Product Design and Production Tooling (PDPT)

Module 1 & 2

Mechanical 6th Semester

By

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Module - 2

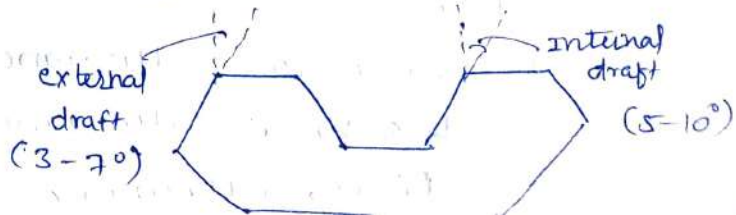
Forging process may be defined as a metal working process by which metals or alloys are plastically deformed to the desired shapes by a compressive force applied with the help of a pair of dies. One die is stationary and other die in a Linear motion. Forging process can be carried out both in cold and hot state of the metal. But unless otherwise mentioned, forging process is considered to be hot forging ~~forging~~ process.

Forging designing factors.

1. Draft angle

It is the angle of taper provided on the wall of forging so as to remove the component from the die impression.

Normally internal draft is provided more than external draft because of shrinkage of material after cooling.



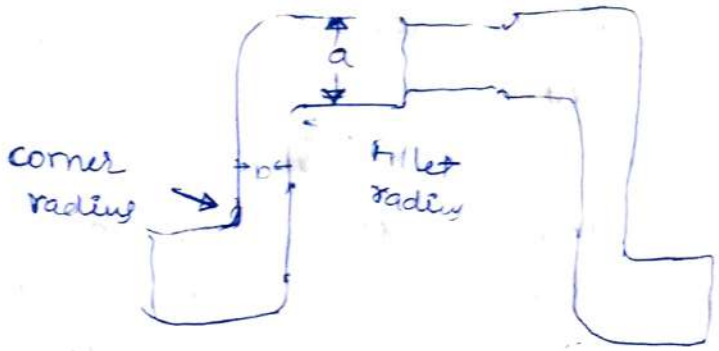
2. Fillet and corner Radius

→ During Flow of meted it is essential to provide an optimum flow path so as to produce a sound forging component. The flow is obstruct-ed when there is a sharp corner on meeting edge of 2 surfaces.

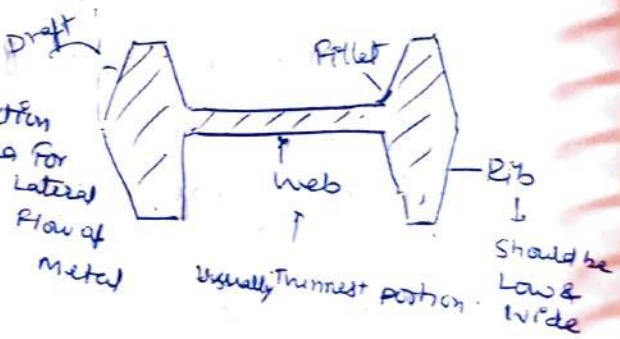
→ so it is needed to provide a corner radius on external surface and fillet on internal surface to produce a defect free component. ~~In which~~

Fillet radius

$$R_f = \frac{1}{3}\left(\frac{a+b}{2}\right)$$



3. Mismatch
4. parting line – should be at Max. cross-section
5. Webs and Ribs
6. Shrinkage and die wear.



Allowances

→ Some extra material provided on actual dimension of workpiece for doing some machining operation or to compensate any shrinkage, is called Allowances.

Forging allowances can be classified as -

1. Shrinkage allowance
2. Die wear allowance
3. Finish allowance

1. Shrinkage allowance.

This allowance is provided to compensate the volume reduced due to shrinkage on cooling of forging component.

generally shrinkage allowance $0.002 \frac{mm}{mm}$

2. Die wear allowance.

→ Forging die generally deals with heated material and compressive force, due to which die cavity

→ After continuous use of forging die, it enlarged due to wear and tear.

→ so to compensate this die wear allowance is provided.

3. Finish Allowance

→ This is the amount of material kept for finish the workpiece dimensions.

→ It should be upto 1 mm per surface.

preliminary operations in Die Design for drop forging.

The art of forging die design aims at determining the minimum no. of steps that lead from starting material (Usually a round or rectangular bar) to the finished shape.

→ Dies are made in set of halves. one half of the die is attached to the ram and other to the stationary anvil.

→ The die halves may be having one or more than one impressions. In single impression dies, the die impression is the finishing impression, and the priliminary forging operations are done on other machines such as forging rolls, upsetters, and benders.

→ Multi-impression dies may have two or more impressions. In these dies, the final shape of product is progressively developed over a series of steps From one die impression to the next. Each impression gradually distributes the flow of metal and changes the shape of workpiece as it is transferred from one impression to the next

Following are the preliminary forging operations that are usually required in shaping the part.

1. Fullering/Swaging.
2. Edging or Rolling
3. Bending
4. Drawing
5. Flattening
6. Blocking
7. Finishing.

1. Fullering :

→ Fullering is usually the first operation performed on the heated bar and its primary function is to reduce cross-section area of the stock

2. Edging or Rolling.

→ It is also called "pre-form Impression". Function is to distribute the metal longitudinally by moving metal from the portions where it is in excess to the portion which is deficient in metal.

3. Bending

→ Bending impression is used for bending the stock when required after fullering and edging.

4. Drawing

→ It is similar to fullering with a difference that fullering reduces the stock at a center place bet^{n}. two ends of stock, whereas the drawing operation reduces the stock size only at one end.

5. Flattening.

→ sometimes there is a need for Flattening the stock before passing it on to the final impression.

→ This is done in Flattening impression, usually very simple and situated in one of front corners of the die block.

6. Blocking

→ These are also called semi-finishing operations. It is a step before finishing which is done for reducing Tool wear in the Finishing operation.

7. Finishing

→ It is the impression where the actual shape is obtained. In this surplus metal will form a flash in

the parting line.

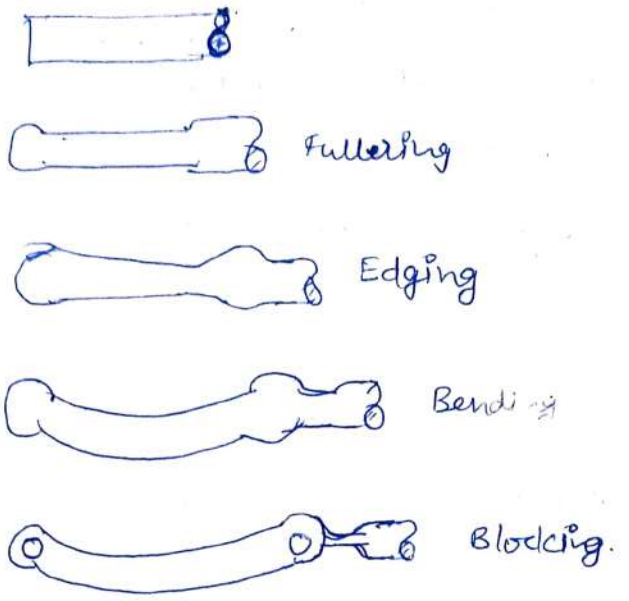


fig: forging sequence of a connecting Rod.

Die Design consideration in drop forging.

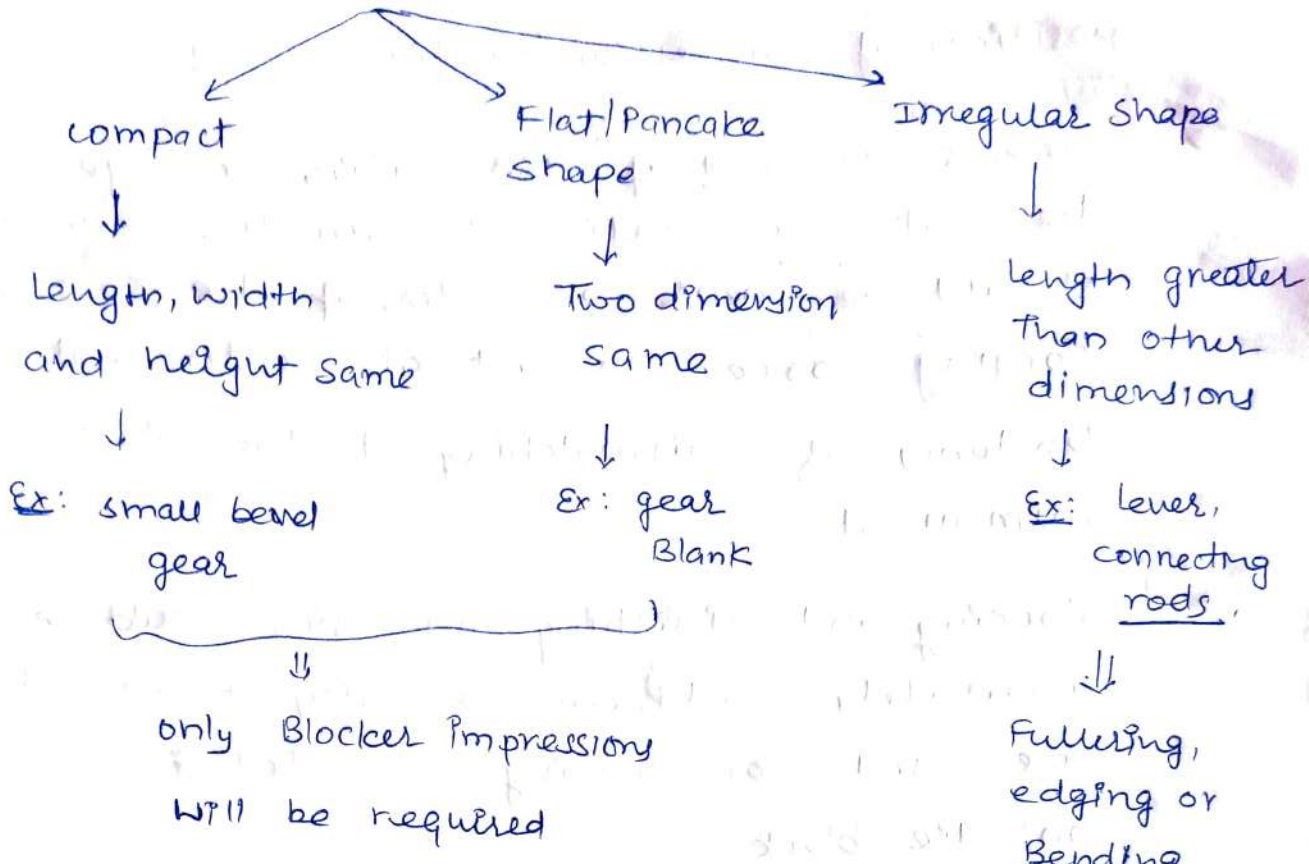
1. Shape of forging and Preform design.

→ The preliminary or preform operations (preform design) needed will depend upon the shape of forging.

→ In case of forgings of simple shapes, preform design before finishing impression may not be necessary. but In forging having wide variations in sections preform operations before finishing will be necessary for improving die life.

→ While designing impressions on die, it must be insured that minimum deformation is required to achieve final shape.

→ The forgings can be classified in three categories based on shape.

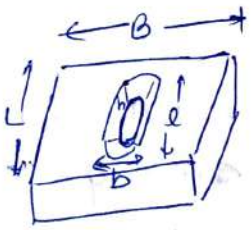


2. Die block dimensions.

→ Dimensions of die block depends upon the length of the finished forging component, depth of impression and the No. of impressions in the die block.

For a single-impression die, the length of die block may be taken as $L = l + 3h$

breadth $B = c \times b$



l = total length of forging impressions.

h = maximum depth of impression.

b = maximum width of the impression.

c = constant

= 3 For b upto 5 cm ($b \leq 5$ cm)

= 2.5 For b upto 25 cm ($b < 25$ cm)

= 2 for b above 25 cm ($b > 25$ cm)

3. positions of impressions in die

→ There is no need of this consideration for single impressio die but for multi-impression dies, impressions should be near to center of die so that the forging force can act at center and the Tendency of mismatching of die halves can be minimised.

→ Blocking and Finishing impression should be accurately machined. generally EDM and ECM are used for making intricated impressions on die block.

→ After completion of impression on die block, a lead-Antimony alloy is poured into die assembly Under true aligned condition. Resulted casting is checked for dimensional and geometrical accuracy of die because lead alloy has nearly zero shrinkage in cooling form.

→ During checking, dimensions should be considered with shrinkage allowance and other die wear allowance.

→ Necessary Flash and gutters should be provided so as to achieve a defect free casting.

→ Proper clearance should be provided betⁿ two Adjacent impressions on die to avoid any type of disturbance.

4. Fastening of the die

Since drop forging process is associated with heavy forces, so it is an important consideration that during forging operation die block should be rigidly fastened so as to produce a defect free component.

→ Fastening of the dies to the anvil block is made by dovetail and long Tapered wedges or by Large diameter screw passing through Heavy forged steel blocks known as 'poppets'

→ Upper die is secured directly to ram. The bottom die is fastened in similar manner usually not directly to base but to the Large steel block called the die holder. The die holder is fixed to the anvil either by dovetail and key or by 4 to 6 poppet screws.

5. Die Maintenance.

Following point should be followed for proper maintenace of forging die.

→ Before forging start, warm the dies to a temperature around 150 - 200°C by placing a heated slab of metal bet^n. the top and bottom dies.

→ Alway remove the scale from hot stock and die surface by using Jet of compressed air.

→ Forging should not be done if the forging metal block is cooled below the min. permissible forging Temp.

→ To prevent the forging from sticking in die impression, the die surfaces should be Lubricated before each new operation.

→ The Forging dies should not get overheated (>400°C). If they do get overheated, cool them with compressed air.

Design of Flash and gutter.

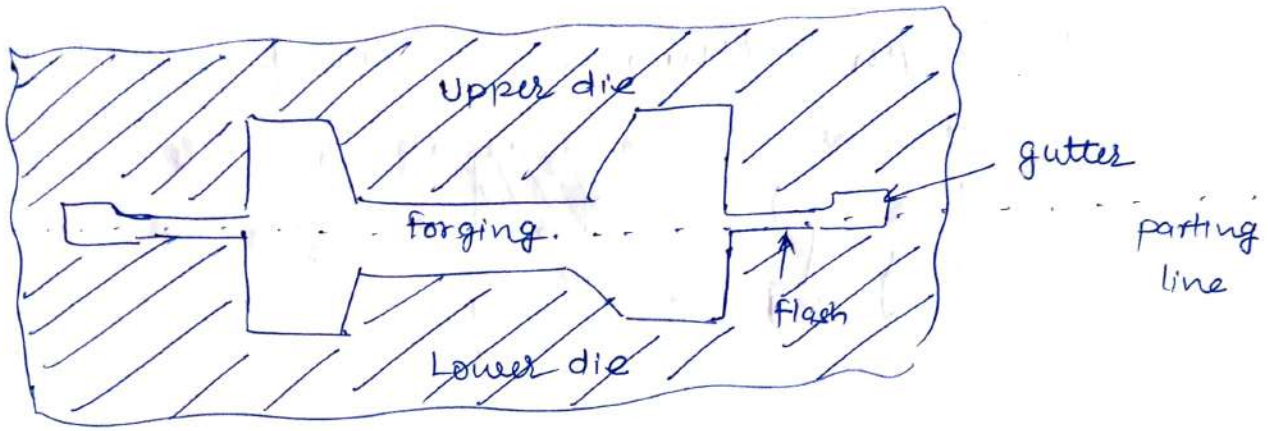
→ The Extra metal the stock to ensure complete filling of the die cavity in the finishing impression is called Flash. It is the portion of excess metal the forging at parting surface.

→ Flash dimensions depends upon the size of forging may vary from 10 to 20% of Forging size. It is provided Uniformly around the periphery of the forging in the parting plane

→ The Flash depression can be made either in One or Both dies.

During the flash design, care must be taken in selecting Flash thickness which is very important. Small thickness will need more forging force or extra blows to bring the forging to size but in case of more thickness of Flash may cause inadequate die-filling.

Gutter - In addition to the flash extension a further provision must be provided in die for storing extra material, it is called gutter. It is also provided along the periphery.



Stock size (mm)	Flash		Gutter	
	Width (mm)	thickness (mm)	Width (mm)	thickness (mm)
upto 35	4.5	0.8	25	3.0
36 to 50	5.3	1.0	25-32	4.5
51 to 65	6.5	1.5	32-38	4.5
66 to 75	8.0	2.0	32-38	4.5
76 to 100	10.0	3.0	38-44	6.5

Upset forging die design.

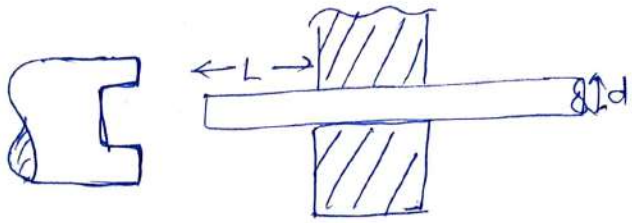
↳ It is also called as "machine forging".

There are some provisions, which should be followed during design of a upset forging die ~~does~~

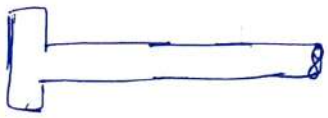
Rule ① The limit of length of unsupported stock material that ~~can be~~ is gathered during upset

Forging, should not more than 3 times of diameter of object/job. otherwise the stock will buckle at a point near the middle of overhanged length.

In practice, it is better to make the Unsupported length within 2.5 times of bar diameter.

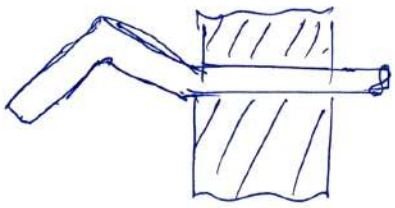


(a) $L \leq 3d$



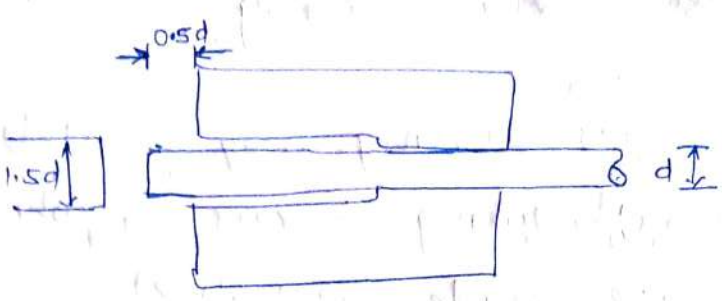
Final product (Bolt)

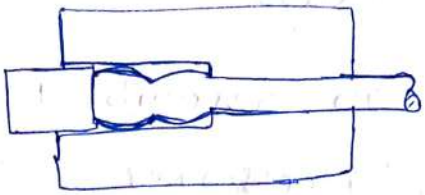
(b) $L > 3d$



Rule ② IF the stock length is longer than 3 times of bar diameter and is to be upset in single stroke, then there should be a provision for providing a die cavity to prevent the buckling effect of stock.

the die cavity should not be exceed ~~from~~ 1.5 times of diameter of bar. and the Free projected length should not more than $\frac{d}{2}$.





Stock upset.

Rule ③ For upsetting the stock whose length is more than 3 times of the diameter ~~and free projected length of stock outside die is max.~~ upto 2.5 times of diameter, the following conditions must be satisfied. The material is to be confirmed into a Taper cavity made in the punch with entrance diameter is 1.5 d. and back side ~~side~~ dia of punch is 1.25 d and length of Taper cavity is $^2/_3$rd projected length.