Manufacturing Process - I

UNIT –VI
Sheet Metal Working

Prepared By
Prof. Shinde Vishal Vasant
Assistant Professor
Dept. of Mechanical Engg.
NDMVP’S Karmaveer Baburao Thakare
College of Engg. Nashik
Contact No- 8928461713
E mail:- nilvasant22@gmail.com
Website:- www.vishalshindeblog.wordpress.com
What is Sheet Metal?

- Sheet is a piece of metal whose thickness is between 0.006 (0.15 mm) and 0.25 inches (6.35 mm).
- Anything thinner is referred to as a foil and thicker is considered as a plate.
- Sheet thickness is generally measured in gauge. Greater the gauge number, thinner the sheet of metal.
- Sheet metal can be cut, bent and stretched into nearly any shape.
- Generally two types of operations are performed-forming and cutting.
Sheet and Plate Metal Products

- Sheet and plate metal parts for consumer and industrial products such as
  - Automobiles and trucks
  - Airplanes
  - Railway cars and locomotives
  - Farm and construction equipment
  - Small and large appliances
  - Office furniture
  - Computers and office equipment
Advantages of Sheet Metal Parts

- High strength
- Good dimensional accuracy
- Good surface finish
- Relatively low cost
- For large quantities, economical mass production operations are available
Sheet metal operations

A) Metal Cutting operations
1) Blanking
2) Punching (piercing)
3) Notching
4) Perforating
5) Slitting
6) Lancing
7) Shaving
8) Shearing
9) nibbling

B) Metal forming operation
1) Bending
2) Drawing
3) Embossing
4) Forming
5) Coining

20/09/2016 PROF. V.V. SHINDE NDMVP'S KBTCOE NASHIK
Basic Types of Sheet Metal Processes

1) Cutting
   - Shearing to separate large sheets
   - Blanking to cut part perimeters out of sheet metal
   - Punching/ Piercing to make holes in sheet metal

2) Bending
   - Straining sheet around a straight axis

3) Drawing
   - Forming of sheet into convex or concave shapes
Shearing

- Shearing is defined as separating material into two parts.
- It utilizes shearing force to cut sheet metal.
Blanking and Punching

**Blanking** - sheet metal cutting to separate piece from surrounding stock

- Cut piece is the desired (Useful) part, called a blank

**Punching** - sheet metal cutting similar to blanking except cut piece is scrap, called a slug

- Remaining stock is the desired (Useful) part.
**Perforating:** punching a number of holes in a sheet.

**Parting:** shearing the sheet into two or more pieces.

**Notching:** removing pieces from the edges.

**Lancing:** leaving a tab without removing any material.

**Slitting:** making an unfinished cut through a limited length only.
Lancing

• Creating a partial cut in the sheet, so that no material is removed. The material is left attached to be bent and form a shape, such as a tab, & vent.
Nibbling

• Punching a series of small overlapping slits or holes along a path to cut-out a larger contoured shape.
Embossing

- Certain designs are embossed on the sheet metal.
- Punch and die are of the same contour but in opposite direction.
Shaving

- Shearing away minimal material from the edges of a feature or part, using a small die clearance. Used to improve accuracy or finish. Tolerances of ±0.025 mm are possible.
Bending

Straining sheet metal around a straight axis to take a permanent bend

(a) Bending of sheet metal
(b) both compression and tensile elongation of the metal occur in bending
V-Bending

- For low production
- Used “V” shape die
- V-dies are simple and inexpensive
Edge Bending

• For high production
• Pressure pad required
• Dies are more complicated and costly

Figure :- Edge bending
Figure:- Air Bending, Bending in a 4 slide machine, roll bending
Drawing

• It is a Sheet metal forming process to make cup-shaped, box-shaped, or other complex-curved, hollow-shaped parts

• Sheet metal blank is positioned over die cavity and then punch pushes metal into opening

• Products: beverage cans, ammunition shells, automobile body panels
Figure -
(a) Drawing of a cup-shaped part:
(1) start of operation before punch contacts work
(2) near end of stroke

(b) Corresponding workpart:
(1) starting blank
(2) drawn part
Shapes other than Cylindrical Cups

• Square or rectangular boxes (as in sinks),
• Stepped cups,
• Cones,
• Cups with spherical rather than flat bases,
• Irregular curved forms (as in automobile body panels)
• Each of these shapes presents its own unique technical problems in drawing
Coining

• It is a cold working sizing operation. It is used for the production of metals coins.
• The coining processes consists of die and punch. By using the punch and die, the impression and images are created on the metal.
• The pressure involved in coining process is about 1600Mpa. The metal flows plastically and squeezed to the shape between the punch and die.
• The metal is caused to flow in the direction of perpendicular force. The type of impression is formed by compressive force. The type of impression obtained on both sides will be different.
Power and Drive Systems

• **Hydraulic presses** - Use a large piston and cylinder to drive the ram
  – Longer ram stroke than mechanical types
  – Suited to deep drawing
  – Slower than mechanical drives

• **Mechanical presses** – Convert rotation of motor to linear motion of ram
  – High forces at bottom of stroke
  – Suited to blanking and punching
Mechanical Press

The ram is actuated using a flywheel. Stroke motion is not uniform.
Hydraulic Press

Longer strokes than mechanical presses, and develop full force throughout the stroke. Stroke motion is of uniform speed, especially adapted to deep drawing operations.
Dies for Sheet Metal Processes

- Most of the press working operations performed with conventional punch-and-die tooling
- The term “stamping die” sometimes used for high production dies.
Types of dies

- Made up of tool steel and used to cut or shape material.

Based on the type of die construction:

- Simple die
- Compound die
- Progressive die
- Transfer die
- Multiple die
• Simple die
  • Perform single operation for each stroke of the press slide
  • Simple dies or single action dies perform single operation for each stroke of the press slide.
  • The operation may be one of the cutting or forming operations.
• Compound Dies
  • Several operations on the same strip may be performed in one stroke with a compound die in one station.
  • These operations are usually limited to relatively simple shearing because they are somewhat slow and the dies are more expensive than those for individual shearing operations.
Simple Die

- Perforating Punch
- Stripper
- Part
- Matrix
- Matrix Retainer

- Hand Fed
- One hit operation
- Secondary operations
Compound Die

Schematic illustrations: (a) before and (b) after blanking a common washer in a compound die.

Note the separate movements of the die (for blanking) and the punch (for punching the hole in the washer).
Progressive Dies

- Parts requiring multiple operations, such as punching, blanking and notching are made at high production rates in progressive dies.
- The sheet metal is fed through a coil strip and a different operation is performed at the same station with each stroke of a series of punches.
Progressive die

• A progressive has a series of operations.
• At each station, an operation is performed on a work piece during a stroke of the press.
Transfer Dies (Combination Dies)

• In a transfer die setup, the sheet metal undergoes different operations at different stations, which are arranged along a straight line or a circular path.

• After each operation, the part is transferred to the next operation for additional operations.
Transfer Dies (Combination Dies)
In short, details of different dies are:-

- **Simple** - single operation with a single stroke
- **Compound** - two operations with a single stroke
- **Combination** - two operations at two stations
- **Progressive** - two or more operations at two or more stations with each press stroke, creates what is called a strip development
Punch and Die Sizes for Blanking and Punching

- **Blanking** (Blank diameter is controlled)

  - For a round **blank** of diameter, \( D_b \)
    
    - Diameter of die = **blank** diameter ( \( D_b \) )
    
    - Diameter of punch = \( D_b - 2c \)

    where \( c = \) clearance

- **Punching** (Hole diameter is controlled)

  - For a round **hole** of diameter , \( D_h \)
    
    - Diameter of punch = **hole** diameter (\( D_h \))
    
    - Diameter of die = \( D_h + 2c \)

    where \( c = \) clearance
Figure:- Die size determines blank size $D_b$; punch size determines hole size $D_h$; $c =$ clearance
Clearance in Sheet Metal Cutting

Distance between the punch and die

• Typical values range between 4% and 8% of stock thickness
  – If too small, fracture lines pass each other, causing double burnishing and larger force
  – If too large, metal is pinched between cutting edges and excessive burr results
Angular Clearance

Purpose: allows slug or blank to drop through die

• Typical values: 0.25° to 1.5° on each side

Figure:- Angular clearance
Springback in Bending

Springback = increase in included angle of bent part relative to included angle of forming tool after tool is removed

• Reason for springback:
  – When bending pressure is removed, elastic energy remains in bent part, causing it to recover partially toward its original shape
Figure: - Springback in bending shows itself as a decrease in bend angle and an increase in bend radius: (1) during bending, the work is forced to take the radius $R_b$ and included angle $A_b'$ of the bending tool (punch in V-bending), (2) after punch is removed, the work springs back to radius $R$ and angle $A'$
STRIPPERS

• They are used to remove the stock from the punch after a blanking or piercing operation
• Classified as fixed or stationary and spring-operated or Movable type
• Fixed strippers are solidly attached to the die block or die shoe
• Spring operated strippers travel up and down on the shank of the punch
CHANNEL STRIPPERS:

• A type of fixed stripper
• Consists of a rectangular plate mounted on top of die block
• A channel or groove is milled through which the strip is passed
• The height of the channel should be 1 ½ times the stock thickness
• The width must be equal to the strip width plus some clearance to allow variation in strip width
SPRING-OPERATED STRIPPERS

- Also called pressure pad strippers
- Employ springs to apply pressure to the stock strip
- Suspended from punch holder with stripper bolts and compression springs
- An advantage of this type is that it tends to hold the strip flat during the press cycle
SPRING-OPERATED STRIPPERS
DIE STOPS (STOCK STOPS)

• Used to locate the stock in the die set when hand feeding
• The simplest form of stock stop is dowel pin
• An edge of previously blanked opening is pushed against this pin
• The stock is lifted above the pin on return stroke to release the strip from pin
• Demands considerable skill on the part of operator
STOCK STOPS

Dowel pin used as stop

[Diagram showing a punch, stripper, blanked part, stop pin, and die block]
Stretch Forming

- Stretch forming is a metal forming process in which a piece of sheet metal is stretched and bent simultaneously over a die in order to form large bent parts.
• In stretch forming, the sheet metal is clamped around its edges and stretched over a die or form block, which moves upward, downward or sideways, depending on the particular machine.

• Stretch forming is used primarily to make aircraft-wing skin panel, automobile door panels and window frames.
Beading

• In beading the edge of the sheet metal is bent into the cavity of a die.
• The bead gives stiffness to the part by increasing the moment on inertia of the edges. Also, it improves the appearance of the part and eliminates exposed sharp edges.

(a) Bead forming with a single die. (b) Bead forming with two dies, in a press brake.
Bulging

• The basic forming process of bulging involves placing tabular, conical or curvilinear part into a split-female die and expanding it with, say, a polyurethane plug.

• The punch is then retracted, the plug returns to its original shape and the part is removed by opening the dies.
(a) Bulging of a tubular part with a flexible plug. Water pitchers can be made by this method. (b) Production of fittings for plumbing by expanding tubular blanks with internal pressure. The bottom of the piece is then punched out to produce a “T.” (c) Manufacturing of Bellows.
Strip layout

• In the design of blanking parts from strip material, the first step is to prepare blanking layout, that is, to layout the position of the work pieces in the strip and their orientation with respect to one another. While doing so, the major consideration is the economy of material.

• Another important consideration in strip layout is the distance between the blanks and the strip edge and distance between blank to blank. To prevent the scrap from twisting and wedging between the punch and the die. The distance must increase with material thickness.
A general rule of thumb is to keep this distance equal to from 1 to 1.5 times the material thickness. The following figure are example of strip layouts.

A – Front scrap
B – Bridge thickness
(spaces between parts and strip edge, and part to parts)
C – the distance from a point on one part to the corresponding point on the next part.
H – Part width
I – Length of part
W – Width of strip
Y – Scrap recovery at end
N – Number of blanks
t – thickness of strip
L – Length of strip
Strip layout

Lead end

Back scrap

Front scrap

Advance

Scrap bridge

Tail end

Stock width

Feed direction
Method of reducing Cutting force

• The Cutting force is the force which has to act on the on the stock material in order to cut out the blanker slug. This determines the capacity of the press to be used for particular tool.
• It sometimes becomes necessary to reduce the cutting force to prevent press over loading.
  1. Stepped punches to be used.
  2. Grinding the face of the punch or die to a small shear angle.
• **1. Stepped punches**

  - The method of reducing cutting forces is to step punch length. Punches or group of punches progressively become shorter by about one stock material thickness.
  - This will result in distribution of force during the blanking or piercing action on the punches interns reducing in total force.
  - During shearing action lengthier punches will take cutting action at first time and once the sheet is pierced for a sheet thickness, other shorter punches will enter the sheet to get the required holes. This type is mainly used in piercing of more number of holes on the component.
2) Grinding the face of the punch or die to a small shear angle.

- A second method is to grind the face of the punch or die to a small shear angle with the horizontal. This has the effect of reducing the contact area while shearing at one time. Providing shear also reduces the shock to the press and smoothens out the cutting operation. The shear angle chosen should provide a change in punch from 1 to 1.5 sheet thickness.

- Various types of shear angle are shown in the figure. Double shear angle is preferred force acting on the punch. Double shear angle on punches should be concave to prevent the stretching of the material before it is cut. Shear angle may be applied either to the punch face or to the die face, depending on whether the operation is blanking or piercing because shear will distort the work material.
• The shear angle for blanking operation will be on the die member, while, as the piercing operation the shear angle will be given on the punch member.