Stamping Dies design textbook for Website

JETRO SUPPORTING INDUSTRY PROGRAM

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1. Designing of Blanking dies

1.1 Outline of designing blanking die

Blanking dies are intended to blank out the desired shape shown under Diagram 1.

Blanked out items is sometimes the final shape, or requires the element of succeeding procedures such as bending or drawing.

Diagram 1. Blanking

Diagram 2. Indicates the standard blanking die structure. This is fixed stripper structure die. Die sets are made of “Upper dies” (composed of shank, punch holder, punch plate and punch) and, “Lower dies” (composed of Stripper, die, and die holder)

Diagram 2. Standard Blanking dies

Just as indicated in Diagram 3, the upper die is attached to the slides of stamping machines. In this example, the “Shank” attached to the upper die holder is fixed to the shank holder found upon sliding of stamping machine. This method usually applies to fix relatively small –sized upper dies.
On the other hand, the lower die is fixed to the "Bolster plate" of stamping machine.
An important factor to consider in this set up of die is the "Blanking clearance".
In this example, it is a must to adjust the clearance upon setting the die sets on the stamping machine. These kinds of dies are called "Open Dies". We use terminologies such as "Die preparation: Kanagata dandori" meaning setting of dies to stamping machines. In Open dies, clearance may vary depending on the level of skill of the worker.
Which means, there are always possibilities that the finished product quality may become different every time the worker sets dies on the machine.
To avoid such incidence, we utilize the guide post and guide bushing as those are indicated in Diagram 4, so that the upper-lower die relation is kept intact within the die set.
In actual workmanship, there are many similar dies mentioned above to keep the upper & lower die relation.
When punch holder, guide bushing, guide post and die holder are placed in one unit, we call this as "Die set". When put together, this is called dies with die set.

Diagram 4. punch & die positioning

1.2 Design flow of blank die
The illustration of design flow is indicated in diagram 5, prior to the actual designing of blank dies. It is an outline of the design flow. Some are simplified and some are explained in details.

Diagram 5. Design flow of punch & blanking die sets
Each designed part is presented in layouts as are indicated in Diagram 6, and are assembled as in Diagram 7.

“Blank layouts” refer to material dimensions which can blank out without any problem as these are indicated in Diagram 8.

“Feed bridge” and “Edge bridge” are necessary factors for one to determine the material dimensions. Those bridges are indicated in Diagram 9. After all, material width as well as feed length will have to be determined. .

![Diagram 6. Arrangement of Parts](image)

![Diagram 7. Assembled die set](image)

![Diagram 8. Blank](image)

![Diagram 9. Blanking layout](image)
Table 1. Bridge width dimension

<table>
<thead>
<tr>
<th>bridge width</th>
<th>bridge dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Over $1.5 \times t$ or $\geq 0.7\text{mm}$</td>
</tr>
<tr>
<td>B</td>
<td>$\geq A \times 1.5$</td>
</tr>
</tbody>
</table>

Feed bridge: A  
Edge bridge: B  
Material thickness: t

You may refer to Table 1 to determine the “Bridge width”. First, you must decide the bridge width. Next, you will decide Edge Bridge. Too small bridge-width will cause abnormal shearing surface which will also advance the generation of blanking burrs. On the other hand, too large bridge will cause wastage of materials.

One must tryout several blank layouts as these are indicated in Diagram 10., so that material wastage may be minimal.
1.4 Designing the Blanking dies

“Dies” are considered very important tools in the context that these tools determine the final shape of the product. Die holes made on the die plates must be exactly the same shape and dimension as the finished product (Diagram 11).

![Diagram 11. Shape & dimension of Die hole](image)

So far, explanation is given from the “Plane view shape” points. Another point necessary to consider is the “Cross-sectional view” (indicating the die plate thickness) This activity is important, because the long duration of rubbing of materials on the side surface of the die hole may cause burn and deformation in the process. To avoid the incidence of potential damage, one must select the style of cross section type of die hole indicated in Diagram 12. Set 3-4 layers of materials will accumulate at the area (s) of dies, and the rest of materials will drop down.

![Diagram 12. Cross sectional shape of blanking dies](image)
In the blanking works, “Lateral force” occurs during blanking. This occurrence might cause the die plate to crack if there is not enough distance from the outline of die hole to the circumference of the plate. Diagram 13. Indicates general guideline for the distance between the outline of the die hole to the circumference of the plate.

\[ A \geq 1.5T: \text{straight area, gentle curve} \]
\[ B \geq 2.0T: \text{shape with an angle} \]
\[ C \geq 1.2T: \text{Arc area} \]

T: die plate thickness

Diagram 13. Distance from die contour to plate edge

In general, die materials which has undergone heat treatment to set SKD11 materials into 60HRC are considered “Standard die materials”. One may use the alternative materials such as SKS3 and similar ones when the volume of order seems small.

1.5 Designing of the fixed stripper

Let us explain the role of the fixed stripper. Diagram 14(a) indicates the condition where the punch has blank out material. Blanked - out products will then drop down thru the die hole. At this juncture, the pierced material is still attached to the punch (Diagram14(b)). It is necessary to separate the attached material(s) from punch. Usually, materials are attached firmly to the punch. According to a study, the attachment force of materials to the punch is approximately 5% of the blanking force. One must successfully remove the materials from the punch. It is the “stripper” which takes that role of removing the material(s). Diagram14(c) shows the appearance of the stripper.
In the blanking works for thin plate fabrication, the fixed part (stripper) where the punch passes thru is used to scratch out materials efficiently. Diagram 15. Shows the important functions of the fixed strippers. First, the hole that allows punch to pass thru is necessary. Generally speaking, the size of the hole is for the punch to easily pass thru, and not much of precision is required. There is no problem as long as the size of the hole is the same size as the die hole.
It is necessary to provide space to allow materials to pass below the hole where the punch passes thru. Generally speaking, it is set 5～8×as material thickness. It is also required to control the material width, so that sideward shaking can be suppressed and enable one to work easily.

There are some variations on the stripper. Diagram 15 is the standard shape of fixed stripper. It is designed to blank out certain material width in one raw as indicated in Diagram 15(b).

On the other hand, there are times when there is a need to blank out 2 rows from wide material. In such case, the stripper is set in a cantilever style as indicated in Diagram 16.

The stripper actually weakens the strength but the workability becomes even better because the operator can see fabrication of parts.

The demerit of the fixed stripper is that the fabrication of parts becomes hidden because of the cover, which makes the operator anxious.

To makeup for such demerit, unnecessary portions are removed as shown in Diagram 17 so that inside becomes visible.
One may scrape out the stripper from one piece without much burden if the size of such fixed stripper is relatively small. But then this becomes difficult if the size of the fixed stripper becomes bigger. In such case, the fixed stripper is fabricated separating the functional parts and parts where it creates space for materials to pass. Although the number of parts pieces becomes greater, parts fabrication, on the other hand become easier. Consider factors such as easy fabrication or cost to decide on whether to prepare one-piece type or split type.

This serves as “guide” to material width creating material space. Sometimes it is also called “Stock guide part”

Easy insertion of materials at stock guide part makes press work easy. If one prepares separate stock guide part just like Diagram 19. Extended stock guide will further attach backing plate, so that materials can be
placed before pushing in.

Diagram 19. devise easy way of receiving materials

As long as it is small sized die, one-piece fixed stripper will not affect much on stamping works. One will encounter difficulties to place material into the die if the sizes become bigger. That is the reason for the countermeasure. In the fabrication of standard-sized materials, materials are placed in front of dies and pushed into the posterior. By doing this, there must be pedestal in between die and worker. Make sure materials will not drop down while the operator releases hands from the material and placing its hands on 2 switches on the stamping machine. That explains why half equivalent length of standard material should be fabricated first, pullout materials, reverse materials are fabricated from opposite side. It is difficult and dangerous if we do not work in this manner. It is sometimes difficult to work in this manner because materials cover two-hand control safety button. Some people fabricate moving materials horizontally just to avoid the way the above manner is done. In this operation, the operator still releases its hands from the material, press two-hand control button to operate the stamping machines. If fabricating dies is done without considering the above, materials will hang down and work cannot be done. Diagram 20 shows the contraption of moving materials horizontally. Material used for the fixed strippers is SKS3. It undergoes heat treatment to create 56HRC.
If the production volume is less, you may also use S50C materials without
any heat treatment.

Diagram 20. Combine “holding & guide” of standard materials
1.6 Designing of piercing die holder

Just as indicated in Diagram 21, extraction force will be applied on lower die.
As a necessity, overall body tries to warp. It is not possible to eliminate such warp totally, but minimizing warp is ideal. Attempt to eliminate warp by just using die plate, you may have to use expensive materials which is wasteful. Make use of minimum thickness of die plate, then use die holder to backup and minimize warping.

Die holder is a part to fix lower dies. The method is presented in Diagram 22. Diagram 22(a) is a method which will fix using clamping. Die setting will be much easier if the clamping height (thickness) is unified. Diagram 22(b) indicates fixing method using U-shape groove. In this type of setting, we must adjust with U-shape groove position of stamping machines. U-shape groove depth is 2~3× that of bolt diameter.

In die holder, it is necessary to provide product trap hole. Such trap hole shape shall be a simple one like circle or square, but in case shape comes with凹凸 just like in Diagram 23(a), 凸 part may be easily get damaged once a simple square trap hole is provided. (shape indicated as NONE good in Diagram 23(b))
Just like “Good shape” indicated in Diagram 23(c), we must provide △ part on die holder to backup weak portions of die hole shape. S50C or SS400 are usual choices as holder materials.

Diagram 23. Relation between die shape & product trap hole

1.7 Designing of blanking punch

In blanking works, die hole and blanking punch must come in same shape. Blanking punch dimension must be smaller than the die hole dimension equivalent of clearance.(Diagram 24) Clearance may be different according to materials. Table 2 indicates clearance for main materials.
In the designing of dies, the basic practice is always to design die parts shape in simple shape as much as possible. The design of the blanking punch depends on the size of punch.

(1) Designing large punch (refer to Diagram25)

For the large- sized punch, because of its large area of punch, we can provide screws and Dowel pins (Knocking pins) at inner part to fix punch. Such illustration is shown in Diagram25 (a). Such shape can be fabricated simply using wire cut EDM. It is a standard form that Diagram25 (b) has been assembled as upper die. Eliminating the punch plate, the structure becomes a simplified one.

Table 2. Clearance for shearing work

<table>
<thead>
<tr>
<th>Work Piece</th>
<th>Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild Steel Plate</td>
<td>6 ~ 10</td>
</tr>
<tr>
<td>hard steel plate</td>
<td>9 ~ 13</td>
</tr>
<tr>
<td>stainless</td>
<td>7 ~ 11</td>
</tr>
<tr>
<td>Brass</td>
<td>5 ~ 10</td>
</tr>
<tr>
<td>soft aluminum</td>
<td>4 ~ 8</td>
</tr>
<tr>
<td>hard aluminum</td>
<td>6 ~ 10</td>
</tr>
</tbody>
</table>

Clearance indicated is based on % vs. material thickness
because the punch is directly attached to the punch holder.
If the shape is a simple circle, the shank and punch can be integrated just
like in the Diagram 25 (c).

(2) Medium-sized punch design (refer to Diagram 26)

This image shows that fabricating the screw and knocking the hole inside
punch of this size is rather difficult.
If the shape comes in simple circle, we can provide flanges and place screw
and dowel pin at flange area to simplify structure without punch plate.
When shape is complicated, place flange at simple part to design similar
form.
Once things mentioned above seem to be difficult, then one may use punch
plate to fix punch.
Please take note that punch plate is NOT an inevitable part.
(3) Small-sized punch design (refer Diagram 27)

If the product shape is small, the punch size becomes small too. In that case, it is difficult for punch alone to fix itself in the upper die. So we embed punch into plate and fix it. This plate fixing punch is called “Punch plate”.

Please refer to Diagram 27(a). Try to set punch as straight as possible. Design “Shoulder-type punch” is used if you find problem in the relation between punch areas and punch length.

Relation of punch and punch plate is designed that punch will press-fit lightly into (insertion made by small plastic hammer to knock in) punch plate hole.

In doing the above, it is set perpendicularly.

It is to attain perpendicular fixing of punch by caulking, so try to avoid this method as much as possible.

Standard punch plate material is S50C or SS400. Thickness of punch plate is ranging from 30~40% of punch.

Diagram 27. Punch & Punch plate design
(4) Punch materials

Standard punch material is SKD11. Expected hardness thru heat treatment is approximately 60HRC. Usual manner of die fabrication is to make use of “wirecut EDM”. This is because wire cut character has good compatibility with SKD11, at the same time it is abrasion resistance. Using SKD11 as standard material, changing the materials to other types depend on process number and product work piece.

1.8 Blanking punch plate design

It is difficult to hold by punch alone if size of punch is small. In this case punch is embedded and fixed into plate. The plate that holds punch is called “Punch plate”. In the fixed stripper structure, perpendicularity and punch position is set by punch plate. Method of fitting is to press-fit lightly. Image of press-fit light means tapping the punch lightly into hole. Press-fit stronger may warp punch plate. We must also take in to consideration how to prevent punch removal and drop out. (prevention of dropping out) Diagram 28 shows the relation of punch shape and prevention of dropping out.

Diagram 28. Change depends on punch shape and attachment of punch
Diagram 28(a) is an example of simple round and angular shape. In this kind of punch, we provide flange (guard) to prevent from dropping out.

Diagram 28(b) is an example of irregular-shaped punch made by wire cut EDM.
Place screw on punch, use bolt to join backing plate (backup plate).

Diagram 28(c) is an example showing that punch section area is relatively large.
You may eliminate backing plate when the section area becomes larger, then directly fix punch plate to punch holder. This is an example of bolt prevented from dropping out. Please compare the difference between Diagram 28(b) and Diagram 28(c). This is an example indicating that depending on manners of parts attachment, it will affect other parts.

Diagram 29 shows the die plate hole design.

Diagram 29(a) is an example of angular shape shank hole. In angular shape, the corner becomes problem area. Corner may catch and may not allow entry. If we do not realize this, we tend to expand the straight side section and damage those.

To prevent this, contraption must be made so as to make assembling easy by giving recess to corner. (X) Indicates when recess is provided at corner by arc, we shift center of arc to inner part.

Diagram 29(b) indicates a contraption how to embed irregular-shaped punch hole. We don’t have to adjust shape finely, but to press the significant points on simple hole.

Usual choice of punch plate materials are S50C or SS400.
1.9 Punch holder design

Punch holder is the part to hold upper dies. Except for some special cases (attach shank directly to punch etc.) all the upper die components are attached to punch holder.
It is also a function of the punch holder to support rigidity of upper dies.
In upper die structure which has springs, we need to adjust the holder thickness according to spring length.
If having difficulty attaching upper die to press machine just by the shank, you may use punch holder to attach.
Diagram 30 shows different ways of attachment.
Diagram 30(a) is assumption of fixture by clamp. You don’t need to do anything on punch holder.

Diagram 30(b) shows fixing U-shape groove with bolt. It is necessary to design U-shape groove depending upon the size of the bolt.
Diagram 30(c) indicates fixing method by hole prepared on holder and bolt.
Diagram 30(d) indicates fixing method by screw hole prepared on holder and bolt.
Above are usual ways to fix punch holder.
It will make setting easier if punch holder thickness is uniform in Diagram (a),(b), and (c).

In Diagram 30(b),(c),(d) is shown the necessity of contraption on U-shape groove position and hole position depending upon the specification of stamping machines.

In punch holder, “thickness” becomes important element. Peripheral can stay in melted appearance.

It is convenient if you attach shank for location setting purpose, in case you need to match center of dies to center of stamping machines.

Usual choice of punch holder materials are S50C or SS400.

Diagram 30. Fixing method by use of “Punch holders”

1.10 Shank design

Shank is a part intended to attach upper die to slides of stamping machines. This part may apply not only to blanking but also to other types of dies. Shank and punch holder relation is indicated in Diagram 31.
Parts that punch holder becomes a base, a shank will be attached on top of it.
Shank is a pillar-shaped part, used for attachment of relatively small upper dies (dies used on stamping machines up to 30t capacity) to the slide of stamping machines.
Standard shank diameters are 25, 32, 38 and 50mm. One must take care using old stamping machines, because sometimes those old machines have sizes like 25.4mm and “inch” indications.
Shank length is usually ranging from 50~65mm.
Usual choice of materials is SS400 or S50C and its equivalent, FC250 types.

(1) Shank types (refer Diagram32)

Stud shank, flange shank are used for upper die fixing purpose.
There are also shanks to position setting purpose.
1) Stud shank

Stud shanks have screw at edge, used to insert screw hole of punch holder. Sometimes one will apply rotating prevention after screwing in.

2) Flange shank

It is a shank with round shape flange. Shank is generally attached to center of die. (Dies with eccentric load must adjust the position of shank depending on the eccentricity)
Dies with knockout mechanism (shown in inverted layout structure of blanking dies), sometimes stud shank becomes obstruction. In this case, flange shanks are utilized.

3) Flange shank B

This shank has square - shaped flange. Unlike the round shape flange shank which can integrate, you have to combine standard plate to stud shank in many cases. This is used when the flange is desired to cover a wide area.

4) Position setting shank

In large die sets, holding upper die by shank becomes dangerous (falling of upper dies).

In such case, upper dies are attached by punch holder.
In case there is a necessity for center setting, use a shorter length against shank diameter.
Usual choice of shank materials is S50C or SS400. There are also casted shank materials which are commercially available.

1.11 Post length of die set

Paying attention to guide post is necessary when die set is used on dies.
This is due to the reason that accurate punch and die relation cannot be maintained if guide post is too short during bottom dead point of die. Just as it is indicated in Diagram 33(a), it is necessary that insertion must be at least 1.5× that of guide post diameter.

Also take note, that during bottom dead point, upper part of guide post just like in Diagram 33(b) must have at least 10mm space between post upper part and slide bottom surface.

This also applies even there will be re-grinding works done on blanking dies which has lower die heights.

In some cases, if guide post upper edge protrudes in the punch holder upper surface, we can use flange shank to maintain slide lower surface vs. post relation.

It will be a major accident if the upper post and slide lower surface will crash. Enough study must be made upon designing.

Diagram 33. Relation between shank & die set post

1.12 Joining part design

(1) size of bolt and location

1) plate joining
Size of the bolt is determined by the relation of dimension (B) from the plate indicated in Diagram34, bolt pitch (F), and plate thickness (T) indicated in Diagram35.

Provision of bolts around is not enough once plate size is large. In such case, it is a must to decide on the location of bolts within plate shown in Diagram36.
2) Joining of block parts

Using bolts shown in Diagram 37 applies to block parts. To avoid damage to bolts, select as large size bolt as possible considering size of the blocks. If there are mixed sizes of blocks in one die, use uniform bolt size considering the balance.

![Diagram 37. Joint purpose bolt of block parts](image)

D: diameter of bolt  
A: A ≥ bolt diameter

3) Bolt diameter and Tap depth

Point is what should be the sufficient depth of insertion of bolts against bolt diameter. This is also related to Tap depth preparation. Generally, Tap depth is about 1.5~3× of tap diameter. Deep tap preparation is very difficult. Minimum depth of insertion of bolt to Tap hole is equivalent to bolt diameter. Standard is for bolt to be inserted into tap hole equivalent of 1.5× that of bolt diameter. Deepest may be 2.5×.

(2) Size of dowel pin and location

Dowel pins are used for setting position of plates and block parts. Dowel pins are press-fit lightly into holes.

1) Size of dowel pin

When you use a dowel pin, dowel pin diameter must be same diameter as that of bolts used for joining, or 1 size bigger than bolt diameter.
2) Location of dowel pin

Dowel pins are usually located as far position as possible within plate shown in Diagram 38. The accuracy of position setting will improved by doing so.

![Diagram 38. Location of Dowel pins](image)

3) Relation of dowel pin diameter to hole

Diagram 39 shows the relation of dowel pin and dowel pin insertion hole.

It is not economical if we create hole depth more than three times that of diameter.
If the insertion of dowel pin depth is less than pin diameter, position setting accuracy will be less.
Diagram 40 shows condition when dowel pin passes thru 3 layers of plates.
In middle plate hole, drill holes are used instead of press-fit holes. Size of hole diameter is approximately dowel pin diameter +1mm.

![Diagram 39. Relation between Dowel pin diameter & hole](image)
Diagram 40. Middle plate handling