CMR
INSTITUTE OF
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Internal Assesment Test - II

Sub:	Manufacturing Process III							Code:	10ME55
Date:	04 / 11 / 2016	Duration:	90 mins	Max Marks:	50	Sem:	V	Branch:	MECH

Answer Any FIVE FULL Questions

		Marks	OBE	
			CO	RBT
1	Derive an expression for drawing load by slab analysis.	[10]	CO3	L3
2(a)	List and explain a few important process variables that affect the drawing force in wire drawing process	[06]	CO3	L4
(b)	Explain tube drawing with floating mandrel	[04]	CO3	L4
3(a)	Calculate the drawing stress to produce 20% reduction in a 10mm stainless steel wire. The mean flow stress σ is given by 637 MPa. The die angle is 12^o and the μ is 0.09. Also determine the power required to draw when the wire is moving through the die at 3 m/sec.	[06]	CO3	L3
(b)	Explain in detail with neat sketch the deformation and lubrication in drawing process.	[04]	CO3	L4
4(a)	How seamless pipes are produced in extrusion process? Explain.	[06]	CO3	L4
(b)	Discuss any four extrusion defects with their causes and remedies	[04]	CO3	L2
5(a)	Discuss with a neat sketch extrusion variables.	[10]	CO3	L2
6(a)	In the hot extrusion of aluminum at 350^o C, σ_o= 83 MPa. a) For a 300 mm diameter billet & 1m long, what is the break through pressure required to extrude a 75 mm diameter bar if μ=0.10. Take $\alpha=60^o$. b) What is the required extrusion pressure at the end of the stroke? c) What capacity press would be needed for this extrusion?	[10]	CO3	L4
7(a)	With neat sketches, explain combination die and progressive die.	[10]	CO4	L4

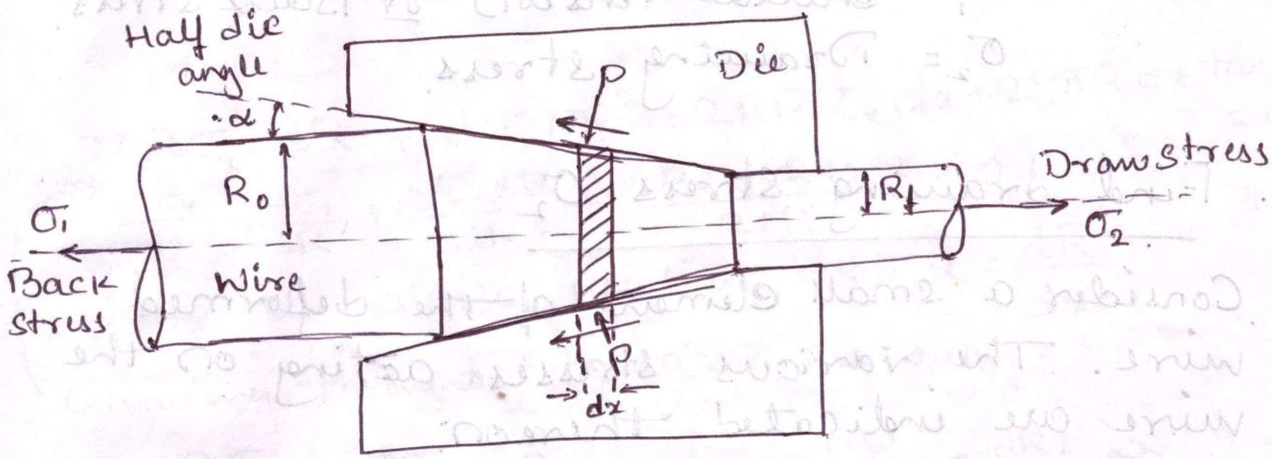
Course Outcomes		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1:	***Apply*** the concept of plastic deformation for metals and alloys to convert them in to useful shapes. ***Discuss*** different types of stresses in metal working and solve simple numerical on related concepts. ***Discuss*** in detail various parameters in metal working.	3											
CO2:	***Classify*** various metals forming process like forging ***Describe*** various analysis to determine force and factors affecting it. solve simple numerical on related concepts	3	2										
CO3:	***Illustrate*** with sketches the constructional features and ***describe*** the various operations related to the Rolling, Drawing and Extrusion process. ***Describe*** various analyses to determine force and factors affecting it. solve simple numerical on related concepts	3	2										
CO4:	***Illustrate*** with sketches the constructional features and ***describe*** the various operations related to the Sheet metal forming process. ***Describe*** various analyses to determine force and factors affecting it. solve simple numerical on related concepts	3	2										
CO5:	***Explain*** the various principles and applications of High Energy Rate Forming Methods (HERF). Look into the concepts related to powder metallurgy.	3											

Cognitive level	KEYWORDS
L1	List, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where, etc.
L2	summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend
L3	Apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover.
L4	Analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer.
L5	Assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize.

PO1 - *Engineering knowledge*; PO2 - *Problem analysis*; PO3 - *Design/development of solutions*; PO4 - *Conduct investigations of complex problems*; PO5 - *Modern tool usage*; PO6 - *The Engineer and society*; PO7- *Environment and sustainability*; PO8 – *Ethics*; PO9 - *Individual and team work*; PO10 - *Communication*; PO11 - *Project management and finance*; PO12 - *Life-long learning*

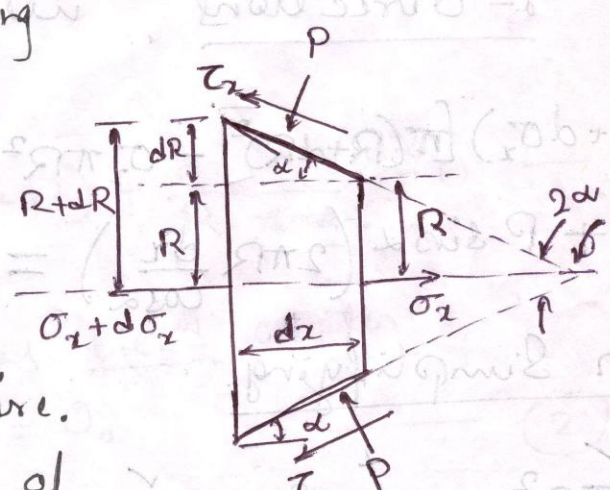
1)
a)

Expression for Drawing load by SLAB ~~Anaty~~ Analysis



wire drawing.

Consider the drawing of wire. As the wire passes through the die, it gets plastically deformed due to the stress acting on the wire. As such the diameter of the wire decreases.



From Fig

Let R_0 = Initial radius of wire
R_f = final radius of wire
α = Half die angle.
σ_1 = Initial tension or Back stress.
σ_2 = Drawing stress.

Find drawing stress σ_2

Consider a small element of the deformed wire. The various stresses acting on the wire are indicated thereon.

~~That~~ Under equillibrium conditions in the x-directions, we have $\Sigma F_x = 0$

$$(\sigma_x + d\sigma_x)\left[\pi(R+dR)^2\right] - \sigma_x \pi R^2 + \tau_x \cos\alpha\left(2\pi R \frac{dx}{\cos\alpha}\right)$$
$$+ P\sin\alpha\left(2\pi R\frac{dx}{\cos\alpha}\right) = 0 \quad \text{(a)}$$

On Simplifying.

$$\sigma_x \pi R^2 + \sigma_x \pi dR^2 + \sigma_x 2\pi R dR + d\sigma_x \pi R^2 + d\sigma_x \pi dR^2$$
$$+ d\sigma_x R dR \pi - \sigma_x \pi R^2 + \tau_x \cos\alpha\left(\frac{2\pi R dx}{\cos\alpha}\right)$$
$$+ P\sin\alpha\left(\frac{2\pi R dx}{\cos\alpha}\right) = 0.$$

Since dx & dR are very small hence their squares can be negleted.

$$\sigma_x \pi R^2 + 2\pi R\sigma_x . dR + d\sigma_x \pi R^2 - \sigma_x \pi R^2 + 2\pi R \tau_x dx + 2P\pi R dx \tan\alpha = 0.$$

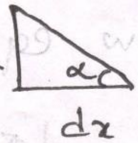
$$2\pi R\sigma_x . dR + d\sigma_x \pi R^2 + 2\pi R \tau_x dx + 2P\pi R dx . \tan\alpha = 0$$

$$\frac{2\sigma_x}{R} + \frac{d\sigma_x}{dR} + \frac{2\tau_x dx}{dR} + \frac{2P dx . \tan\alpha}{R dR} = 0.$$

from the ΔABC, we have $\tan\alpha = \frac{dR}{dx}$

dividing throughout by $\pi R^2 dR$, we have.

$$\therefore \frac{2\sigma_x}{R} + \frac{d\sigma_x}{dR} + \frac{2\tau_x}{R}\frac{1}{\tan\alpha} + \frac{2P}{R} = 0.$$



Re-arranging,

$$\frac{d\sigma_x}{dR} + \frac{2}{R}(\sigma_x + P) + \frac{2}{R}\tau_x \cot\alpha = 0. \quad \text{— (1)}$$

From tresca - ~~mises~~ yield criteria,

$$\sigma_1 - \sigma_3 = \sigma_0. \quad \text{— (2)}$$

where σ_1 = Max. Principle stress
σ_3 = Min " "
σ_0 = Yield strength of the work-material

In the present case, $\sigma_1 = \sigma_x$; $\sigma_3 = -P$.

[-ve sign due to horizontal component of P being opposite to σ_x]

eqn (2) becomes,

$$\sigma_x + P = \sigma_0 \quad \text{--- (3)}$$

From <u>Coulombus law of friction</u>, we have,

$$\tau = \mu p$$

$$\therefore \tau = \mu(\sigma_0 - \sigma_x) \quad \text{from eqn (3).}$$

Now eqn (1) reduced to,

$$\frac{d\sigma_x}{dR} + \frac{2}{R}\sigma_0 + \frac{2}{R}\mu(\sigma_0 - \sigma_x)\cot\alpha = 0$$

Let $B = \mu \cot\alpha$

$$\therefore \frac{d\sigma_x}{dR} + \frac{2}{R}\sigma_0 + \frac{2}{R}B(\sigma_0 - \sigma_x) = 0.$$

<u>or</u>

$$\frac{d\sigma_x}{dR} = \frac{2}{R}\left[-\sigma_0 - B(\sigma_0 - \sigma_x)\right]$$

$$\frac{d\sigma_x}{dR} = \frac{2}{R}\left[B\sigma_x - (1+B)\sigma_0\right]$$

$$\frac{d\sigma_x}{2\left[B\sigma_x - (1+B)\sigma_0\right]} = \frac{dR}{R}$$

On integrating, we get

$$\frac{1}{2}\left\{\ln\left[B\sigma_x - (1+B)\sigma_0\right] \cdot \frac{1}{B}\right\} = \ln R + \ln C$$

where C is constant of integration obtained by applying Boundary conditions.

$$\frac{1}{2B}\ln\left[B\sigma_x - (1+B)\sigma_0\right] = \ln RC$$

or $\ln\left[B\sigma_x - (1+B)\sigma_0\right] = 2B\ln RC$

or

$$\ln\left[B\sigma_x - (1+B)\sigma_0\right] = \ln(RC)^{2B}$$

or

$$B\sigma_x - (1+B)\sigma_0 = (RC)^{2B} \quad \text{——} \ (4)$$

Applying 1st Boundary condition i.e.

at $R = R_0$, $\sigma_x = \sigma_1$

eqn (4) becomes $B\sigma_1 - (1+B)\sigma_0 = (R_0 C)^{2B}$

$$C = \left\{\frac{\left[B\sigma_1 - (1+B)\sigma_0\right]^{1/2B}}{B}\right\}^{2B} \quad \text{——} \ (5)$$

Substituting eqn ⑤ in ④, we get.

$$B\sigma_r - (1+B)\sigma_0 = (R)^{2B}\left\{\frac{[B\sigma_1 - (1+B)\sigma_0]^{1/2B}}{R_0}\right\}^{2B}$$

$$B\sigma_r - (1+B)\sigma_0 = \left(\frac{R}{R_0}\right)^{2B}[B\sigma_1 - (1+B)\sigma_0]$$

$$\sigma_r = \frac{\left(\frac{R}{R_0}\right)^{2B}[B\sigma_1 - (1+B)\sigma_0] + (1+B)\sigma_0}{B}$$

$$\sigma_r = \left(\frac{R}{R_0}\right)^{2B}\left[\sigma_1 - \frac{(1+B)\sigma_0}{B}\right] + \frac{(1+B)\sigma_0}{B}$$

$$\sigma_r = \frac{(1+B)\sigma_0}{B}\left[1 - \left(\frac{R}{R_0}\right)^{2B}\right] + \sigma_1\left(\frac{R}{R_0}\right)^{2B} \quad \text{— ⑥}$$

Applying the 2nd Boundary condition,
i.e at $R = R_f$, $\sigma_r = \sigma_2$ (drawing stress)

eqn ⑥ becomes

$$\sigma_2 = \frac{\sigma_0(1+B)}{B}\left[1 - \left(\frac{R_f}{R_0}\right)^{2B}\right] + \sigma_1\left(\frac{R_f}{R_0}\right)^{2B}$$

when initial or Back stress (σ_1) is neglected, the above eqn becomes.

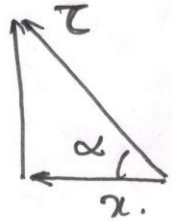
$$\sigma_2 = \frac{\sigma_0(1+B)}{B}\left[1 + \left(\frac{R_f}{R_0}\right)^{2B}\right]$$

eqn used to calculate drawing stress (σ_2) for wires or rods.

Equation (a) is written based on the following calculations.

Force = stress × area

where → area = πR^2

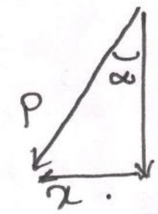


Horizontal component (x)

$$\cos\alpha = \frac{x}{\tau}$$

or

$$x = \tau\cos\alpha.$$



Horizontal Component (x)

$$\sin\alpha = \frac{x}{p}$$

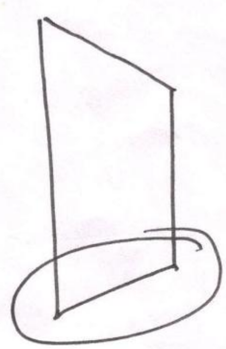
or

$$x = p\sin\alpha.$$

Surface area = $2\pi R.\frac{dx}{\cos\alpha}$.

where $2\pi R$ = Perimeter.

$\frac{dx}{\cos\alpha}$ = Angle subtended.



2)

a) Drawing Variable

A few important process variables that affect the drawing force in wire drawing process includes:

1) Die angle
2) Temperature
3) Friction/Lubrication
4) Deformation or Reduction in cross sectional area per pass
5) Temperature
6) Drawing speed

Die angle

For small die angle, contact length between wire and the die is more and friction work will be more. With large die angle redundant work will be increases resulting in the internal distortion of the leading of the work leading to surface defects in the drawn products. Thus optimum die angel must be selected.

Friction

Friction exists between the work and the die surface, will be more for low die angle, and reduces as the die angle is increased up to an optimum value.

Temperature

Heat is generated during preliminary by work deformation and sliding friction at the die surface. This cause dies to expand thermally. To prevent the effects of thermal expansion, it is necessary to flood sufficient lubricants at the forming sections, or in rare cases, even cool the dies by running a cooling agent through them.

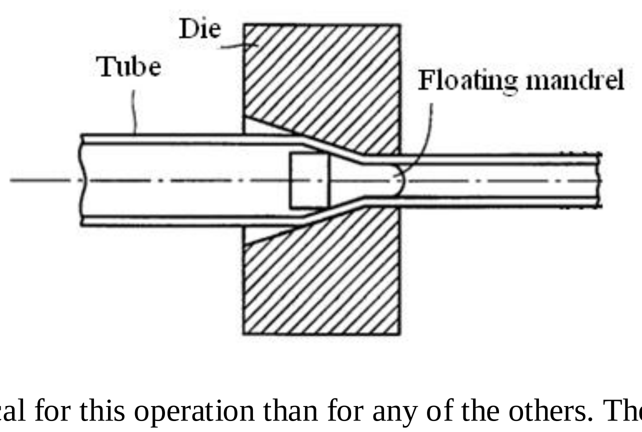
Drawing speed

A faster speed creates more sliding friction; the more the friction, the more is the heat generated and as a result the amount of strain and stress generated increases. The speed of drawing is hence limited, and is selected suitably based on the type of material drawn and its diameter.

2)

b) Drawing over a floating mandrel

Figure shows drawing with floating mandrel. In this tube drawing process, carefully matched floating mandrel is used for drawing long tubes. In this process mandrel is not fixed, instead mandrel is pushed in, before drawing takes place. Because of its conical shape, during the drawing process it is automatically held in position at throat of the die due to friction between mandrel and tube. It is possible to achieve a reduction in area of 45% and for the same reduction the drawing loads are lower than for drawing with a fixed mandrel.



Tooling is more critical for this operation than for any of the others. The die land must be long enough to permit the mandrel to seat in the tube inner diameter, but not so long that friction becomes a problem. In addition to tool design, lubrication and tube cleanness are critical to successful floating plug drawing. Two chief advantages of floating plug drawing are that it achieves a higher material yield than any of the other processes and its long-length capability.

It is the only drawing process for applications that require long lengths with a smooth inner diameter surface, such as down-hole oil exploration. Thermocouple sheathing that requires a smooth and ultraclean inner diameter surface is best produced by floating or tethered plug drawing methods.

3)

a)

Given

% reduction = 20%

$\Rightarrow r = 0.2$

Initial diameter of wire = 10 mm = D_0

$\Rightarrow R_0 = 5$ mm

reduction = 10 (0.2) = 2 mm

Final diameter of wire = 10 − 2 = 8 mm 1

$\Rightarrow D_f = 8$ mm

$\Rightarrow R_f = 4$ mm

Flow stress = $\sigma_0 = 637$ MPa

die angle = $2\alpha = 12^\circ$

half-die angle $\Rightarrow \alpha = 6^\circ$

$\mu = 0.09$

Velocity of drawn stress = V = 3 m/sec

Drawing stress

$$\sigma_2 = \frac{\sigma_0 (1+B)}{B}\left[1-(1-r)^B\right]$$

where $B = \mu \cot \alpha$

$= 0.09 \cot 6$

$\boxed{B = 0.856}$ 1

$$\sigma_2 = \frac{637(1+0.856)}{0.856}\left[1-(0.8)^{0.856}\right]$$

$\boxed{\sigma_2 = 240.05 \text{ N/mm}^2}$ 2

for 20% reduction

Power required

$P = \text{Force} \times \text{Velocity}$

$\therefore$ WKT $= \text{Stress} = \frac{\text{Force}}{\text{Area}}$

$\text{Force} = \text{Stress} \times \text{Area}$

$= \sigma_2 \times \frac{\pi}{4} D_f^2$

$= 240.05 \times \frac{\pi}{4} (8)^2$ 1

$\text{Force} = 12.067 \times 10^3 \text{ N}$

$\therefore \text{Power} = 12.067 \times 10^3 \times 3$

$P = 36.201 \text{ KN m/s}$ 1

3)

b) Deformation in Drawing Process

The total work required in actual drawing operation are divided into three components are, work required for homogeneous deformation (W_h), work spent on friction (W_f) and redundant or unwanted (W_r) deformation.

Homogenous work is used to reduce the cross-section, is essentially independent of the die and involves no losses.

Frictional work spent on overcoming the friction resistance at the work-tool interface.

Redundant work is the work spent in causing internal distortion of the work more than that is actually desired. Redundant deformation caused by the unwanted internal macro shear in the metal.

In homogenous deformation, plane section remains plane after deformation. While in actual deformation process, internal macro shear causes distortion of the plane sections. Due to this metal undergoes an excessive strain than the ideal work. This leads to work hardening and makes the work less ductile.

Redundant work and frictional work have adverse effects on wire properties in addition to increasing the energy needed for drawing. One consequence is that mechanical properties will not be homogeneous across the wire cross section. Redundant and frictional deformations are concentrated near the wire surface, higher levels of strain hardening will result in the surface and near-surface layers (analogous to temper rolling) and will be greater than the strain that results from cross section reduction. This strain gradient can be verified easily by performing a hardness survey on a transverse section of cold drawn wire. Also, redundant deformation has an adverse effect on ductility.

Lubrication

Proper lubrication is essential to improve die life, reduce drawing forces and temperature, and improve surface finish
Lubrication is more difficult between the mandrel and workpiece in tube drawing
Methods

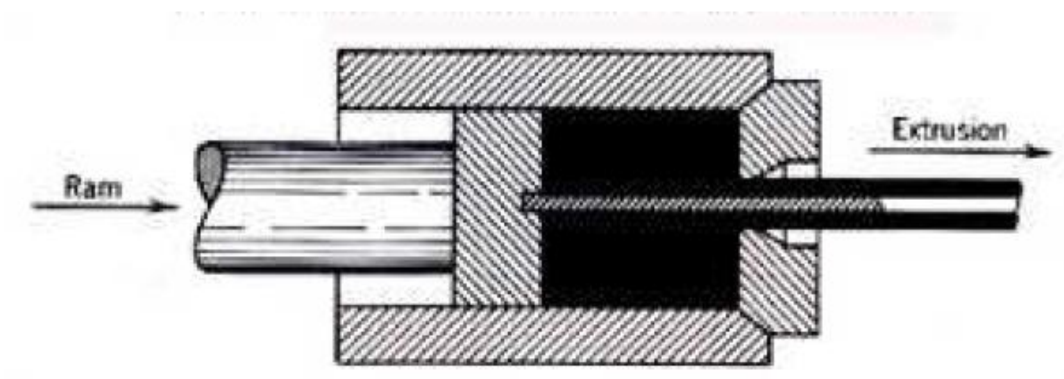
- Wet drawing –dies and rod completely immersed in lubricant (oils or emulsions)

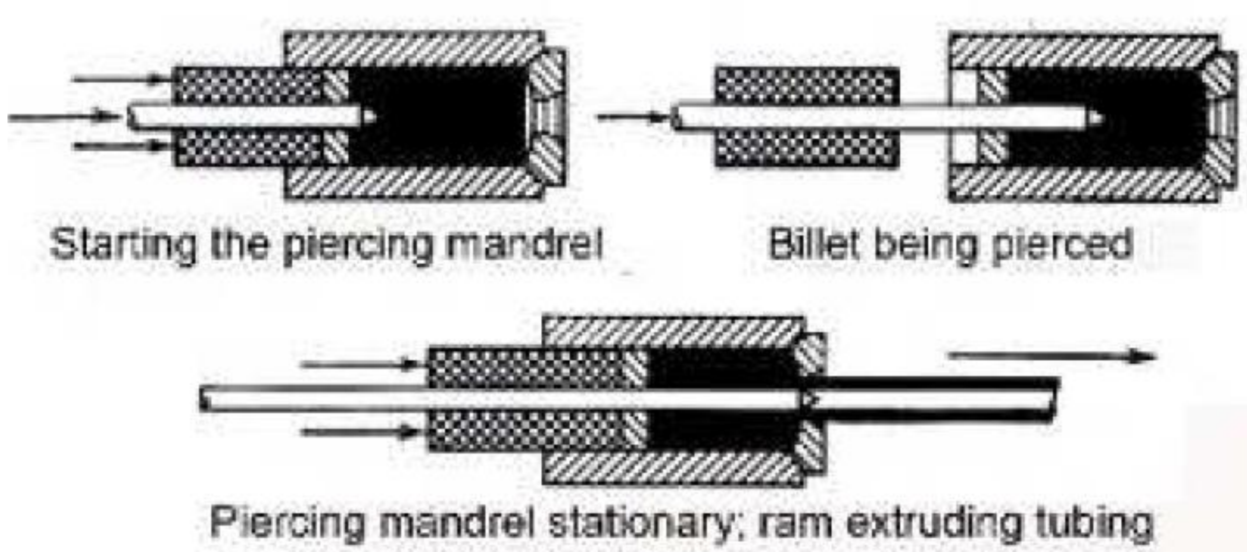
- Dry drawing –surface of rod is coated with a lubricant such as soap by passing it through a box filled with the lubricant (stuffing box)
- Coating –the rod or wire is coated with a soft metal (copper or tin) that acts as a solid lubricant
- Ultrasonic vibration of the dies and mandrels –reduces friction and allows larger reductions per pass without failure

4)
a) SEAMLESS PIPE

Tubes can also be produced by **hollow billet** and by using mandrel. The mandrel is fitted at the end of the ram; hollow sections such as tubes can be extruded to closer tolerances. A mandrel that matches the diameter of the cast hole in the billet (but slightly smaller than the hole in the die at the opposite end of the chamber) are used. Initially the mandrel is extends upto the entrance of the die. Clearance between the mandrel and die wall decides the wall thickness of the tube shown in figure 4.10.a. The mandrel is made to travel along with the ram in order to make concentric tubes by extrusion. Suitable force is applied to the ram, as the ram moves forward; the metal is forced over the mandrel and through the hole in the die, causing a long hollow tube.

Tubes can also be made using **solid billet** and using a **piercing mandrel** to produce the hollow. The piercing mandrel is made to move independently with the help of hydraulic press (Refer fig 4.10.b). It moves along with the ram coaxially. First the ram upsets the billet, keeping the mandrel withdrawn. Next the mandrel first pierced the solid billet by applying suitable force and mandrel ejects a plug of material from central. Mandrel is extends upto the entrance of the die (Refer 4.10.c). Clearance between the mandrel and die wall decides the wall thickness of the tube. As the ram moves forward, the metal is forced over the mandrel and through the hole in the die, causing a long hollow tube (Refer fig 4.10.d). Just like toothpaste, only hollow.





4)

b) DEFECTS IN EXTRUSION

1) Inhomogeneous deformation in direct extrusion provides the dead zone along the outer surface of the billet due to the movement of the metal in the centre being higher than the periphery.
   - After 2/3 of the billet is extruded, the outer surface of the billet (normally with oxidized skin) moves toward the centre and extrudes to the through the die, resulting in internal oxide stringers. Transverse section can be seen as an annular ring of oxide.
   - If lubricant film is carried into the interior of the extrusion along the shear bands, this will show as longitudinal laminations in a similar way as oxide.

Solutions:
   - Discard the remainder of the billet (~30%) where the surface oxide begins to enter the die **_** not economical.
   - Use a follower block with a smaller diameter of the die to scalps the billet and the oxidized layer remains in the container (in brass extrusion).

2) **Surface cracking:** it is in the form of rough surface or fir-tree cracking**.**
   Causes:
   - This is due to longitudinal tensile stresses generated as the extrusion passes through the die. In hot extrusion, this form of cracking usually is inter-granular and is associated with hot shortness.
   - The most common case is too high ram speed for the extrusion temperature.
   - At lower temperature, sticking in the die land and the sudden building up of pressure and then breakaway will cause transverse cracking.

   Solution: use of optimal ram speed and billet interface to obtain a sound product.
3) **Laminations of glass/ oxide** into the interior of extrusion.
   Cause: Improper lubrication method
   Remedy: To provide optimum lubrication on the outside of billet and to use optimal ram speed.
4) **Extrusion defect:** The last 1/3rd of extrusion may have oxides and other impurities in it rendering it unfit for use because of poor mechanical properties. This leads to the formation of "annular ring of oxide" in the extruded product.
   Cause: The metal in the middle (2/3rd) is first extruded as it moves faster than the periphery of billet due to friction. This tendency of extrusion defect increases with friction between billet and container wall.
   Remedy: The last 1/3rd of billet is left out without extruding it. But this is economically not feasible. Instead a "follower block" is widely used. This block is slightly smaller diameter than the container and it scalps or scrapes the billet, leaving behind the oxide layers in the container.
5) **Axial Hole/ Funnel**: It is an axial hole in the back end of extrusion.
   Cause: Rapid radial flow of metal during extrusion of last 1/4th of billet.
   Remedy: Inclining the face of the ram at an angle to the ram axis.
6) **Variations in hot structure and properties** within the extrusions due to non-uniform deformation, for example at the front and the back of the extrusion in both longitudinal and transverse directions.

5)

a) EXTRUSION VARIABLES

They affect the extrusion process considerably. They are:

1) Type of extrusion (direct or indirect)

In direct extrusion process, metal begins to flow through the die at the maximum value of the pressure called "break through pressure". As billet extrudes, the pressure required progressively decreases with decreasing length of the billet in the container (because, the friction between the billet and container decreases).

- In indirect extrusion, there is no relative motion between billet and wall. Therefore extrusion pressure is almost constant with increase in ram travel.

- It represents the stress required to deform the metal through the die.
- Limited in application by the need of hollow ram, which limits the size of extrusion & pressure.
- Hence most of the hot extrusion is done by direct extrusion.
- At the end of the ram stroke, there is a rapid pressure build up & therefore a small " discard '' is left behind in the container, without extruding it.

2. Extrusion Ratio : (R)

R= Initial cross area of the billet / final cross section area after extrusion

R = Ao / Af

Up to = 40: 1 for hot extrusion of steel

Up to = 400: 1 for Aluminium

- A small change in the fractional reduction results in large increase in extrusion ratio

Velocity of extruded product = ram velocity x R

Therefore high sliding velocities exist along the die land.

Extrusion Pr. = P = K Ao ln (Ao / Af)

K = extrusion constant, which accounts for flow stress, friction, and inhomogeneous deformation.

3. Temperature:

Hot extrusion decreases flow stress of metal, but increases oxidation of billet & extrusion tools. Other features are:

Softens die & tools

- Difficult to provide lubrication
- Therefore it is advantageous to use the min. temp. which provides required plasticity to metal.
- The upper hot working temp. of metal is the temp. at which " Hot shortness " occurs.
- Higher plastic deformations involved also lead to internal heating of the metal.
- Therefore max. working temp. must be safely below the melting point.
- Typical Values steel billets heated to 11000 C to 12000 C
- Tooling's: preheated to 350 0 C.

4. **Extrusion pressures** – range: 800 MPa to 1200 MPa

5. Lubrication: (Glass)

- To be maintained at high temperature & under high pressure.
- Low strength alloy (Al) does not require lubrication.
- Metal deformation is non – uniform and therefore wide variation in heat treatment response is observed
- Effect of temperature, pressure & strain rate on the allowable working range or interdependence of extrusion speed & temperature:
- For a given working pressure & temperature there will be a maximum amount of deformation possible on the work piece.
- As pre heat temperature of billet increases, the flow stress falls & therefore amount of possible deformation increases
- As strain rate of deformation increases, more heat is retained in the work & therefore work temperature will have to be reduced so that final temperature is below hot shortness temperature.

6. Ram speed:

Increase in ram speed increases the extrusion pressure.

Whereas, low ram speeds leads to cooling of the billet and because of billet cooling, flow stress is increased.

- The higher the temperature of billet, the greater the effect of low extrusion speed on the cooling of the billet.
- Therefore high extrusion speeds are required with high strength alloys which need high extrusion temperatures.
- At the same time at high extrusion speeds, temperature rise due to deformation is greater.

- The selection of proper extrusion speed & temperature is best determined by trial & error for each alloy and billet size.
- For a given extrusion pressure the extrusion ratio which can be obtained increases with increasing temperature.
- For a given temperature a large extrusion ratio can be obtained with high pressure.
- Maximum billet temperature is determined by the temperature at which melting is about to occur.
- The temperature rise of extrusion is determined by the speed of extrusion & extrusion ratio.

6)
a)

Given

Original dia. $= D_0 = 300$ mm

$R_0 = 150$ mm

Length of work $= L = 1\text{m} = 1000$ mm

Final work dia. $= D_f = 75$ mm 1

$R_f = 37.5$ mm

$\mu = 0.1$, $\alpha = 60^0$

$\sigma_0 = 83$ MPa

Case a)

extrusion pressure $= P_e = \sigma_2 + \dfrac{4\tau_i L}{D_0}$ 1

$$\sigma_2 = \frac{\sigma_0(1+B)}{B}\left[1 - R^B\right]$$

$R =$ extrusion ratio $= \dfrac{A_0}{A_f} = \dfrac{D_0^2}{D_f^2} = \dfrac{300^2}{75^2} = 16$ 1

$B = \mu \cot\alpha = 0.1 \cot 60 = 0.0577$ 4

$\tau_i = \dfrac{\sigma_0}{\sqrt{3}} = \dfrac{83}{\sqrt{3}} = 47.9\ \text{N/mm}^2$ 1

$$\sigma_2 = \frac{83(1+0.0577)}{0.0577}\left[1 - 16^{0.0577}\right]$$

$\sigma_2 = -263.95\ N/mm^2$ 1

$\simeq \sigma_2 = 263.95\ N/mm^2$

Thus – $P_e = 263.95 + \frac{4(47.92)1000}{300}$

$P_e = 902.88$ 1

$P_e \simeq 903\ N/mm^2$

Case (b)

Extrusion pressure at the end of the stroke is nothing but the extrusion stress. 1

$\sigma_2 = 263.95\ N/mm^2$

Case (c)

Press Capacity $(F) = P_e \cdot A_o$ 1

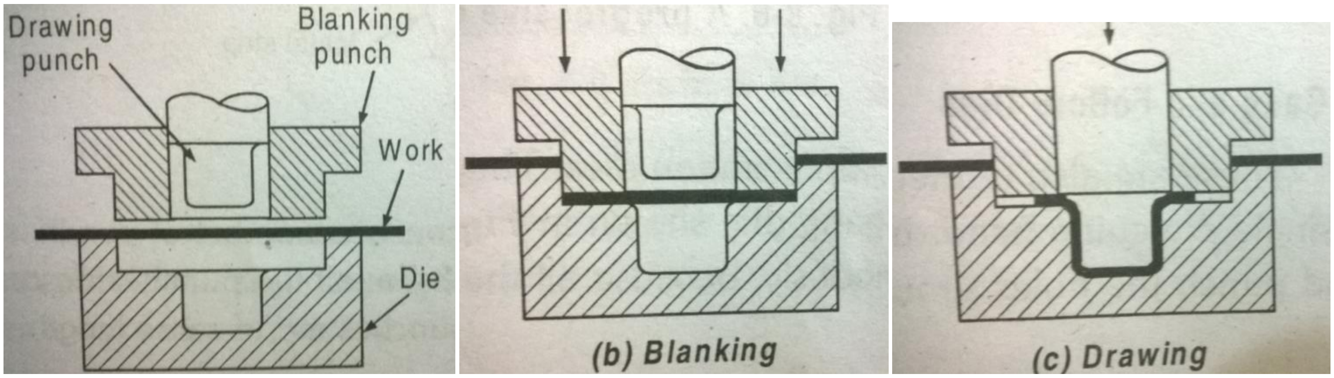
$= (903)\left(\frac{\pi}{4} 300^2\right)$

$\boxed{F = 63.82 \times 10^6\ N}$ 1

7)

a) Combination dies

In this die more than one operation may be performed at one stroke. It differs from compound die in that in this die, a cutting operation is combined with a bending or drawing operation. Figure explains the working of a combination blank and draw die. Combination of blanking and drawing die is mounted on the ram and the stock of sheet metal is kept on the corresponding die set up (fig a). First blanking is done by the blanking die (fig b) and as the ram advances further, the drawing punch descends and draws the sheet to the required shape (fig c).



Progressive or follow on dies

This dies have a series of stations. At each station, an operation is performed on a workpiece during a stroke of the press. Between the strokes, the piece in the metal sheet is transferred to the next station. A finished workpiece is made at each stroke of the press. First piercing is done and sheet metal is moved under the blanking punch and blanking can be performed to finish the job. Thus after the first stroke when only a hole will be punched, each stroke of press produces a finished washer as a result rate of production increases.