UPPSC-AE 2020

Uttar Pradesh Public Service Commission

Combined State Engineering Services Examination

Assistant Engineer

Mechanical Engineering

Manufacturing

Well Illustrated **Theory** *with*
Solved Examples and **Practice Questions**

MADE EASY Publications

Manufacturing

Contents

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CHAPTER 4

Sheet Metal Forming Processes

4.1 Introduction

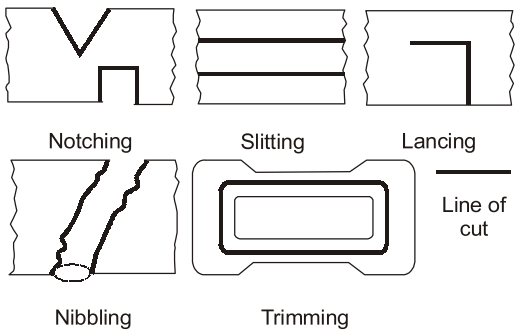
Sheet metal forming processes are those in which force is applied to a piece of sheet metal to modify its geometry rather than remove any material.

4.2 Shearing

- Shearing of sheet metal is process in which a piece of sheet metal is separated by applying a great enough force to cause the material to fail.

4.2.1 Die cutting (Shearing operation)

- **Perforating:** Punching a number of holes in a sheet (1 mm to 75 mm)
- **Parting:** Shearing the sheet into two or more pieces.
- **Notching:** Removing pieces from the edges.
- **Lancing:** Leaving a tab without removing any material.
- **Slitting:** Shearing operations can be carried out by means of a pair of circular blades similar to those in a can opener. The blades follow either a straight line or a circular or curved path.
- **Steel Rules:** Soft metals can be blanked with steel rule dies.
- **Nibbling:** In nibbling, a machine called a nibbler moves a small straight punch up and down rapidly into a die. A sheet is fed through the gap and many overlapping holes are made.
- **Nesting:** A significant factor in manufacturing cost, scrap can be reduced substantially by proper arrangement of the shapes on the sheet to be cut.



NOTE: Generally, clearance for soft materials are less than those for hard grades and also thicker the sheet, larger the clearance.

- In a process called trimming the extra material from a rough sheared edge is trimmed by cutting.
- Beveling is particularly suitable for shearing of thick blanks, because it reduces the force of beginning of the stroke and it also reduces the operation's noise level.

4.2.2 Types of DIES

- **Simple die:** One operation on one station in one stroke.
- **Compound Die:** Several operations on the same strip may be performed in one stroke at one station with a compound Die.
- **Progressive Dies:** Parts require multiple operation, such as punching, blanking and notching, can be made at high production rate in progressive dies.

4.2.3 Punching

- When sheet metal is punched then punched out material is a waste.
- In punching operation punch is exact and clearance is provided to the dies.

4.2.4 Blanking

- When punched out material is useful then it is blanking.
- In Blanking operation, dies are exact and clearance is provided to the punch.

Punching: Punch = Size of hole

Die = Punch size + $(2 \times C)$

Blanking: Die = Size of product

Punch = Die size – $(2 \times C)$

Where, C = Clearance = $0.0032 \times t\sqrt{\tau}$

τ = Ultimeate shear strength of the material (MPa or N/mm)^2

Punching and Blanking force:

$$F_{max} = Lt.\tau_{ut}$$

$L = \pi D$ (For circular hole)

$= 2(l + b)$ (for rectangular hole)

Actual energy required (E and J) = $F_{max} \times (p \times t) \times C$

where, $p \times t$ = Penetration

C = 1.1 to 1.75 depending on profile,

Shear on Punch:

- It reduce shearing force, but work done required will remain same.
- Shear is ground on face of the die or punch.
- It distribute the cutting action over a period of time.
- Force required with shear on punch:

$$F = \frac{F_{max} \times Pt}{s + Pt}$$

$$= \frac{F_{max} \times Pt}{s} \quad (F \text{ as displacement curve is trapezoidal})$$

4.2.5 Bending

- Bend allowance is the length of the neutral axis in the bend and is used to determine the blank length for a bent part **Bend allowance,** $L_b = \alpha (R + kT)$.

$\alpha \rightarrow$ Bend angle

$\begin{bmatrix} \text{For } R > 2t \Rightarrow k = 0.5 \\ R < 2t \Rightarrow k = 0.33 \end{bmatrix}$

$R \rightarrow$ Bend Radius

$T \rightarrow$ Sheet thickness

Bending force: $F = \dfrac{kl\sigma_{ut}t^2}{w}$

l = Bend length; σ_{ut} = Ultimate tensile strength; t = Blank thickness;

w = Width of die opening; k = Die opening factor

- Force required in V-bending: U-bending: edge bending = 1 : 2 : 0.5.

4.2.6 Hemming

In the hemming process the edge of the sheet is folded over itself. It increases the stiffness of the part.

4.2.7 Dimpling

In this operation first a hole is punched and then it is expanded into a flange.

4.2.8 Drawing

- It is a plastic deformation process in which a flat sheet or plate is formed into a 3-D part with a depth more than several times the thickness.
- **Hot drawing:** For thick walled parts (Thining of wall may takes place)
- **Cold drawing:** For thin metal (No thining occurs)

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

Drawing force = $P = \pi dt\sigma\left[\dfrac{D}{d} - C\right]$

4.2.9 Deep Drawing

- The important variables in deep drawing are the properties of sheet metal, the ratio of blank diameter D_o to punch diameter D_p, the clearance 'C' between punch and die, the punch radius R_p, die Radius R_d.

  Deep drawability is expressed by the **limiting drawing Ratio (LDR)**

  $LDR = \dfrac{D_o}{D_p}$.
- In drawing, the edges of cups may become wavy, this phenomenon is called **earing.**

4.2.10 Spinning

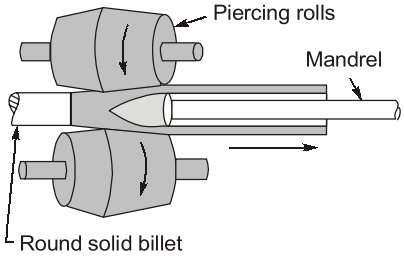
- It involves the forming of axisymmetric parts over a mandrel by the use of various tool and rollers.
- Shear spinning also known as **power spinning**, flow turning, hydrospining produces an axisymmetric conical or curvilinear shape while maintaining the parts maximum diameter and reducing its thickness.

4.2.11 Peen Forming

Peen forming is used to produce curvature on thin sheet metals by **shot peening** one surface of the sheet.

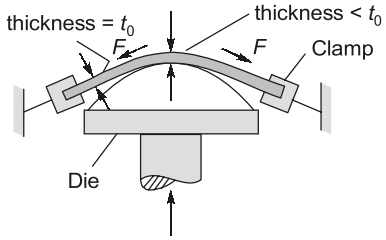
4.2.12 Piercing

- This production is employed for the production of seamless tube. It consists of passing hot rolled billet at 1100°C between two conical rollers over a mandrel, one pass is applicable upto 15 cm diameter. For large diameter second pass is necessary.



4.2.13 Stretch Forming

- In the sheet metal bending operation compressive stress is always developed and under certain circumstances this may be large enough to cause local buckling or wrinkling.
- The process of simultaneous stretching and bending is called stretch forming.
- It is not suitable for large production.
- It is used for aircraft wing-skin panel, automobile door panel etc.



For biaxial stretching of sheets, $\in_1 = \ln\left(\frac{L_{i1}}{L_{01}}\right)$ and $\in_2 = \ln\left(\frac{L_{i2}}{L_{02}}\right)$

$$\text{Final thickness} = \frac{\text{Initial thickness}(t_i)}{e^{\in_1} \times e^{\in_2}}$$

4.2.14 Wire Drawing

- When $d \leq 3/8$ inch, known as wire. The wire drawing die is of conical shape. The end of rod or wire which is to be further reduced is made to point at end and inserted in the die opening and gripped by a gripper on other side which pull the wire through die. The wire thus drawn is then called round a power reel.
- The wire cleaning is done by acid prickling and lubricated by special method such as cappering.
- Wire drawing die is chilled cast iron, tool steel, tungsten carbide.
- Wire drawing improves it's mechanical properties.
- For repeated wire drawing intermediate annealing is required due to loss of ductility.

4.2.15 Embossing

- Embossing is the operation through which raised figures are made on metal sheet with its corresponding relief on other side. Embossing involves drawing and bending. Die set consists of die and punch with desired contours.

- Uses of Embassing:
  - To impart a raised design or depressed design. (Name plate, specification plate).
  - To provide dimples on sheet to increase rigidity and strength.
  - In projection welding operation.

4.2.16 Defects of Drawing

1. **Wrinkle:** An insufficient blank holder pressure causes wrinkles are the flange.
2. **Fracture:** Too much blank hold pressure causes fracture at flange.
3. **Earing:** While drawing a rolled stock, ars or lobes tend to occur due to anisotropic material.
4. **Miss strike:** Due to misplacement of the stock.
5. **Orange peel:** A surface roughening encountered that has a coarse grain size.

Example - 4.1 Estimate the force required for punching a 25 mm diameter hole through a 3.2 mm thick annealed titanium alloy whose ultimate shear stress is 1000 MPa.

Solution:

$$\text{Punching force} = (\pi)3.2\times\frac{(25)}{2}(1000) = \frac{251327}{2}\text{ N}$$

$$= \frac{251.33}{2}\text{ kN} = 125.665\text{ kN}$$

Example - 4.2 A hole of diameter 35 mm is to be punched in a sheet metal of thickness t and ultimate shear strength 400 MPa, using punching force of 44 kN. The maximum value of 't' is

Solution:

$$(44)(1000) = \frac{\pi(35)(t)(400)}{2} \qquad \text{we get, } t = 2\text{ mm}$$

Example - 4.3 Consider the following statements related to piercing and blanking

(i) Shear on the punch reduces the maximum cutting forces
(ii) Shear increases the capacity of the press needed.
(iii) Shear increases the life of the punch.
(iv) The total energy needed to make the cut remains unaltered due to provision of shear.
Whose of these statements are correct?

(a) 1 and 2 (b) 1 and 4
(c) 2 and 3 (d) 3 and 4

Solution: (*b*)

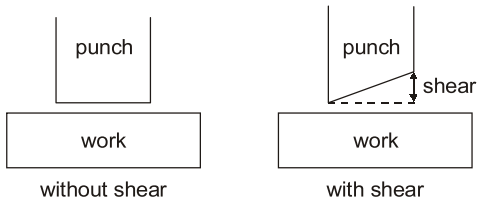
To reduce the required shearing force on the punch. For example to accumulate a compression on a smaller capacity punch press, shear is ground on the face on the die or punch.

It may be noted that providing the shear only reduces the maximum force to be applied but not the total work done in shearing the component. The provision of the shear on the punch will change the slug where as shear, provided on die would make the stock left on the die to bend. Hence the shear is provided on the die for blanking and on the punch for piercing.

Example - 4.4 Why shear is given to the punch in punching and blanking operations?

Solution:

Shear is given to reduce the maximum force required to perform the operation.



Student's Assignment

Q.1 In a blanking operation, the clearance is provided on
(a) The die
(b) Both the die and the punch equally
(c) The punch
(d) Brittle the punch nor the die

Q.2 The cutting force in punching and blanking operations mainly depends on
(a) The modulus of elasticity of metal
(b) The shear strength of metal
(c) The bulk modulus of metal
(d) The yield strength of metal

Q.3 In sheet metal blanking, shear is provided on punches and dies so that
(a) Press load is reduced
(b) Good cut edge is obtained.
(c) Warping of sheet is minimized
(d) Cut blanks are straight.

Q.4 A 50 mm diameter disc is to be punched out from a carbon steel sheet 1.0 mm thick. The diameter of the punch should be
(a) 49.925 mm (b) 50.00 mm
(c) 50.075 mm (d) none of these

Q.5 In deciding the clearance between punch and die in presswork in shearing, the following rule is helpful:
(a) Punch size controls hole size die size controls blank size
(b) Punchsize controls bothhole size and blank size
(c) Die size controls both hole size and blank size
(d) Die size controls hole size, punch size controls blank size

Q.6 Punching a number of holes in a sheet is known as?
(a) Perforating (b) Nibbling
(c) Notching (d) Lancing

Q.7 Moving a small straight punch up and down rapidly into a die is done by a process known as?
(a) Perforating (b) Notching
(c) Nibbling (d) Lancing

Q.8 Which of the following die can perform multiple operations such as blanking, punching, notching etc.?
(a) Simple dies (b) Progressive dies
(c) Compound die (d) None of the these

Q.9 Which of the following materials is used for the manufacturing of dies and punches in the sheet metal forming?
(a) Grey cast iron (b) Copper
(c) Aluminium (d) Tungusten Carbide

Q.10 Which of the following methods of manufacturing is used for the production of appliances like the fridge and vacuum cleaner?
(a) Extrusion
(b) Deep drawing
(c) Sheet metal operation
(d) Rolling

ANSWER KEY // STUDENT'S ASSIGNMENT

1. (c)	**2.** (b)	**3.** (d)	**4.** (b)	**5.** (a)
6. (a)	**7.** (c)	**8.** (b)	**9.** (d)	**10.** (c)

HINTS & SOLUTIONS // STUDENT'S ASSIGNMENT

1. (c)

In planking operation clearance is provided on punch and actual product size = die size.

2. (b)

Cutting force on blanking and punching depends on (τ_{ut}) ultimate shear strength of materials.
[$F_{max} = L.t.\tau_{ut}$]

3. (d)

Shear provided on punches and die to reduce press load.

4. (b)

Correction answer (d)
Making of disc in a blanking operation. So clearance is provided in punch.
Punch size = Die size – ($2 \times C$)
But data to find clearance is insufficient.

5. (a)

Punch size controls hole size and die size control blank size.

6. (a)

Punching a number of holes in a sheet is known as perforating. Removing the pieces from the edge in shearing operation is known as notching.
Lancing is a cutting process in which material is sliced or cut without producing a slug or separating the workpiece.

7. (c)

Nibbling is a process in which a single punch is moved up and down rapidly each time cutting off a small amout of material.

8. (b)

Progressive dies is used to perform two or more operation simultaneously in a single stroke of a punch press so that a complete component is obtained for each stroke.

9. (d)

Tungusten carbide is used for the manufacturing of dies and punches in the sheet metal operations.

10. (c)

Sheet metal operation are widely used for the manufacturing of home appliances like fridge, vacuum cleaner radio, toys, dryers, automobile bodies, aircraft parts etc.

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