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SHAMBHUNATH INSTITUTE OF ENGINEERING AND TECHNOLOGY

Subject Code KME 403 Subject: Manufacturing Processes

B.Tech: II Yr SEMESTER: IV

FIRST SESSIONAL EXAMINATION, EVEN SEMESTER, (2019-2020)

Branch: Mechanical Engineering

Solution

Time –1hr 30 min **Maximum Marks – 30**

SECTION – A

1. Attempt all questions in brief. (1*5 = 5)

Q N	QUESTION	Marks	CO	BL
a.	How metal forming processes are classified? Ans: i) Casting, foundary or moulding processes ii) Forming or metal working iii) Machining processes	1	1	1
b.	Define elastic and plastic deformation. Ans: (a) Elastic deformation (b) Plastic deformation (c) Fracture Elastic deformation is defined as the deformation which completely disappears as soon as the action of external forces ceases. When the stresses exceeds the elastic limit then plastic deformation starts. Plastic deformation is associated with displacements of the atoms within the grains and causes permanent changes in the shape of the specimen. The time dependent part of the permanent deformation is called creep. Fully recoverable but time dependent deformation is called inelastic deformation. However, in viscoelastic materials like polymers, the recoverable and time dependent permanent deformations occur together. The plastic deformation of metals may occur in the following ways 1. By slip 2. By formation of twins 3. Deviations from regular positions of atoms. 4. Breakdown of structure.	1	1	2
c.	Name different types of casting defects. Ans: 1. Pinholes 2. Subsurface blowhole 3. Run out 4. Swells 5. Drops 6. Metal penetration 7. Shift/mismatch	1	1	1
d.	Write different defects of deep drawing.	1	1	1

<table>
<tr><td></td><td>1. Earing
2. Bulging
3. Buckling
4. Scratch</td><td></td><td></td><td></td></tr>
<tr><td>e.</td><td>Explain hand forging.
Ans: Hand Forging. Hand forging is also known as blacksmithing and is the simplest form of forging. The metal which is to be forged is firstly heated to red heat in the fire of a forge. It is then beaten into the wanted shape on a metal anvil with hammers.</td><td>1</td><td>1</td><td>2</td></tr>
</table>

SECTION - B

2. Attempt any TWO of the following: (2*5 = 10)

<table>
<tr><th>Q N</th><th>QUESTION</th><th>Marks</th><th>CO</th><th>BL</th></tr>
<tr><td>a.</td><td>Differentiate between hot working and cold working.
Ans:
[UPTU: 2001-02, 2003-04, 2004-05,
<table>
<tr><th>Hot Working</th><th>Cold Working</th></tr>
<tr><td>1. Hot working is done at a temperature above recrystallization but below its melting point. It can therefore be regarded as a simultaneous process of deformation and recovery.</td><td>1. Cold working is done at temperature below recrystallization temperature. So no appreciable recovery can take place during deformation.</td></tr>
<tr><td>2. Hardening due to plastic deformation is completely eliminated by recovery and recrystallization .</td><td>2. Hardening is not eliminated since working is done below recrystallization temperature.</td></tr>
<tr><td>3. Improvement of mechanical properties such as elongation, reduction of area and impact values.</td><td>3. Decreases elongation, reduction of area etc.</td></tr>
<tr><td>4. No effect on ultimate tensile strength, yield point, fatigue strength and hardness.</td><td>4. Increase in ultimate tensile strength, yield point and hardness.</td></tr>
<tr><td>5. Poor surface finish due to oxidation and scaling.</td><td>5. Good surface finish is obtained.</td></tr>
<tr><td>6. Refinement of crystals occurs.</td><td>6. Crystallization does not occur. Grains are only elongated.</td></tr>
<tr><td>7. Due to hot working cracks and blowholes are welded up.</td><td>7. Possibility of crack formation and propagation is great.</td></tr>
<tr><td>8. No internal or residual stress developed.</td><td>8. Internal and residual stresses are developed in the metal.</td></tr>
<tr><td>9. Force required for deformation is less.</td><td>9. Force required for deformation is high.</td></tr>
<tr><td>10. Light equipment is used in hot working.</td><td>10. Heavy & powerful equipment is used for cold working.</td></tr>
<tr><td>11. Difficult to handle a hot worked metal.</td><td>11. Easier to handle cold parts.</td></tr>
<tr><td>12. Hot working processes are— Hot forging, Hot rolling, Hot spinning, Hot extrusion, Hot drawing, Hot piercing, Pipe welding.</td><td>12. Cold working processes are— Cold rolling, Cold extrusion, Press work (Drawing, Squeezing, Bending, Shearing).</td></tr>
</table>
</td><td>5</td><td>1</td><td>2</td></tr>
<tr><td>b.</td><td>What do you understand by yield criteria for ductile materials? Find out the relation between Von Mises and Tresca’s yield criteria.
Ans:</td><td>5</td><td>1</td><td>4</td></tr>
</table>

[UPTU: ...

2.3.1 Tresca's Yield Criteria

Since the plastic flow depends on slip which essentially is a shearing process, Tresca suggested that "the plastic flow initiates when the maximum shear stress reaches a critical value." This limiting value is defined as the shear yield stress K.

If the principal stresses at a point in the material are σ_1, σ_2 and σ_3.

Assuming $\sigma_1 > \sigma_2 > \sigma_3$, then maximum shear stress τ_{max} is,

$$\tau_{max} = \frac{\sigma_1 - \sigma_3}{2}$$

Plastic deformation occurs when τ_{max} is equal to K.

∴ Tresca's criterion becomes

$$\frac{\sigma_1 - \sigma_3}{2} = K \qquad \text{...(2.1)}$$

Equation (2.1) shows that yielding is independent of the intermediate principal stress σ_2.

2.3.2 Von-Mises Yield Criteria *[UPTU: 2002-03, 2003-04, 2005-06]*

This yield criteria is based upon the distortion energy theory. According to this criteria "yielding begins when the shear strain energy reaches a critical value" for the particular material.

The energy of distortion is given by—

$$U = \frac{1}{6G}\left[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2\right] \qquad \text{...(2.2)}$$

where U is the shear strain energy per unit volume,

σ_1, σ_2, σ_3 are the three principal stresses, and G is the shear modulus of the material.

According to this criterion, the plastic flow initiates when the right-hand side of equation (2.2) reaches a particular value, say, C_1.

∴ Von Mises criterion will be

$$(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 = 6\,G\,C_1 = C \text{ (constant)} \qquad \text{...(2.3)}$$

Equation (2.3) shows that the initiation of plastic flow depends on all the principal stresses.

2.3.3 Relation Between Shear Yield Stress and Tensile Yield Stress

[UPTU: 2002-03, 2003-04, 2005-06, 2006-07, 2008-09]

1. For Tresca's Yield Criterion

To apply this criterion, we have to find the value of constant in equation (2.1).

Both is uniaxial tension : $\sigma_1 = \sigma_y$ (tensile yield stress),

$\sigma_2 = \sigma_3 = 0$

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and in uniaxial compression : $\sigma_1 = \sigma_2 = 0,$

$\sigma_3 = -\sigma_y$

Substituting these values in equation (2.1), we get

$$\frac{\sigma_y - 0}{2} = K \quad \text{...(Uniaxial tension)}$$

and

$$\frac{0-(-\sigma_y)}{2} = K \quad \text{...(Uniaxial compression)}$$

$$\therefore \quad K = \frac{\sigma_y}{2} \quad \text{...(2.4)}$$

2. For Von-Mises Yield Criterion

When yielding occurs under uniaxial tensile loading,

$$\sigma_1 = \sigma_y, \sigma_2 = \sigma_3 = 0$$

Substituting these values in equation (2.3), we get

$$C = (\sigma_y - 0)^2 + (0 - 0) + (0 - \sigma_y)^2$$

or

$$C = 2\sigma_y^2 \quad \text{...(2.5)}$$

Considering yielding under pure torsion.

$\therefore$ For pure shear : $\sigma_1 = K, \sigma_2 = 0, \sigma_3 = -K$

Substituting these value in equation (2.3), we get

$$C = (K-0)^2 + (0+K)^2 + (-K-K)^2$$

or

$$C = 6K^2 \quad \text{...(2.6)}$$

Since the magnitude of C is independent of the type of loading, hence equating equations (2.5) and (2.6), we get

$$2\sigma_y^2 = 6K^2$$

$$\therefore \quad K = \frac{\sigma_y}{\sqrt{3}} \quad \text{...(2.7)}$$
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<td>c.</td>
<td>
Discuss the role of casting volume and surface area as they relate to the total solidification time.

Ans:

[UPTU: 2008-09]

The function of a riser is to feed the casting during solidification so that no shrinkage cavities are formed. Gray cast iron needs very little feeding since it expands during solidification. Steel, white cast iron and many non-ferrous alloys require more feeding because of their higher shrinkages during solidification. Casting can be subdivided into several sections and each section can be provided with a riser. A riser is designed in such a way that it stays molten longer than the casting.

Caine's Method : Since solidification of the casting occurs by losing heat from the surfaces and the amount of heat is given by the volume of the casting, the cooling characteristics of a casting can be represented by the surface area to volume ratio.

Since the riser is also similar to the casting in its solidification behaviour, the riser characteristic can also be specified by the ratio of its surface area to volume. If this ratio of the casting is higher, then it is expected to cool faster. Chvorinov has shown that the solidification time of a casting is proportional to the square of the ratio of volume to surface area of the casting. The constant of proportionality called mould constant depends on the pouring temperature, casting and mould thermal characteristics.

$$t = K\left(\frac{V}{SA}\right)^2$$

Where t = Solidification time, s

V = Volume of casting

SA = Surface area

K = Mould constant
</td>
<td>5</td>
<td>1</td>
<td>4</td>
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<td>d.</td>
<td>What do you understand by powder metallurgy process? Explain atomization process of powder production.</td>
<td>5</td>
<td>1</td>
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	Ans: BASIC PROCESSES OF POWDER METALLURGY. The basic operation of powder metallurgy techniques • The four basic operations of the powder metallurgy are: 1. Manufacture of powder 2. Mixing or blending powder particles. 3. Compacting. 4. Sintering. Atomization is accomplished by forcing a molten metal stream through an orifice at moderate pressures. A gas is introduced into the metal stream just before it leaves the nozzle, serving to create turbulence as the entrained gas expands (due to heating) and exits into a large collection volume exterior to the orifice. The collection volume is filled with gas to promote further turbulence of the molten metal jet. Air and powder streams are segregated using gravity or cyclonic separation. Most atomized powders are annealed, which helps reduce the oxide and carbon content. The water atomized particles are smaller, cleaner, and nonporous and have a greater breadth of size, which allows better compacting. The particles produced through this method are normally of spherical or pear shape. Usually, they also carry a layer of oxide over them. There are three types of atomization: • Liquid atomization • Gas atomization • Centrifugal atomization			

SECTION - C

3. Attempt any ONE part of the following: (1*5 = 5)

Q N	QUESTION	Marks	CO	BL
a.	How does a compound die differs from a progressive die? Giving a neat sketch describe constructional features. Ans: **Dies and its Types:** **Die:** The die may be defined as the female part of a complete tool for producing work in a press. It is also referred to a complete tool consists of a pair of mating members for producing work in a press. **Types of dies:** The dies may be classified according to the type of press operation and according to the method of operation. **(A) According to type of press operation:** According to this criterion, the dies may be classified as cutting dies and forming dies. **1: Cutting Dies:** These dies are used to cut the metal. They utilize the cutting or shearing action. The common cutting dies are: blanking dies, perforating dies , notching dies , trimming , shaving and nibbling dies. **2: Forming Dies:** These dies change the appearance of the blank without removing any stock. Theses dies include bending, drawing and squeezing dies etc. **(B) According to the method of operation:** According to this criterion, the dies may be classified as : single operation or simple dies ,	5	1	4

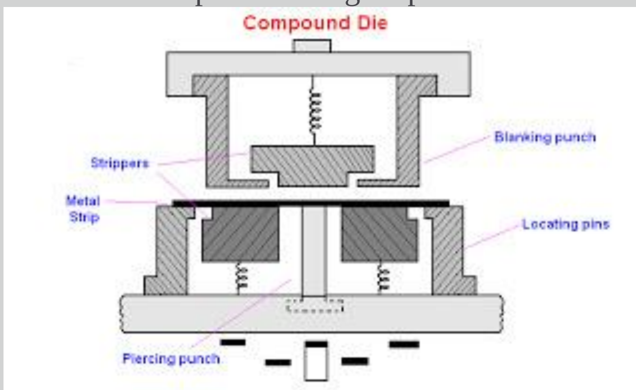
compound dies , combination dies , progressive dies , transfer dies and multiple dies.

1: Simple Dies:

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

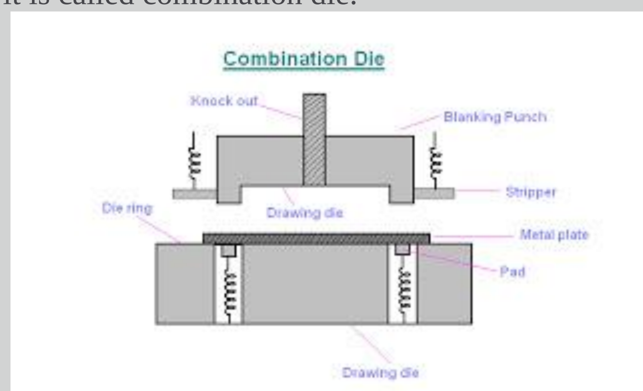
2: Compound Dies:

In these dies, two or more operations may be performed at one station. Such dies are considered as cutting tools since, only cutting operations are carried out. Figure shows a simple compound die in which a washer is made by one stroke of the press. The washer is produced by simulation blanking and piercing operations. Compound dies are more accurate and economical in production as compared to single operation dies.



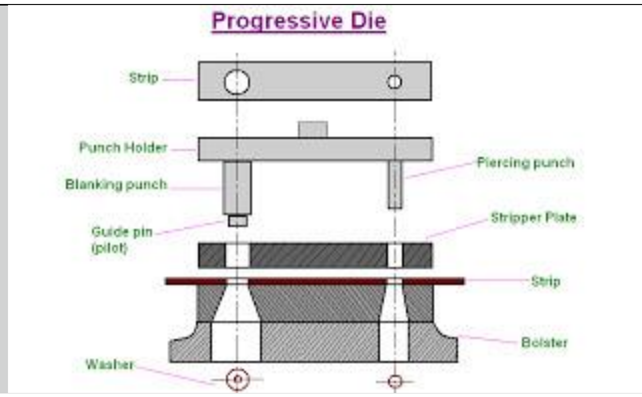
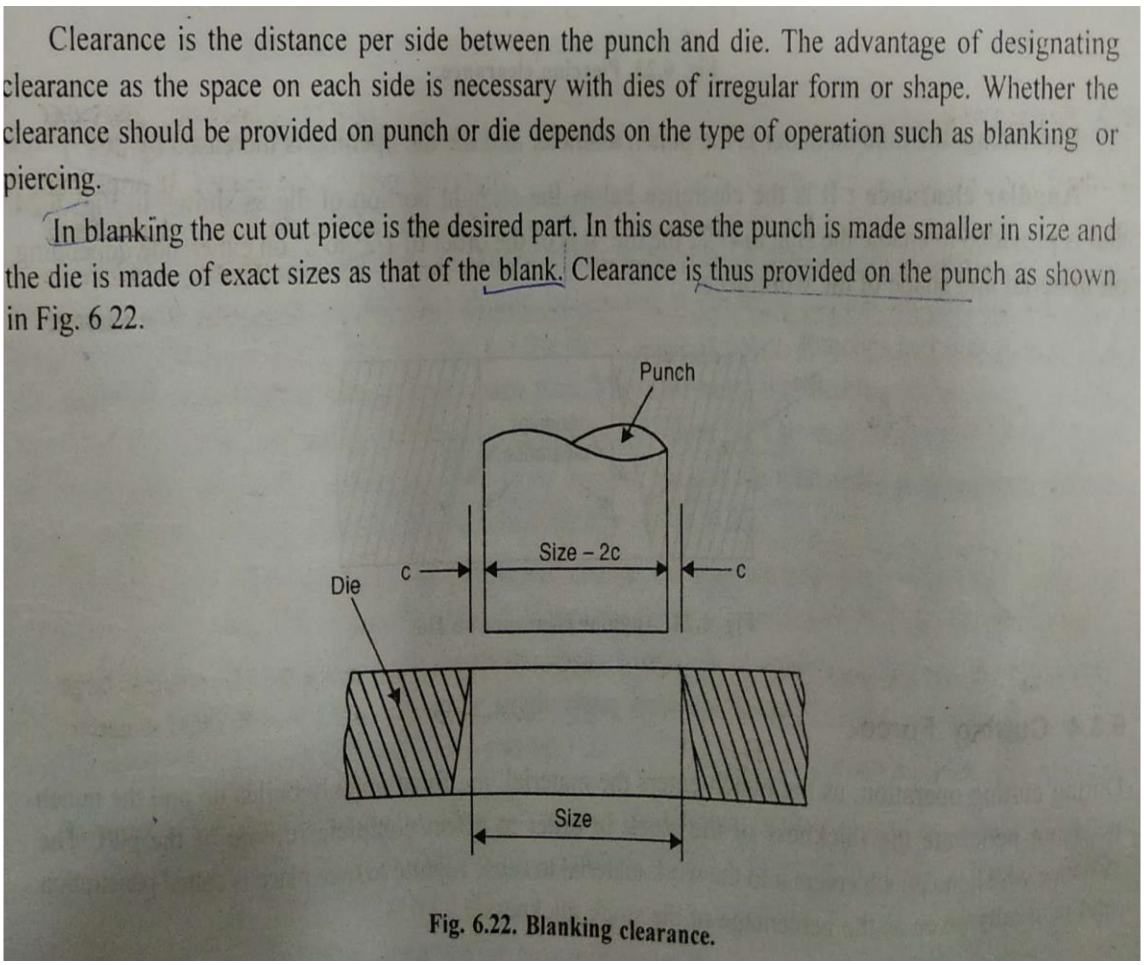
3: Combination Dies:

In this die also , more than one operation may be performed at one station. It is difficult from compound die in that in this die, a cutting operation is combined with a bending or drawing operation, due to that it is called combination die.



4: Progressive Dies:

A progressive or follow on die has a series of operations. At each station , an operation is performed on a work piece during a stroke of the press. Between stroke the piece in the metal strip is transferred to the next station. A finished work piece is made at each stroke of the press. While the piercing punch cuts a hole in the stroke , the blanking punch blanks out a portion of the metal in which a hole had been pierced at a previous station. Thus after the first stroke , when only a hole will be punched , each stroke of the press produces a finished washer.

	 			
b.	What is a role of clearance in blanking and piercing operations? How clearance is provided on punch and die? Ans:  Clearance is the distance per side between the punch and die. The advantage of designating clearance as the space on each side is necessary with dies of irregular form or shape. Whether the clearance should be provided on punch or die depends on the type of operation such as blanking or piercing. In blanking the cut out piece is the desired part. In this case the punch is made smaller in size and the die is made of exact sizes as that of the blank. Clearance is thus provided on the punch as shown in Fig. 6 22. Fig. 6.22. Blanking clearance.	5	1	3

The blanking dimension is the size of the die opening and the punch is reduced b
is the clearance factor times the thickness.

In piercing the cut out part is waste and left out piece is required. In this case the
of exact size and die is made of bigger size as shown in Fig. 6.23.

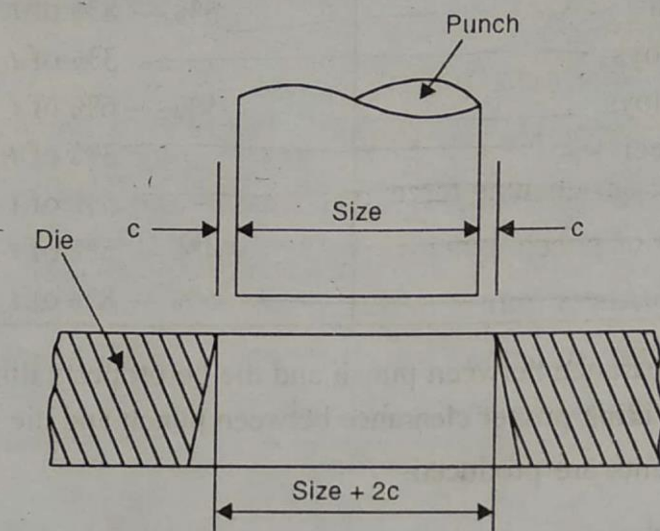


Fig. 6.23. Piercing clearance.

In piercing, the hole diameter is the punch diameter and the die opening is increase

4. Attempt any ONE part of the following: (1*5 = 5)

QN	QUESTION	Marks	CO	BL
a.	A hole of 100 mm is to be punched in a cold rolled medium carbon steel plate of 5.6 mm thickness. The ultimate shear strength of plate material is 550 MPa. With normal clearance of 10% on the press tool, cutting is completed at 40% penetration of the punch. Calculate the die for the punch and die required for the purpose. If the shop has press of 30 tonnes capacity. Calculate the shear angle to be provided on the punch in order to bring the work within the capacity of the existing press. Ans: Clearance per side = 10% of plate thickness = 0.56 mm Punch Dia= hole dia =100mm Die diameter = hole diameter + $2c$ $= 100 + 2 \times 0.56 = 101.12$ mm **Ans.** Without any shear, the maximum punching load is given as, $F = \pi D t \tau_s$ $= \pi \times 100 \times 5.6 \times 550 = 967.61\ kN$ Total work done in punching $= F \times p \times t$ $= 967.61 \times 10^3 \times 0.4 \times 5.6 \times 10^{-3}$ $= 2167.45\ Nm$ Work done with shearing and 30 tonne maximum load $= 30 \times 10^3 \times 9.81 \times (0.4 \times 5.6 \times 10^{-3} + S)$ here S = depth of shear on the punch Equating the work done, we get $S = \frac{2167.45}{30 \times 1000 \times 9.81} - 0.4 \times 0.0056$ $= 5.12 \times 10^{-3}$ m = 5.12 mm Assuming a balanced shear on the punch, we get the shear angle as, $\theta = \tan^{-1}\left(\frac{S}{D/2}\right)$ $= \tan^{-1}\left(\frac{5.12}{100/2}\right) = 5.85°$. **Ans.**	5	1	3

b.

Show that during deep drawing of a cup, the radial stresses σ_r at radius r is given by

$$\frac{\sigma_r}{2K} = \frac{\mu F_h}{2\pi K r_j t} + \log_e \frac{r_j}{r}$$

Where,

F_h is the blank holding force, r_j is the initial blank radius, t is the thickness and μ is coefficient of friction, K is the shear yield strength.

Ans:

In deep drawing process, various types of forces operate simultaneously, which are listed as follows :

(*i*) The annular portion of the sheet metal workpiece between the blank holder and the die is subjected to a pure radial drawing.

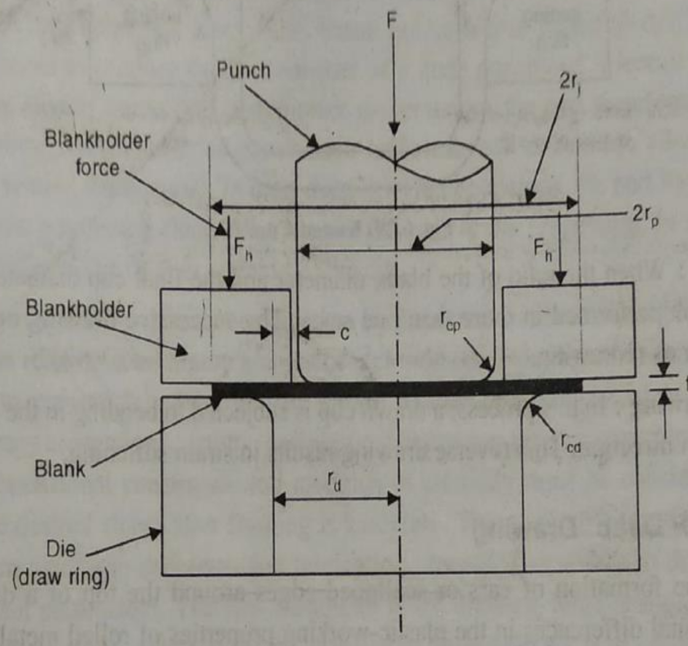


Fig. 6.31. Schematic of cup drawing process.

(*ii*) The portions of the workpiece around the corners of the punch and the die are subjected to a bending operation.

(*iii*) The portion of the job between the punch and the die walls undergoes a longitudinal drawing.

Fig. 6.31. shows the cup drawing operation with the relevant dimensions.

Let r_p, r_j, r_d = radii of punch, job and die respectively

r_{cp}, r_{cd} = corner radii of punch and die respectively

c = clearance between the punch and the blank holder

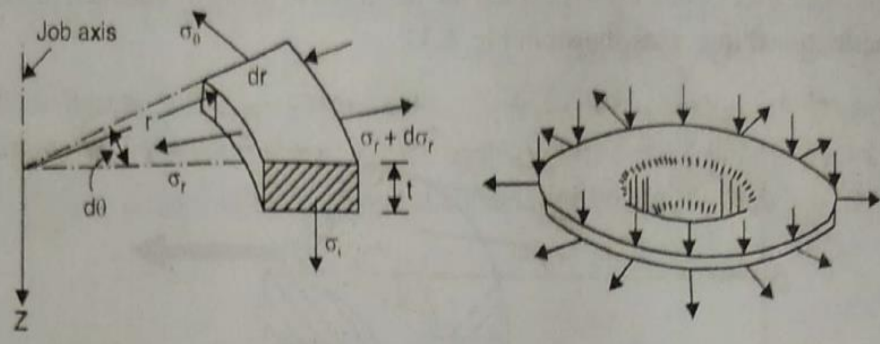
F_h = blank holder force.

Neglecting the thickening and thinning of the job, we have

Job thickness, $t = r_d - r_p$

Fig. 6.32 (*a*) shows the stresses acting on an element of the job between the blank holder and the die. It is noted that the maximum thickening occurs at the outer periphery, hence the entire blank holder force F_h is assumed to act along the circumference [see Fig. 6.32 (*b*)]. Thus, the radial stress due to friction can also be represented by an equivalent radial stress $2\mu F_h/(2\pi r_j t)$ at the outer periphery.

5 | 1 | 5



(a) Stresses acting on element during drawing

(b) Blank holder force on element during drawing

Fig. 6.32. Analysis of deep drawing operation.

Considering the radial equilibrium of the element shown in Fig. 6.32 (*a*), we have

$$r d\sigma_r + \sigma_r dr - \sigma_\theta \, dr = 0 \quad \ldots(6.8)$$

Since σ_r and σ_θ are the principal stresses, hence using Tresca's yield criteria, we have

$$\sigma_r - \sigma_\theta = 2K \quad \ldots(6.9)$$

Substituting σ_θ from equation (6.9) in equation (6.8), we get

$$\frac{dr}{r} + \frac{d\sigma_r}{2K} = 0$$

Integrating, we get

$$\ln r + \frac{\sigma_r}{2K} = C \quad \ldots(6.10)$$

Where C is constant of integration.

At $r = r_j$, $\sigma_r = \mu F_h/(\pi r_j t)$. Hence, we have

$$C = \frac{\mu F_h}{2\pi K r_j t} + \ln r_j$$

Substituting the value of C in equation (6.10), we have

$$\frac{\sigma_r}{2K} = \frac{\mu F_h}{2\pi K r_j t} + \ln \frac{r_j}{r} \quad \ldots(6.11)$$

Hence, the radial stress at the beginning of the die corner, *i.e.*, at $r = r_d = r_p + t$, is given by

$$\left.\frac{\sigma_r}{2K}\right|_{r=r_d} = \frac{\mu F_h}{2\pi K r_j t} + \ln\left(\frac{r_j}{r_d}\right) \quad \ldots(6.12)$$

5. Attempt any ONE part of the following: (1*5 = 5)

Q	QUESTION	Mark	C	B

<table>
<tr><th>N</th><th></th><th>s</th><th>O</th><th>L</th></tr>
<tr><td>a.</td><td>
For an ease of molding, it is decided to replace a spherical riser of dia 100 mm by a cylindrical riser. Determine the size of the cylindrical riser that will have the identical solidification time. Ratio of height to radius of cylinder is 2:1.
Ans:

$$\text{Volume of sphere} = \frac{4}{3}\pi r_s^3$$

$$\text{Surface area of sphere} = 4\pi r_s^2$$

where r_s = radius of sphere

$$\text{Solidification time : } t = K\left(\frac{V}{SA}\right)^2_{\text{sphere}}$$

$$t = K\left(\frac{4\pi r_s^3}{3\times 4\pi r_s^2}\right)^2_{\text{sphere}}$$

$$\text{Volume of cylinder} = \pi r_c^2 . h$$

$$= 2\pi r_c^3$$

$$\text{Surface area of cylinder} = 2\pi r_c^2 + 2\pi r_c h_c$$

$$= 6\pi r_c^2$$

where r_c = radius of cylinder
h_c = height of cylinder
and height = 2 × radius (given for cylinder)

$$\text{Solidification time : } t = K\left(\frac{2\pi r_c^3}{6\pi r_c^2}\right)^2_{\text{cylinder}}$$

Equation (1) and (2) are equal

$$\Rightarrow \left(\frac{4\pi r_s^3}{3\times 4\pi r_s^2}\right)^2 = \left(\frac{2\pi r_c^3}{6\pi r_c^2}\right)^2$$

or

$$\frac{r_s}{3} = \frac{r_c}{3}$$

$$\Rightarrow r_c = r_s = 50 \text{ mm} \quad \textbf{Ans.}$$

and

$$h_c = 100 \text{ mm} \quad \textbf{Ans.}$$
</td><td>5</td><td>1</td><td>3</td></tr>
<tr><td>b</td><td>Drive the following expression for pressure distributions (for sliding friction) for forging of</td><td>5</td><td>1</td><td>5</td></tr>
</table>

. a rectangular block (b x h x w) and show the variation

$$\frac{p}{2K} = e^{\frac{-2\mu(x-\frac{b}{2})}{h}}$$

where p is the pressure at a distance x from center, K is shear strength of material and μ is the coefficient of sliding friction, h is the height and b the width.

Ans:

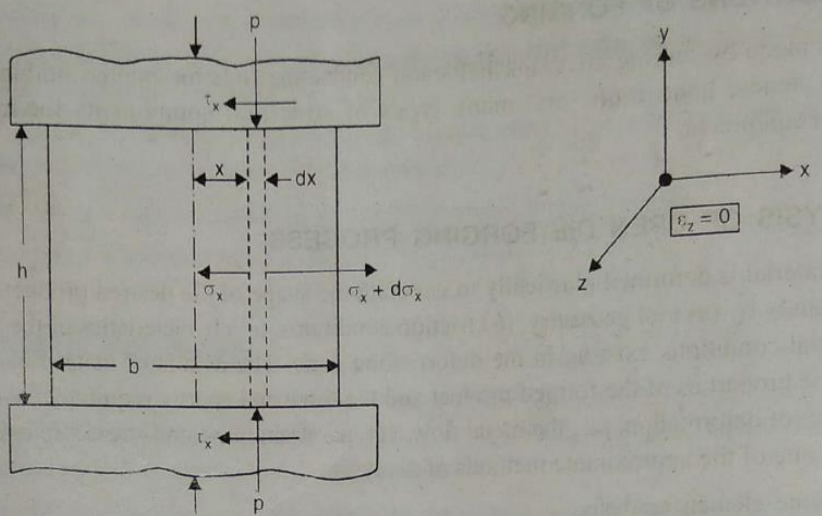


Fig. 3.11. Force balance in an open-die forging of a strip.

Considering the equilibrium of the forces in the x-direction, we get

$$(\sigma_x + d\sigma_x).hw - \sigma_x.hw - 2\,\tau_x.dx.w = 0$$

or $$hd\sigma_x - 2\,\tau_x.dx = 0 \quad ...(3.1)$$

Assuming σ_x and p as principal stresses *i.e.*, $\sigma_1 = \sigma_x$ and $\sigma_3 = -p$ (p being compressive), and taking Tresca's yield theory, we have for plane strain

$$\sigma_1 - \sigma_3 = \sigma_y = 2K$$

$$\sigma_x + p = 2K$$

or $$d\sigma_x = -dp$$

Substituting $d\sigma_x$ from the foregoing relation in equation (3.1), we get

$$dp = -2\frac{\tau_x}{h}.dx \quad ...(3.2)$$

1. Sliding Friction

Assuming Coulomb friction with constant coefficient of friction μ, we have

$$\tau_x = \mu p$$

Substituting above relation in equation (3.2).

$$\frac{dp}{p} = -\frac{2\mu}{h}.dx$$

Integrating, $$\ln p = -\frac{2\mu}{h}x + C$$

Now at $x = \frac{b}{2}$, $\sigma_x = 0$ (stress free surface), we have

$$p = 2K$$

$$\ln 2K = -\frac{2\mu}{h} \cdot \frac{b}{2} + C$$

$\therefore$

$$C = \ln 2K + \frac{2\mu}{h} \cdot \frac{b}{2}$$

$$\ln \frac{p}{2K} = -\frac{2\mu}{h}\left(x - \frac{b}{2}\right)$$

or

$$p = 2K \cdot e^{-\frac{2\mu}{h}\left(x - \frac{b}{2}\right)}$$

or

$$\frac{p}{2K} = \frac{p}{\sigma_y} = e^{-\frac{2\mu}{h}\left(x - \frac{b}{2}\right)}$$

Also,

$$\sigma_x = 2K - p = 2K\left[1 - e^{-\frac{2\mu}{h}\left(x - \frac{b}{2}\right)}\right]$$