Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for anyequivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constantvalues may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q.1. A) Attempt any THREE **12 M**

1. Different types of cutting fluid: 2 M

a. Cutting Oils- Cutting oils are cutting fluids based on mineral or fatty oil mixtures. Chemical additives like sulphur improve oil lubricant capabilities. Areas of application depend on the properties of the particular oil but commonly, cutting oils are used for heavy cutting operations on tough steels. Eg. mineral oils, straight fatty oils, compounded or blended oils, sulphurised oils, chlorinated oils.

b. Soluble Oils- The most common, cheap and effective form of cutting fluids consisting of oil droplets suspended in water in a typical ratio water to oil 30:1. Emulsifying agents are also added to promote stability of emulsion. For heavy-duty work, extreme pressure additives are used. Oil emulsions are typically used for aluminum and cooper alloys.

c. Chemical fluids- These cutting fluids consists of chemical diluted in water. They possess good flushing and cooling abilities. Tend to form more stable emulsions but may have harmful effects to the skin.

Desirable properties of cutting fluid: (any four 2 m)

1. Good cooling capacity

2. Good lubricating qualities
3. Resistance to rancidity
4. Relatively low viscosity
5. Stability (long life)
6. Rust resistance
7. Nontoxic
8. Transparent
9. Nonflammable

2. Tool wear and Tool Life (1 M each for definition)

Tool wear-Tool wear describes the gradual failure of cuttingtools due to regular operation. It is a term often associated with tipped tools, tool bits, or drill bits that are used with machine tools.

Tool Life- Tool life is generally defined by the span of actual uninterrupted machining time through which the tool or tool-tip renders desired service and satisfactory performance and after which that tool needs replacement.

Factors affecting tool life (any four 2 M)

1. Cutting speed
2. Feed rate
3. Depth of cut
4. Spindle speed
5. Tool geometry
6. Tool material
7. Cutting fluid (coolants)

3. Die clearance (definition 2 M)

Dies clearance – Die clearance is defined as intentional space between the punch cutting edge and die cutting edge. It is always expressed as the amount of clearance per side.

Effect of excessive and in sufficient clearance: (2 M)

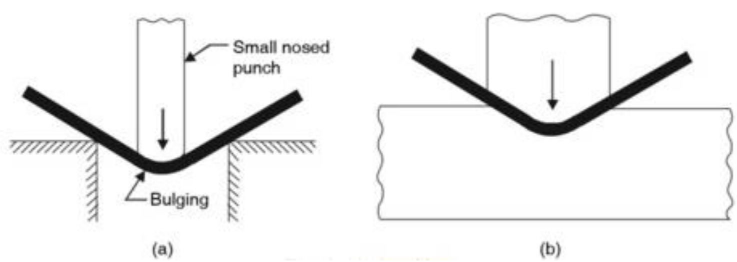
Excessive clearance allows a large edge radius and excessive plastic deformation. The edge of the material tends to be drawn in the direction of the working force and the break is not smooth.

Insufficient clearance causes the fractures to miss and prevents a clean break. A partial break occurs and a secondary break connects the original or main fractures.

4. Definition for Bending allowance and Spanking (2 M each) 4 M

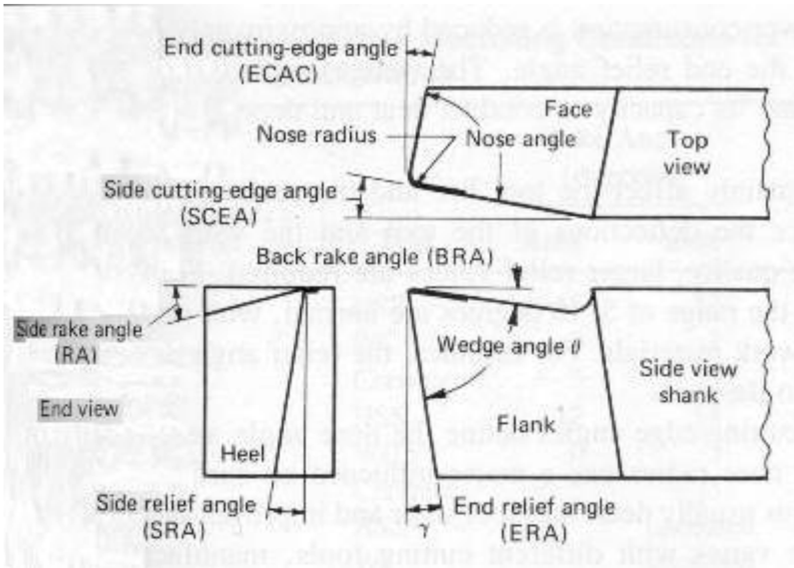
Bending allowance- For calculating the blank length for bending the length of material in the curved section or bend area has to be calculated. This length in the bend area which will be more than the corresponding length of blank before bending is called as 'Bending Allowance'.

Spanking –During bending, the area of the sheet under the punch has a tendency to flow and form a bulge on the outer surface as shown in fig. a. This is prevented by having tool surfaces of sufficient area to restrain metal flow. Thus the nose radius of the punch is gradually blending into the punch faces as shown in fig. b. The lower die should be provided with mating surfaces, so that when the punch and die are completely closed on the blank, any bulging developed earlier will be completely pressed and is called as spanking or spanked out.

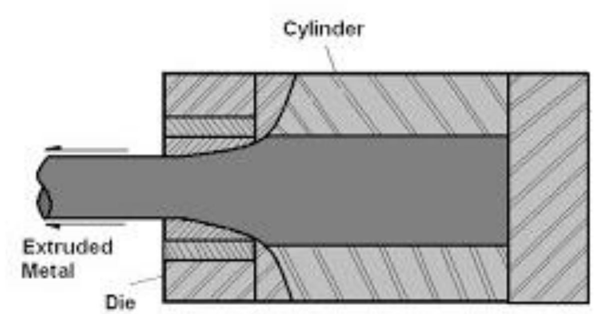


Q.1. B) Attempt any ONE 12 M

1. Sketch of Single point V Tool (4 M) and labeling of parts (2 M)



2. Back extrusion process (Fig. 2 M and Explanation 2 M and its suitability 2 M) 6 M



The backward hot extrusion as shown in above figure, in this process the metal is confined fully by the cylinder, the ram which houses the die also compresses the metal against the container, forcing it to flow backward to the die in the hollow plunger or ram.It is termed backward because of the opposite direction of the flow of the metal. Thus the billet in the container remains stationary and hence produce no friction. Also the extrusion pressure is not affected by the length. In the extrusion press since the friction is not loss.

Suitability of backward extrusion process (any four points 2 M)

- It is continuous process
- High production volumes

- Low cost per pound
- Efficient melting
- Many types of raw materials extruded
- Good mixing (compounding) is possible
- Variety of products to be extruded

Q.2. Attempt any FOUR **16 M**

1. Different types of metal cutting process (any four 2 M)

1. Turning process (Orthogonal and Oblique cutting)
2. Milling process
3. Drilling process
4. Grinding process
5. Broaching process

Utility of orthogonal cutting process (any four points 2 M)

1. Generation of continuous chips that affects the final surface integrity.
2. Less tool wear due to straight cutting action.
3. Higher depth of cuts may be possible for softer materials.
4. Generation of less cutting forces that affects the final surface integrity.
5. Moderate surface finished on machined components

2. Shearing operations by using punch and die (any eight operations 1/2 M each) **4 M**

1. Punching
2. Blanking
3. Piercing
4. Trimming
5. Notching
6. Nibbling
7. Perforating
8. Lancing
9. Parting

10. Shaving

11. Dinking

3. Machinability and Machinability index (Definition 2 M each) 4 M

Machinability-The term Machinability refers to the ease with which a metal can be cut permitting the removal of the material with a satisfactory finish at low cost.

Factors affecting machinability are:

Capacity of the machine (i.e. power torque and accuracy of the machine) , rigidity of the machine and work holding devices, tool material, Tool geometry, cutting speed, feed, depth of cut, work material variables like hardness, tensile strength, chemical composition, microstructure, shape and dimensions of the work etc.

Machinability Index- A numerical value that designates the degree of difficulty or ease with which a particular material can be machined.

The machinability index of free cutting steel is fixed at 100 %. For the other material the index is found as

Machinability index , % = (cutting speed of material obtained for 20 min. tool life) / (cutting speed of free cutting steel for 20 min. tool life)

The above is one of the methods of machinability rating of various materials. Other methods are measure of cutting forces, measure of tool wear and surface finish etc.

Eg. For the austenitic 302 SS steel, the **Machinability index** is KM = 0.23/0.5 = 0.46 (tool life of 60 min for 302 SS is reached for cutting at 0.23 m/s).

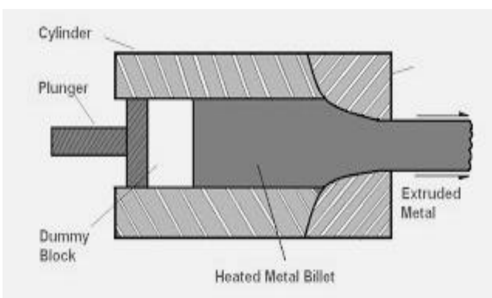
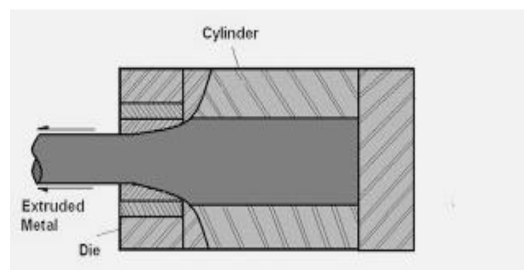
4. OBI Press (Definition 2 M)

A stamping press that has an opening at the back between the two side members of the frame and is arranged to be inclinable to facilitate part feeding and removal by gravity. Can be abbreviated OBI (Open Back Inclinable) press.

Function of Flywheel in OBI Press (2 M)

In OBI press the crank shaft carries a flywheel at the end. The rotation of the crank shaft makes the slide to move up and down. The function of flywheel is to store the energy and makes the ram to move at constant speed.

5. Difference between Direct and In-direct Extrusion (any four points 4 M)

Sr.	***Direct Extrusion***	***Sr.***	***In-direct Extrusion***
1	Simple, but the material must slide along the chamber wall.	1	In this case, material does not move but the dies are move.
2	High frictional forces must be overcome.	2	Low frictional forces are generated as the mass of material does not move.
3	High extrusion forces required but mechanically simple and complicated.	3	25-30% less extruding force required as compared to direct extrusion.
4	High scrap or more material waste- 18 to 20% on an average.	4	Low scrap or material wastage only 5-6 % of billet weight.
5			

Q.3. Attempt any TWO

1) The certain orthogonal cutting process, generate the chip of thickness 0.53 mm. The feed of the tool is 0.2 mm/rev and rake angle is 16^0 Find
   i. Shear angle
   ii. Coefficient of chip reduction
   iii. Cutting ratio.

Ans: feed f = t= 0.2 mm, t_c = 0.53 mm, $\alpha = 16^0$

i. **Cutting ratio or chip thickness ratio**(1 mark)

$$r = \frac{t}{t_c} = \frac{0.2}{0.53} = 0.377$$

Where $t =$ uncut or undeformed chip thickness

$t_c =$ chip thickness after the metal is cut

ii. Chip Reduction Coefficient (1mark)

$\zeta = \frac{1}{r} = \frac{t_c}{t} = \frac{0.53}{0.2} = 2.65$

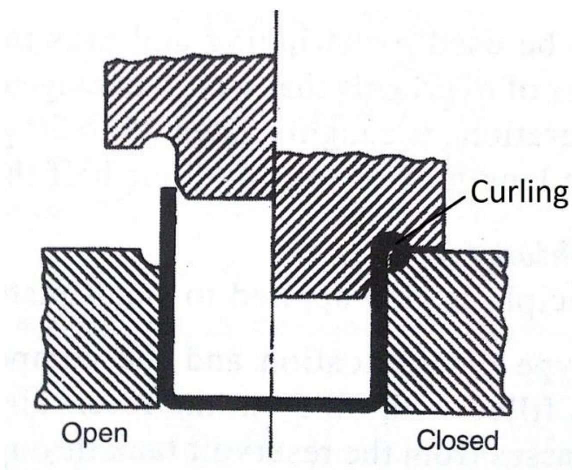
iii. Shear angle (2 marks)

$tan\varphi = \frac{r\cos\alpha}{1 - r\sin\alpha} = \frac{0.377 \times \cos 16}{1 - 0.377 \times \sin 16} = \frac{0.3624}{0.8961} = 0.4044$

$\varphi = tan^{-1}(0.4044) = 22.0184^0$

2) Explain with sketches following bending operations

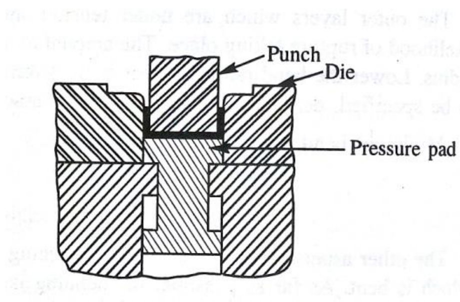
i. Curling: (Sketch: 2 marks, Explanation: 2 marks)



PRINCIPLE OF CURLING DIE

a) Curling is an operation of rolling the edges of sheet metal into a curl or roll.
b) The purpose is to straighten and provide a protective edge.
c) It also improves the appearance of the product.
d) It is often applied over a wire ring for increased strength.
e) Curling die rolls a draw edge of sheet into a roll or curl as shown in figure.
f) The sheet metal to be curled must be soft enough to roll properly.
g) The size of the curling groove in the die is the same as the curl diameter on the part.
h) The size of the curl is determined by the metal thickness. Generally it should not have a diameter less than 4 times the metal thickness.

ii. **Cup forming :** (Sketch: 2 marks, Explanation: 2 marks)



(c) U-die

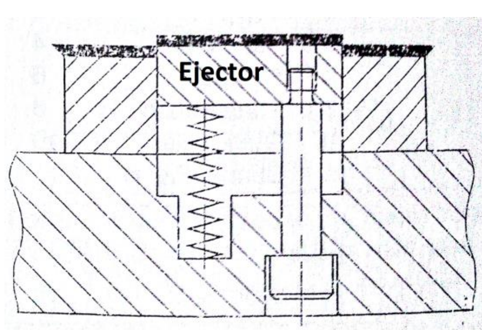
Typical tools used for drawing are shown in fig. the set up similar to that used in blanking operation except that the punch and die are provided with the necessary rounding at the corner to allow smooth flow of metal during drawing.

The blank is first kept on the die plate. The punch slowly descends on the blank and forces it to take cup shape formed by the end of the punch.

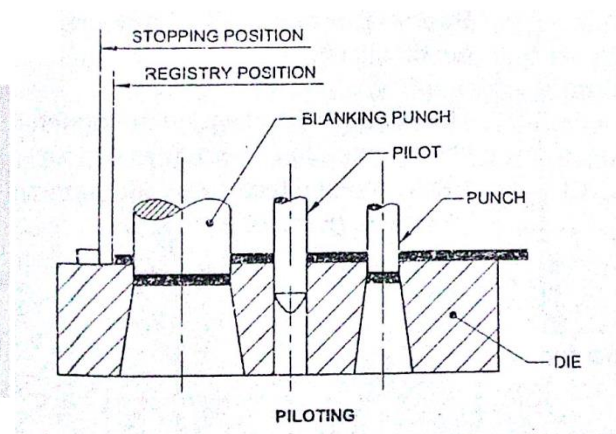
3) List the various die accessories. Describe any two with neat sketches.

Various die accessories are as follows (2 marks)

a. Punch
b. Punch holder or plate
c. Die block
d. Stripper plate
e. Guide pins or pilots
f. Pressure pad
g. Knockouts
h. Ejectors
i. Stoppers



Spring type Ejector



Above figure shows spring type ejector and pilots

Ejector:(Sketch: 2 marks, explanation: 1mark)

In the conventional position, die is the lower member of the tool. If the expulsion of the blank is achieved by forcing it upwards, the action is known as ejection. The element of the tool which ejects the blank is called as ejector.

Ejector may be actuated by compression springs, rubber, pneumatic or hydraulic devices.

Pilot: (Sketch: 2 marks, explanation: 1mark)

Pilot positions the stock strip in relation with the die opening. This is termed as registering.

When the press is tripped the pilot comes down and engages the prepierced hole. The strip is dragged back into the registry position.

When the mechanical feeding is employed the strip in underfed. The pilot pulls the strip into registry position.

Note:-any TWO die accessories

Q.4. (A) Attempt any THREE

1) Compare press forging with drop forging. (Any four points: 4 marks)

Sr. No.	Press Forging	Drop Forging
1	Quieter in operation	Noisy operation
2	Only one squeeze is needed at each die impression, hence faster in operation	Slower in operation as needs more than one squeeze at each die impression.
3	Alignment of two die halves can be more easily maintained.	Alignment of two die halves is difficult compared to press forging
4	More accurate	Less accurate
5	Low machining allowances	High machining allowances
6	Higher die life.	Lower die life due to higher number of strokes to be hammered for each forged component
7	Requires unskilled labour due simple handling	Requires skilled labour due complex handling
8	Higher productivity	Low Productivity
9	Easy for maintenance	Difficult for maintenance
10	Ecologically safer than drop forging	Not safe ecologically compared to press forging

2) **Why cemented carbide is considered as an useful tool material.(Any four points: 4 marks)**

Cemented carbides is considered as an useful tool material due to its following good properties.

(i) Higher wear resistance hence greater tool life and cutting efficiency.
(ii) High hot hardness hence tool retains its hardness at high temperature developed at tool chip interface when depth of cut is increased which results in higher productivity.
(iii) Chipping of cutting edge of tool material is prevented due to its high hardness.
(iv) As it is used as inserts and mounted on the shank made by other tough material, it can also withstand the forces and absorb shocks associated with interrupted cuts.
(v) Also cost becomes less as these are used as inserts and does have wide range of grades for machining of different materials.

3) Determine the size of square hole to be punched in an M.S. plate 16 mm thickness. The ultimate shear strength of plate is 300 N/mm^2. The permissible compressive stress in punch is 1200 N/mm^2.

Ans: $\tau = 300\ N/mm^2$, $\sigma_c = 1200\ N/mm^2$, t = 16 mm, Let side of square hole be ***s***

Punching force F = $(2 \times \boldsymbol{s} \times t) \times \tau = (2 \times \boldsymbol{s} \times 16) \times 300 = 9600$ Newtons.........(2 marks)

Permissible compressive stress $\sigma_c = \frac{Puching\ force\ F}{Area} = \frac{9600\ \boldsymbol{s}}{s \times s}$................................(1 mark)

$\boldsymbol{s} = \frac{9600}{1200} = 8\ mm$................................(1 mark)

4) **What is material utilization factor? State its importance.**

Material utilization factor $= \frac{Area\ of\ blanks\ from\ strip}{Area\ of\ the\ strip\ before\ blanking}$..........................(1 mark)

$= \frac{Weight\ of\ blank/strip}{Weight\ of\ the\ strip\ before\ blanking}$.....................(1 mark)

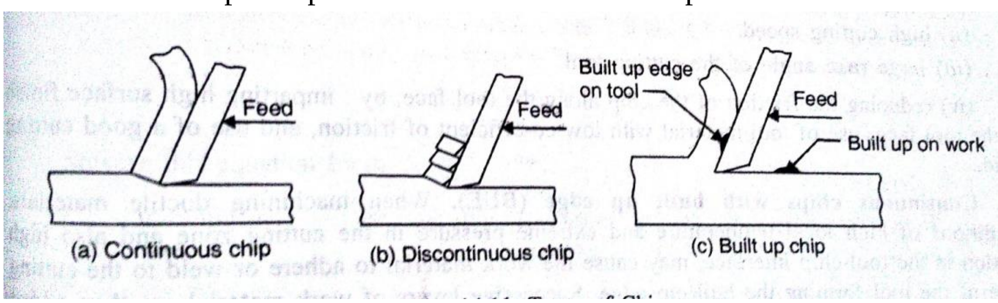
Importance of material utilization factor:..(Any two=2 marks)

a) Raw material economy can be affected by using most economical strip layout which can give the highest material utilization.

b) Hence material utilization factor gives us the idea about the best strip layout in which wastage of strip material is minimum with scrap strip have sufficient strength.
c) Higher the material utilization factor, higher the productivity.
d) Depending on material utilization, strip layout is prepared which is further useful for the selection of die and number of passes to be carried out.

Q.4. (B) Attempt any **ONE**

1) List the different types of chips produced during metal cutting process. Why discontinuous chips are preferred over continuous chips.



Types of chips produced during metal cutting process are as follows....(**List: - 2 marks, Preference to discontinuous chips: 2 marks,sketch preferred but not essential**)

(i) Continuous chips
(ii) Discontinuous chips
(iii)Chips with Built up edge

Discontinuous chips are preferred because chips break into small segments, the friction between the tool and chip reduces resulting in better surface finish. These chips are convenient to collect, handle and dispose off

2) A sheet of 75 mm diameter is to be drawn and its height has to be 200 mm. How many drawing operations would be required, if there were an annealing operation in between? Assume reduction of 50%, 40% and 30% etc. for each draw without annealing. Also determine height of each draw.

Ans:

Blank diameter is D = 75 mm

Height of cup h = 200 mm

As h/D ratio = 2.67, number of draws can be 3 or more without annealing

Sr. No.	Draw No.	% Reduction Possible Without annealing	% reduction possible with annealing after second draw .i.e. after 60% reduction
1	First	50	50
2	Second	40	40
3	Third	30	**45**
4	Fourth	20	**45**
5	Fifth	10	**45**

Drawing without annealing ....(3 marks)

i) First draw d_1= D × 0.5 = 75 × 0.5 = 37.5 mm

Cup height $h_1 = \frac{D^2 - {d_1}^2}{4 \times d_1} = 28.12mm$

ii) Second draw d_2= d_1 × 0.6 = 37.5 × 0.6 = 22.5 mm

Cup height $h_2 = \frac{D^2 - {d_2}^2}{4 \times d_2} = 56.875mm$

iii) Third draw d_3= d_2 × 0.7 = 22.5 × 0.7 = 15.75 mm

Cup height $h_3 = \frac{D^2 - {d_3}^2}{4 \times d_3} = 85.34mm$

iv) Fourth draw d_4= d_3 × 0.7 = 15.75 × 0.8 = 12.6 mm

Cup height $h_4 = \frac{D^2 - {d_4}^2}{4 \times d_4} = 108.45mm$

v) Fifth draw d_5= d_4 × 0.8 = 12.6 × 0.9 = 11.34 mm

Cup height $h_5 = \frac{D^2 - {d_5}^2}{4 \times d_5} = 121.17mm$

After five draws the required height is not obtained without annealing.

Drawing with annealing ....(3 marks)

j) First draw d_1= D × 0.5 = 75 × 0.5 = 37.5 mm

Cup height $h_1 = \frac{D^2 - {d_1}^2}{4 \times d_1} = 28.12mm$

ii) Second draw $d_2 = d_1 \times 0.6 = 37.5 \times 0.6 = 22.5$ mm

Cup height $h_2 = \frac{D^2 - {d_2}^2}{4 \times d_2} = 56.875\ mm$

iii) Third draw $d_3 = d_2 \times 0.55 = 22.5 \times 0.55 = 12.375$mm

Cup height $h_3 = \frac{D^2 - {d_3}^2}{4 \times d_3} = 110.54mm$

iv) Fourth draw $d_4 = d_3 \times 0.55 = 12.375 \times 0.55 = 6.8$ mm

Cup height $h_4 = \frac{D^2 - {d_4}^2}{4 \times d_4} = 205.10\ mm$

With the annealing the cup can be drawn up to height of 200 mm at the end of fourth draw.

Q.5 Attempt any FOUR

a) Define

(i) **Cutting Ratio :**(definition: 2 mark, **mathematical expression preferred but not essential**)It is defined as the ratio of uncut chip thickness (prior to metal cutting) to chip thickness after metal is cut.

Cutting ratio or chip thickness ratio $r = \frac{t}{t_c}$,

Where $t =$ uncut or undeformed chip thickness

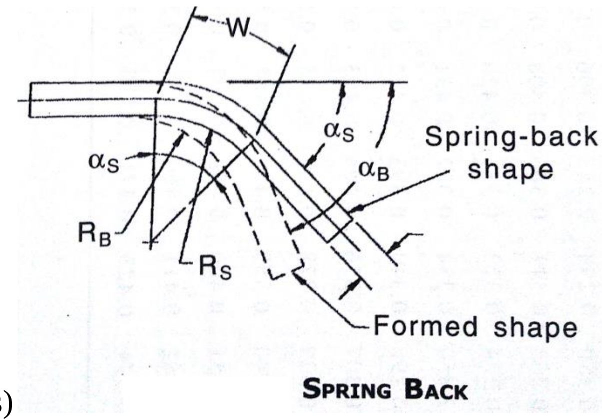
$t_c =$ chip thickness after the metal is cut

(ii) **Chip Reduction Coefficient:** (definition: 2 mark, **mathematical expression preferred but not essential**)

It is defined as the ratio of chip thickness after metal is cut to uncut chip thickness (prior to metal cutting) .

It is the reciprocal of cutting ratio $\zeta = \frac{1}{r} = \frac{t_c}{t}$,

b) What is spring back in bending operation? State its causes(**Explanation: 2 mark,Any two causes: 2 markssketch preferred but not essential**)



c) 1 mark, Any two causes: 2 marks)

At the end of the bending operation, when the pressure on the metal is released, there is an elastic recovery by the material. The material on tension side tries to contract.

This causes the decrease in the bend angle and this phenomenon is termed as spring back.

Causes of spring back:

i. Spring back increases as hardness of stock material increases.
ii. Thickness of stock material.
iii. Spring back is directly proportional to the bend radius.

d) The useful life of certain cutting tool at 23 m/min is 4.2 hours. Calculate the tool life when tool operates at 32 m/min. Assume tool life exponential n = 0.125

Ans: $VT^n = C$

V = 23 m/min

T = 4.2 hrs = 4.2 × 60 = 252 min

$C = VT^n = 23 \times 252^{0.125}$= 45.9095 ....(2 marks)

Now V_1 = 32 m/min

$$C = VT^n$$

$$45.9095 = 32 \times {T_1}^{0.125}$$

$$T_1 = \left(\frac{45.9095}{32}\right)^{\frac{1}{0.125}}$$

$T_1 = (1.4347)^8$ = 17.95 min ....(2 marks)

e) Draw neat sketch of following operation

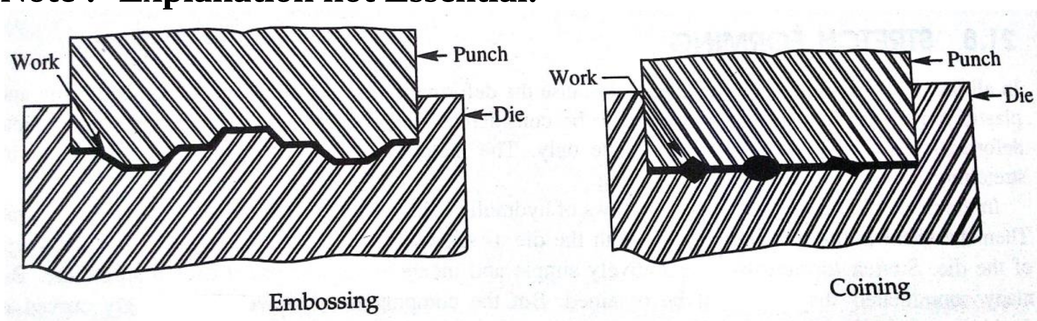
(i) Stamping: (Sketch: 2 marks)

Note: (For Examiner only)

A metal stamping can be defined as one which is usually made of , but not limited to, sheet or strip metal that has been cut, coined ,pierced, bent, formed or drawn in one or more operations between matching dies under pressure. It includes a variety of operations, such as punching, blanking, embossing,bending, flanging, and coining; simple or complex shapes formed at highproduction rates; tooling and equipment costs can be high, but labor costsare low.

The sketch for any of the above operations shall be given due credit.

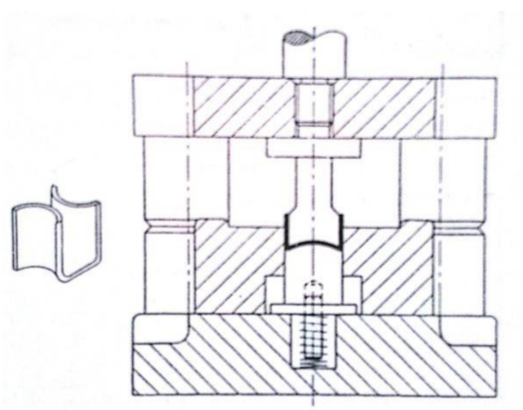
Note :- Explanation not Essential.



(ii) Forming: (Sketch: 2 Marks)

It is a operation that forms the blank without removing any stock. Forming operations include bending, drawing, squeezing operations. E.g. embossing, coining, bulging etc.**Any suitable technically correct sketch of any forming operation shall be given due credit.**

Note :- Explanation not essential.

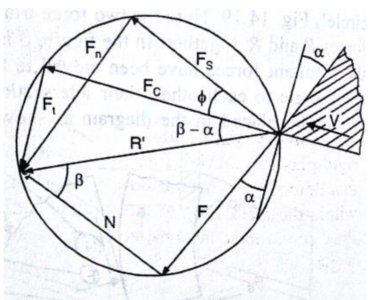


FORMING TOOL

State two components produced by these operations.

- Stamping: Truck frames, beer cans, fan blades, watch gears.
- Forming: Automobile components such as, channels for chassis, coins, embossed components, mounting brackets,

f) Draw the Merchant's Circle and state its utility.



Merchant Force Circle. ....(Sketch: 2 marks)

Utility of Merchant's force circle ....(2 marks)

(i) It helps to determine the cutting power required for machining using the different forces acting on the tool.

(ii) Helps to understand the influence of shear angle on cutting geometry and also analyses the optimum value of shear angle for productive machining.

g) The washer of 20 mm outer diameter and 8 mm inner diameter are to be made by press operation from M.S. sheet of 1 mm thickness. Calculate

(i) Clearance

(ii) Size of punch and die.

Ans:

(i) **Clearance :** 5 % of the thickness t

$C = 0.05 \times 1 = 0.05$ mm....................................(1 mark)

(ii) Size of punch and die.

Blanking die opening size is equal to blank size. But to allow for expansion of blank, die opening should be made smaller, thus

Blank die opening = 20.00 -0.05 = 19.95 mm

Blanking punch size = Blanking die opening -2C

= 19.95 – 2 × 0.05

= 19.85 mm ....(1 mark)

Punch size is made larger to compensate elastic recovery

Piercing Punch size = 8 + 0.05

= 8.05 mm ....(1 mark)

Piercing die size = Piercing Punch size + 2C

= 8.05 + 2 × (0.05)

= 8.15 mm ....(1 mark)

OR

(iii) Size of punch and die.

Blank die opening = Blank size = 20.00 mm

Blanking punch size = Blanking die opening -2C

= 20.00 – 2 × 0.05

= 19.90 mm ....(1 mark)

Punch size is made larger to compensate elastic recovery

Piercing Punch size = Hole size (dia) = 8 mm ....(1 mark)

Piercing die size = Piercing Punch size + 2C

= 8.00 + 2 × (0.05)

= 8.10 mm ....(1 mark)

Note :- The given problem can solve by any one of the above way, Consider any one solution out of the above two

Q.6 Attempt ant **TWO**

a) Name any four tool materials. State at least four most important characteristics of good tool material. Which is better on above criterion amongst the four materials listed above?

Tool materials: (Any four: 3 marks)

(i) Carbon tool steels
(ii) High Speed steels
(iii) Cast Cobalt alloys
(iv) Carbides
(v) Ceramics
(vi) Cubic Born Nitrides
(vii) Diamonds.

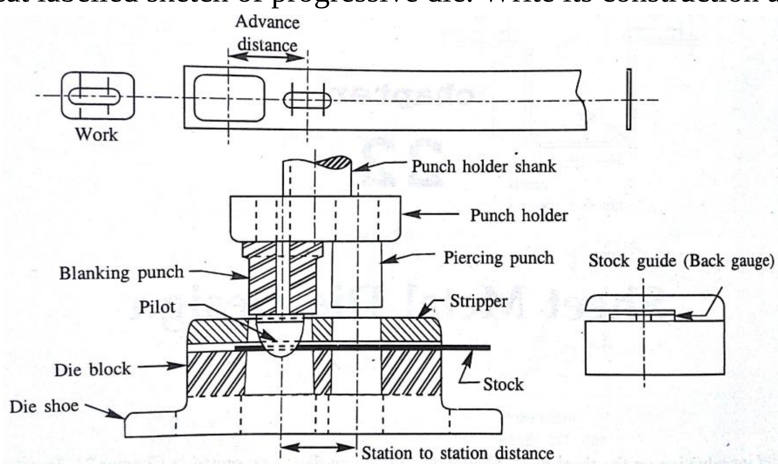
Most important characteristics of good tool material:(Any four: 3 marks)

(i) High wear resistant
(ii) High hot hardness

(iii) High toughness
(iv) Fast recovery hardness
(v) Grindability
(vi) Weldabilty
(vii) Freedom from distortion after heat treatment.

Considering the above properties for the mentioned materials, carbides can be considered as the best material which optimises the combination of most important characteristics of good tool material ....(2 marks for **correct answer**)

b) Draw neat labelled sketch of progressive die. Write its construction and working.



A simple progressive die ….(3 marks)

Construction:..(3 marks)

Progressive die contain large number of stations. Each station is meant for different metal forming operation.

Punch contains pilots for the positioning of strip. Sometimes special pilots are to be incorporated.

Upper die contains the number of punches arranged in sequence of operations to be performed. E.g. piercing, blanking, lancing, trimming, nibbling etc.

Lower die is mounted on bolster plate. Lower die contains strip feed mechanism, stripper, and stoppers, pressure pads, stock guides, etc.

The figure shows the construction of progressive die.

Working of progressive die:..(2 marks)

Progressive tools perform two or more operations at different stages every time the press is operated.

The stock strip is advanced through a series of stations that performs one or more distinct press working operations.

The strip must move from the first to each succeeding station to produce a complete workpiece.

c) A symmetrical cup work piece is shown in figure, is to be made from 0.8 mm M.S. Sheet Calculate,

(i) Size of blank
(ii) % Reduction
(iii) Number of draw
(iv) Radius of punch and die.

Ans:

Shelll diameter ***d*** = 60 mm, radius of bottom corner ***r*** = 1.6 mm

(i) **Size of blank**..(2 marks)

The ratio $\frac{d}{r} = \frac{60}{1.6} = 37.5$

As $\frac{d}{r} = 37.5 > 20$

Hence formula for determining shell blank size will be

$D = \sqrt{d^2 + 4dh} = \sqrt{60^2 + 4(60 \times 60)} = \sqrt{18000} = 134.16\ mm$

Add trimming allowance i.e.3.2 mm/ each 25 cm of cup diameter.

As cup diameter is 60 mm, 7.68 mm is to be added.

Hence D = 134.16 + 7.68 = 141.84 mm

(ii) **% Reduction** ....(2 marks)

%Reduction=$100\left(1 - \frac{d}{D}\right)$

$= 100\left(1 - \frac{60}{141.84}\right) = 57.70\ \%$

As per practise, a reduction of about 40 to 50 % is permissible for first draw. So it is clear that above cup cannot be drawn in a single draw.

(iii) **Number of draws**..(2 marks)

Height to diameter ratio = $\frac{60}{60} = 1$

Number of draws for $\frac{h}{d}$ ratio ranging from 0.7 to 1.5 is 2

Let the first reduction be 45%

Diameter d_1 at first draw = 141.84 – 0.45 × 141.84 = 78.012 mm

Reduction for second draw $=100\left(1-\frac{60}{78.012}\right)$

$= 23.09\ \%$

this is less than 30% permissible limit for second draw.

(iv) **Radius of punch and die.**..(2 marks)

For the first draw,

Punch radius at the bottom should be at least = 4t = 4× 0.8 = 3.2 $\cong 4\ mm$

For second draw,

punch radius is determined by the corner radius of the finished shell that is, it should be equal to 1.6 mm

The die radius ,$\mathbf{r_d}$ should be 4 to 10 times the stock thickness

$\mathbf{r_d}$ = 3.2 to 8 mm $\cong 6\ mm$