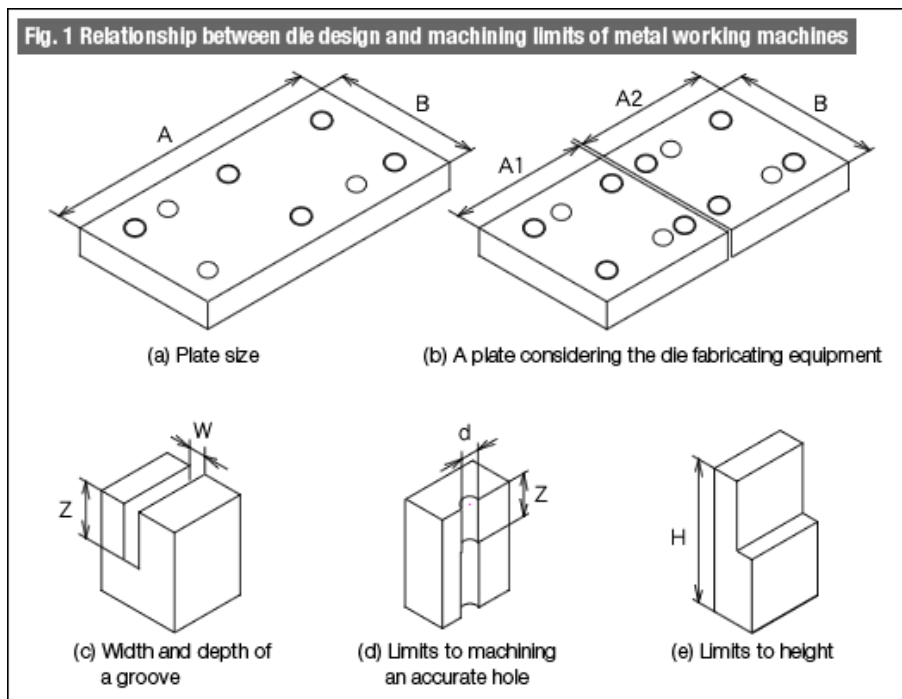


The method of expressing the top die changes because of the differences in the method of expressing the top die. When only the plate drawing has been sent to the machining site, if the machining is done without being aware of this difference, the prepared plates will not be usable. Unify the method of expressing the top die so that there are no mistakes in machining the plates.

Equipment for Preparing Dies and Die Design

The size of the dies becomes apparent when the process design of product machining is completed. In general, dies are planned to be fabricated from a single plate as shown in Fig. 1(a). Although there are no problems if the dimensions A and B shown in Fig. 1(a) are within the machining limits of the machining equipment, if the design is made without paying attention, there will be problems that the dimensions exceed the limits of the machining equipment. In the machining of plates, it is possible to think of the involvement of various types of machines such as milling machines for rough machining, surface grinders for surface machining, milling machines or machining centers for machining holes, and wire discharge cutting machines, etc. Each of these machines has its own maximum working dimensions, or maximum load weight limits. Designing so that the size or weight of the plates constituting the dies are within the limiting ranges of the metal working machines makes it possible to fabricate dies that are easy to fabricate and maintain. If the maximum dimensions of the plate are determined, it is possible to carry out a design considering the position of division in the process design stage, and it becomes possible to fabricate dies that are well balanced as shown in fig. 1(b).

It is also necessary to pay attention to detailed and minute aspects. For example, in the case of a block component, when a groove such as the one shown in Fig. 1(c) is required, if machining using an end mill or a grinder is assumed, it is necessary to decide paying attention to the tools or the grinding wheel, etc. Similarly, there are also situations such as those shown in Fig. 1(d) and Fig. 1(e). In the case of the hole machining in Fig. 1 (d), if an accurate hole is required, the limit for the dimension Z is considered to be three times the dimension d in terms of economy. Awareness of such machining limits requires the knowledge of the economically required accuracy. It is important to machine the components safely.

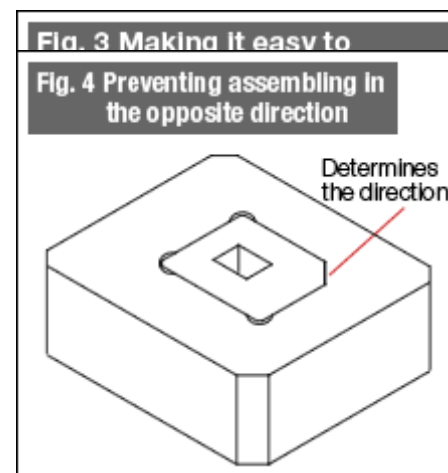
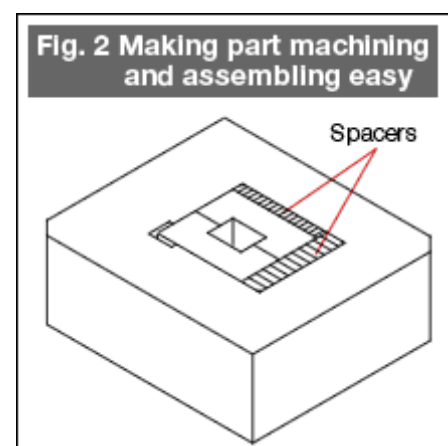
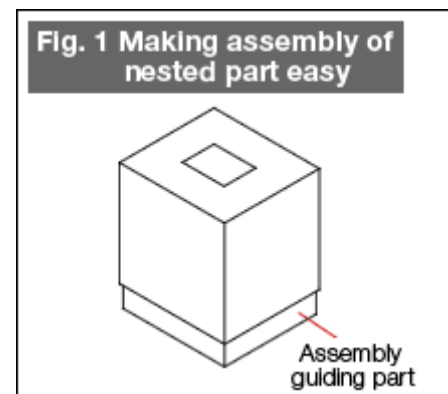


Considerations Regarding Die Assembly and Disassembly

In the preparation of dies, the assembly and disassembly should be easy, and also there should be no fluctuations in the accuracy of the die even if the assembly and disassembly are carried out repeatedly. For example, although an inserted component such as that shown in Fig. 1 is very often pressed into a hole in the plate, if there is no assembly guiding part (which is an all round step of about 0,01 mm), the inserted part becomes slant with respect to the hole and pressing it inside cannot be done properly, and the inside surface of the hole may get damaged.

Fig. 2 shows a countermeasure for component machining errors. It is very difficult to finish the machining of the hole and the inserted component accurately to their dimensions in the condition after inserting by pressing. A method that can be thought of is that of matching the actual items by first finishing the hole in the plate and then machining the inserted part while matching it with the hole, but this method cannot be said to be an efficient one. Fig. 2 is a design in which the dimensions from the reference surface are taken of both the hole and the inserted part, the remaining parts are finished with somewhat easier accuracy, and the realization of the pressed and inserted state and error adjustment are carried out using spacers. The efficiency of part machining will be increased. As a consequence of that, to some extent, the load on the die assembling department will increase.

Fig. 3 shows a technique of removing an inserted part that has been pressed inside. Threads are cut by tapping the hole for the bolt for fixing the inserted part, and at the time of removing the inserted part, a bolt is screwed inside this hole and the bolt is pulled to pull out the inserted part. More concretely, if the fixing bolt of the inserted part is of size M4, its hole diameter will be



about 4.3 mm. In that hole, a thread of M5 is tapped inside that hole.

Fig. 4 is a method of fool-proofing so that there is no mistaking the assembling direction of parts. When an assembly requires care to be taken about the direction, some day there will be a mistake in assembling. It is necessary to design so that the assembly can be made only in one direction whoever does the assembling. In a rectangular part, removing the chamfering at any one corner determines the direction of assembling.

The above are some of the aspects to be cautions about. There are many other similar aspects. Take care to attempt to design the parts paying attention to all such aspects.

Considerations Regarding Die Machining and Maintenance

Fig. 1 shows the structure of the part of the die that carries out upward bending inside a progressive die. The parts (a) and (b) of this figure show the conditions before and after forming the metal. The upward bending die projects above the die plate surface (the dimension "s"). Instead of preparing in an integral manner, by inserting a spacer with a thickness of (s) as shown in the figure, it is possible to make the thicknesses of the upward bending die and the knock out equal to the thickness (T) of the die plate, and it is possible to make it easy to form the part. By doing this in the case of an integrated type die plate, it is possible to maintain the dimension (s) constant by removing the upward bending die during maintenance, taking out the spacer, inverting and replacing the upward bending die, and re-grinding, thereby making maintenance easy.

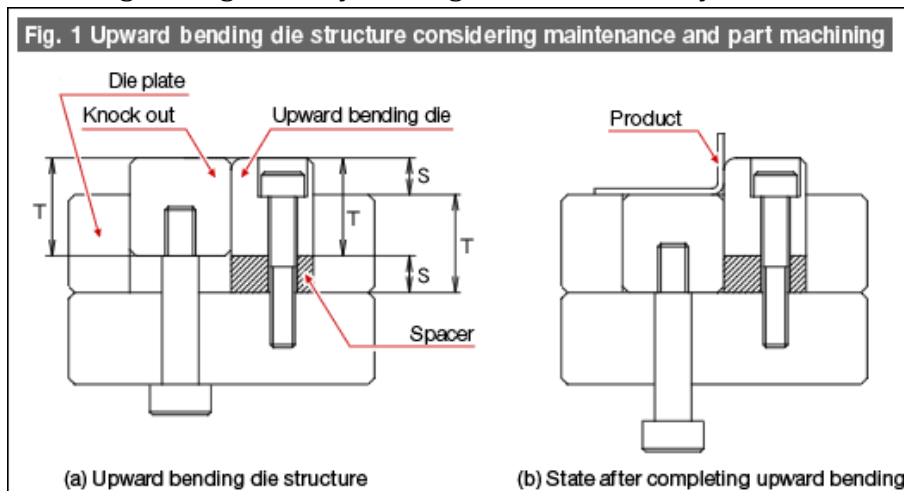


Fig. 2 shows a technique related to the life of inserted parts. In Fig. 2 (c), a new part has been inserted. The fixing screw of this part has been modified so that the bolt is inserted deeper by the amount of re-grinding. Although the level is adjusted by inserting a shim on the underside of the inserted part every time the inserted part is re-ground, it is possible to know that the inserted part has reached its life when the head of the bolt is almost at the same level as the die surface. The machining can be made so that it is possible to know the time to replace the part.

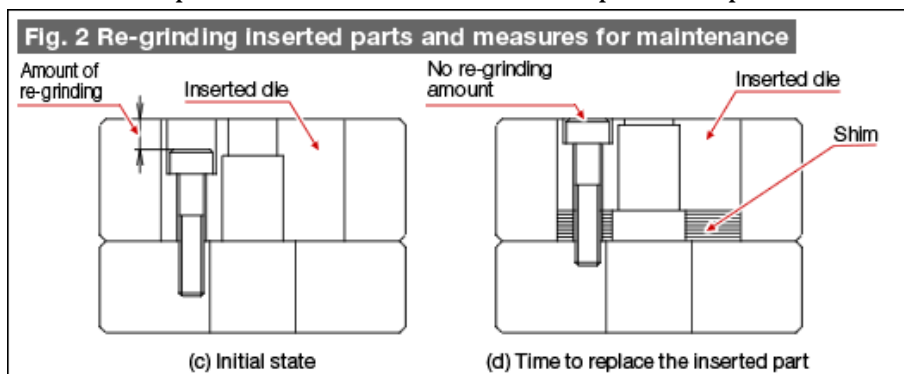
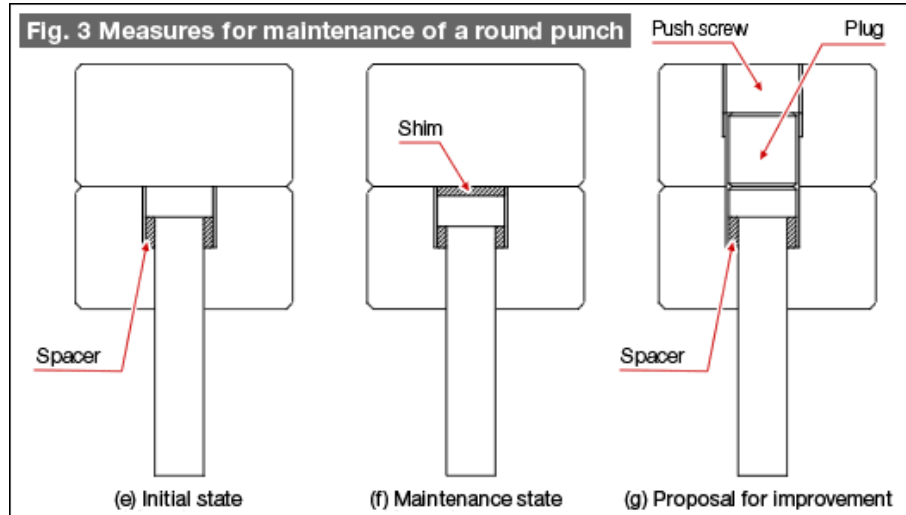


Fig. 3 shows the life management using the punch. As is shown in Fig. 3 (e), a spacer corresponding to the amount of regrinding is inserted. The spacer is ground to match with the amount of

re-grinding of the punch, and a shim equivalent to the amount of grinding it provided at the head part. Fig. 3 (f) shows that state. The life of the punch can be said to have ended when the spacer disappears. In the case of the structure of Fig. 3 (e), it is necessary to separate the top die at the time of taking out the punch. If the structure is made like that shown in Fig. 3 (g) it is possible to eliminate the tediousness of separating and the preparation of the shim.

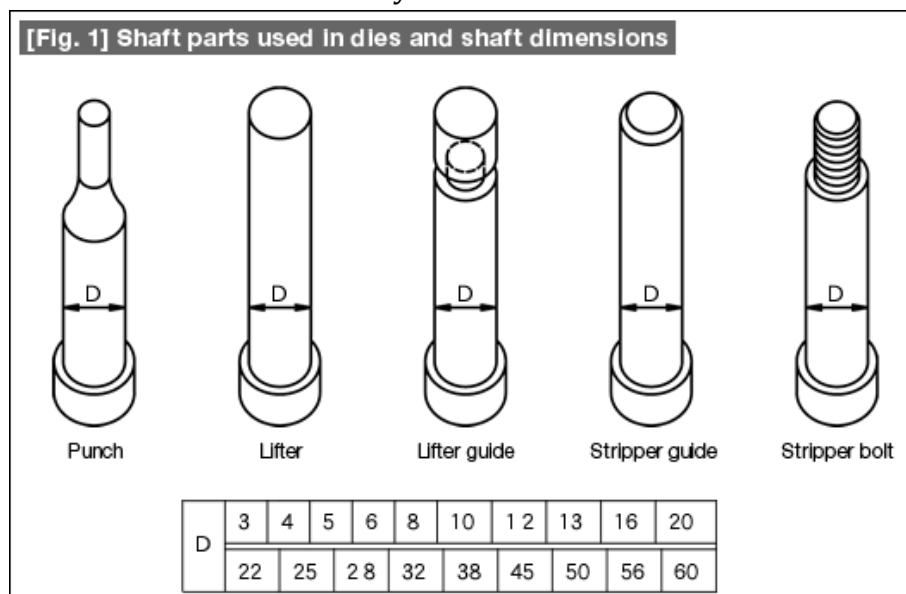
Various techniques are possible if modifications are made paying attention to detailed parts. Use various techniques in part design in order to make it easy to use.



Dimensions of Shafts Used in Dies

The round parts used in dies are very rarely prepared along with the dies, but are mostly procured as standard parts. Therefore, the dimensions of parts embedded inside the die plate (in this case, these are the shaft dimensions) are organized. The method of organizing is based on the standard size numbers in the Japanese standard (JIS Z 8610). There is a basic series of numbers such as R5, R10, R20, and R40 in the standard. In the case of round parts shown in Fig. 1, the shaft dimensions are determined based on the basic series of R20.

Irrespective of how these were determined, if one keeps these shaft numbers in mind, the design of dies often becomes easy. The die plate size is determined based on the size of the product to be produced by press forming. After that, although the different shaft components are placed in the space of the plate, the decision is made while achieving a balance between the size of the plate and the shaft dimensions. This task becomes easy.



Next, organizing the relationship between the parts and holes, the die design becomes still easier. The relationship between the shafts and the holes is "mating" which can be of the three types of – "a tight fit" (press fit), "a gap fit" (a loose condition in which the hole diameter is larger than the shaft), and "an intermediate fit" (which is a relationship between the hole and the shaft that is in between the first two). For example, when a round punch is to be press-fitted into a punch plate, the reliability of die design will not be stable causing problems if the "fitting margin" is considered each and every time.

If the hole dimension is decided to be shaft + 0,005 mm or shaft + 0,01 mm, not only the speed of designing increases, but also the tools for machining the holes and the machining procedures becomes unified. Carrying this out intentionally is called standardization. When preparing dies using CAD/CAM, if the hole dimensions are determined according to the application taking the shaft dimensions as the reference, the design and fabrication of dies becomes efficient.

Relationship Between Stripper Bolt, Screw Plug, and Holes

There is a very close relationship between the stripper bolts, coil springs, and screw plugs. If the hole dimensions related to the respective parts are organized, die design and fabrication become easy.

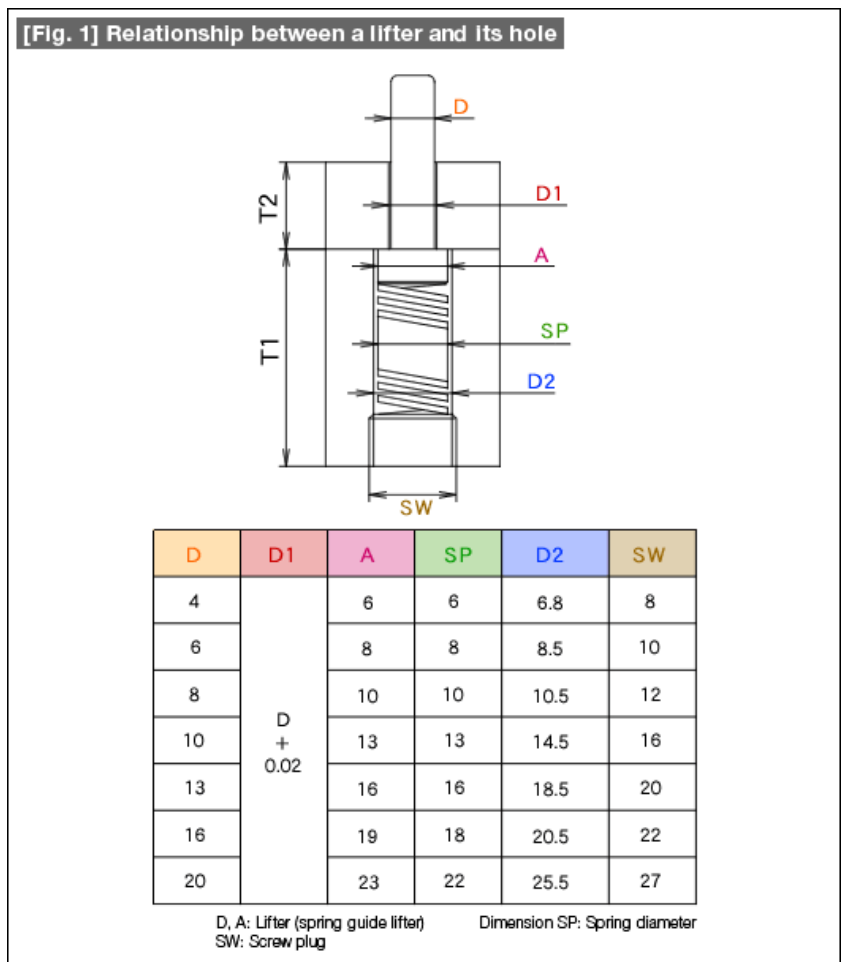
Fig. 1 summarizes their details which are explained below.

The key factors in a stripper bolt are the shaft dimension (D), the head dimension (A), and the thread size (M). Considering the balance with the plate size of the die, the selection is made taking the shaft dimension and thread size of the stripper bolt as the reference. At that time, consider any coil spring diameter that is desired to be used. After that, the coil spring diameter and the screw plug dimensions are determined from the relationship with the head dimension.

It is good to make the head dimension (A) and the coil spring diameter (SP) almost the same, and it is not good to make the SP dimension large or small.

The thread pitch has been unified to 1,5 mm for screw plugs of M10 or higher. With this as the key factor, if the smallest screw plug is selected with the dimension $A + 2$ mm or more, it is possible to finalize the minimum relationship between the stripper bolt and the screw plug. Fig. 1 has been prepared based on this thinking. The bottom hole dimension ($D2$) of the screw plug has been calculated as screw plug diameter minus 1,5 mm (thread pitch dimension). The dimension SP has been selected to be the largest dimension that can enter in the $D2$ hole.

If the method of determining the relationship between the part and the hole is unified in this



manner, even the related parts will be decided. The die design becomes easy if this type of relationship is organized as component units.

As precautions, it is better that the dimension of the hole (**D1**) in which the shaft **D** enters is about that shown in Fig. 1. For the shaft **D**, stripper bolts are available that have been ground and finished to a high accuracy. If the hole dimension is made "intermediate fit" in an attempt to make this shaft **D** as the guide, when the stripper bolt is tightened the shaft can butt against the hole and the movement may become hard. The reason for this is the relationship between the thread part of the stripper bolt and the tapped hole. This is a phenomenon that occurs because it is difficult to cut the tapped part vertically without any bends. It is better not to think of this method of using the stripper bolt.

Relationship Between a Lifter and its Hole

Lifters (including stock guide lifters) are parts used for maintaining the level of the work to be formed from the surface of the die. These are parts that are always used in combination with a spring and a screw plug. Therefore, it is easy to use if the relationship with the hole of the set of the lifter body, the spring, and the screw plug is properly adjusted.

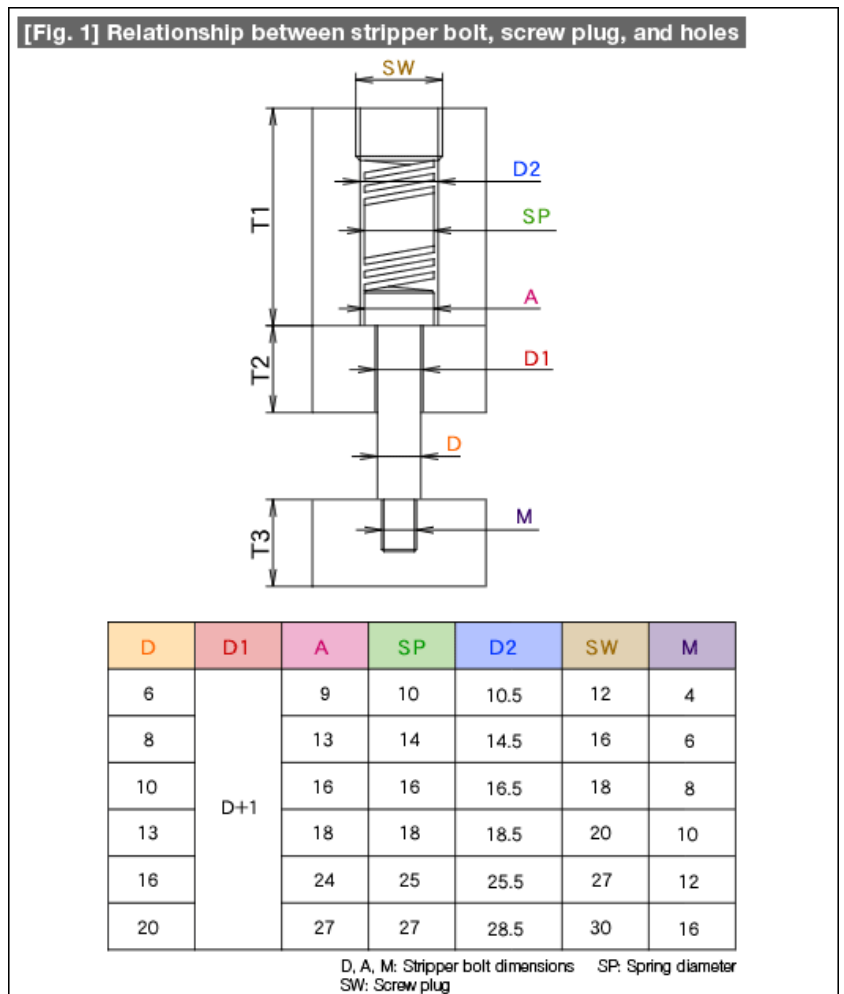
Fig. 1 is an example showing the relationship between the lifter and the hole. This is explained below.

With respect to the shaft (**D**) of the lifter, the dimension of the hole (**D1**) is set so that there is not too much play between them. If there is too much play between the shaft and the hole, the shaft shakes and holding of the work to be formed becomes unstable. If the play is too small, the movement of the lifter becomes bad due to the penetration of very small debris. The lifter should be made to move smoothly even if there is some shaking.

Regarding the relationship between the head dimension (**A**) and the screw plug dimension (**SW**), the screw plug has been selected so that the diameter (**D2**) of the tap bottom hole for the screw plug is as close to the dimension **A** as possible. The spring (**SP**) has been selected to be of a size that is as close to the dimension **A** as possible.

For reference, the key point

in using a lifter is in the method of selecting the spring. The lifter is a weak spring that can lift up the work to be formed. In addition, very often the amount of deflection of the lifter is also very large. If the spring is selected according to these conditions, very often the spring will be one with a large deflection. If the lifter is used with these conditions, the lifter does not stop immediately when



it returns downward, but very frequently carries out a damping movement. If a damping movement is made the supporting of the work to be formed becomes unstable and can cause problems in press forming. The selection of the spring should be made so that its the supporting force is weak and so that the spring is strong enough to eliminate any damping movement.

Relationship Between a Round Punch and Hole

The stud part of the punch (*shaft = D*) is held and supported when inserted into the hole in the punch plate. The methods of supporting are divided into two types of the fixed stripper structure shown in Fig. 1 (including even a movable stripper structure in which the tip of the punch is not guided by the stripper) and the structure shown in Fig. 2 in which the tip of the punch is guided by a movable stripper. These are explained below.

In a mold having the fixed stripper structure of Fig. 1, since it is necessary to maintain the position and perpendicularity of the punch by the punch plate, the hole for inserting a round punch has to be a press-fit hole. The "tightening margin" is very often set at 0,005 mm to 0,01 mm and it is very rare to use a mating tolerance. When a small number of punches are to be inserted in a punch plate, there is no problem even if a mating tolerance is used. However, when a large number of punches are to be inserted, the press-fit becomes too strong if a mating tolerance is used and the punch plate can become warped. Because of this problem, the conditions of the holes are determined by keeping the tightening margin fixed (the machining of the hole becomes more difficult compared to when a mating tolerance is used), thereby making the effect due to press-fitting small, and also, making the supporting of the punch very firm.

Although the seating surface dimension (*H*) has been taken as 5,3 mm, this has been determined because the tolerance of the flange dimension is +0,3/0 for a standard round punch. If possible it is better to finish the punch to have a flange dimension of 5,00 mm 0/-0,02 and an *H* dimension of about 5,00 mm. It is not good if the play between the *H* dimension and the punch flange dimension is too large and the punch moves in the axial direction.

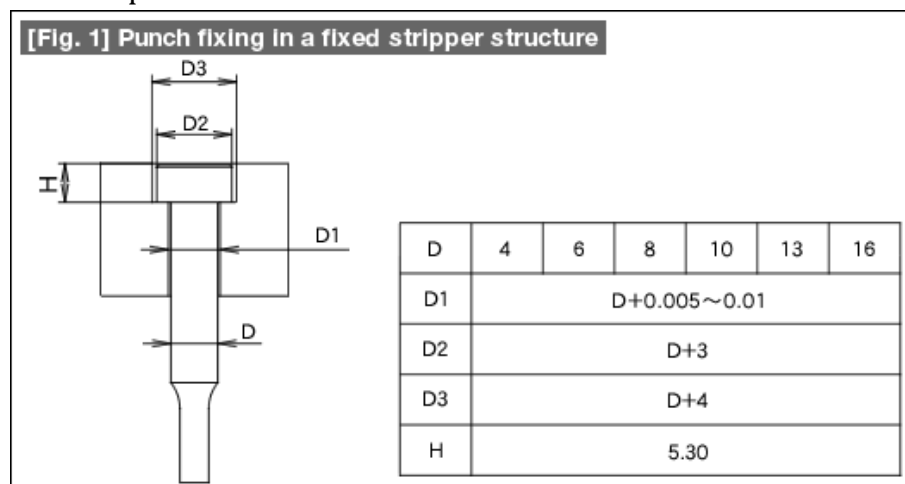
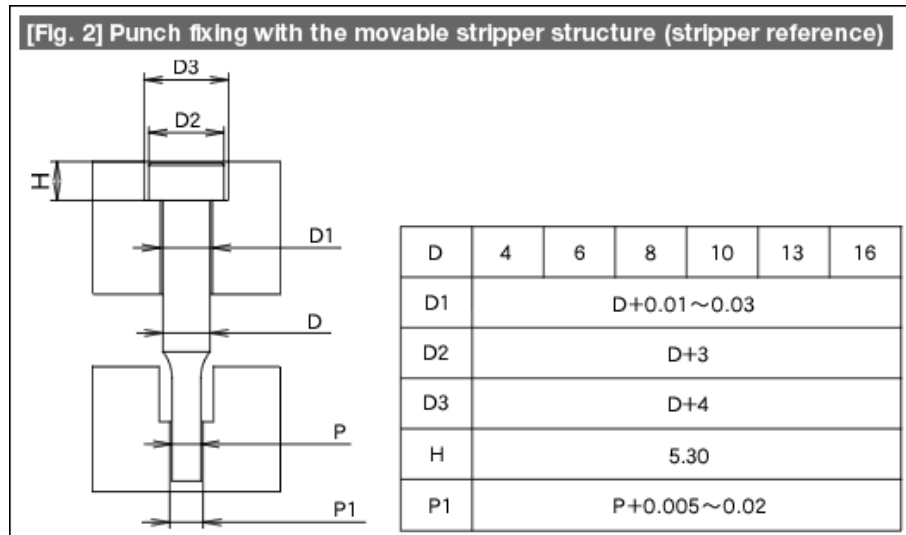


Fig. 2 shows the different hole diameters for the structure when the stripper guides the tip of the punch (stripper reference). With respect to the dimension *P* of the punch, the stripper hole is made about equal to the dimension *P1*. The size of the number and the removing clearance (the plate thickness of the work to be formed) are proportional to each other. This is made loose with respect to the punch plate hole (*D1*). This method of fixing the punch is also called the punch free fixing method. Punch supporting with the stripper as the reference is considered better than when the relationship between the punch and the die is a fixing method based on the punch plate as the reference.

The relationship with the dimension *H* does not differ from that of Fig. 1. There is also a structure that is used in which the tip of the punch is guided by the stripper, and also the shaft of

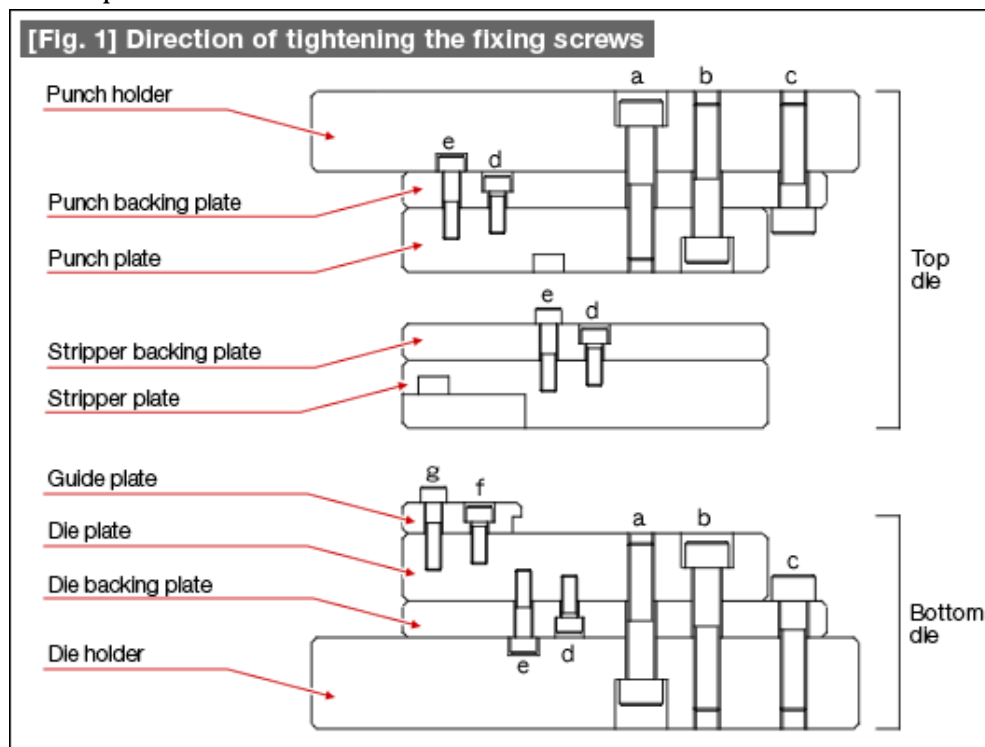
the punch is press-fitted into the punch plate, but this makes the preparation of dies considerably difficult.



Direction of Tightening Fixing Screws

Although there is no problem with fixing screws for the plates constituting a die, there will be complaints that it is difficult to carry out the work during assembling or maintaining the dies.

Let us consider the reason for this, which is explained using Fig. 1. The standard form of screw fixing will be as shown in (a) for both the top die and the bottom die. There will be no problems with the form shown by (a) in the case of a small die because it is possible to easily separate or turn upside down the top and bottom dies.



As the die becomes larger, separating or turning upside down the top die and the bottom die becomes difficult. Sometimes this work will require two persons. In such cases, if the fixing screw of the bottom die is of the form (a), the screws have to be tightened after turning the dies upside down. If the work has to be done in this condition, doing this work will become difficult. In view of this, if the fixing is done as shown in (b) or (c) the work can be done without turning the dies upside down.

Since very often, after the top die and the bottom die are separated, the top die is inverted

and put down, the work becomes easy if the method of fixing shown in (b) or (c) is used. At this time, if the stripper plate is of the movable type, since in the case of (b) the screw tightening work cannot be done unless the stripper plate is removed, the form of fixing shown in (c) may be good.

When fixing the punch backing plate using the form of screw fixing shown in (c), the two plates, the punch plate and the punch backing plate are integrated using the fixing method of (d) or (e). Integrating the backing plate and the body plate or integrating the stripper plate and the die plate are also done in a similar manner. When the surface of a die plate, etc., is machined without separating the backing plate, etc., it will be difficult to carry out the machining work if the method of using the fixing screws is like (e).

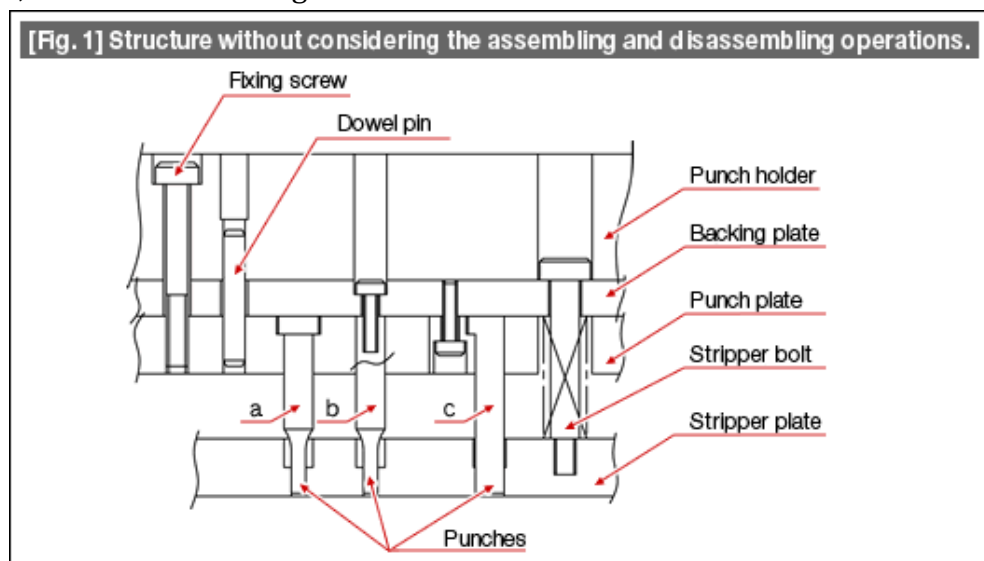
Even fixing by screws of parts that go on top of the die plate, such as the guide plate, will be like (f) or (g), but the escape on the side of the stripper plate becomes cumbersome, or providing this escape may be forgotten sometimes. If there is no problem with the thickness of the plate, it is good to sink the head part of the screw as in (f). Some techniques can be thought of since there are some screws available with thin heads.

Although it looks obvious when explanations such as the above are given while showing the figures, in actual dies fixing screws are very often used without thinking. It is necessary to grasp the features of the die structure and to use the fixing screws that make the work easy. Sometimes, because of this, it may also be good to change the structure of the dies.

Direction of Tightening Fixing Screws

The operations of assembling and disassembling a die vary depending on the method of affixing the parts constituting the die.

Fig. 1 shows an example of affixing the parts of a die without any considerations. While there are three punches, the method of fixing is different in each of them.



[Fig. 1] Structure without considering the assembling and disassembling operations.

Removing the punch (a) is not possible unless the fixing screw and the dowel pin are detached, and the die is disassembled.

The punch (b) is removed by detaching the stripper bolt, detaching the stripper plate, inverting the top die, and detaching the punch fixing screw.

The punch (c) can be removed by detaching the stripper bolt and the stripper plate, and then detaching the punch without having to turn the top die upside down.

In this manner, if there are many methods of fixing present in a single die, the operations become confusing leading to problems.

It is good to design a die considering the nature of the die and with aim towards unifying the assembling and disassembling methods.

Fig. 2 is a structure in which the punch is fixed from the punch holder side. This is the method of fixing a punch seen very often in the case of dies having punches that are prepared by wire cut discharge machining. A round punch with a flange is fixed considering the ease of detaching it.

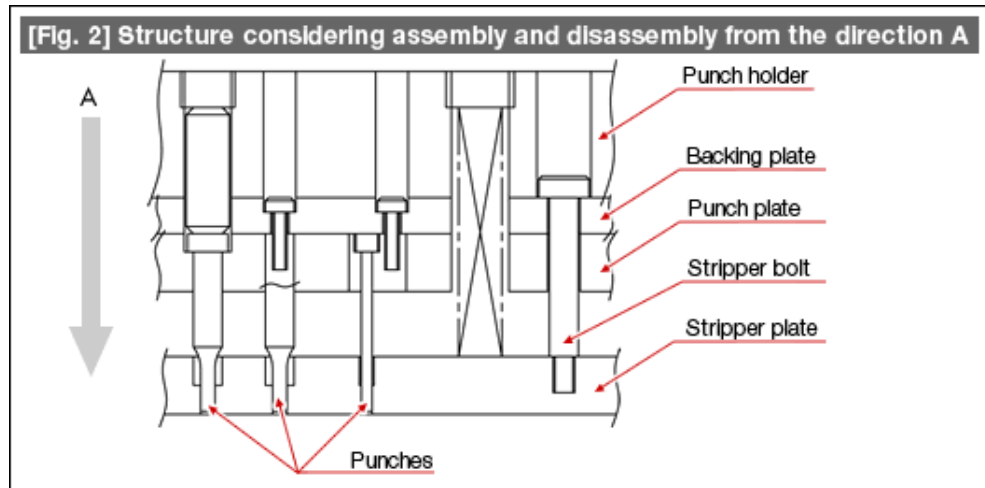
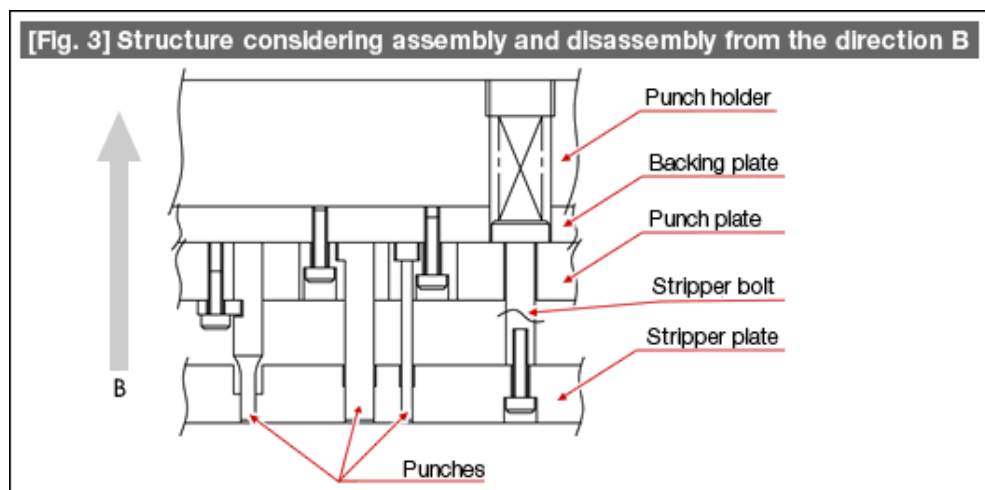


Fig. 3 is a structure that makes attaching and detaching the punch easy from the stripper side. When the punch material is an ultra hard alloy, very frequently fixing it using a key is common, and hence this structure is used very often.

The stripper bolt is a part that is related to the method of fixing a punch. It is good to match even the stripper bolt with the method of fixing the punch. There are some people who are afraid of using the stripper bolt (internal thread type) of Fig. 3 because it drops out, but there is no problem unless somebody has forgotten to tighten the bolt properly. Even measures for preventing loosening of the bolt have progressed, by using such improved bolts it is possible to obtain a still higher feeling of assurance.



TERMINOLOGY AND SURROUNDINGS

Die

The word "Die" is used very frequently in the preparation of dies and the press forming of products.

This word has the following meanings:

(1) Die ... Refers to the entire die. (Die)

In this case, the "die" is not used alone but is used along with a "mold". When used in this meaning, the word die is used after a word indicating its purpose of use. For example, a die can be called a "blanking" die. If the word "die" is used to refer to the entire die, many people may not understand it.

In addition, a "die" is used for forming shapes from plate-shaped or solid materials. These

can be dies for press forming or dies for formation by forging.

When the word "die" is used to mean a "mold", it is used to refer to a die that prepares shapes from a molten material. These are molds used for injection molding or casting.

Therefore, use of the words "die" and "mold" is for referring to the entire die or mold

Also, a die can be made of metal, or can be made of sand (casting), or can be made of wood.

(2) Die ... When a die is separated into a top (upper) die and a bottom (lower) die, the word "die" in this case refers to the lower die. (Lower die)

Although it is very common to call this a bottom mold or a bottom die, sometimes it is merely called a "die". In this case, unless judgment is based on the context, a mistake can be made.

(3) Die ... This refers to a plate that constitutes the side in the die that receives the punch. (Die plate)

When people use the word "die" in spoken sentences such as "how is the die?", or "bring the die", or "the die is broken", etc., they mean the "die plate". Also, when used in expressions like "integrated die", or "insert type die", etc., the word "die" also refers to the "die plate".

(4) Die ... This refers to the shape of the punch receiving side of a plate that constitutes the punch receiving side. (Die)

There is no other expression other than "die" for expressing the side that receives the punch. The terms used in the work place may also be "the male die", "the female die", or the "millstone" (a drawing die), etc.

The word "die" refers to this part of a die in the expressions such as "die shape", "die radius", "the die is cracked", or "the polishing of the die", etc.

In daily usage, the term die only refers to the shape of the punch receiving side. Because this is difficult to understand, the word "die" is also used for referring to the plate or block constituting the die.

When you can correctly understand this word in its various forms of usage in conversations, then you can have confidence that you have understood press forming and dies quite well.

Punch

A punch is a tool that is used by pressing it against a material. Normally a punch is used in combination with a die, and transfers the shape to the material.

A punch is called by various names, such as, punch, male die, and the words expressing a hole punching punch are needle, pin, and arrow, and a punch for drawing is also called "Bouzu" in Japanese. Recently, the names of punches are converging to punch and male die. In Japan, the Japanese Metal Press Industries Association has determined standard terminology (about a quarter century ago). At that time, the standard name was "punch". But the names that people are used to using are still surviving. Any term that is easy to get accustomed to is used frequently because of familiarity. There is no problem in using different terms as long as you have understood them and are using them.

This term is normally used in the form of a purpose word plus "punch". Examples are a blanking punch, a bending punch, a drawing punch, etc. Apart from this type of usage indicating the purpose of the punch, there is also the usage that indicates the shape of the punch such as, a straight punch, a stepped punch, etc.

The names of punches used in compound operations are difficult to understand, such as a total blanking punch, or a blanking and drawing punch, etc. In such compound operations, on the inside of a blanking punch are prepared hole punching dies, in the case of total blanking. A drawing die is prepared in the case of blanking and drawing.

We get confused as to whether to call it an outer shape blanking punch or to call it a hole punching die or a drawing die. The common expression in such cases is "compound punch". In individual expressions, such a punch can be called a "total blanking punch" or a "blanking and drawing punch", which would be easy to understand.

There are other punches with similar nuances, such as slitting or lancing punches that make a cut in the work, or "a cutting and bending punch" that bends the work, or "a hole punching and burring punch" that does exactly that.

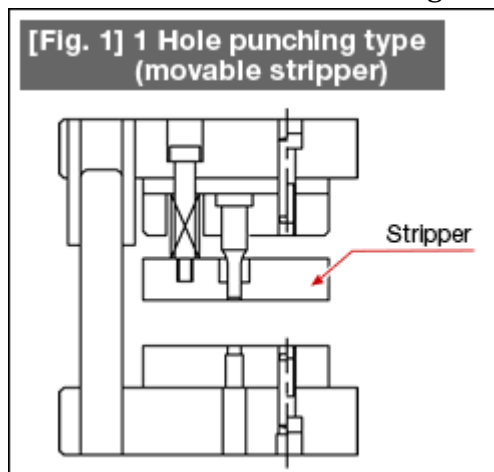
Stripper, Blank Holder, Pressure Pad

Stripper

In press forming, a stripper is a part used for stripping off the material that has become adhered to the punch. This is also called by other names such as "scrap remover", "brush", etc.

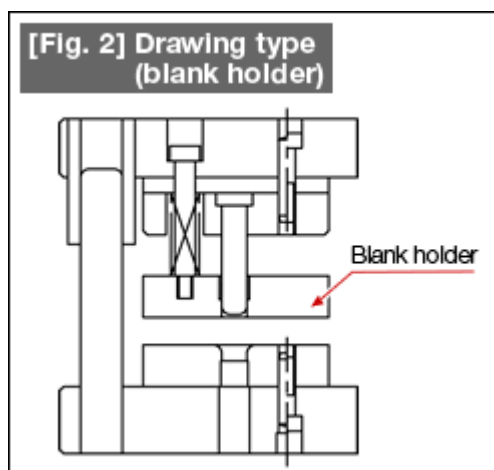
The method of using a stripper can be by fixing to the die plate a "fixed stripper", or "semi-fixed stripper" which is movable although it has been fixed to the die plate. Their only purpose is to strip off the material that has become adhered to the punch.

Further, there is the "movable stripper" which is attached on the punch side and is movable. This type of stripper is also made to have the action of pressing the material to the die plate. The purpose is to prevent deformation of the material used for forming.



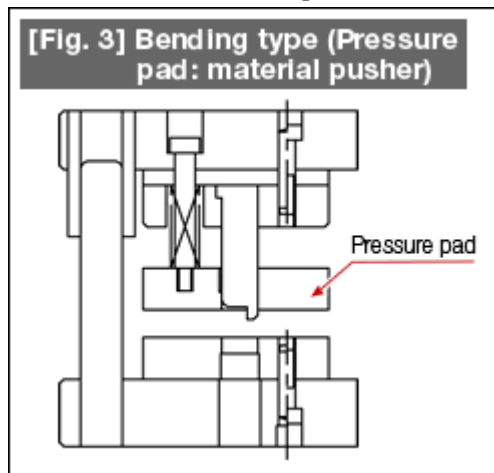
Blank holder

A blank holder is a part that is used in dies for drawing. It is used for pressing the material and for preventing the generation of wrinkles. The blank holder for the first drawing from a blank has the same structure as a movable stripper. The purpose of pressing the material and preventing the generation of wrinkles is the same as the purpose of stripping of the material that has become adhered to the punch.



Pressure pad

A pressure pad presses against the material during L bending or U bending, and is used for preventing the springing back of the material and the sliding of the material during forming. There is also the purpose of stripping off the material from the punch after forming.



As can be understood from the respective figures, the structures are all the same. They are called by different names only depending on their purpose of use. The name indicates what is expected of the part.

Bridge and Carrier

Blanking operation is a typical one among press forming operations. In such a forming operation, a frame is created around the blank as is shown in Fig. 1. The part of this frame in the width direction of the material is called the "edge bridge" and the part in the direction of feeding is called the "feed bridge". These are necessary for forming the contour shape of the blank in blanking. Since these bridges become scrap, making them large wastes the material. Therefore, they are made as small as possible. The limit would be the smallest dimensions that cause no abnormalities in blanking.

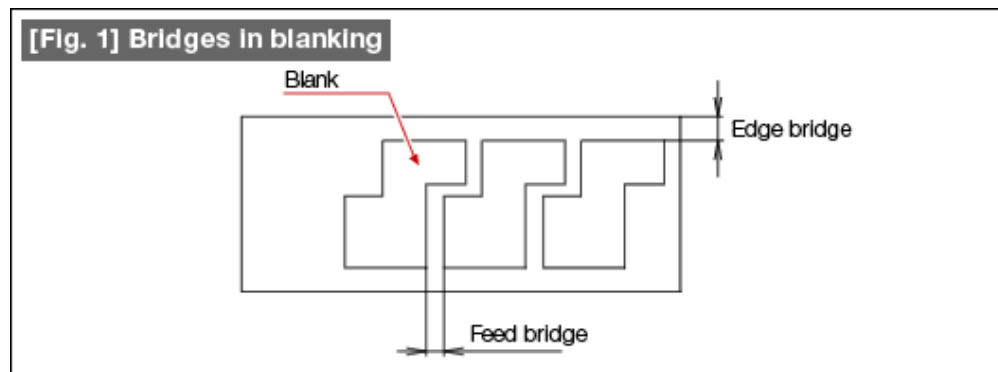
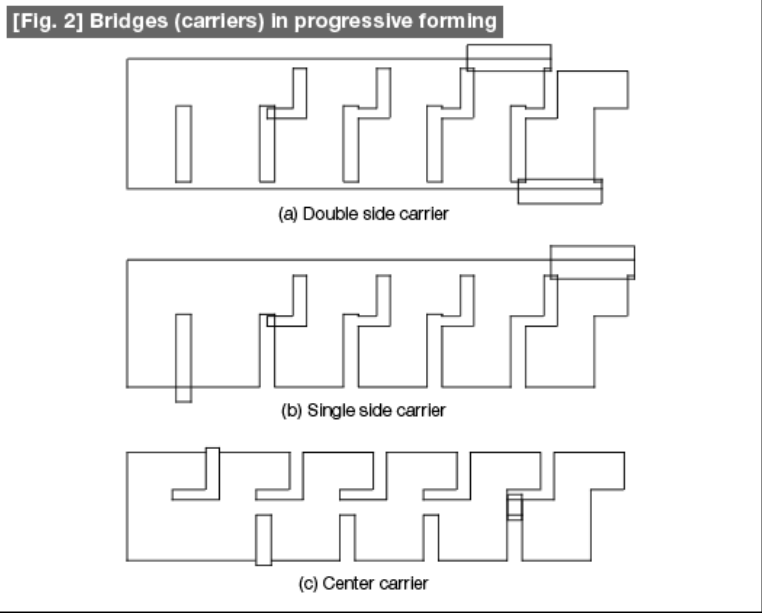


Fig. 2 shows the progressive blanking operation. In progressive blanking, the blanking is done successively while moving the material which is kept connected by the bridge part. The "bridge" in this case is not important for the blanking operation but is mainly intended to hold the blank in a stable manner, and to feed the blank to the next process. Therefore, in order to distinguish this from the blanking bridges, most often such "bridges" are called "carriers" in progressive blanking. The three types of carriers shown in Fig. 2 are the double side carrier, the single side carrier, and the center carrier. The double side carrier holds the blank in a stable manner. Depending on the method of using, the instability remains in the cases of the single side carrier and the center carrier.



Although in general the part of the material that connects the blanks is called a "bridge", depending on the application, if the method of using is mistaken, there will be abnormalities in the product quality. Do not make simple judgments merely based on the way it is called.

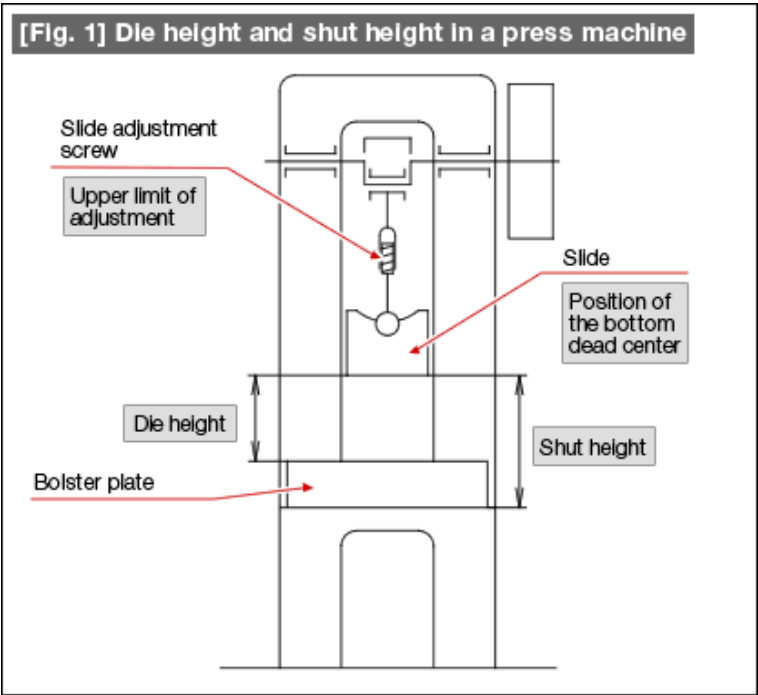
Die Height and Shut Height

In a press machine, there is a maximum height of the die that can be installed. If this maximum height is exceeded, it is not possible to install the die in the press machine. There are two methods of expressing this height, namely, die height and shut height.

These are explained using Fig. 1. When the slide is at the bottom dead center position and the slide adjustment screw has been raised to the topmost position, the distance from the bottom surface of the slide to the surface of the bolster plate is called the "die height". When the bolster plate is removed from the press machine, the surface on which the bolster plate was is called the "head surface", and the "shut height" is the distance from this head surface to the bottom surface of the slide.

Some people might have thought that these two heights are the same, but they are not, and it is important to understand the difference between them. However, recently, since the bolster plate is almost never removed from the press machine, there may not be any problem if these two words are being used interchangeably.

However, why this shut height is used is because in the olden days it was difficult to possess a press machine because it was very costly. In those days, the bolster plate was being changed to suit the application. For example, when carrying out a blanking operation, since the work becomes easy if the blanked part is made to fall through a hole in the bolster plate, a bolster plate with a hole at the center was being used. In compression forming, since it is necessary to firmly support the bottom die, a bolster plate



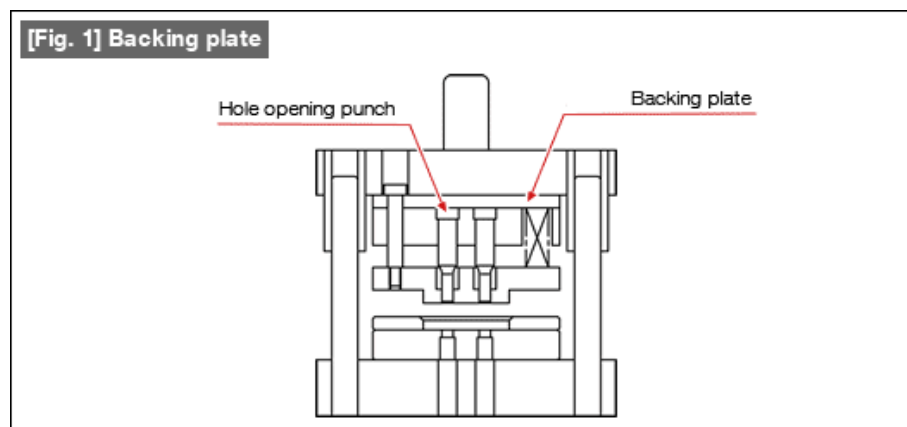
without any hole in it was being used.

For the sake of reference, when a die lower than the maximum adjustable height is installed, it is easy to install the die if the height is within the adjustment range of the slide adjustment screw. In the case of a die with a height smaller than the adjustment range of the slide adjustment screw, the height is adjusted using spacers (which is normally a block called "Geta" in Japanese). The work of installing a die in the press machine is called "die setting up", and this height adjustment is a big factor that affects the time taken for this die setting up. As far as possible, the height of installation of the dies should be made uniform.

Backing Plate

The backing plate is a very important die component which is also called a back up plate (perhaps this is a more accurate name), a back plate, or a backing, etc. It is used as shown in Fig. 1.

However, a backing plate is not necessary for all dies. When a large force acts on a small area such as in the case of a hole opening punch, the punch gets pressed and can dent the punch holder. A backing plate is necessary in such situations. It is not necessary as long as such a condition does not arise.



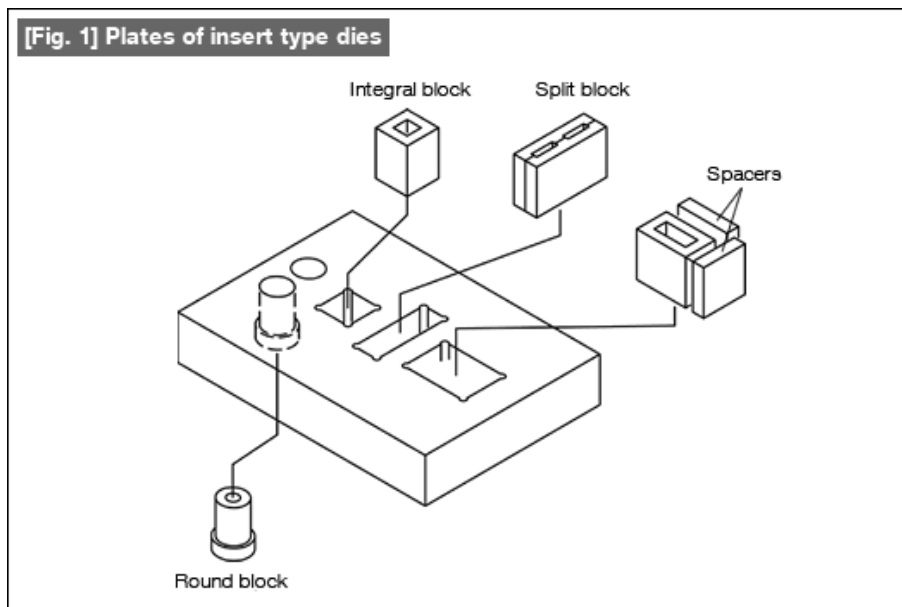
Because of this purpose of use, a certain amount of hardness is required of the backing plate, such as a hardness of about 56 HRC. If it is too hard, it can get cracked. Generally tool steel (SK steel) or special tool steel (SKS steel) is used.

Among the plates constituting dies, a backing plate is the one that goes mostly unnoticed. Therefore, it does not get much attention. Changes in its condition are very rarely checked during die maintenance, and not much attention is paid even if there are any dents or deformations in it. However, paying it as much attention as that given to punches or dies and maintaining its surface in good condition leads to maintaining the die quality.

Insert Dies

Insert type die shown in Fig. 1 is a generic name given to die using an insert type plate. Insert type plates are used frequently as die plates or as stripper plates. Very often dies using this type of plates are called precision dies, and from the point of view of accumulation of error, the positioning accuracy is lower compared to integrated dies. The reasons why they are considered precision in spite of this are the following.

1. It is possible to machine the inserted components with high accuracy.
2. It is possible to adjust the positioning accuracy by moving the insert plate.



In recent precision dies, it has become very common to assemble the dies with the stripper as the reference. Stripper reference means that the relationships such as the tolerances, etc., are adjusted by adjusting the die to correspond to the punch which is guided by the stripper. The adjustment becomes easy because of using the insert type. The changes in the method of preparing inserts are explained below.

1. Although the shape of the hole for an integrated block type insert is prepared by the wire cut electric discharge method (WEDM), etc., which is not different from the method of preparing an integrated type insert. This is used when wanting to increase the positioning accuracy.

2. A split type insert is intended to be prepared by machining the shape by grinding. This is used for increasing the accuracy of the shape of the hole or for increasing the accuracy of the second draught, etc. The positioning accuracy is the same as that of integrated type inserts.

3. Inserts using spacers are designed for the purpose of making it easy to adjust the positioning accuracy. The positioning adjustment of inserts is made using shims (thin plates). Expertise is required for the handling of shims. This can be said to be an insert type which has been improved by making it easy to carry out adjustments using thick spacers. Position adjustment is not possible in the case of round inserts.

In the case of insert type dies, when the tip of a die gets worn out, only the insert is ground. The level is adjusted by putting a shim corresponding to the extent of grinding. In the case of integrated type inserts, since the grinding is done entirely, the die height changes.

In the case of insert type dies, by using materials with high wear resistance (cemented carbide, etc.) for the inserts, it is possible to extend the life of the dies.

Although round blocks are suitable from this aspect and are suitable for regrinding, there are problems in using them from the point of view of increasing the positioning accuracy.

Floating Dies

Fig. 1 shows a die for a product having an upward bend and a downward bend. In this structure, movable punch and die are used which are supported by springs. Such dies and punches are called floating dies and floating punches.

Let us explain why such cumbersome structure is necessary. Consider the downward bend in the structure of Fig. 1. The floating punch becomes a pad. The floating punch (= pad) presses the material, and after that, the spring behind the pad flexes and the downward bend punch starts the downward bending operation. The bending is not possible unless the floating punch (pad) and the downward bending punch are not in this relationship.

When we consider the upward bending, the floating punch is the upward bending punch. The floating die becomes the pad for upward bending. The floating punch presses the material, and starts the upward bending by pushing down the upward bending pad (floating die).

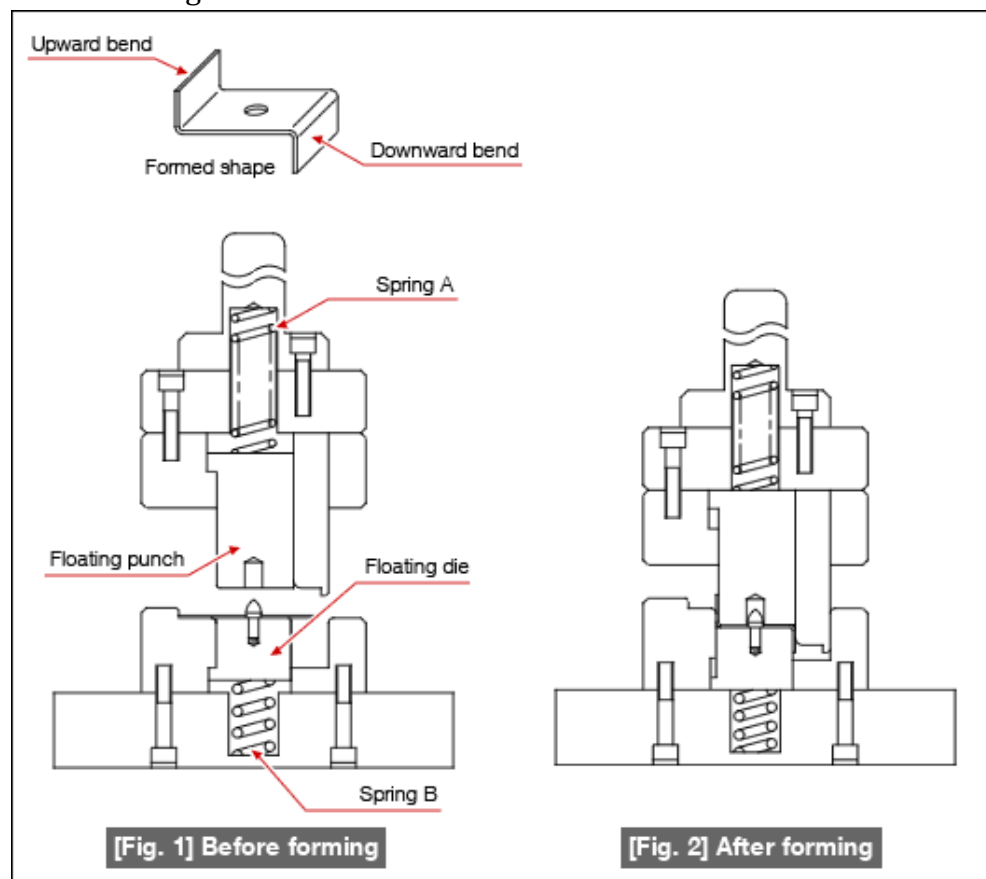
It can be understood that the floating punch and the floating die are compound components having the function of pads. Since a pad is a component that moves while pressing, it is supported by a spring and is in the floating state. Since this component is simultaneously used as a punch or a die, the term floating punch or floating die have come to be used. This is a die structure with such floating components which is used frequently for complex forming or progressive forming.

The relationship between the forces of the spring A and the spring B in Fig. 1 is discussed below.

1. When $A=B$ and both are stronger than the bending force, the upward bending and the downward bending progress simultaneously. After the floating punches press the material, since the springs A and B flex equally. However, since it is very difficult to prepare this state, normally this kind of design is not done.

2. In the state in which $A>B$, if the spring force of the spring A is more than the bending force + the spring force of B, when the floating punch presses the material, the spring B below the floating die starts to flex and the upward bending starts. The upward bending is completed when the floating die has hit the bottom. The spring A starts flexing from this state and the downward bending starts, and the upward bending and downward bending both are completed in the state shown in Fig. 2.

3. In the state in which $A<B$, if the spring force of the spring B is more than the bending force + the spring force of A, the downward bending starts first and when the floating punch hits the bottom, the spring B starts flexing and the upward bending starts. The bending progresses with relationships opposite to that of (2) above and the upward and downward bending both are completed in the state shown in Fig. 2.

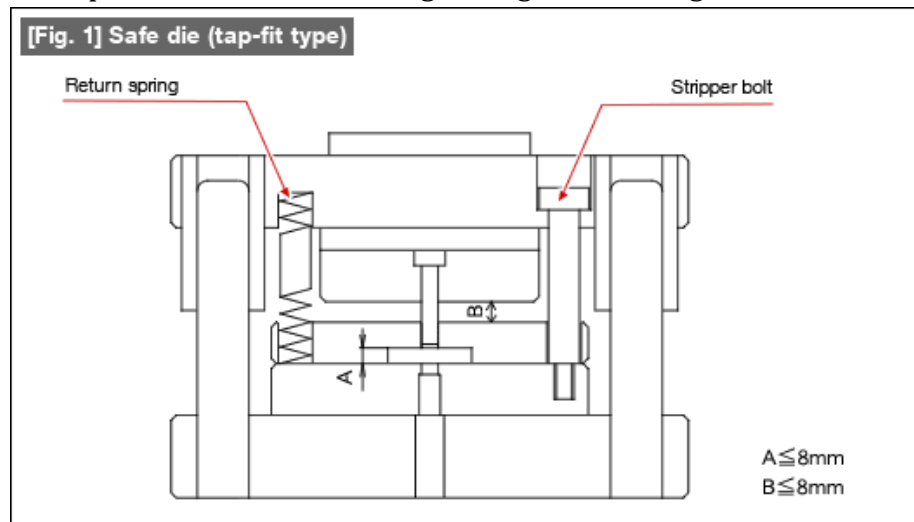


Safe Dies

A safe die (see Fig. 1) is a die which has been prepared so that the gaps (A or B) in which a hand or finger can get in is 8 mm or less in order to ensure that any part of the body (mainly finger tips) of the person carrying out the work does not enter dangerous regions (between the punch and the die). Recently, since the hands of women are small, there is also the opinion that "8 mm is too large a gap and the appropriate gap would be 6 mm". However, if such dies are prepared, the actual work becomes very difficult. An automated type while incorporating the concepts of safe dies has the structure of Fig. 1. This is called the tap-fit type.

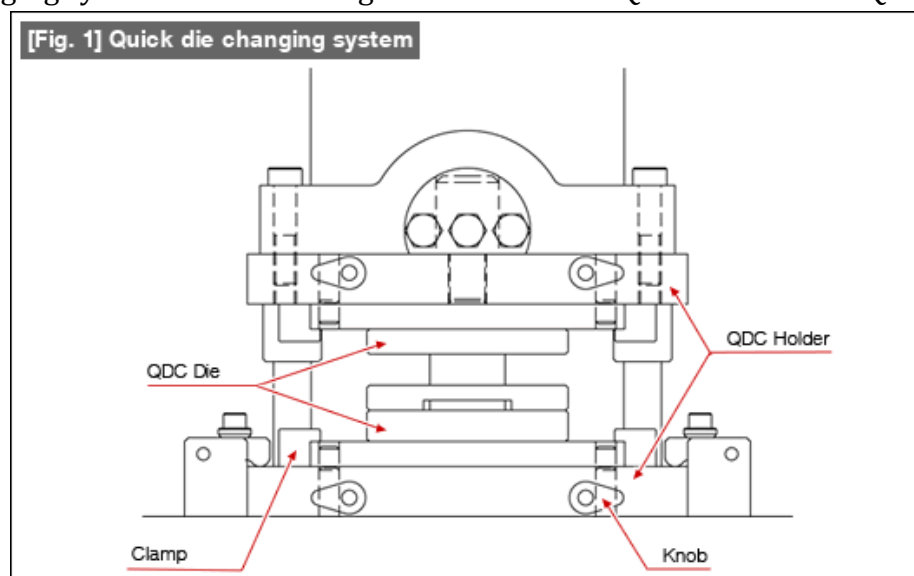
The top die and the bottom die are connected by stripper bolts, and the top die is lifted up by a return spring. The return spring has to have a spring force equal to or more than the stripping force + weight of top die.

When this structure is used, even the work of preparing the dies becomes fast, and also the relationship between the punch and the die becomes stable. It is suitable for products that only need to be blanked. The precaution required is that, while the top die is pressed (tapped) by the slide of the press machine, since the slide moves by its stroke length, it is necessary to protect using bellows, etc., so that the operator's hand does not get caught in this region.



Quick Die Change Type Dies

A die of the quick die change (QDC) type is a die which can be changed quickly. The schematic of quick die changing system is shown in Fig. 1. It consists of a QDC holder and a QDC die.

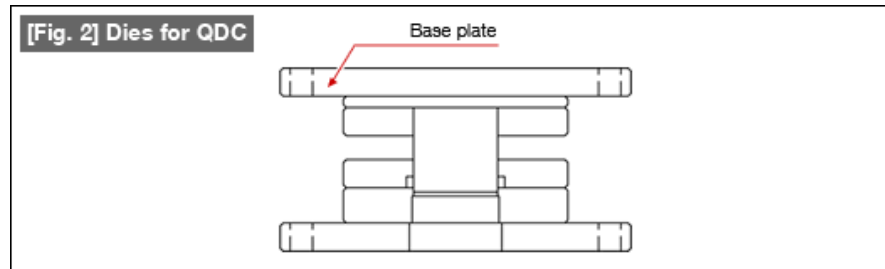


The QDC holder has a structure in which the die set has clamps and location pins. The loca-

tion pins are raised or lowered by knobs. The location pins can be thought of as movable type dowel pins (notch pins) which are inserted in the die set and die. The clamp is of the mechanical type or of the hydraulic type, and techniques have been used so that it can be locked with a single touch.

A QDC die is assembled in the base plate. The base plate is matched with the location pin of the QDC unit. A QDC die can be changed in a short time, and is also intended to reduce the cost of setting up the dies. It was proposed for small volume production of a large variety of products. Since changing the dies becomes difficult if the die becomes heavy, dies that can be held in the hand easily are used very frequently.

In a QDC system with this structure, a die matching jig will be needed at the time of preparing the QDC dies.

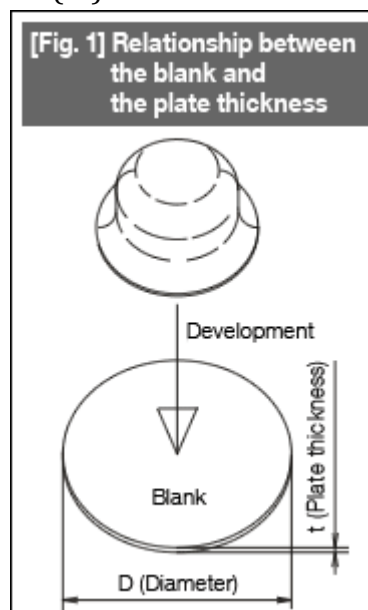


The concept of changing the dies in a short time is spreading to ordinary dies as well, and the improvement called "simple die setup" came to be used widely. This is the technique of making it possible to complete the setting up of dies within 10 minutes. The major points of improvement are the die height, feed line height, clamp height, clamping method, and the method of leveling the die, etc.

Relative Plate Thickness (Drawing Operation)

While investigating the process of a drawing operation (consider cylindrical drawing), although the number of drawings is determined from the development of the blank and the drawing ratio, it is also possible to continue investigations even if the plate thickness is omitted. However, when we consider the actual drawing, if we assume that the blank diameter obtained during blank calculations is 100 mm, nobody will think that the ease of drawing is the same when the plate thickness is 1 mm as when it is 0,1 mm. "Relative plate thickness" is an attempt to judge the state of drawing from the relationship between the blank diameter and the plate thickness. The relative plate thickness (see Fig. 1) is expressed as follows.

$$\text{Relative plate thickness} = t / D \times 100(\%)$$



The result of calculation will be in the range of 0,1 to 2,0 in the case of usual products. A product with a smaller value is more difficult to draw, and a product with a larger value is easier to draw.

When the blank diameter is 100 mm and the plate thickness is 0,1 mm, the relative plate thickness becomes 0,1 and is difficult to draw. The meaning of this is that, wrinkles or cracks appear when a small change is made in the conditions such as the wrinkle suppression force, etc.

When the blank diameter is 100 mm and the plate thickness is 1,0 mm, the relative plate thickness becomes 1,0, and with this value, it is possible to draw without much difficulty using a die with a wrinkle suppressor.

When the relative thickness is 3,0 or more, it is possible to draw without a wrinkle suppressor. When the relative thickness becomes still larger, the plate cracks and it becomes difficult to draw the product.

Using relative thickness, it becomes possible to make judgments in this manner. It is possible to know still more detailed conditions when combined with the drawing ratio.

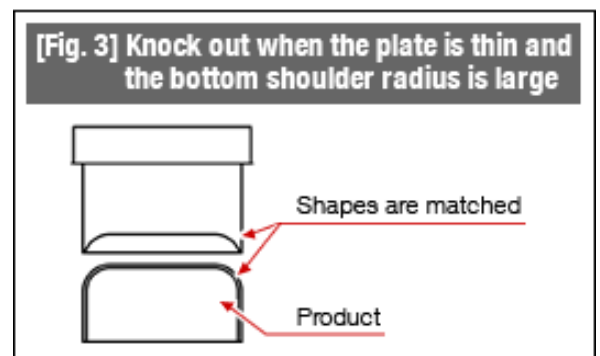
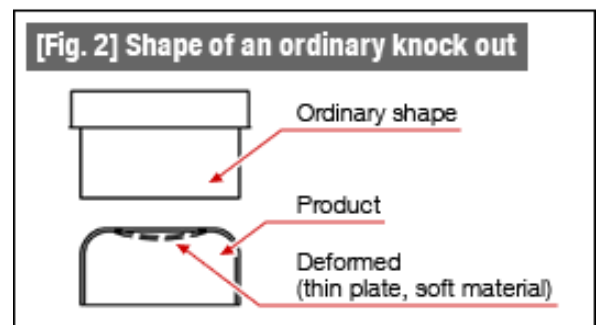
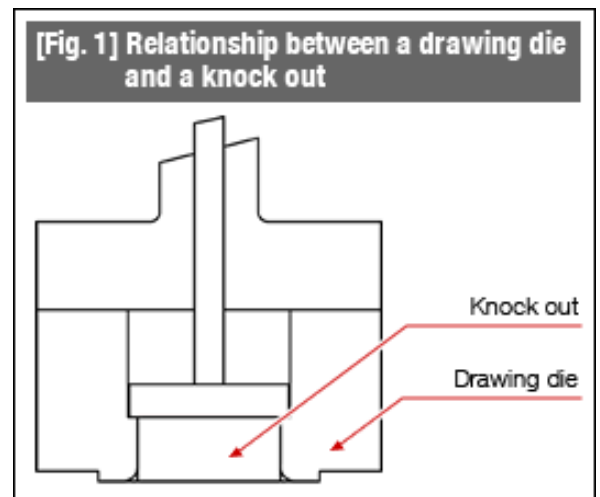
Knock Out in Drawing Operations

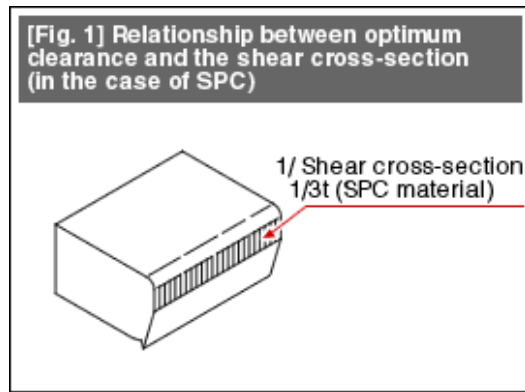
In drawing operations, the product that has entered into the die is pushed out by using a knock out as shown in Fig. 1. At that time, if the material of the product is soft, the plate thickness is small, and also if the shape is such that the shoulder radius of the bottom part (the punch shoulder radius) is large, the bottom of the product becomes deformed if the product is pushed out using a knock out with the shape as shown in Fig. 2.

In the case of such products, the shape of the knock out is made to match with the bottom radius of the product as shown in Fig. 3, and the product is pushed out not at the bottom of the product but at the stronger shoulder radius part of the product. If the die design is made with a simplistic thinking that it is sufficient if the knock out just pushes out the product, you will meet with failure in such situations.

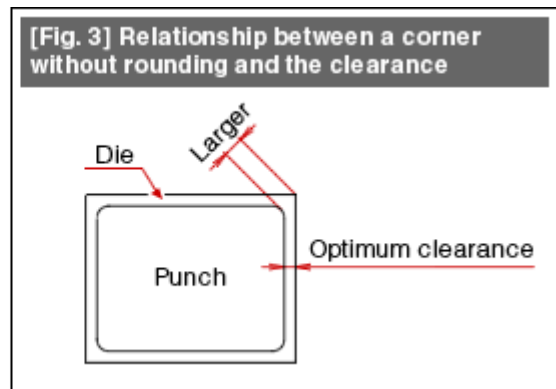
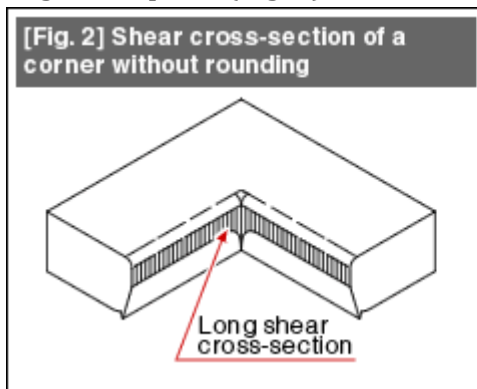
Selection of the Blanking Clearance

The discussion here assumes a soft steel material (SPC). In general, when blanking is done using an optimum clearance, a shear cross-section of about 30% of the plate thickness appears in the cut cross-section. The optimum clearance is about 6% to 8% of the plate thickness (Fig. 1). Optimum clearance is a condition that results in the best durability of the tool. Some times there are products in the case where we would like to make the length of the shear cross-section in the cut cross-section longer, or the shear droop smaller. In such situations, we adopt what is called the clearance for fine blanking. This clearance becomes smaller and will be about 3% to 5%.



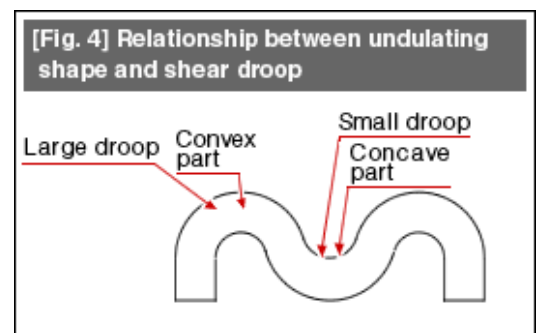


The above condition is the situation when blanking a shape having straight lines or gradual curves. At corners where two straight lines meet, even when the blanking is done using optimum clearance, the length of the shear cross-section extends to the entire plate thickness (Fig. 2). Under such conditions, there is the problem that the corner part of the punch wears out fast. If a rounding of 50% or more of the plate thickness is provided at the corner parts, the blanked state will be almost the same as in the straight line parts. When rounding cannot be provided at the corner parts, the clearance is made larger at the corners. This additional clearance is about 50% of the clearance used for the straight line parts (Fig. 3).



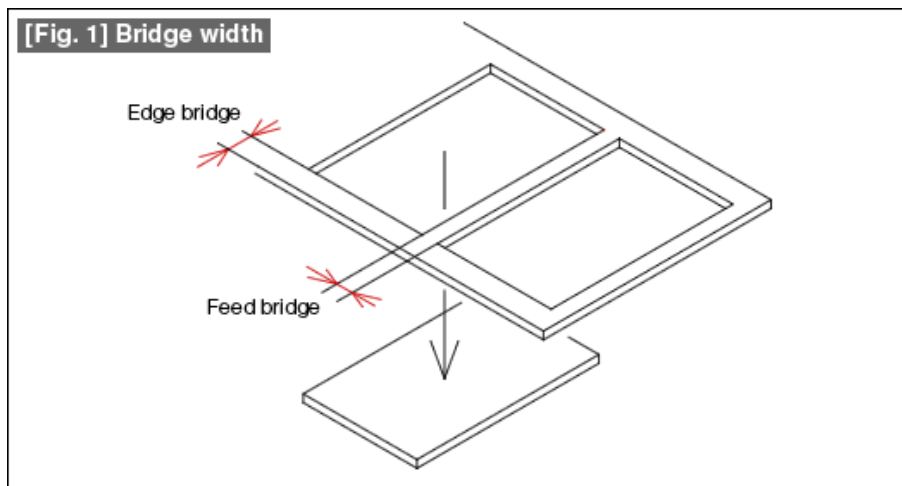
In the case of an undulating shape as shown in Fig. 4, if a uniform clearance is used, the shear droop becomes larger in the convex part and smaller in the concave part. When it is desired to make the shear droop uniform, the clearance is made larger in the convex part and smaller in the concave part, thereby making the resultant shear droop uniform.

The changes in the shear droop imply that there are changes in the bending moment and lateral force generated at the time of the blanking operation. Twisting and warping become matters of concern when blanking finely varying shapes. By changing the clearance to match the shape, it is possible to make some improvements. A greater effect can be obtained by combining with pressure pads.



Width of Blanking Bridges

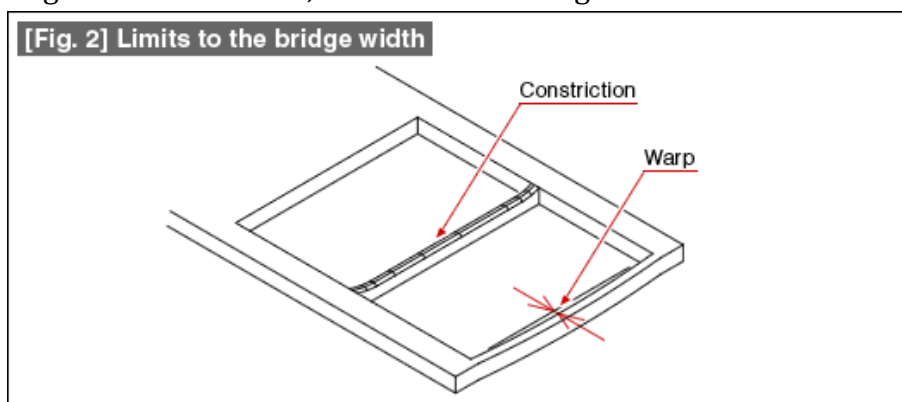
The bridges in blanking are the feed bridge and the edge bridge as shown in [Fig. 1] The minimum values of common bridge widths in blanking operations are shown in [Table 1] The reason why the width of edge bridge is larger compared to feed bridge is the relationship with the material width guide. The material width guide is made slightly wider than the material width so that the material can move smoothly. Although the edge bridge width changes because of this, it is made wider than the feed bridge so that the minimum bridge width is maintained even in the most oblique state.



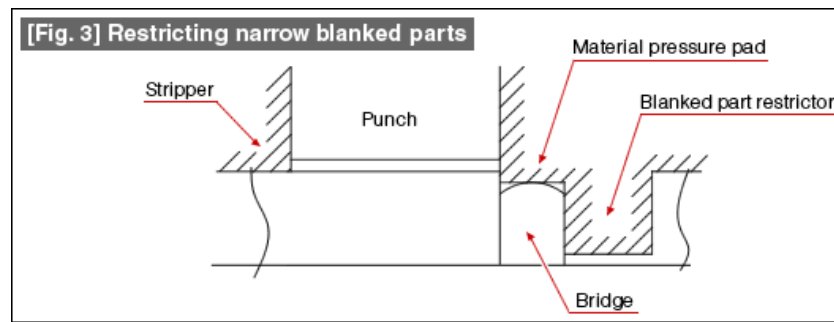
[Table 1] Standard bridge widths in blanking

Material used	Parallel section length Plate thickness	Feed bridge width			Edge bridge
		Less than 50	50 or more but less than 100	100 or more	
Ordinary metal	Less than 0.5	0.7	1	1.2	1.2A
	0.5 or more	$0.4 + 0.6t$	$0.65 + 0.7t$	$0.8 + 0.8t$	1.2A

When the bridge width becomes close to the limit to product formation or becomes so narrow as to exceed that limit as shown in Fig. 2, a constriction or twisting occurs due to the effect of bending or droop caused by a sideward pressure. This effect is large in soft materials. When this phenomenon occurs, the state of the cut cross-section will no longer be normal, and the external appearance of the blank becomes poor. In addition, the wearing out of the punch and die becomes faster speeding up the generation of burrs, and also shortening the maintenance interval of the dies.



However, there are also times when a narrow and long object is to be prepared by blanking. The phenomena described regarding the bridge width in blanking operations occur as they are in such situations. This means that we are expecting contradicting things from the point of view of blanking. The reason is the same phenomena that occur in the bridge width during blanking. It is effective to observe well the phenomena that occur in the bridge width, and to take countermeasures to prevent deformation. As shown in Fig. 3, it is most effective to make the material pressure pad stronger. It is also possible to think of restricting the blanked part in order to prevent slipping. In addition, it is also effective to use a smaller clearance than normal.



Even the bridge width in blanking becomes useful for a different purpose depending on the viewpoint.

Economic Speed of Press Forming

A large number of people think that increasing the press forming speed (*spm*) increases the productivity in press forming operations. This is good if you are calculating the numbers while sitting at a table because the problems that occur are not considered, and the numbers come out fine.

However, there are various problems in actual practice. For example, when forming a connector, increasing the speed caused more frequent damages to springs or stripper bolts. The fluttering of the fed material becomes large, causing more frequent misfeeds into the die, which causes the die to break more frequently. Therefore, there will be such problems that were not present before increasing the speed. Since these problems are caused because the die is not suitable for that *spm*, they can be of course solved by making improvements.

If the *spm* is increased ignoring the production quantity, the production will be completed early, and hence the waiting period for the next job increases and there will be more frequent changes in preparations, causing the equipment utilization rate to decrease, and as a result there is also the problem that the productivity has not increased.

In addition, even the cost of peripheral equipment such as the feeding device or the uncoiler, etc. increases, the cost of the equipment including the press machine becomes high, and the cost per unit time increases due to the relationship with the cost of equipment depreciation, the cost reduction obtained by increasing the *spm* gets cancelled out, and the expected cost reduction may not be achieved.

In press forming, there is a state of good balance among the equipment, die life, and production quantity. This kind of state is called the economic speed of press forming. However, although progress will stop if too much importance is given to this state, but it is also necessary to understand that ignoring this and trying to speed up change can lead to obstructions to production. The economic speed should be found out from the contents of the respective press operations and it is important to aim at carrying out the work efficiently.

In the example of forming connectors, the economic speed is about 600 to 800 *spm*. The range of the *spm* value depends on the shape and the number of products per shot. There is no hard and fast rule.

In drawing presses, the speed of drawing the product from the material is limited by the *spm* of the press machine, and it is not possible to increase the *spm* profusely. Therefore, in progressive forming, the number of products per shot is increased to increase the productivity. Instead of the appropriate value of three in a row, the number of products per shot is made five or seven in a row. The problems do not increase in proportion to the number of products per shot, but there is a multiplication relationship. If stoppages increase due to increasing the number of products per shot, the effect of having multiple products in a row becomes less. Increasing the number per shot to meet a tight deadline can lead to a production in which several of the rows are to be thrown away. Such increases in the number in a row should be limited.

Names of Different Parts of Bending Shapes

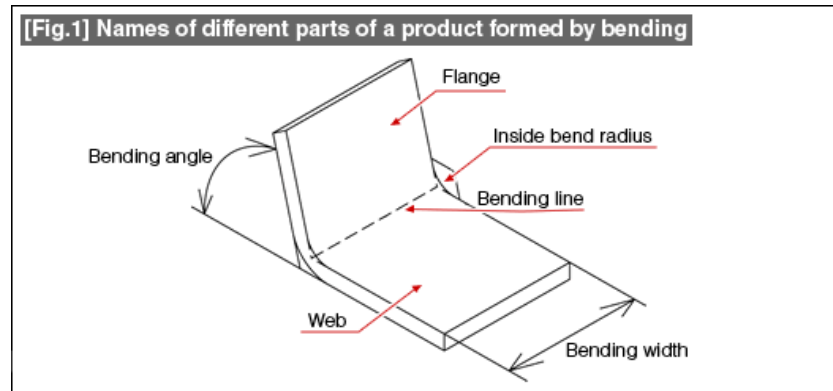
Sometimes it is difficult to refer by names to detailed parts when investigating a product of bending. The names of some parts that are convenient if remembered are given below.

[Fig. 1] shows the names related to the product shape.

(1) Web: The shape of the part that is being pressed by a pad during L-bending or U-bending is called a web.

(2) Flange: This is the name for the part that is bent lifted upward. In the case of V-bending of the plate both sides will become flanges.

(3) Inside bend radius: this is the rounding generated on the inside of the bend. There is a minimum value for this since cracks will be generated if this is too small. This is called the minimum inside bend radius.

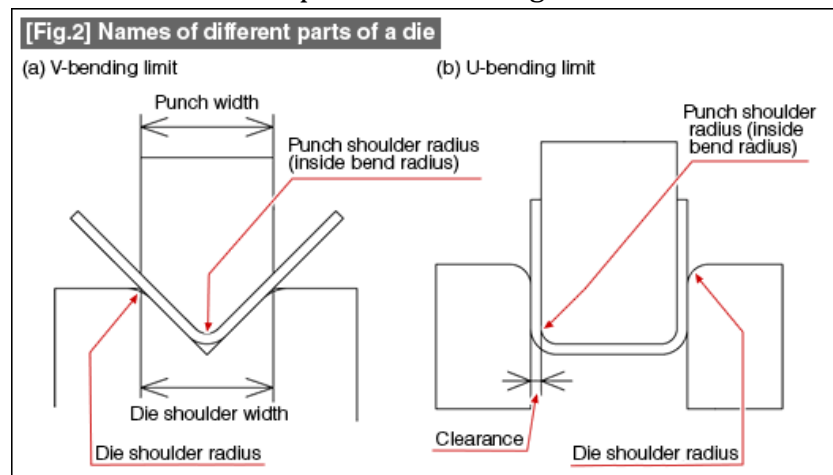


(4) Bending angle: This is the angle from the web surface. This is not the angle on the side of the bending radius. This bending angle is used while calculating the development.

(5) Bending line: This is the line of intersection between the web surface and the flange surface.

(6) Bending width: This is the width corresponding to the length of the bending line.

[Fig. 2] shows the names of different parts of a bending die.



In V-bending:

(1) Die shoulder width: The width between the lines of intersection of the V-shaped inclined surfaces and the top surface of the die.

(2) Die shoulder radius: This is the radius of the chamfer provided at the die shoulder. Normally this is made equal to the die shoulder width.

(3) Punch width: This is the width of the punch corresponding to the die shoulder width. Normally this is made equal to the die shoulder width.

(4) Punch shoulder radius: This is the radius of the chamfer provided at the tip of the punch. This will be the same as the inside bend radius of the product.

In U-bending:

(1) Die shoulder radius: This is the radius of the chamfer provided at the die shoulder. Normally, this is made equal to 2 to 4 times the blank plate thickness. The blank is bent while sliding along this surface.

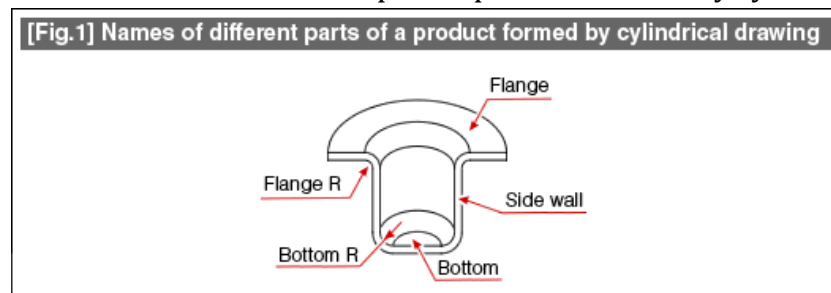
(2) Punch shoulder radius (inside bend radius): This is the radius of the chamfer provided at the tip of the punch.

(3) Clearance: This is the size of the gap on one side between the punch and the die. Normally, this is made equal to the nominal dimensions of the blank plate thickness.

Names of Different Parts of Drawing Shapes

Sometimes it is difficult to refer by names to detailed parts when investigating a product of drawing. The names of some parts that are convenient if remembered are given below.

[Fig. 1] shows the names related to the shape of a product formed by cylindrical drawing.



(1) Flange: The part of the blank that is remaining on the surface of the die after blank has been drawn. The edges of the flange will become thicker than the original plate thickness.

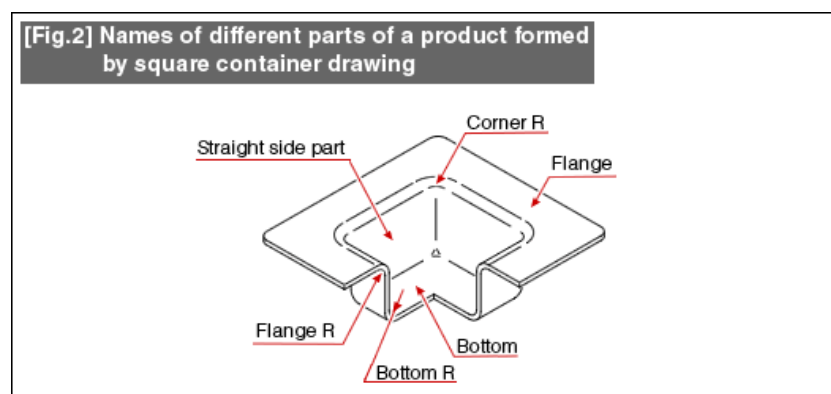
(2) Flange R: This is the rounding (chamfer) provided between the flange and the side wall. This corresponds to the die shoulder radius (die R) of the drawing die.

(3) Side wall: This is the part that has risen with respect to the flange when the blank is pushed inside the die by the punch.

(4) Bottom R: This is the rounding of the part corresponding to the punch shoulder radius (punch R). This name has come to be used because this is the rounding of the bottom of the drawn container.

(5) Bottom: This is the surface constituting the bottom of the container. Instead of being called the bottom, it is sometimes referred to as the roof, but recently the name bottom seems to be used more frequently.

[Fig. 2] shows the names related to the shape of a product formed by square container drawing.



(1) **Flange**: The part of the blank that is remaining on the surface of the die after blank has been drawn. There is a big difference in the function of the material of the flange part at the straight side part and at the corner R part.

(2) **Straight side part**: This is the side wall part formed in the straight line part of the square

container drawing. When investigating the forming operation, the forming is done thinking of this part as a bending part.

(3) **Corner R:** This is the part constituting the rounding of the corner of the side wall part. When investigating the forming operation, this is treated as a part of a cylindrical drawing operation.

(4) **Flange R:** This is the rounding of the part constituted by the flange and the side wall part. Although as a product we would like to have the same rounding all around the circumference of the product, in terms of the forming operation, it is desired that the rounding of the straight side part is made smaller and the rounding of the corner R part is made larger.

(5) **Bottom:** This is the surface constituting the bottom of the square container.

(6) **Bottom R:** This is the rounding of the part at the intersection between the side wall and the bottom surface. In general, this is frequently made the same as the Corner R.

PRESS FORMING FORCE

Blanking Force

Knowing the forming force necessary for carrying out a press blanking operation (shearing operation) is indispensable for selecting the press machine and for carrying out the die and punch design.

The blanking force (P) is obtained using the following equation.

Equation 1

$$P = L * t * S$$

P: Blanking force (kgf)

L: Forming circumference (mm)

t: Plate thickness (mm)

S: Shear resistance (kgf/mm²)

However, when it is difficult to know the shear resistance (S), it is substituted by a value equal to 80% of the tensile strength (Ts) of the material. The equation in this case will be as follows.

Equation 2

$$P = K * L * t * Ts$$

P: Blanking force (kgf)

K: Coefficient = 0,8

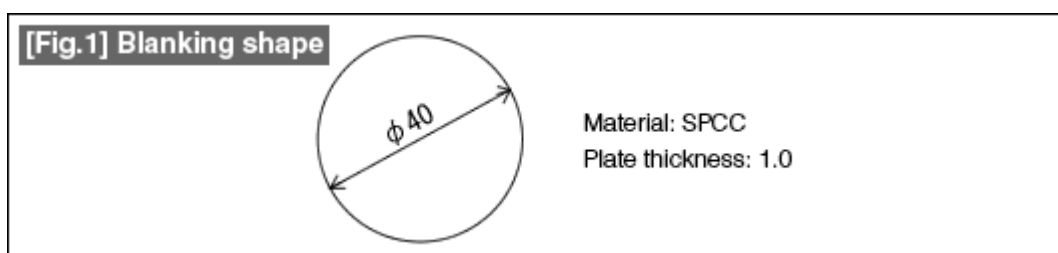
L: Forming circumference (mm)

t: Plate thickness (mm)

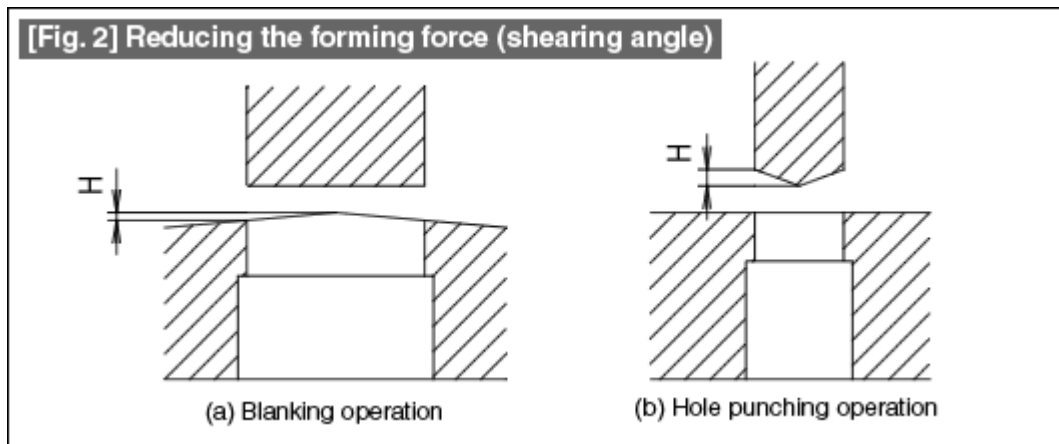
Ts: Tensile strength (kgf/mm²)

Taking the example of Fig. 1, the blanking force will be as follows. In this case the tensile strength of SPCC is taken as 30 kgf/mm².

$$P = 0,8 * \pi * 40 * 1 * 30 = 3014.4 \text{ (kgf)}$$



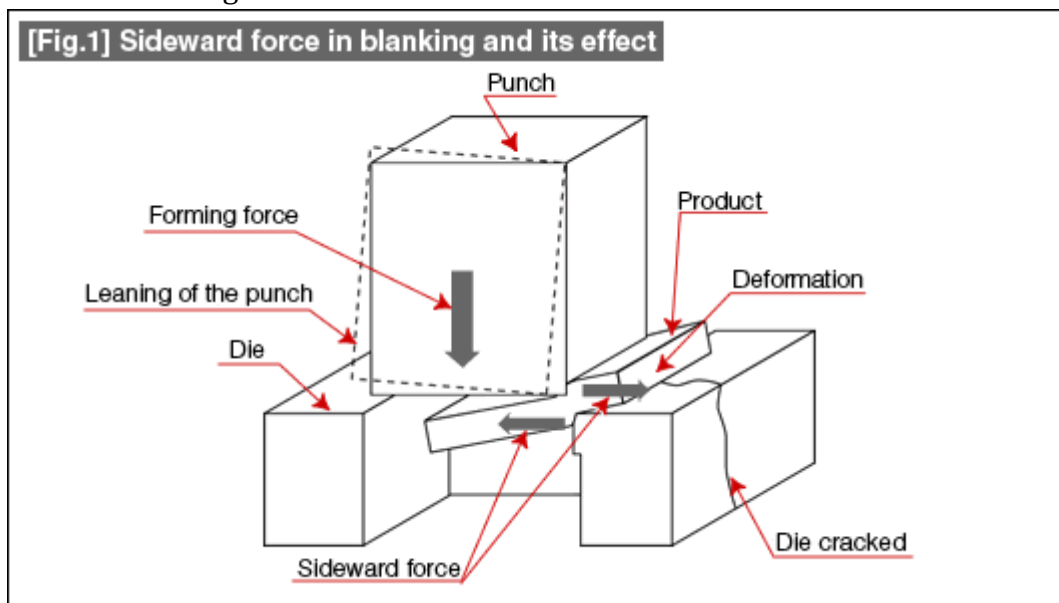
As a method of reducing the blanking force, there is a method of providing a shearing angle as shown in Fig. 2. The shearing angle is provided in the die in the case of blanking operations and in the punch in the case of hole punching operations. Most often the shearing angle is provided so that the dimension H is roughly equal to or more than the plate thickness. By the way, the blanking force can be reduced by about 30% when the dimension H of the shearing angle is made equal to the plate thickness.



BLANKING SIDEWARD FORCE AND SCRAP REMOVING FORCE

Sideward Force (F)

As shown in Fig. 1, the sideward force is the force that is generated in a direction at right angles to the forming force. When the remaining width of the material is small, the material is pressed by the sideward force and can get deformed.



The effect on the punch is that it is pushed to one side, and the clearance changes thereby changing the blanking state. The die can break if its cutting edge part is weak. The sideward force increases in proportional to the blanking process. It also changes depending on the size of the blanking clearance. The sideward force is expressed as follows.

$$P = K_f * P \text{ (kgf)}$$

F : Sideward force (kgf)

P : Blanking force (kgf)

K_f : Coefficient for P

Fig. 2 shows the coefficient (K_f) of the sideward force when the clearance is 3%. In the case of a soft steel plate, care should be taken because this can become even larger than 30% of the

blanking force.

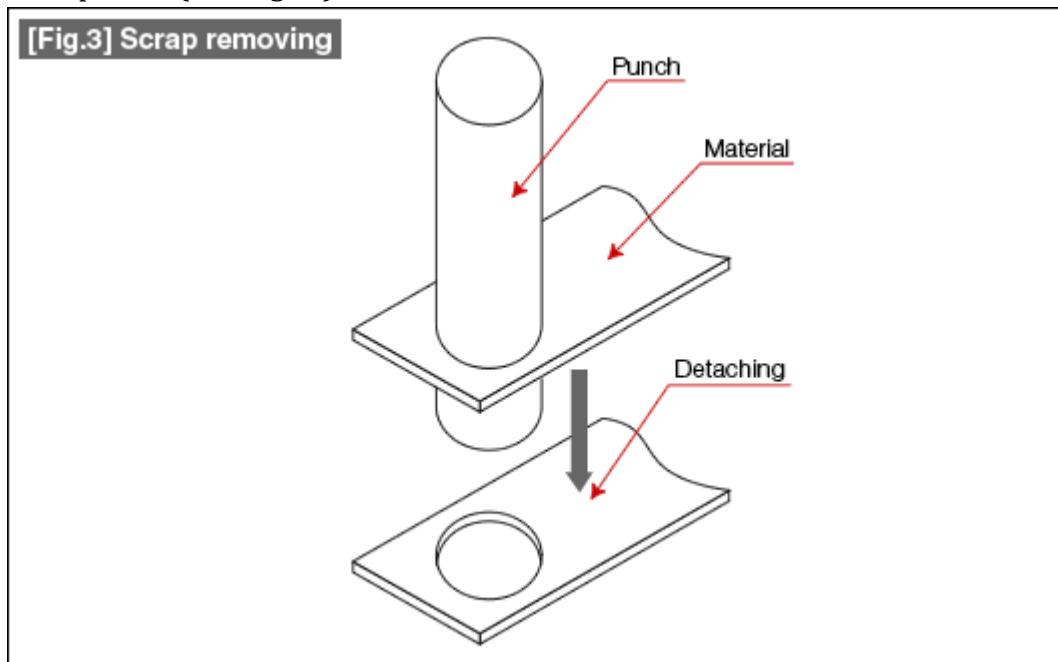
[Fig.2] Magnitude of sideward force for different materials

Material	Sideward force (Kf)
Steel plate	0.28 to 0.38
Brass plate	0.24
Copper plate	0.14 to 0.17
Pure aluminum	0.08

Note: These are the values when the clearance is 3%.

Scrap Removing Force (P_s)

This is also called the stripping force. This is the force required to detach the material that has got stuck to the punch. (See Fig. 3.)



This force is indicated as follows with respect to the blanking force (P).

$$P_s = K_s * P \text{ (kgf)}$$

P_s : Scrap removing force (kgf)

P : Blanking force (kgf)

K_s : Coefficient with respect to the blanking force

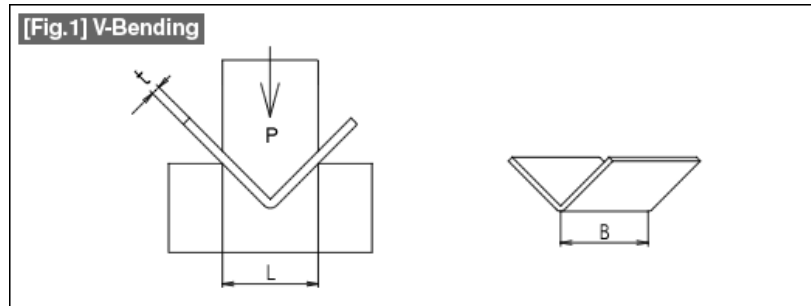
The scrap removing force varies between 0,03 and 0,08. The scrap removing force changes greatly with the clearance. This force becomes large as the clearance becomes small and becomes a minimum at a clearance of about 20%.

In the case of a movable stripper type die, this scrap removing force is required to determine the strength of the spring. When flatness is obtained by pressing the material using a movable stripper, the above value of K_s is insufficient, and it will have to be made much larger. The value of K_s in this case will be about 0,1 to 1,0. The more frequently used value of K_s is in the range of 0,1 to 0,3.

Bending Force

The bending force discussed here is the force of forming a free bend. In bending operations, bottom bending is used frequently at the bottom dead center in order to stabilize the shape. An extremely large force is required in bottom bending depending on the amount of bottoming. The size of that force is considered to be 5 to 10 times the free bending force.

Bending force for V-bending



The bending force for V-bending is obtained using the following equation.

$$P = \frac{C1 \cdot B \cdot t^2 \cdot Ts}{L} \text{ (Kgf)}$$

P: Bending force (kgf)

C1: Coefficient

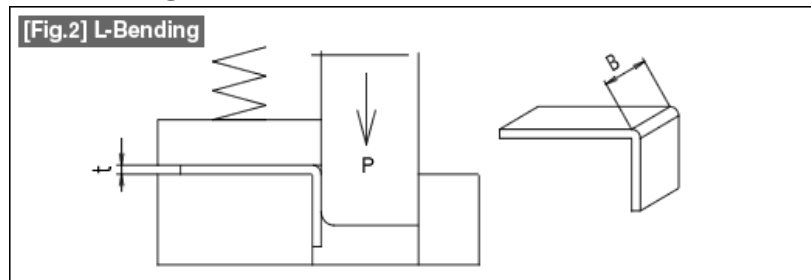
B: Bending line length (mm)

t: Plate thickness (mm)

Ts: Tensile strength (Kgf/mm²)

The coefficient (C1) is 1.33 when the die shoulder width (L) is 8 times the material plate thickness (t), 1.5 when the die shoulder width is about 5 times the plate thickness, and about 1.2 when it is about 16 times the plate thickness.

Bending force for L-bending



The bending force for L-bending is obtained using the following equation.

$$P = C/3 \cdot B \cdot t \cdot Ts \text{ (Kgf)}$$

P: Bending force (kgf)

C: Coefficient 1,0 to 2,0 (Select a larger coefficient when the punch R and the Die R are small.)

B: Bending line length (mm)

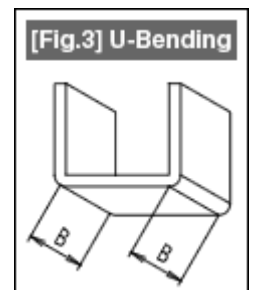
t: Plate thickness (mm)

Ts: Tensile strength (Kgf/mm²)

This shape is taken as the basis for the bending force for pad-pressed bending.

In the case of U-bending such as shown in Fig. 3, since the bending line (B) is present at two locations, the above calculation is made by doubling the value of the bending line length (B) in the above equation.

In this manner, when bending is done in several locations at the same time, the total length of the bending lines is taken as the value of B.



Drawing Force

The forming force (P) necessary for a cylindrical drawing is the force with which the punch pushes a circular blank into the die. The major factor related to the forming force is the resistance of the blank material to deformation. Apart from this, there is also the effect of the friction between

the blank material and the die, the blank holding force (see course No. 10 for details of the blank holding force), etc. The sum of all these is the necessary drawing force.

The forming force of cylindrical drawing is determined very often using the following equation. Refer to Fig. 1.

$$P = K * \pi * d * t * Ts \text{ (kgf)}$$

P: Drawing force (kgf)

K: Coefficient

π : Circumference ratio (3.14)

d: Drawing diameter (mm)

t: Plate thickness (mm)

Ts: Tensile strength (kgf)

The factors having large influences on the drawing force are the tensile strength of the material, the drawing ratio, relative plate thickness (defined as material plate thickness / blank diameter * 100 (%)).

When the drawing ratio is fixed, the coefficient (K) becomes smaller as the relative plate thickness becomes larger, and on the contrary, becomes larger as the relative plate thickness becomes smaller. Its limiting value is 1,0.

In the above equation, the material cracks when **K** exceeds 1.

If the relative plate thickness is fixed, it changes depending on the drawing ratio.

The coefficient is given for reference in the example of a steel plate (SPC).

The following is the value of **K** when the relative plate thickness is 1.2%.

(1) Initial drawing

Drawing ratio (m) = 0,50	→ K = 1,0
0,55	→ K = 0,80
0,60	→ K = 0,68
0,70	→ K = 0,42

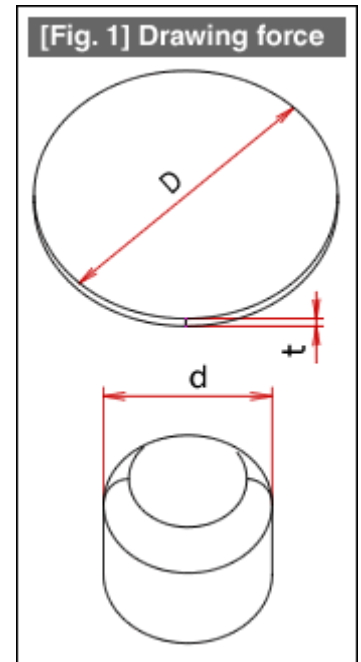
(2) Redrawing

Drawing ratio (m) = 0,75	→ K = 0,90
0,80	→ K = 0,62
0,82	→ K = 0,52
0,85	→ K = 0,42
0,90	→ K = 0,20

When the drawing ratio is the same in both initial drawing and redrawing, the **K** value will be larger in redrawing. This is due to the effect of work hardening of the material.

The drawing force obtained by calculation appears considerably above the bottom dead center of the press machine. The press used is selected considering the torque capacity of the press machine.

The press machine is not selected based on the relationship between the drawing force and the nominal capacity of the press machine.



DESIGN OF BLANKING DIES

Outline of Blanking Die Design

Outline of Dies

A blanking die is one which is used for producing contour shapes as is shown in Fig. 1. While the blanked contour becomes the contour of the product as it is in some cases, it is the developed shape of a product formed by bending or drawing, etc. in other cases. This can be said to be one of the basic press forming types.

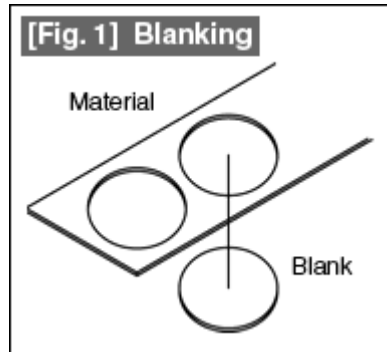
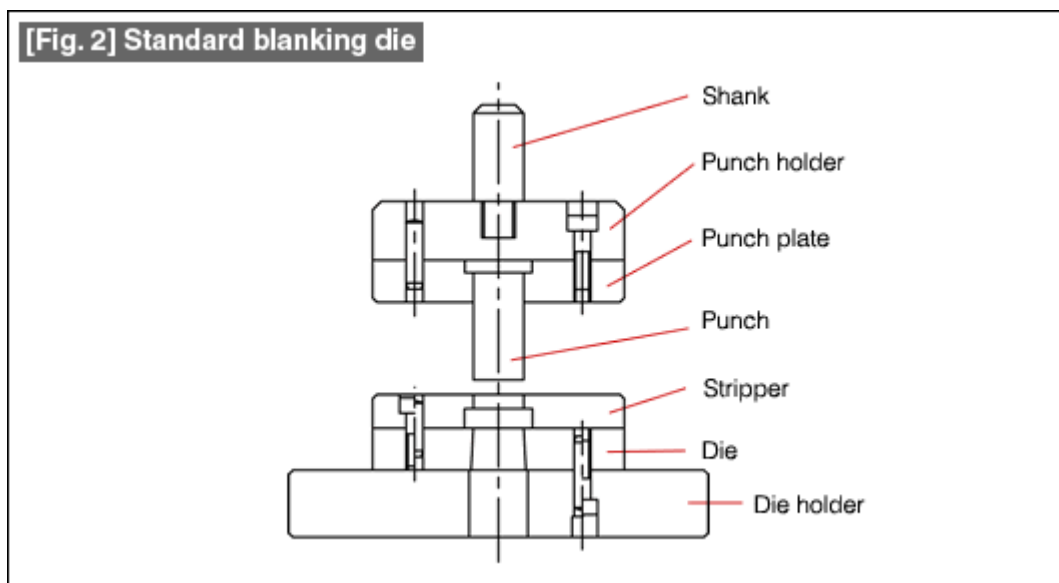


Fig. 2 shows the structure of a standard blanking die. This is a die of the fixed stripper structure. The blanking die is divided into a top die (which is constructed from a shank, a punch holder, a punch plate, and a punch) and a bottom die (which is constructed from a stripper, a die, and a die holder).



As shown in Fig. 3, the top die is installed to the slide of the press machine. In this example, the shank of the die is installed by fixing it using a shank holder. This is a method of installing the top die in the case of relatively small dies.

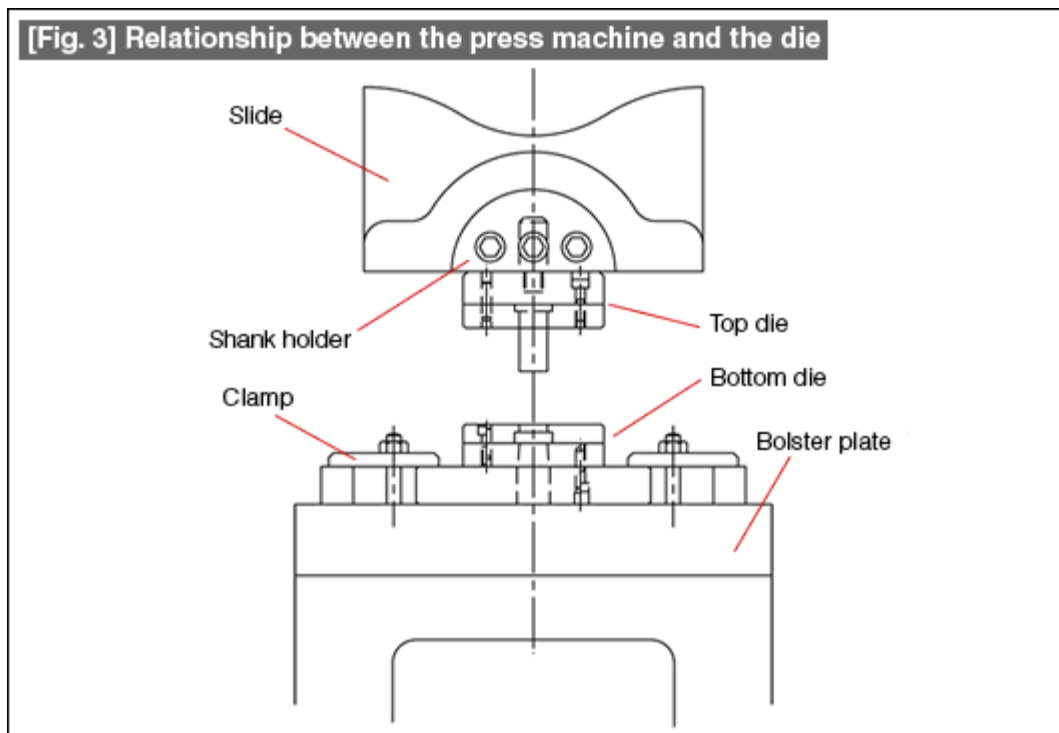
The bottom die is fixed using clamps on the bolster plate of the press machine. A very important factor in dies is the clearance.

In this example, the clearances of the punch and die are matched at the time of installing the die in the press machine. This type of die is called an open die. The operation of installing the die in the press machine is called "setting up the die". The clearance changes depending on the skill of the worker in setting up the die in the case of an open die.

This can also mean that the quality of the formed product is likely to change every time the die is set up.

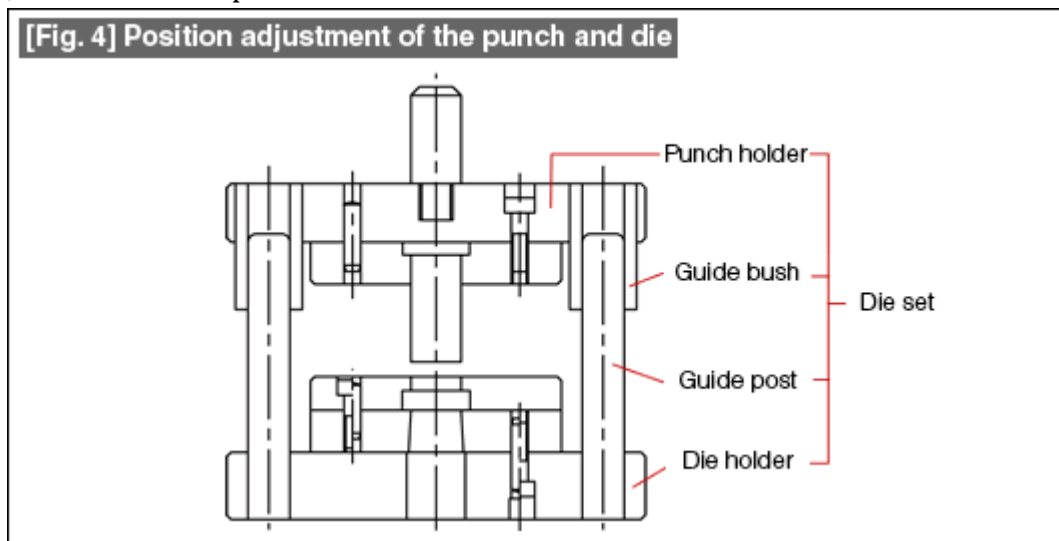
In order to solve this problem, a guide post and a guide bush are used as shown in Fig. 4 so that the relationship between the top die and the bottom die is maintained in the dies themselves. A

large number of dies of this type are being used in which the relationship between the top die and the bottom die are maintained constant.



A unit in which the punch holder, guide bush, guide post, and the die holder are integrated into one single unit is called a "die set".

Further, a die of this shape is called a "die with a die set".



Details of die design

Firstly, a die has a specific purpose of metal forming. In this case it is blanking. The functions necessary for blanking are to be understood first and then the concept is to be established.

Work is started after installing a die in the press machine. The method of installing the die is investigated and determined. In this example, the method of fixing used is that of fixing using a shank and a general purpose clamp.

In addition to take measures to make the setting up of the die easy, measures should be taken so that there is no fluctuation in the product quality even if the die is used repeatedly. In this example, the relationship between the die and the punch is maintained constant using a guide post and a guide bush (preventing fluctuations in the clearance), and setting up the die is made easy.

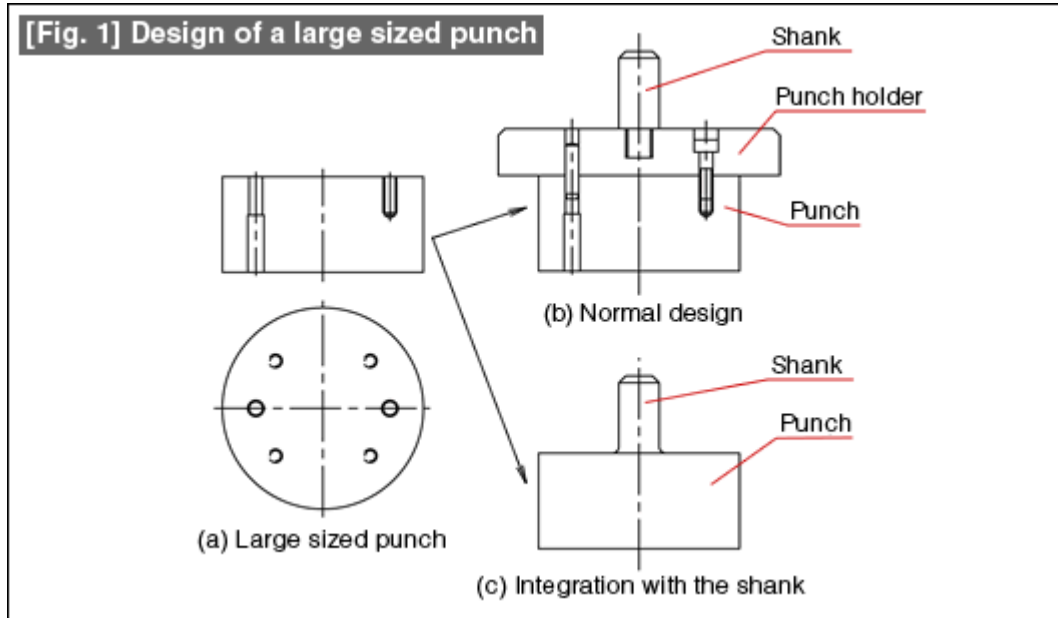
During die design, the necessary items are listed up, the policy is established, and then the detailed design is carried out.

Outline of Blanking Punch Design

In blanking work, the shape of the blanking punch is the same as the shape of the blanked product. The dimensions of the blanking punch at that time are made smaller than the blank dimensions by the amount of clearance.

During the design, it is important to make the shape simple and easy to prepare. The changes depending on the size of the blanking punch are indicated below.

Design of a large sized punch

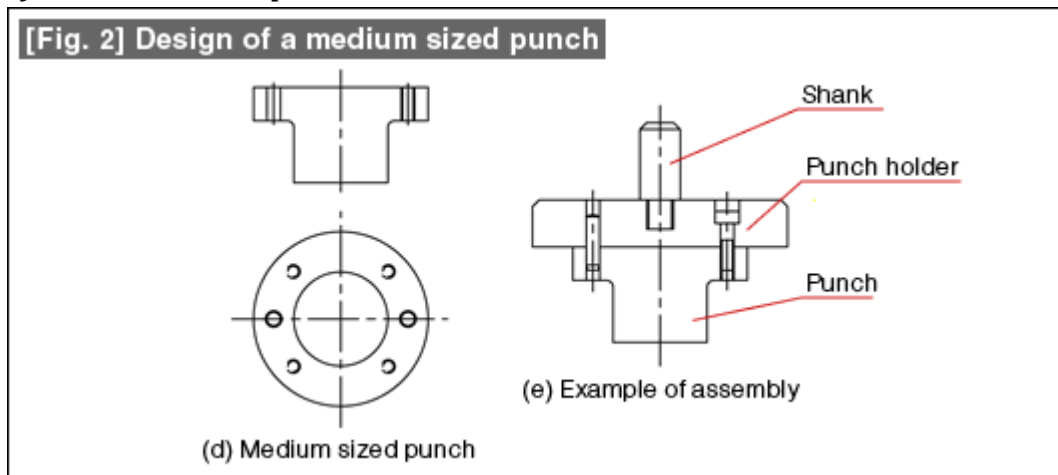


Since the punch area is large in the case of a large sized punch, it is possible to drill threaded holes for fixing the punch and holes for dowel pins (knock pins) inside that area.

This is shown schematically in Fig. 1 (a). This type of shape can be machined easily using a wire cut discharge machine.

Fig. 1 (b) is a standard shape of an assembly of the top die. The punch plate is omitted and the punch is directly installed to the punch holder thereby simplifying the structure. In the case of simple shapes such as a circle, etc., it is possible to prepare in further simplified manner by integrating the shank and the punch as shown in Fig. 1 (c). However, as explained in Lesson No. 168, the problem of adjusting the clearances of the punch and the die remains.

Design of a medium sized punch



This is a type of punch whose size makes it difficult to drill threaded holes or knock holes inside it.

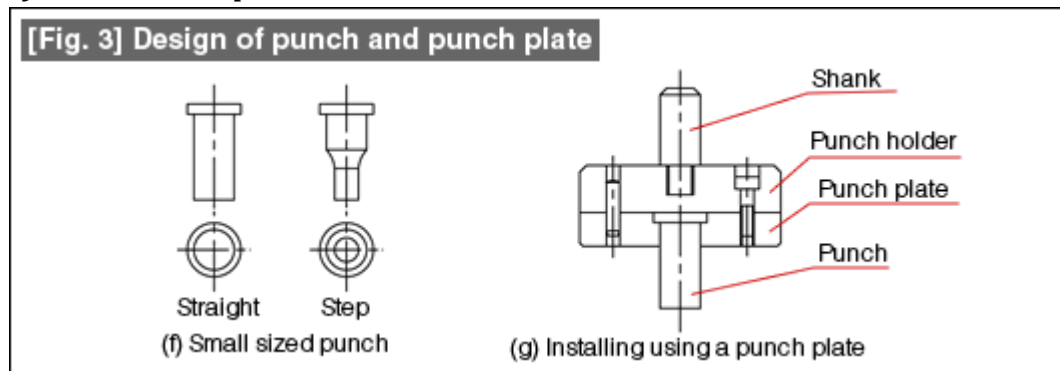
In the case of a simple shape such as a circle, etc., it is possible to provide a flange and to drill threaded holes or knock holes in the flange part, and to design again a structure in which the punch

plate is omitted.

When the shape is complex, a flange is provided at a simple part, and the design is made in a similar fashion.

When this has been determined to be difficult to do, the punch will have to be fixed using a punch plate. Understand that the punch plate is not an indispensable part.

Design of a small sized punch



When the product becomes small, even the punch becomes small. In that case, it becomes difficult to fix only the punch to the top die, and the method is used of fixing the punch after embedding it in a plate. This plate for fixing the punch is called a punch plate.

As shown in figure (f), the punch is made as straight as possible. When there is some problem in the strength due to the relationship between the size of the punch and the punch length, the design is made to provide a step in the punch. The relationship between the punch and the punch plate is designed so that the punch is lightly press fitted inside the hole in the punch plate (so that it can enter the hole with light hit with a plastic hammer).

This ensures the verticality and position of the punch.

Since it is difficult to ensure the verticality of the punch when it is fixed by swaging, this method should be avoided as far as possible.

It is standard practice to use S50C or SS400 as the material for the punch plate. The thickness should be about 30% to 40% of the punch length.

Punch material

The standard punch material is SKD11. The heat treated hardness should be about 60 HRC.

The major method of preparing dies is using wire cut electric discharge machining. This is because the wire cut electric discharge machining is suitable for the material SKD11 and it is also good for wear resistance.

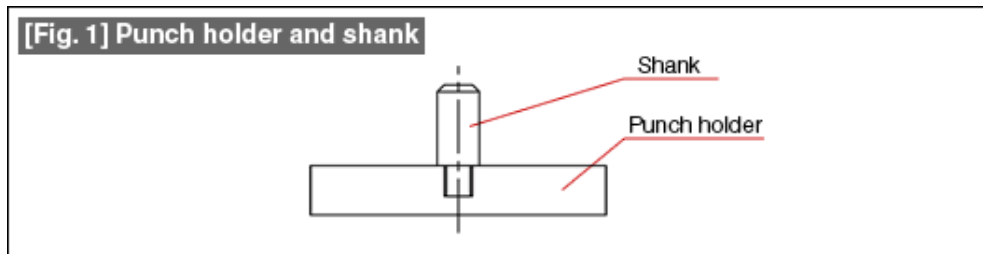
The punch material is changed taking SKD11 as the reference depending on the number of work steps, the material of the product to be worked, etc.

Shank Design

The shank is used as a part for installing the top die in the slide of the press machine. This part is not limited to blanking dies, but is used commonly in all types of dies. We describe this first because it is basic information.

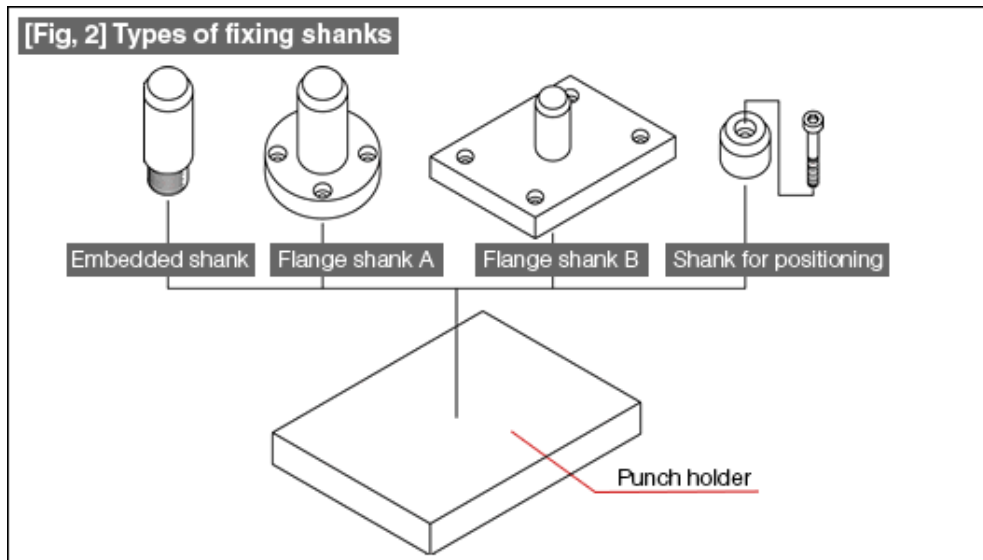
The relationship between the shank and the punch holder is shown in Fig. 1. The punch holder is the part being the base, and the shank is installed above it.

A shank is a part with the shape of a pillar, and is used for installing the top die of a relatively small die in the slide of the press machine. The standard diameters of the shank are 25, 32, 38, and 50 mm. These sizes are a legacy from the sizes in inches. Care should be taken because there are some old machines in which the size is not 25 mm but 25.4 mm. The lengths used are about 50 to 65 mm.



The materials used for shanks are SS400, S50C or equivalent, or FC250.

Embedded shanks and flange shanks are used for fixing the top die. Apart from these, there are shanks for positioning and free shanks (see the descriptions in Lesson No. 171).



Embedded shank

One end of an embedded shank has threads cut on it. The shank is screwed into the hole in the punch holder. After firmly screwing down, sometimes some measure is taken to prevent it from rotating. This is procured at the time of ordering the die set very often.

Flange shank A

This is a shank having a circular flange. Generally, the shank is installed at the center of the die. (In a die with an eccentric load, the position of the shank may be shifted to match with the eccentricity of the load.) In a die having the knock out mechanism (used frequently in blanking dies of the inverted placement structure), an embedded shank may become an obstruction. A flange shank is used in such situations.

Flange shank B

This is a shank having a square flange. While a round flange shank can be machined integrally, this type of shank is very often prepared by combining a standard plate and an embedded shank. This is used when a large area is to be covered by the flange.

Shank for positioning

When the die becomes large, it becomes dangerous to install and retain the top die using a shank (the top die can fall off). In such cases, the top die is fixed using a punch holder. However, when it is necessary to match the centers, a short one is used with respect to the diameter of the shank.

Free Shank Design and Guide Post Length

A free shank (see Fig. 1) is made up of two -- a shank holder and a shank head. The shank holder is installed in the slide of the press machine, and the shank head is installed in the die. The installation is done so that the top part of the shank head is caught in the groove in the shank holder.

This shank has the function of transferring the pressing force to the punch holder and of pulling up the punch holder. There is a considerable play between the two parts.

Because of this, the relationship between the top die and the bottom die should always be maintained by the guide posts and the guide bushes.

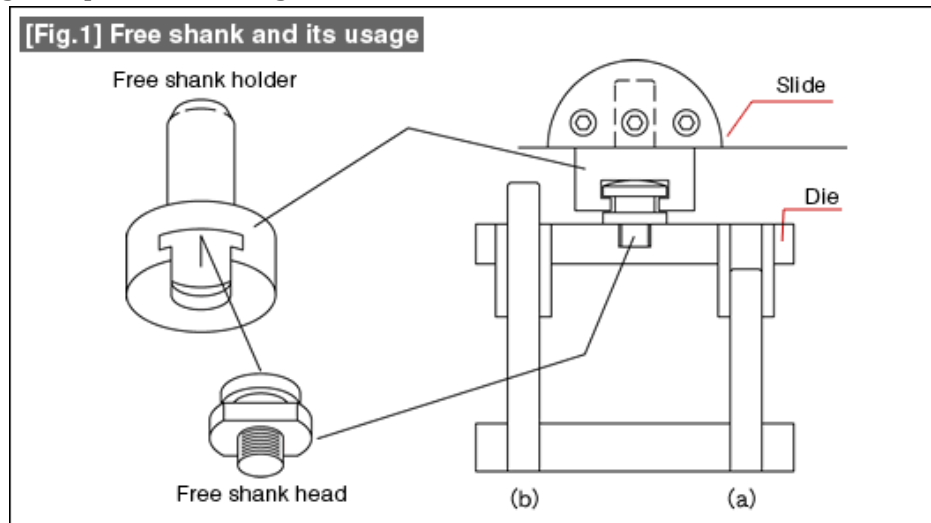


Fig. 1 (a) shows the relationship between the post and the bush when the die is at the top dead center.

Fig. 1 (b) shows the relationship between the post and the bush when the die is at the bottom dead center.

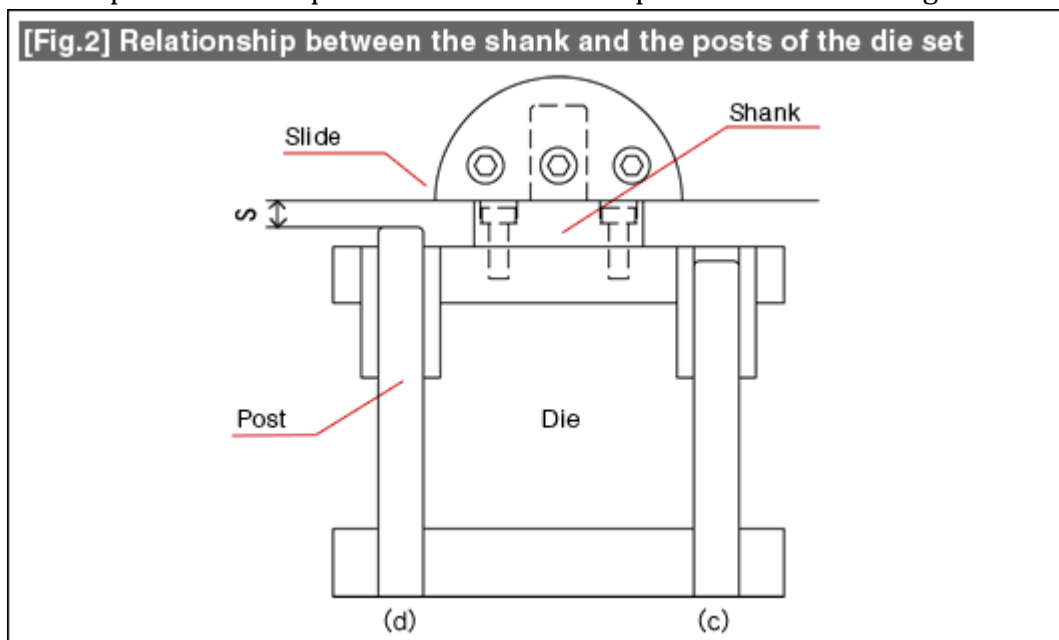
At this time, it should be made sure that the top end of the post does not hit against the bottom surface of the slide.

When the punch and the die are reground, the die height becomes smaller thereby making the gap smaller between the top end of the post and the bottom surface of the slide. The design should be made such that this gap is present and there is no hitting of the one against the other even after regrinding has been repeated several times and the life of the die is approached.

There are two purposes of using a free shank.

One is to maintain the relationship between the punch and the die using posts and bushes, so that the work can be done without this relationship being affected by the press machine. The other is to simplify the setting up of the die.

The relationship between the post and the shank is explained below. See Fig. 2.



Care should be taken about the post length in the case of a die constituted as a die set.

Normally, as shown in Figure 2 (c), at the bottom dead center, it is ensured that the top end of the post is lower than the top surface of the punch holder (even when the die height has become lower after regrinding).

If due to some reason, the top end of the post projects beyond the top surface of the punch holder as shown in Figure 2 (d), a flange shank should be used thereby maintaining the relationship "s" between the bottom surface of the slide and the post.

A very serious accident will occur if the top end of the post hits against the bottom surface of the slide. Sufficient care should be given in the design regarding this aspect.

Design of Punch Holders

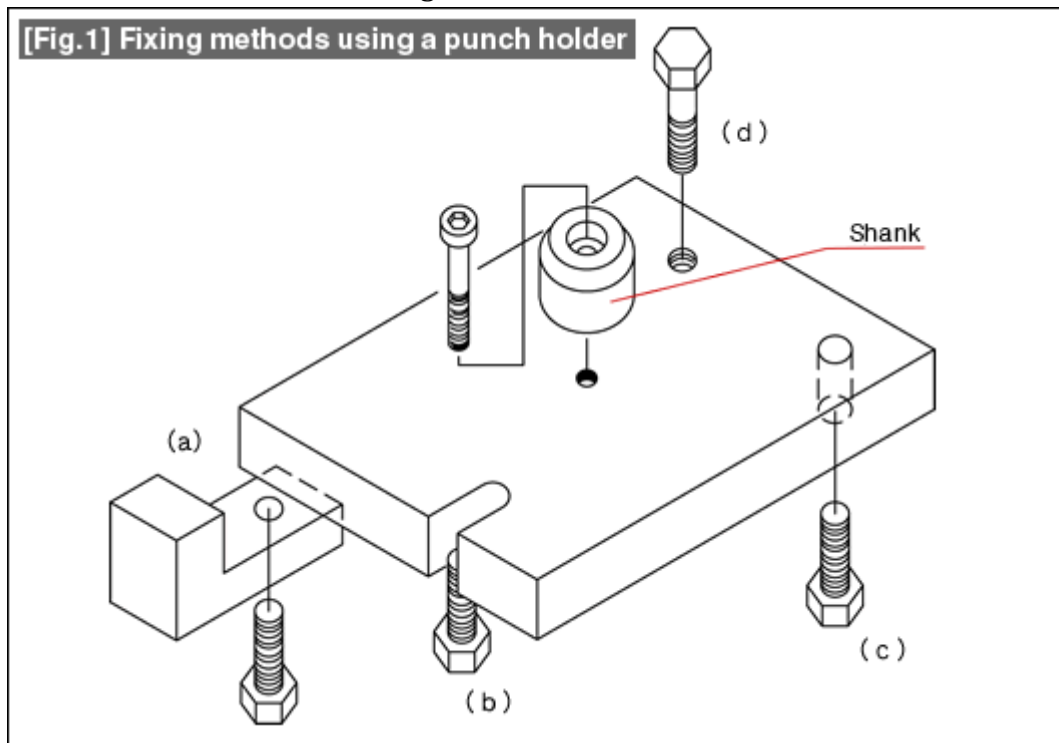
A punch holder is a part that holds the top die. Except for special cases (such as directly providing a shank to the punch, etc.), a constituent part of the top die is mounted in the punch holder.

A punch holder also serves as supporting the rigidity of the top die.

In the case of a die having a structure in which a spring is used in the top die, the length of the holder may also be adjusted in some cases to match with the length of the spring.

In the case of large dies in which the mounting of the top die to the press machine becomes unstable with only a shank, the mounting is done using a punch holder.

Fig. 1 shows some method of mounting.



The method (a) assumes that the fixing is done using a clamp. The punch holder remains in the shape of a plate, and there is nothing addition to be done.

The method (b) is one in which the fixing by a bolt is done using a U-shaped groove. It is necessary to design the U-shaped groove to match with the size of the bolt.

The method of fixing (c) is one using a bolt and a hole drilled in the holder.

The method of fixing (d) is one using a bolt and a threaded hole drilled in the holder.

The above are the most commonly used methods for fixing a punch holder.

In the case of the methods (a), (b), and (c), the preparations become easy if the thickness of the punch holder is standardized.

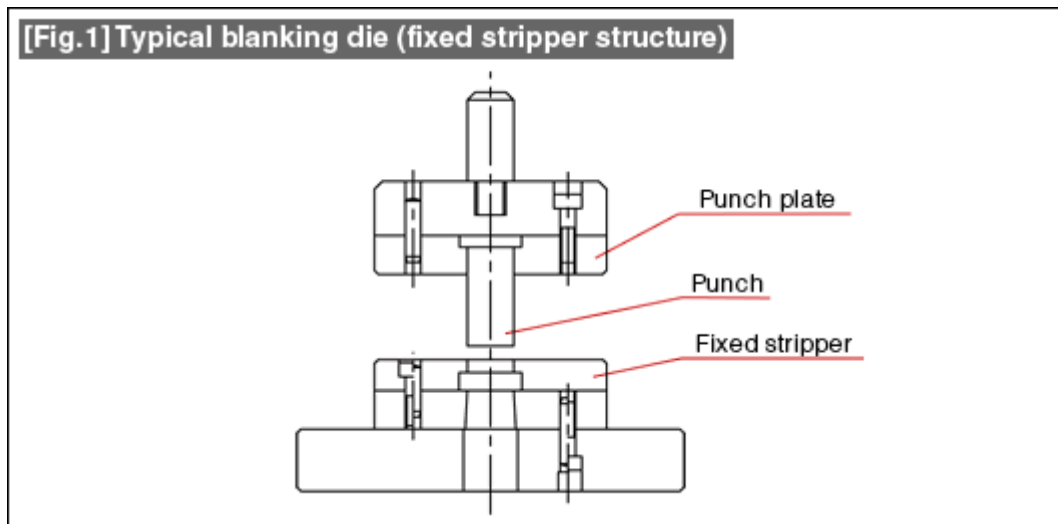
In the case of the methods (b), (c), and (d), it is necessary to determine the position of the U-groove or the position of the hole to match with the specifications of the press machine.

The thickness of a punch holder is a very important factor. Its periphery can be left as it is in the welded state.

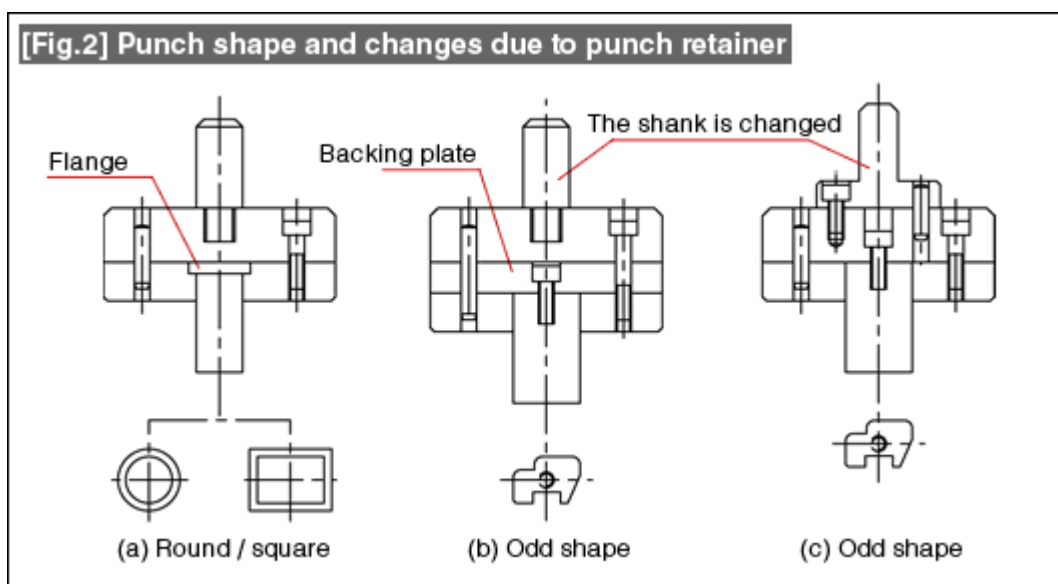
When it is necessary to align the center of the press machine and the center of the die, it is convenient if a positioning shank is affixed.

Design of Punch Plates

The designing of a punch was described in Course [No. 129](#). At that time, it was explained that when the punch becomes small it becomes difficult to hold it independently, and that therefore the method is used of fixing it by embedding it in a plate. This plate that holds the punch is called a punch plate. Fig. 1 shows a typical construction of a fixed stripper type structure using a punch plate.



In the fixed stripper structure, the position and the verticality of the punch is provided by the punch plate. In this method, the punch is lightly press-fitted into a hole in the punch plate. Light press-fitting is driving the punch inside the hole by hitting it lightly. Hard press-fitting is not desirable because it causes the punch plate to get warped or deformed. It is also necessary to consider preventing the punch from coming out the hole and dropping off (punch retainer). The details of this in terms of the relationship between the shape of the punch and the punch retainer are shown in Fig. 2.



The method (a) is an example of punches with simple shapes such as round and square. Such punches are very often prevented from falling off by providing a flange in the punch as a punch retainer.

The method (b) is an example of an odd-shaped punch which is formed by electrical discharge wire-cut machining. Threads are cut in the punch and the punch is fixed to the punch plate (backing plate) using a bolt so that the punch is retained.

The method (c) is an example in which the cross-sectional area of the punch is relatively large. When the cross-sectional area of the punch becomes large, the backing plate is eliminated, and the punch is directly fixed to the punch holder. A method of fixing by bolts is shown here for retaining the punch. See the changes in the shank by comparing the figures (b) and (c). This example is shown here as one in which the method of attaching one component also affects other components and changes them.

Fig. 3 is an example of designing the hole in a punch plate.

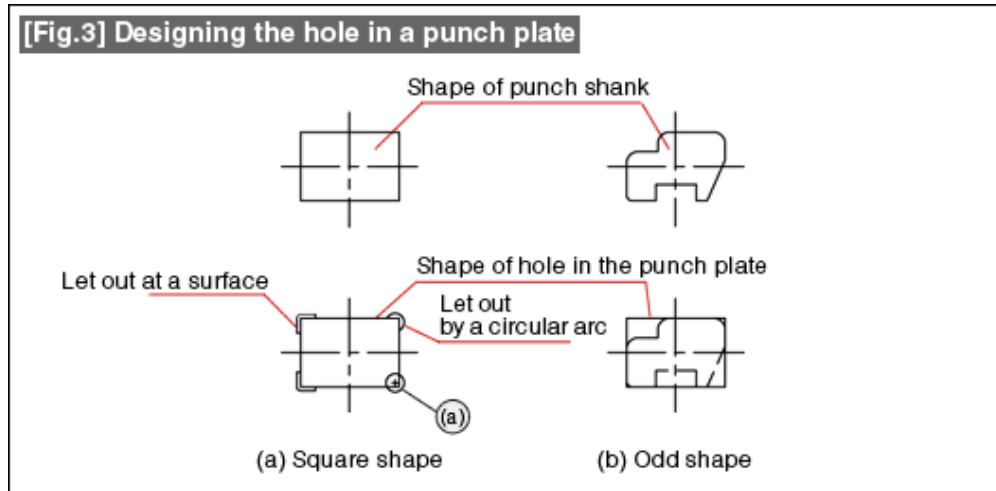


Figure (a) shows an example of a hole for a square shaped shank. The corner parts become problems in the case of a square shape. Although very often the corners get stuck and the punch does not enter the hole, sometimes due to unawareness of it, the plane surface part is widened thereby ruining the punch plate. In order to prevent this, this is an example in which the corner part is let out thereby making the assembling work easy. The part shown in (a) indicates that, when letting a corner out at a circular arc part, it is good to shift the center of the circular arc towards the inside.

Figure (b) is a technique used when driving an odd shaped punch in a hole. There is no need to match the shape of the hole exactly with the shape of the shank, but it is good to design the hole with a simple shape while taking care only about the key parts.

Design of Blanking Dies

A blanking die of the fixed stripper type is shown in Fig. 1.

In this lesson, we will be looking at the role of the fixed stripper of this construction.

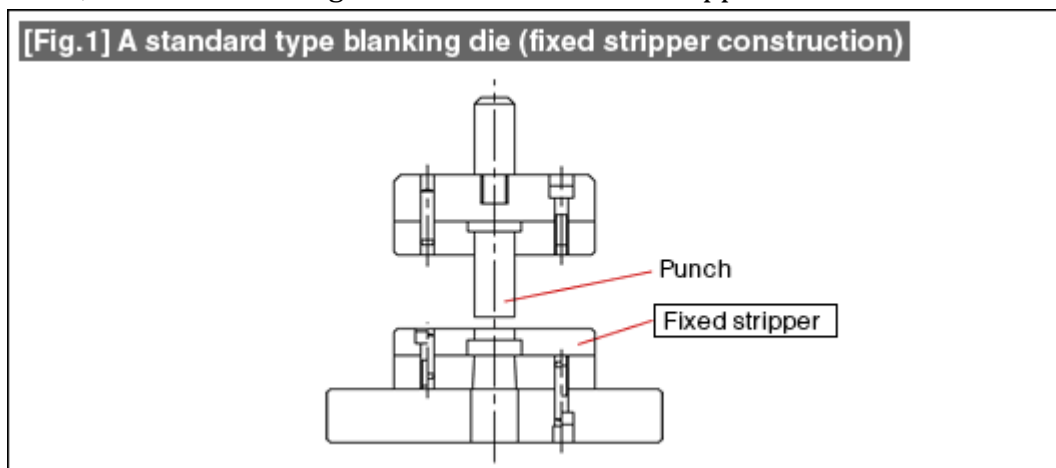


Fig. 2(a) shows the state after the punch has punched through the material. The "blanked item" passes through the die and falls down.

The material in which the punch has penetrated through will be in a state in which it is biting the punch. As is shown in Fig. 2(b), it is necessary for the punch to get detached from the material which is biting it.

Generally, the material would be biting the punch relatively strongly. The strength of this biting is said to be about 5% of the punching force.

It is necessary to remove the punch from the material efficiently. This is done by the stripper.

Fig. 2(c) shows an image of a fixed stripper.

Since it is easy to scrape off the material using a fixed part (stripper) through which the punch passes and since it is efficient, this is used frequently in blanking dies.

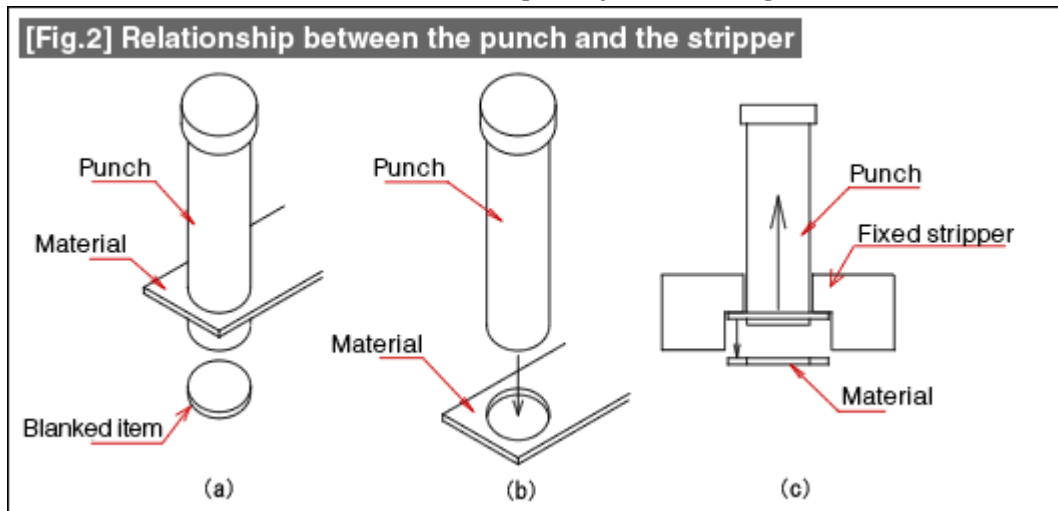
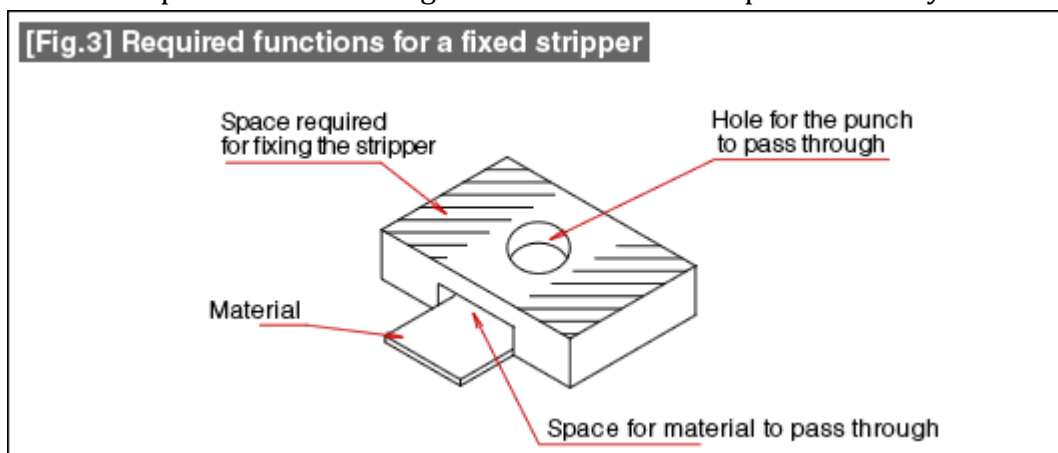


Fig. 3 shows the required functions for a fixed stripper. Firstly, it requires a hole for the punch to pass through. In general, the hole has a size so that the punch can pass through it easily, and it does not require much accuracy.

Below the hole for the punch to pass through, a space is required for the material to pass through. Although it is possible to allow for a large space, it is necessary to restrict the width of the material so as to suppress its sideward wavering thereby making the operations easy, and to determine the space in the up-down direction again so as to make the operations easy.

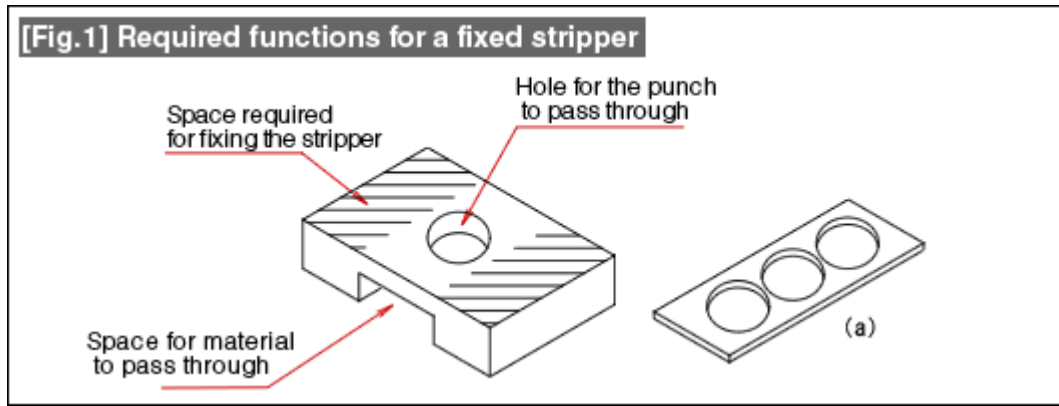


With the consideration of these points, some changes become necessary. These will be explained in the next lesson.

Design of a Fixed Stripper

In the last lesson, we discussed the required functions for a fixed stripper and explained that they had to be as shown in Fig. 1.

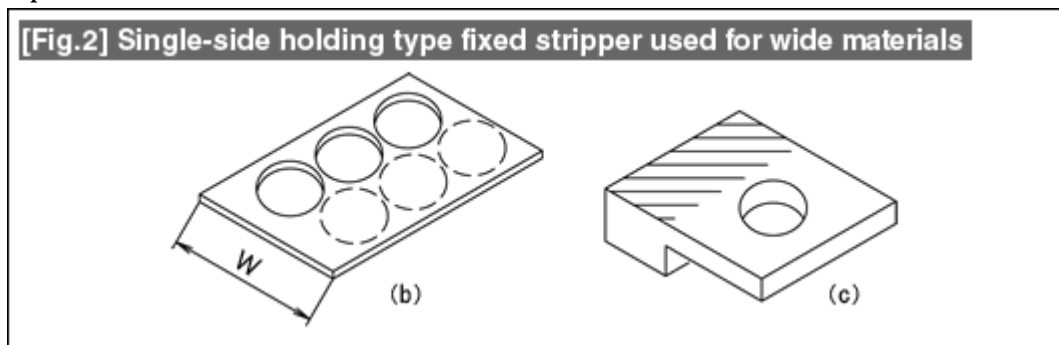
This shape is a basic shape of a fixed stripper, and as is shown in Fig. 1(a), this shape assumes that the blanks are punched in one row with a fixed width of the material.



In contrast with this, there are times when the blanks are to be punched in two rows from a wide material as is shown in Fig. 2(b). In such cases, as is shown in Fig. 2(c), the stripper can also be made to have a single-side holding shape.

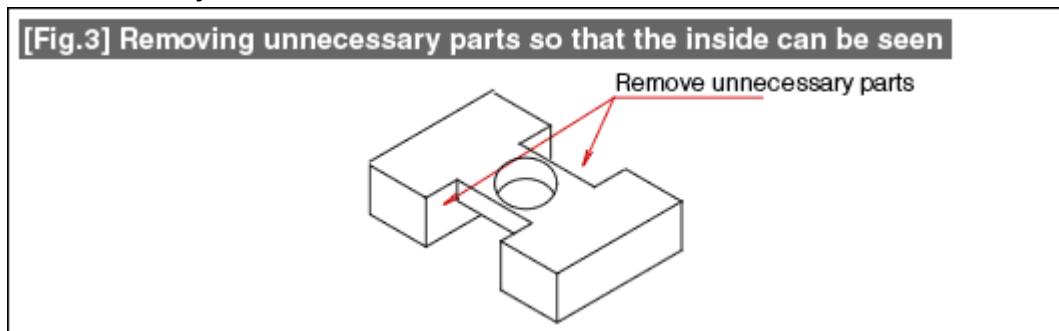
Although the strength becomes weaker, since the part that is being processed can be seen, there is the advantage that the operations become easy.

The disadvantage of a fixed stripper is that the part that is being processed cannot be seen because the stripper acts as a cap on it, and hence sometimes the operator may complain of uneasiness about the operations.



In order to eliminate this disadvantage, as is shown in Fig. 3, sometimes the unnecessary parts are removed thereby making the inside visible.

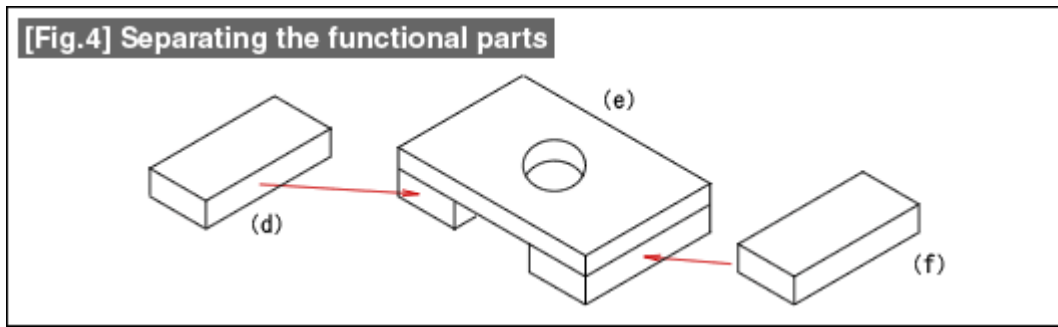
In the case of a relatively small stripper, there will not be much of a load even if parts of an integral stripper are cut away.



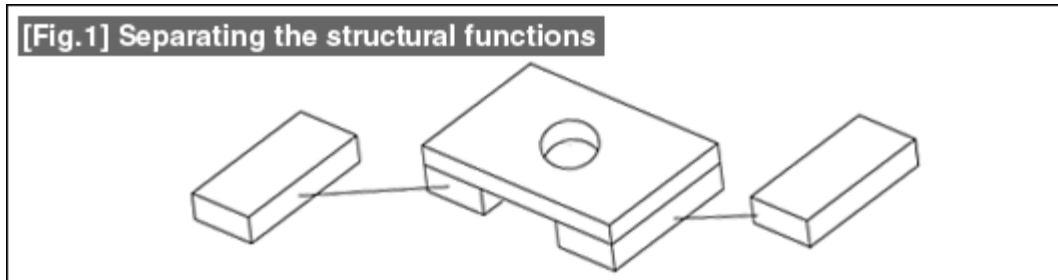
However, if the stripper becomes large, this becomes a problem. In such cases, as is shown in Fig. 4, the stripper is prepared by separating the parts of the stripper functions from the parts creating the space for the material to pass through.

Although the number of parts constituting the die becomes larger, preparing the parts becomes easier.

The decision of whether to form the stripper in one unit or in terms of divided parts should be made considering whether making the machining easy or the cost is important.

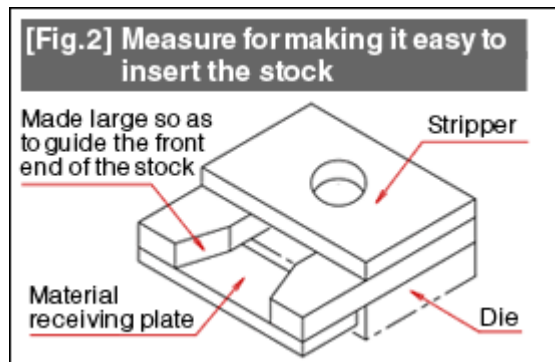


As shown in Fig. 1, a fixed stripper can be thought of as being composed of two parts, namely a stripper portion and a stock guide portion.



If the stock guide portion is made so that it is easy to insert the stock, the die becomes easy to use in press operations. If the stock guide portion is made a separate part, it is possible to make the stock guide long as shown in Fig. 2, and in addition, to provide a stock receiving plate so that the stock is placed first and then pushed in.

If the die is small, there is not much effect on the press operations even if the fixed stripper is prepared integrally with the die, but if the die becomes large, it becomes cumbersome to insert the stock into the die. This is a countermeasure for such situations.



During processing using a coiled stock, once the stock is inserted in the die there will be no problems for some time.

In the case of processing stocks of fixed lengths, when the stock is inserted from the front of the die and the processing is carried out towards the deep end, a stock table for supporting the stock is placed at the front of the die so that when both hands are used for operating the press buttons of the press machine, the stock will not slide and fall off when the operator takes his hands off the stock.

Therefore, very often, when about half the length of a fixed length stock has been processed, the stock is withdrawn and inserted and processed again from the other end. If this is not done, it is difficult to carry out the work (and also dangerous). However, it may be difficult to carry out the work because the stock may come above the press buttons of both hands.

In view of this, sometimes the processing is carried out by moving the stock in the left – right direction. Even in such operations, the press machine is operated by taking both hands off from the stock and pressing the buttons of the press machine. If the die is prepared without thinking about this, the stock will droop when both hands are taken off it, and it becomes impossible to carry out

the work. Fig. 3 shows a measure for carrying out the processing while making the stock move in the left – right direction.

