Various sheet metal operations

- **Blanking** - It is an operation of cutting of flat sheet of a desired shape. In this operation entire periphery is cutout and the cutout portion is our requirement and remaining portion is wastage. In this operation clearance is provided on punch.

Die = size of product

punch = Die size − 2 clearance.

$$\text{Clearance } c = 0.0032\, t\, \sqrt{\tau}$$

↑ Thickness of sheet. ↑ shear strength of material ($\frac{N}{mm^2}$)

- **Piercing / Punching**

It is similar opertion like blanking. But the difference that holes on sheet is our desired product and removed blank is waste material.

punch = size of hole

Die = punch size + 2 · clearance.

punching / Blanking force $F_{max} = L \cdot t \cdot \tau$

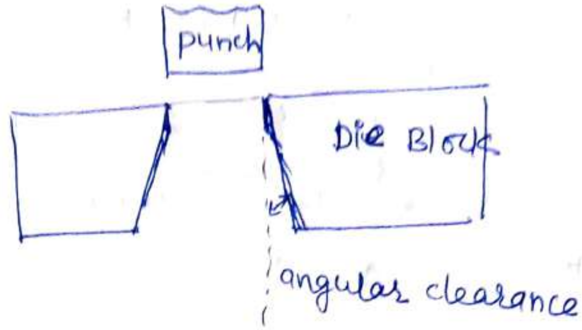
↑ perimeter ↑ Thickness └ Shear strength

$$F = \frac{\pi d t \sigma_t}{\left(\frac{d}{t}\right)^{1/3}}$$

d ⇒ dia. of punch

σ_t → Tensile strength

⇐ for holes smaller than stock thickness (d<t)



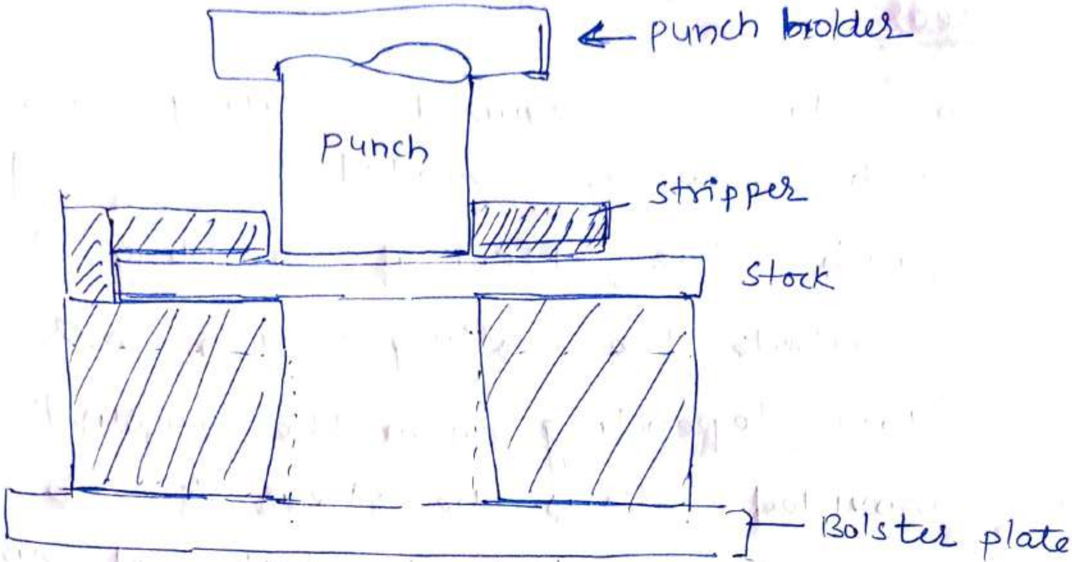
- Angular clearance

In shearing operation, first the material is elastically deformed and then plastically and finally removed from stock strip.
After final breaking, some amount of spring back occurs due to release of stored elastic energy. This will make the blank to cling to the die face unless the die opening is enlarged. This enlargement is reffered as angular clearance or draft.
Draft depends on material thickness and shape of stock used. It is generally vary from 0.25 to 0.75 deg. per side but sometimes used upto 2 degree.

- The angular clearance is provided in the die opening along with a straight portion called as die Land / cutting Land.

→ ~~The long~~ It is made to maintain the die size as per design.

→ die Land = 3 mm For sheet $t \leq 3$ mm
= thickness of sheet (t) $t > 3$ mm



Stripper

→ Due to release of stored elastic energy in the stock left on the die, the stock tends to grip the punch as the punch moves upward. To seperate the stock from punch stripper is used.

→ The force required for stripping depends on material, thickness and size of hole/ blank.

→ Stripping force is generally 2.5 – 20 % of punching force

$F_s = K L t$

- t — stock thickness.
- L — perimeter of cut (mm)
- K — stripping constant.

$K = 0.0103$ For low carbon steel $t < 1.5$ mm

$= 0.0207$ for " " $t > 1.5$ mm

$= 0.0241$ For harder materials.

Types of stripper

- Fixed stripper
- Spring loaded stripper

(a) fixed stripper / channel stripper

→ The stripper is attached at a fixed height over the die block. The height should be sufficient to permit the sheet metal to be feed freely betn. the die surface and surface of stripper plate.

→ The stripper plate is usually of the same width and length as the die block. In simple dies, it is fastened with the same screws which are used for die block.

→ The thickness of the stripper plate should be sufficient to withstand the force needed to seperate the scrap strip from punch. The usual value is 9.5 mm to 16 mm.

stripper thickness $t_{stripper} = \frac{1}{8}\left(\frac{w}{3} + 16t\right)$

w - width of stock strip
t - thickness " "

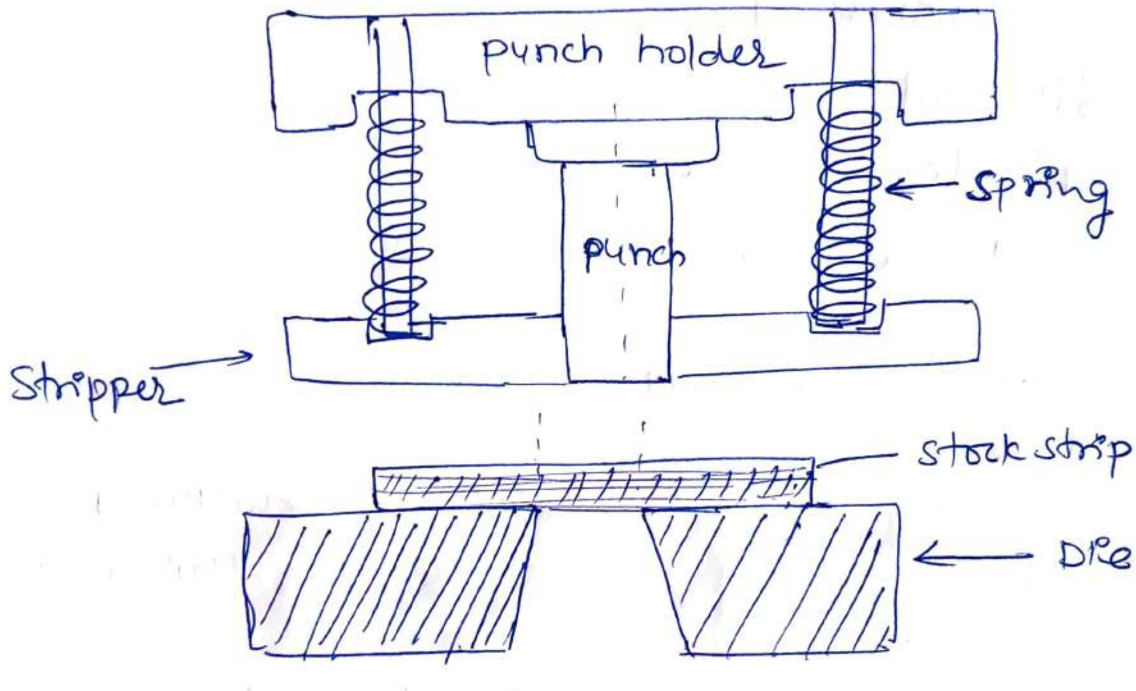
(b) Spring loaded stripper / Floating stripper

→ This Type of stripper is used on Large blanking operations and also on very thin and highly ductile materials where it is desirable to utilize the pad pressure to hold the surrounding stock during the Blanking operation.

→ In this design the stripper plate is mounted over compression springs and suspended by bolts from the punch holder, with the lower surface of the stripper below the cutting end of the punch.

→ As the punch travels downward for the blanking operation, the stripper plate contacts the stock strip first and holds it until the punch clears the strip on its return stroke.

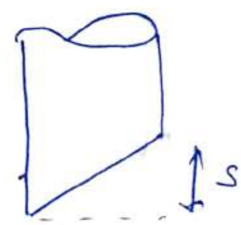
→ As the punch rises, spring pressure holds the ~~spring~~ strip, striping it from the punch surface.



Shear

To reduce the required shearing force on the punch, shear is provided on face of die or punch. The effect of providing shear is to distribute the cutting action over a period of time depending upon the amount of shear provided. Thus the shear is ~~not~~ made so that the contact of stock and punch can be for a period of time. ~~rather~~ By providing the shear only reduces the max. ~~work~~ force to be applied but not total work done in shearing the component.

$$F = Lt\tau \left(\frac{t \cdot p}{s} \right)$$



p - penetration of punch as a fraction.

Ques ~~Estimate the blanking force~~

A Steel washer 44 mm outside diameter, 22.25 mm inside diameter and 1.6 mm thick is to be blanked from a sheet. If the shear stress of sheet metal is 400 N/mm^2. Calculate the max. punch force required and the work done if the % of penetration is 25%.

Sol^n clearance $C = 0.0032\, t\sqrt{\tau}$

$= 0.0032 \times 1.6 \times \sqrt{400}$

$= 0.1024$ mm.

For. Blanking

Die size = blank size = 44 mm

punch size = blank size − 2C

$= 44 - 2\times0.1024$

$= 44 - 0.2048$

$= 43.7952$ mm

Blanking force.

$F_B = L(P.t)\tau$

$= \pi \times 43.7952 \times (0.25\times1.6)\times 400$

$= 22002.708$ N

$= 22$ KN

Work done in Blanking

$= 22 \times 1.6 \times 0.25 \times \frac{1}{100}$

$= 8.8$ KJ

for punching.

punch size = ~~Hole~~ size = 22.25

Die size = blank size + 2C

$= 22.25 + 2\times 0.1024$

$= 22.4548$ mm.

punching force $= L\,(P.t)\tau$

$= \pi \times 22.25 \times 0.25 \times 1.6 \times 400$

$= 11178.4$ N

$= 11.17$ KN

work done in punching

= F × displacement

$= 11.17 \times 0.25 \times 1.6 \times \frac{1}{100}$

$= 4.468$ KJ

Que A hole of 60 mm diameter is to be produced in steel plate of 2.5 mm thickness. The Ultimate shear strength of the plate material is 450 N/mm². If the punching force is to be reduced to half of the Force

using a punch without shear, estimate the amount of shear on the punch.
Take % of penetration as 40%

Sol^n. Punching Force (without shear)

$$F_{max} = L\,t\,\tau = (\pi D)\,t\,\tau$$

$$= \pi \times 60 \times 2.5 \times 450$$

$$= 212\ kN$$

$$\text{work done} = F_{max} \times \underset{(P \cdot t)}{\text{punch Travel}}$$

$$= 212 \times 10^3 \times 0.4 \times 2.5 \times \frac{1}{10^3}$$

$$= 212\ Nm$$

For the punch with shear

$$\text{Total punch Travel} = \text{punch Travel} + \text{shear}$$

$$= (P \cdot t) + S$$

Since work done will be same in punch with shear and without shear

$$F_{max}\,(P \cdot t) = F\,(Pt + S)$$

$$\Rightarrow S = \frac{(F_{max} - F)\,Pt}{F} \qquad \left\{ \because F = \frac{F_{max}}{2} \right\}$$

$$\Rightarrow S = \frac{(212 - 106)\,(0.40 \times 2.5)}{106}$$

$$= 1\ mm$$

~~Die~~ ~~Types of~~

Die Design for sheet metal working

- Types of die ~~according to~~ Based on ~~construction~~ ~~method of~~ Type of operation.

~~(1) simple dies~~

(1) **Forming dies**

These dies change the appearance of the blank without removing any stock. These dies include bending dies, drawing dies, squeezing die etc.

(2) **Cutting dies**

These dies are ~~used~~ to cut the metal. They utilize in the cutting and shearing action. The common cutting dies are blanking die, piercing dies, perforating dies etc.

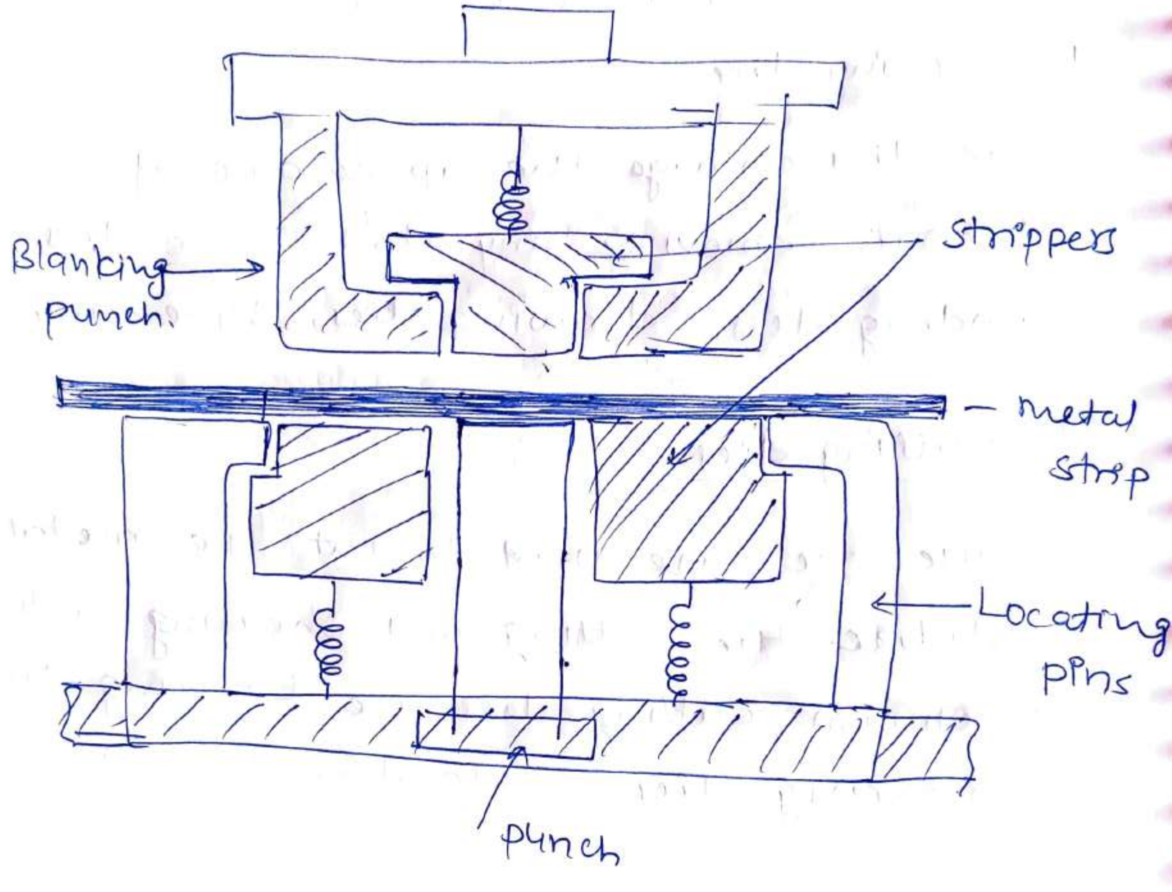
- **Based on Method of operation.**

(1) **Simple dies**

Simple dies or single action dies perform single operation for each stroke of press slide. The operation may be any of the operations listed under cutting or forming dies.

(2) **Compound dies**

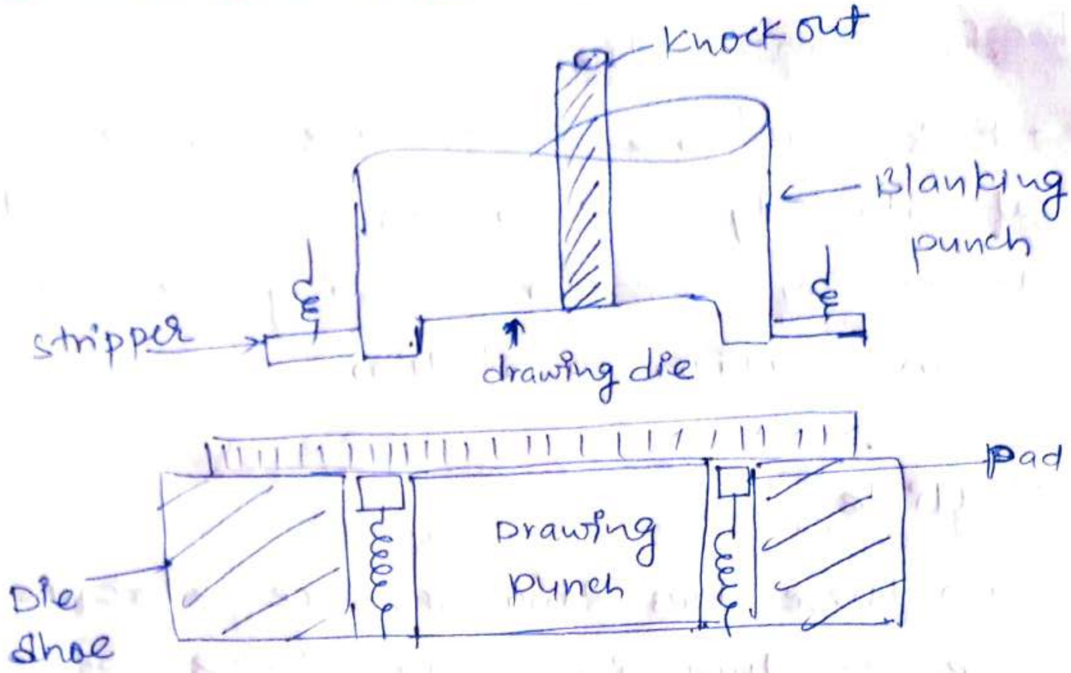
These dies perform two or more ~~than~~ cutting operation during one stroke of press ram at single station. In order to do this both the upper and lower half carry piercing and blanking elements which are directly opposite to each other.



In these dies washer is produced by simultaneous blanking and piercing operation.

(3) <u>Combination dies</u>

In this dies more than one operation may be performed at single station. it differs from compound die in such a way that in this die a cutting operation is combined with a bending or drawing operation

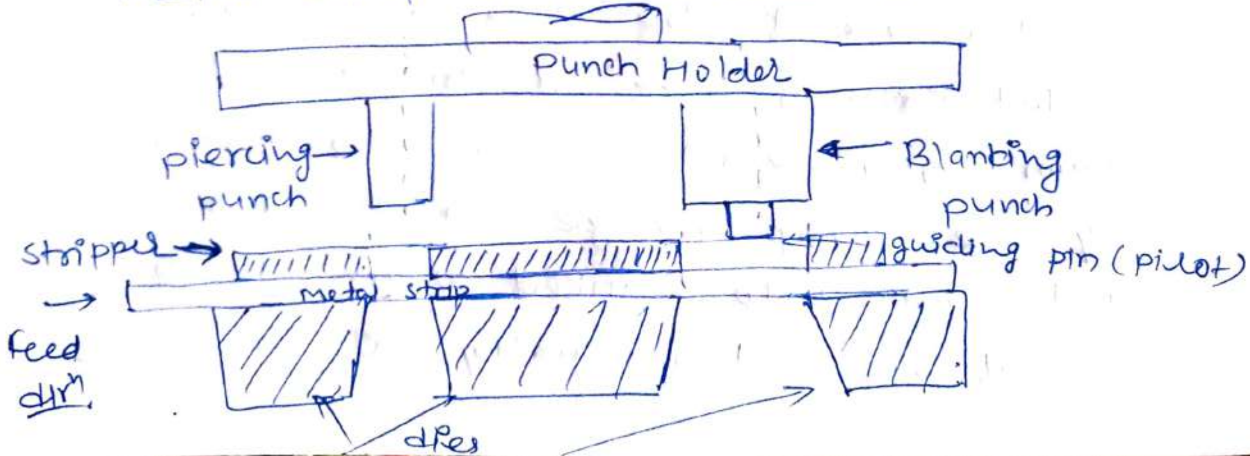


A drawing punch of required shape is fastened to the die shoe. The blanking punch is attached to punch holder. A spring stripper strips the skelton from blanking punch.

A knockout extending through center opening used to eject the part from drawing die.

(4) progressive dies

A progressive or follow on die has a series of stations. At each station an operation is performed on a work piece during a stroke of press. Between the two strokes, metal strip is transferred to the next station.



(4) ~~Transfer~~ Transfer dies

→ It is act like progressive die with a difference of already cut blanks are punched in these by ~~transfer~~ feeding mechanically from station to station.

(5) Multiple dies

→ In these dies two or more workpieces are produce in single stroke because it has multiple stations.

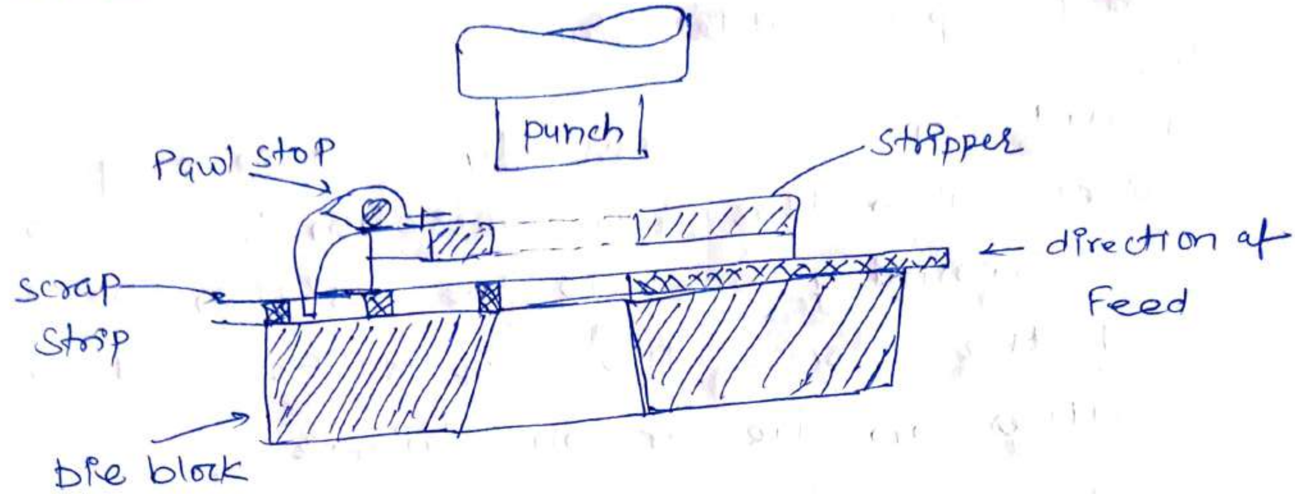
Stock stop

The strip of sheet metal is fed and guided through a slot in the stock guide or through a slot in the stripper plate. After each blanking, the strip has to be advanced ~~or~~ correct distance. The device used to achieve this is called Stock stop.

Types of stop

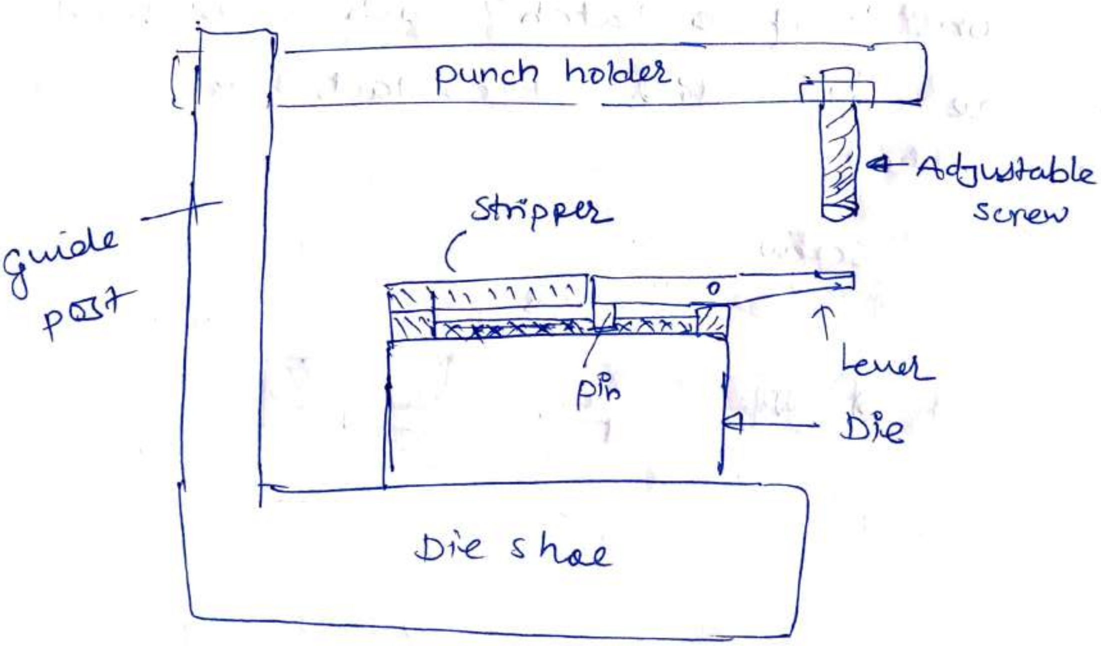
1. Latch stop / Pawl stop / Trip stop.

In this type of stop, a latch is pivoted on a pin fitted into a block on stripper and is held down by a tension spring. The Latch is lifted by the scrap bridge on the ratchet principle and drops into blanked area, as the stock is fed forward manually into the die.



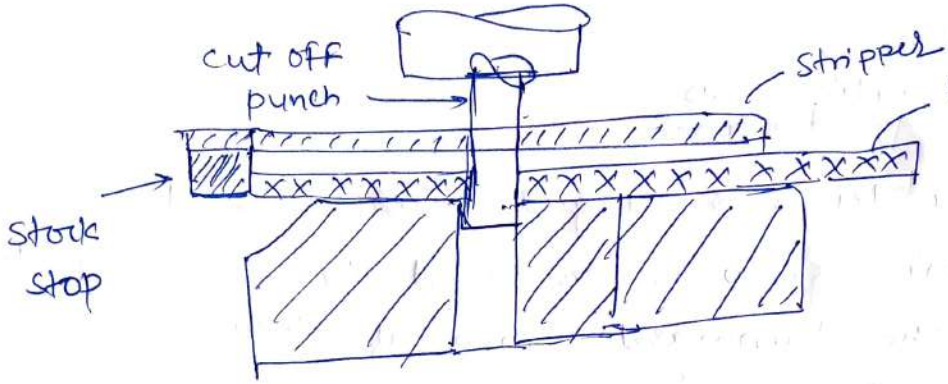
2. Automatic stop.

In this design a hinged Lever is used. An Adjust-able strip screw is fastened to punch holder. During the downward stroke of slide, as the punch cut the blank, this strip screw strikes the end of Lever and lifts it's pin end. On the return stroke, the pin end drops.



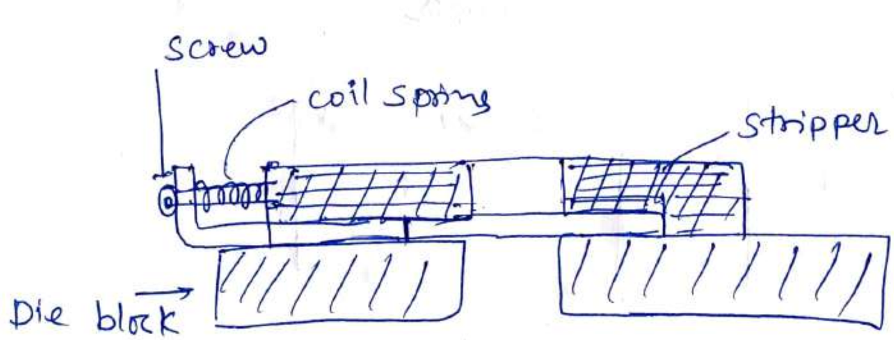
3. solid stop / shoulder stop.

solid stops are extensively used on progressive dies, when the Last operation is a cutt off or trimming one to ~~the~~ position the end of the stock. The stop is Fastened to either on die or on stripper.



4. starting stop

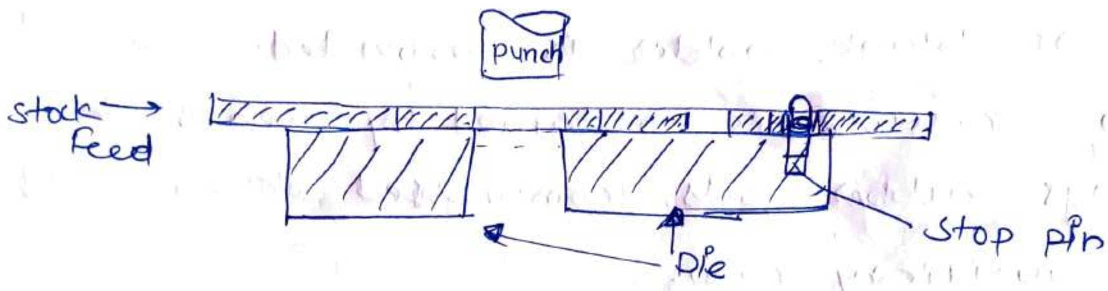
As starting stop or a primary stop is used to position stock as it is initially fed into the die. It is mounted on the stripper plate. It consist of a Latch, which is pushed inward by one end untill it contacts the stripper plate.



5. pin stop

→ A cylindrical pin with or without a head. It is press fitted in die. ~~Those according~~

→ The operator needs to lift the stock over the pin for feeding and hence this pin stop is not suitable for high speed dies.



Drawing and deep drawing

Drawing – Drawing operation is the process of forming a flat piece of material (Blank) into a hollow shape by means of a punch which causes the blank to flow into die cavity.

If the depth of the formed cup is upto half of its diameter, the process is called "shallow drawing".

$$\frac{d}{h} \geq 2 \rightarrow \text{shallow drawing.}$$

If the depth of formed cup exceeds the diameter it is termed as 'deep drawing."

$$\frac{d}{h} < 2 \rightarrow \text{deep drawing}$$

As the drawing progresses that means as the punch forces the blank into die cavity, the blank diameter decreases and causes the blank to become ~~thinner~~ thicker at its outer portions. This is due to the circumferential compressive stresses to which the material element in the outer portion is subjected.

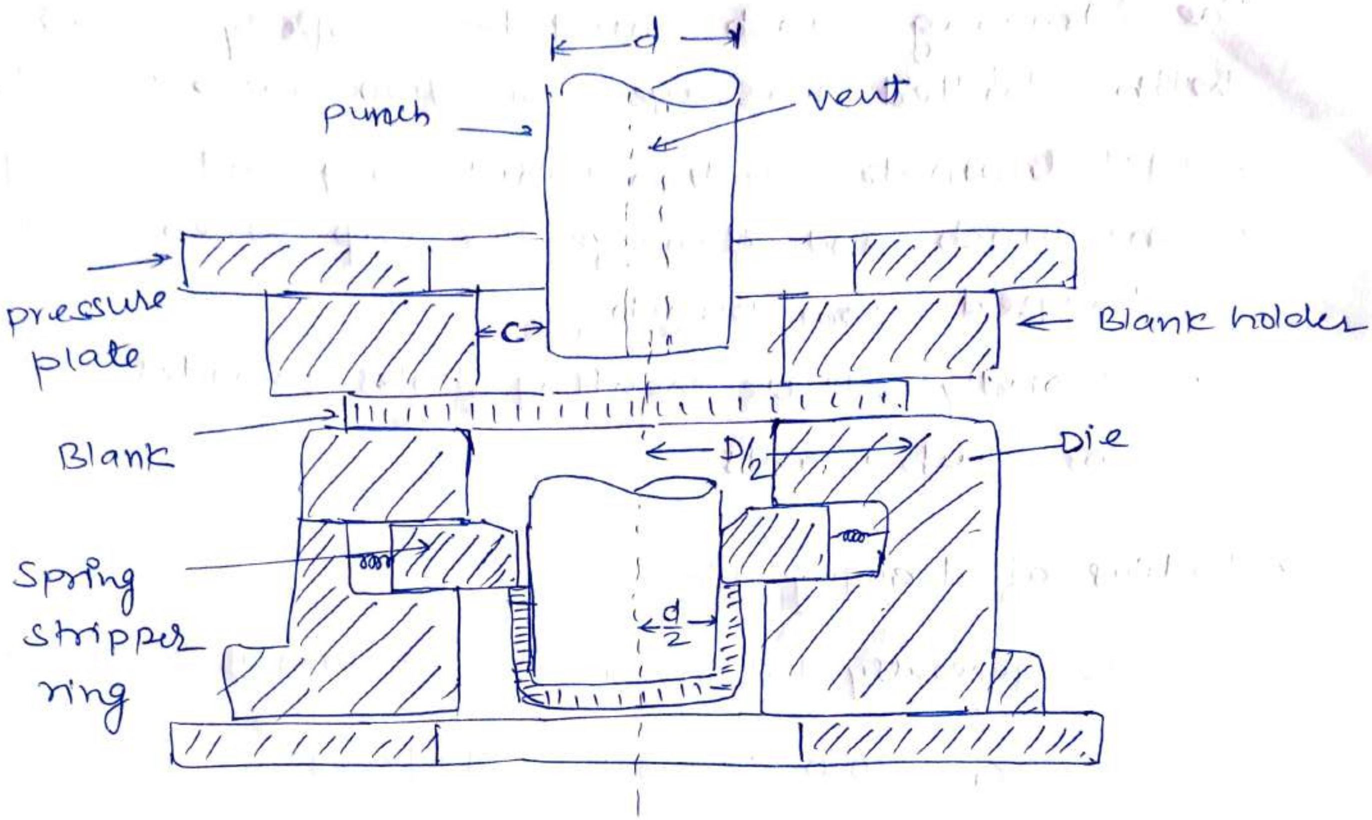
If this stress become excessive, outer portion of blank (flange) will have the tendency to buckle or wrinkle. To avoid this, a pressure pad or blank holder is provided. The holding down pressure is obtained by means of springs, rubber pads, compressed air cylinders or auxiliary ram.

The portion of the blank betn. the die wall and the punch surface is subjected to nearly pure tension and tends to stretch and become thinner.

The portion of the formed cup, which wraps around the ~~cup~~ punch radius is under tension in presence of bending. This part becomes the thinnest part of the cup. This action is called 'Necking' and this is the first place to fracture.

As the ~~the~~ ~~thickness of~~ outer portion remain thicker in compare to inner portion of blank due to blank holder pressure, the wall thickness may become non-uniform.

To overcome this problem ironing is done to make uniform thickness by drawing it again in die cavity.



Drawing ratio (β) or deep drawability

It is the ratio of maximum blank diameter to the diameter of the cup drawn from blank

$$\beta = \frac{D}{d}$$

For a given material there is a limiting drawing ratio after which the punch will pierce a hole in the blank instead of drawing.
This ratio depends on many factors as type of material, amount of friction present etc.

generally $\beta \Rightarrow 1.6 - 2.3$

Reduction ratio (R)

$$R = \frac{D-d}{D} = 1 - \frac{d}{D} = 1 - \frac{1}{\beta}$$

$$\Rightarrow \beta = \frac{1}{1-R}$$

The drawing punch must be properly vented with drilled passage for two purpose. Firstly

- It eliminate suction which may hold the cup on punch and damage the cup when it is stripped from punch.
- Secondly, These venting holes provides passage for Lubricants.

Radius of drawing die

It is generally taken as 4 – 10 times of blank thickness.

$$r_d = 0.035[50 + (D-d)] \times \sqrt{t}$$

punch radius

The edges of punch must be rounded to avoid cutting or tearing the metal. An excessive punch radius increases the tendency of material to buckle.

$$r_p = (3 \text{ to } 6) \times t$$ — thickness of blank.

Draw clearance.

It is provided for avoiding any Jamming of blank betn. die and punch.

It is taken as 1.25 times of stock thickness.

⇒ punch diameter = Die opening diameter – 2.5t

Drawing speed.

⇒ Drawing speed is important because sufficient time should be given to punch to travel otherwise metal can rupture instead of drawing. Proper die design, proper Lubrication help to increase the permissible speed of ram

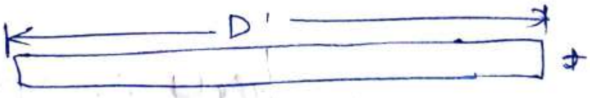
Al → 45 - 52.5 m/min

Brass → 52.5 - 60

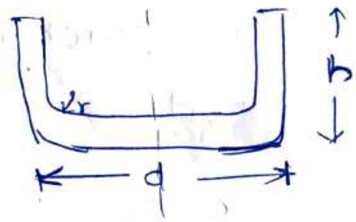
SS → 9 - 12 m/min.

Blank size

It is calculated based on Area method. In this method it is assumed that the surface Area of blank is equal to surface Area of finished shell.



- When shell has sharp edge inside corners or $\frac{d}{r} > 20$



$$D = \sqrt{d^2 + 4dh}$$

- when round corner of $\frac{d}{r} = 15 - 20$

$$D = \sqrt{d^2 + 4dh} - 0.5r$$

- when round corner of $\frac{d}{r} = 10 - 15$

$$D = \sqrt{d^2 + 4dh} - r$$

No. of draws

If the reduction required is ~~greater~~, more than one draw will be needed to reduce the diameter and increase the height of workpiece to the desired dimensions.

In practice, Reduction in diameter

For first draw – 45-50%
IInd draw – 30 %
IIIrd draw – 25 %
IVth draw – 16 %
Vth draw – 13 %

Drawing force

For a cylindrical shell

$$F = \sigma_{yt} (\pi d \cdot t) \left(\frac{D}{d} - C\right) \text{ Newton.}$$

σ_{yt} = yield strength in tension of work material.
t = thickness of Blank.
D, d = Diameter of Blank and shell (part drawn) Respectively
C = constant (0.6 to 0.7)

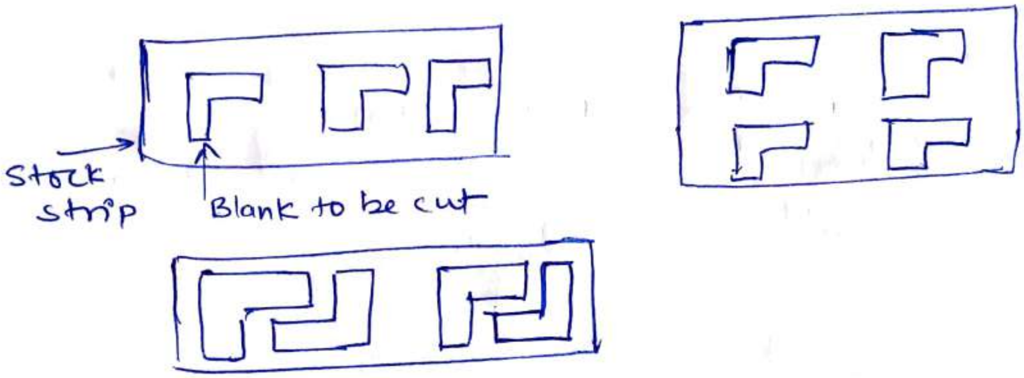
Blank Holding pressure.

It is the amount of pressure to be applied by the blank holder on the Blank.
It should be sufficient to prevent wrinkle or Fracture.
generally it is 33 % of drawing force.
Since tendency of wrinkle decrease with increase in stock thickness, so thick blanks may be drawn without using a blank holder.

⇒ press capacity = Drawing Force + Blank Holder Force + Ironing Force.

Strip Layout

In design of a blanking die set, the first step is to prepare blanking Layout, that is, to Layout the position of workpiece in the stock strip and their orientation with respect to one another. This is called strip Layout.



Following factor influence the stock strip.

1. Economy of material
2. Direction of material gain or fiber
3. strip or coiled stock
4. Direction of burr
5. press used
6. production required
7. Die cost.