

SHEET METAL FORMING

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Introduction

- Sheet metal forming is a process that materials undergo permanent deformation by cold forming to produce a variety of complex three dimensional shapes.
- The thickness of the sheet metal is called its **gauge**. The gauge of sheet metal ranges from 30 to 8.
- Sheet metal has applications in car bodies, airplane wings, medical tables, roofs for buildings and many other things.

Historical Note

Sheet metal stamping was developed as a mass production technology for the production of bicycles around the 1890's. This technology played an important role in making the system of interchangeable parts economical.

Metals used in Sheet Metal Forming

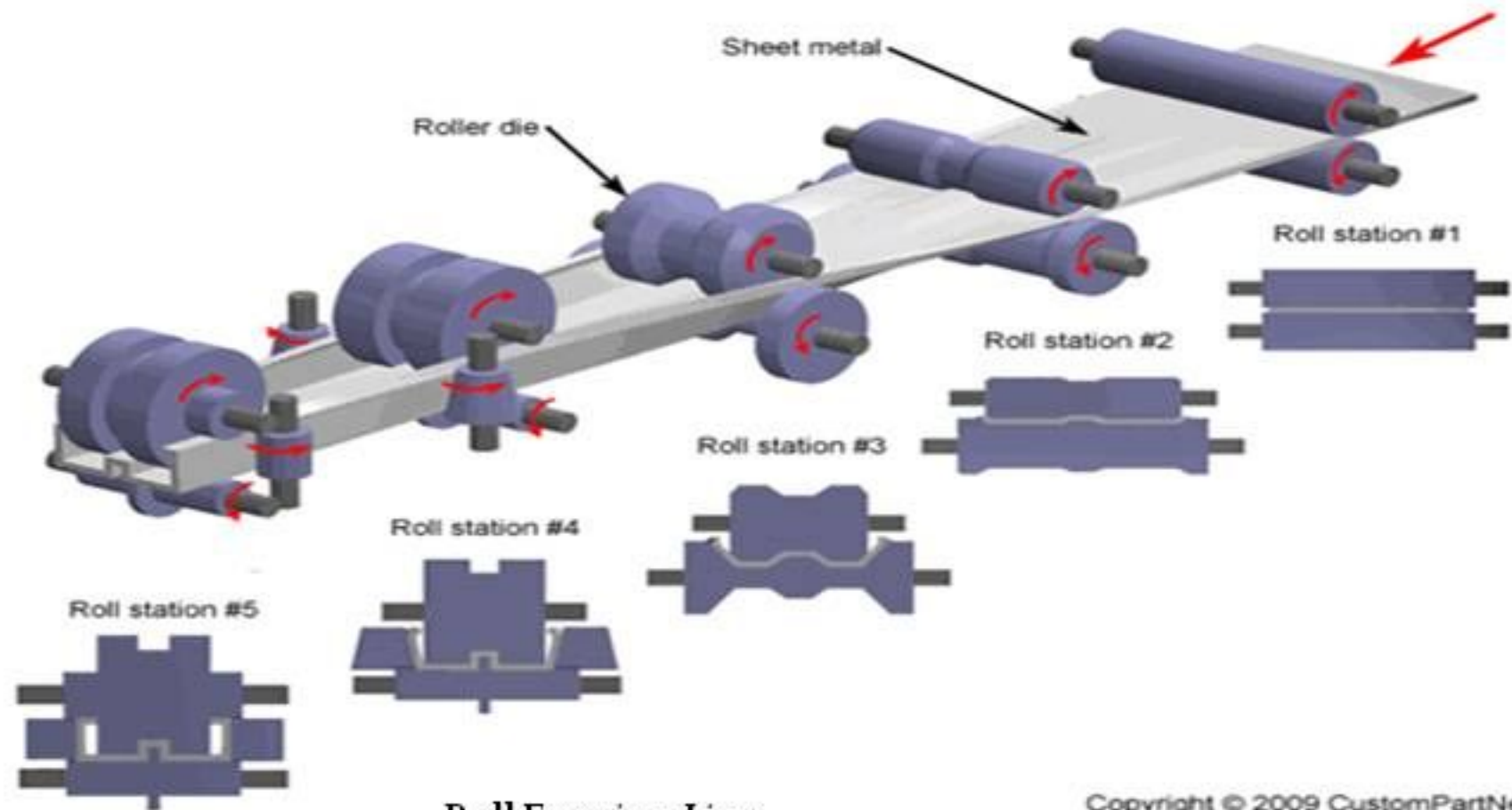
- black iron, galvanized iron, copper, brass, tin, aluminum, lead and zinc.
- Black Iron Sheet or uncoated sheet is the cheapest material used for sheet metal work. Since these sheets carry no protection coatings on their surfaces, these are likely to corrode quickly.

Sheet Metal Forming Operations

- Rolling
- Blanking
- Bending
- Deep Drawing
- Piercing
- Fine Blanking
- Punching
- Trimming
- Nibbling
- Notching
- Spinning
- Embossing
- Coining

Rolling

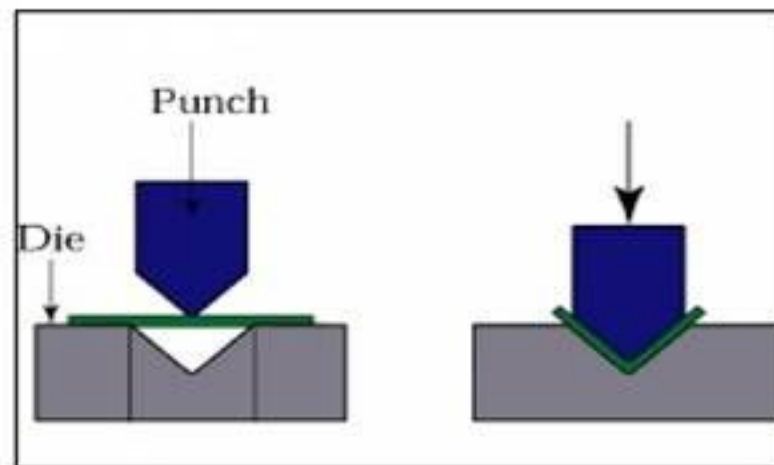
-Metal forming process in which sheet metal is progressively shaped through a series of bending operations.



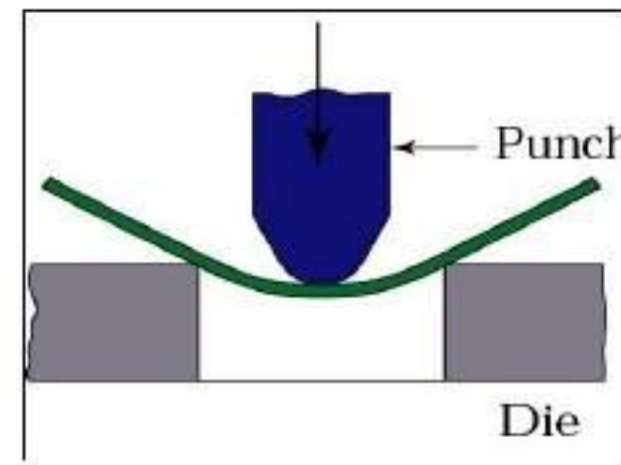
- The roll forming process can be used to form a sheet into a wide variety of cross-section profiles.
- Roll forming is used to create very long sheet metal parts with typical widths of 1-20 inches and thicknesses of 0.004-0.125 inches
- These parts are commonly used in industrial and commercial buildings for roofing, lighting, storage units etc..

Bending (2D)

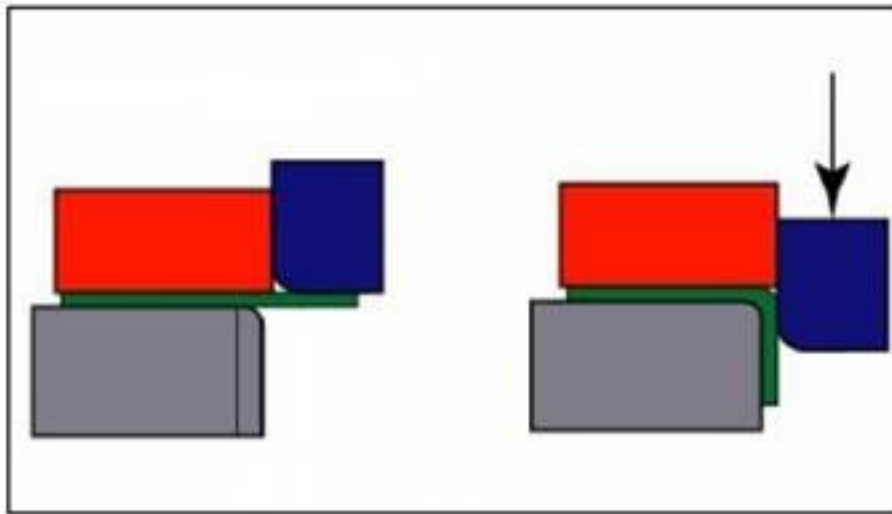
- The bending operation is the act of bending blanks at a predetermined angle (hot or cold).



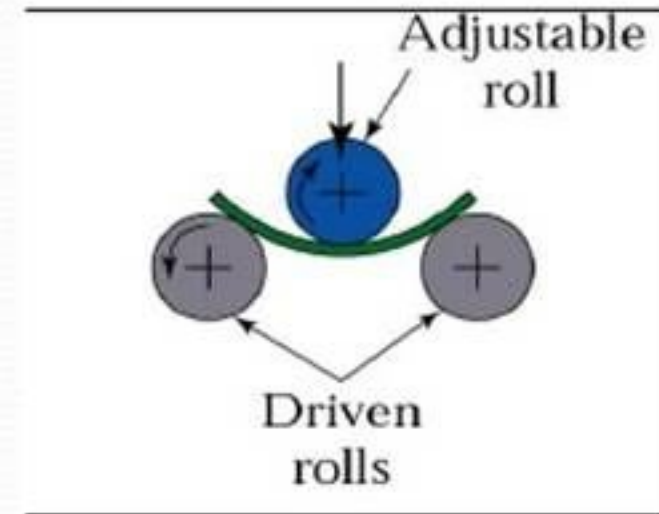
V-Bending



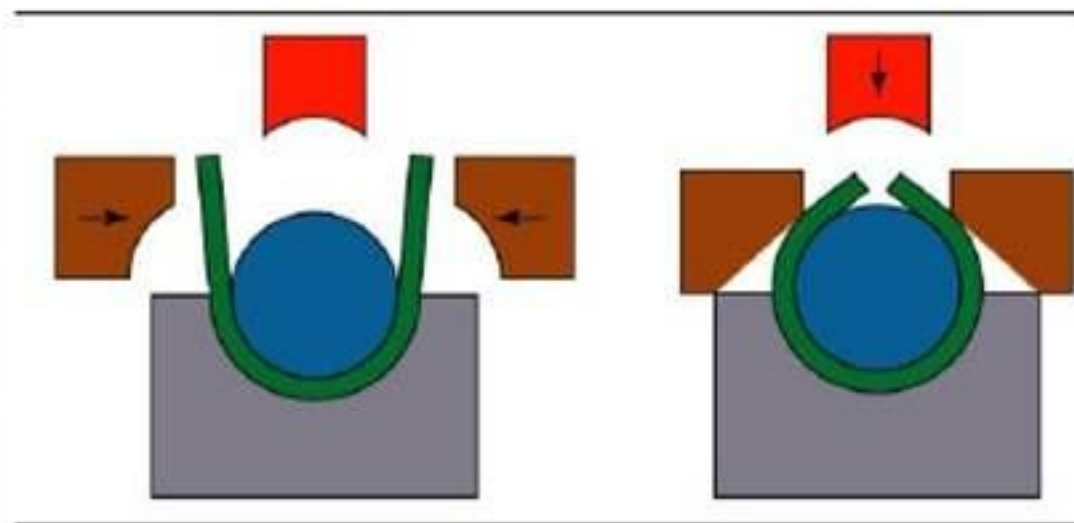
Air Bending



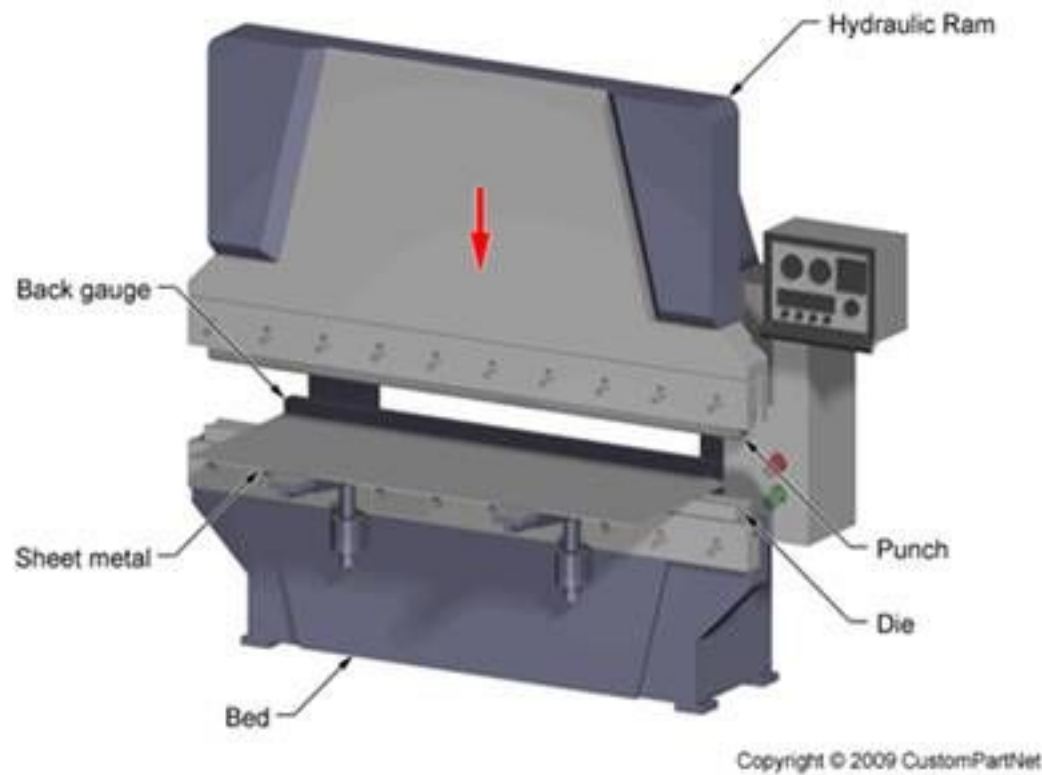
Edge Bending



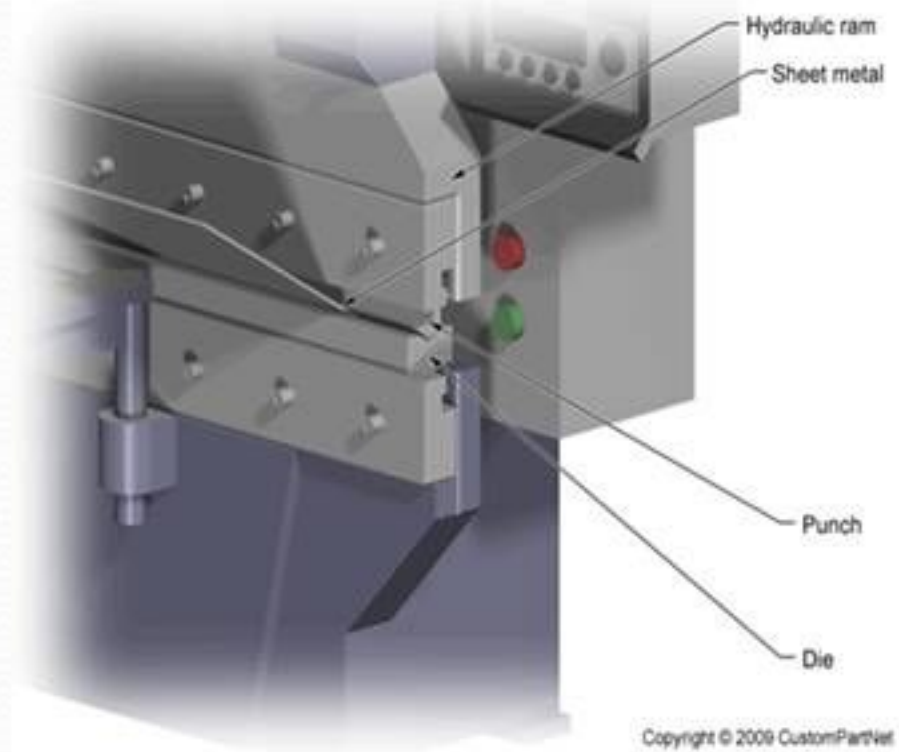
Roll Bending



Bending in 4-slide machine



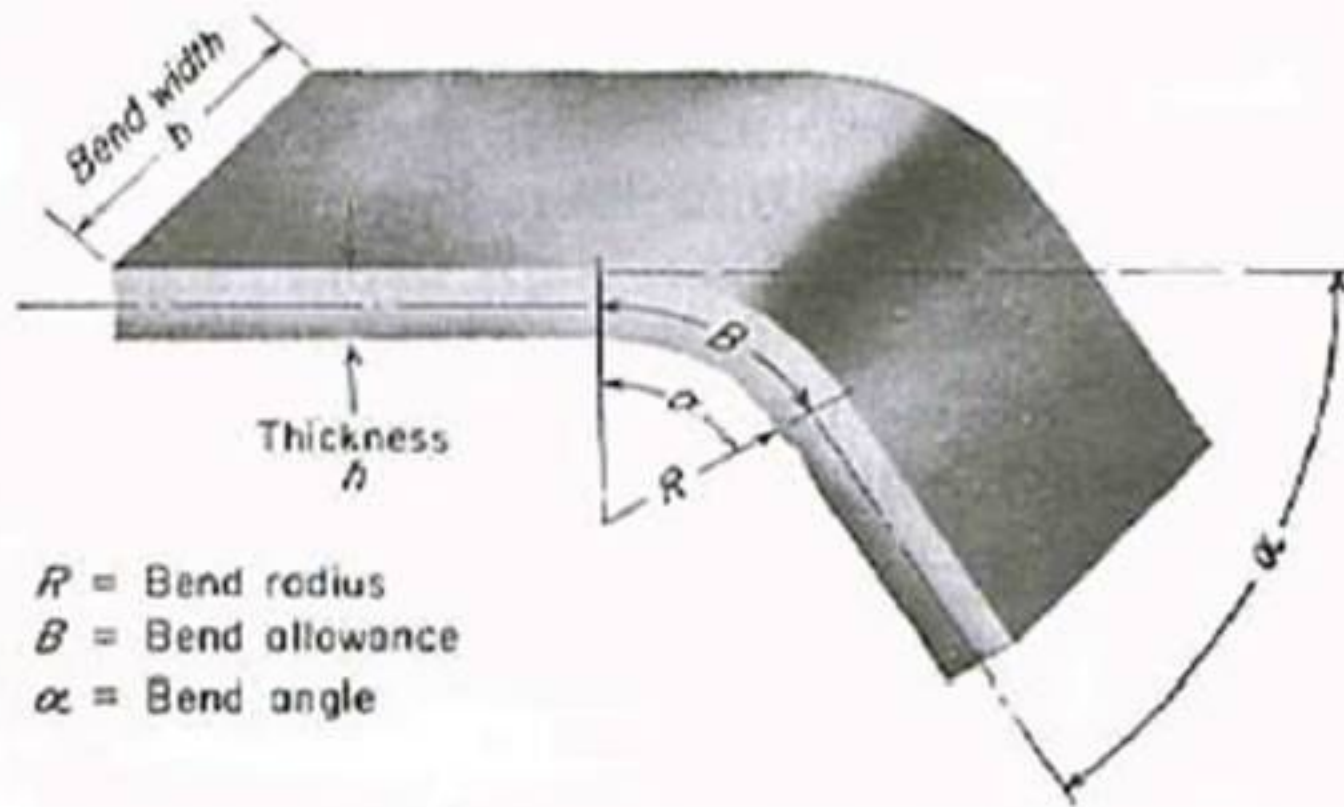
Press Brake
(Open)



Press Brake
(Closed)

Bend Radius

-The bend radius R is the radius of curvature on the concave, or inside surface of the bend.



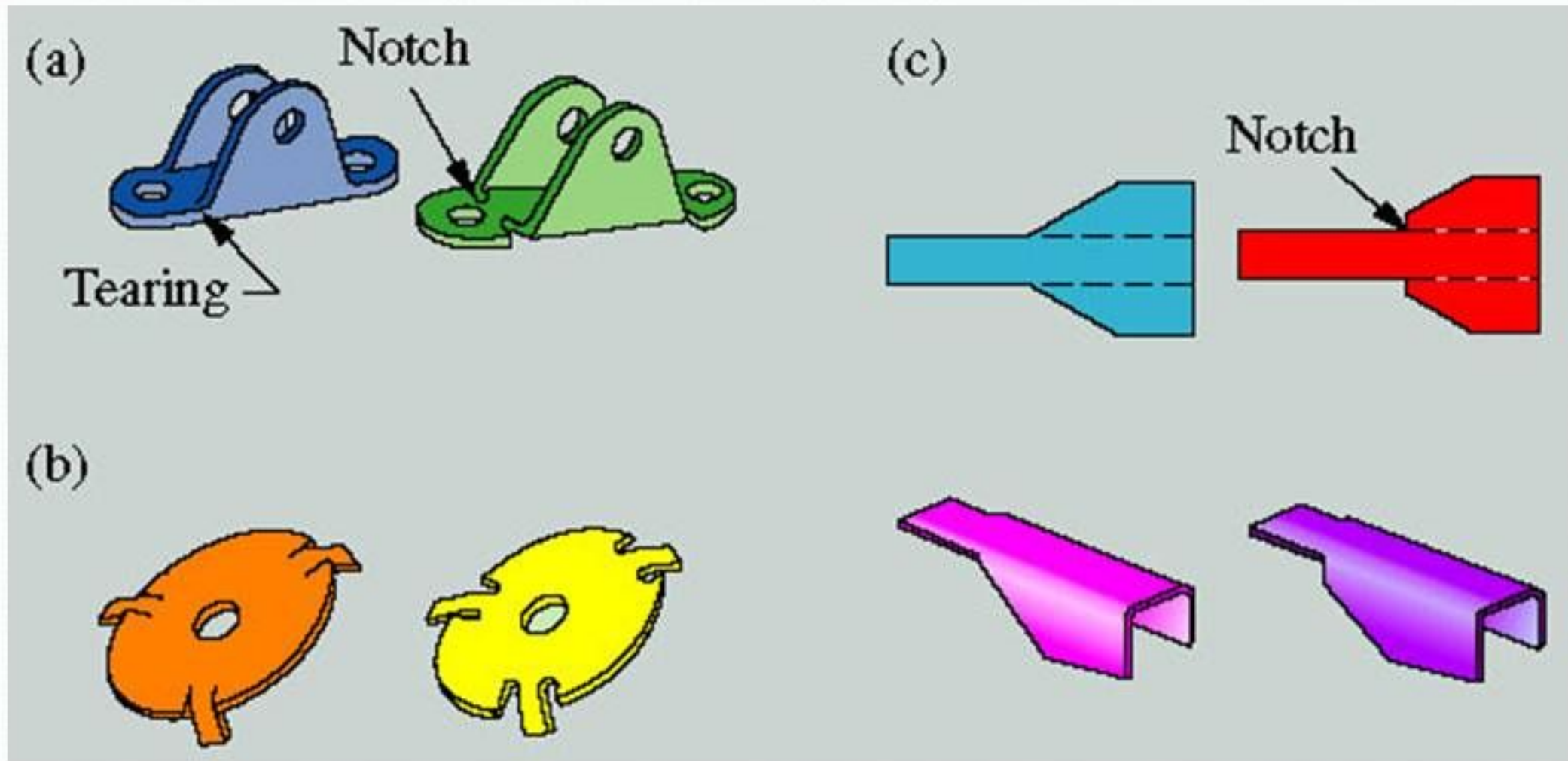
The minimum bend radius

- The smallest bend radius can be made without cracking on the outer tensile surface.

- Normally expressed in multiples of sheet thickness.

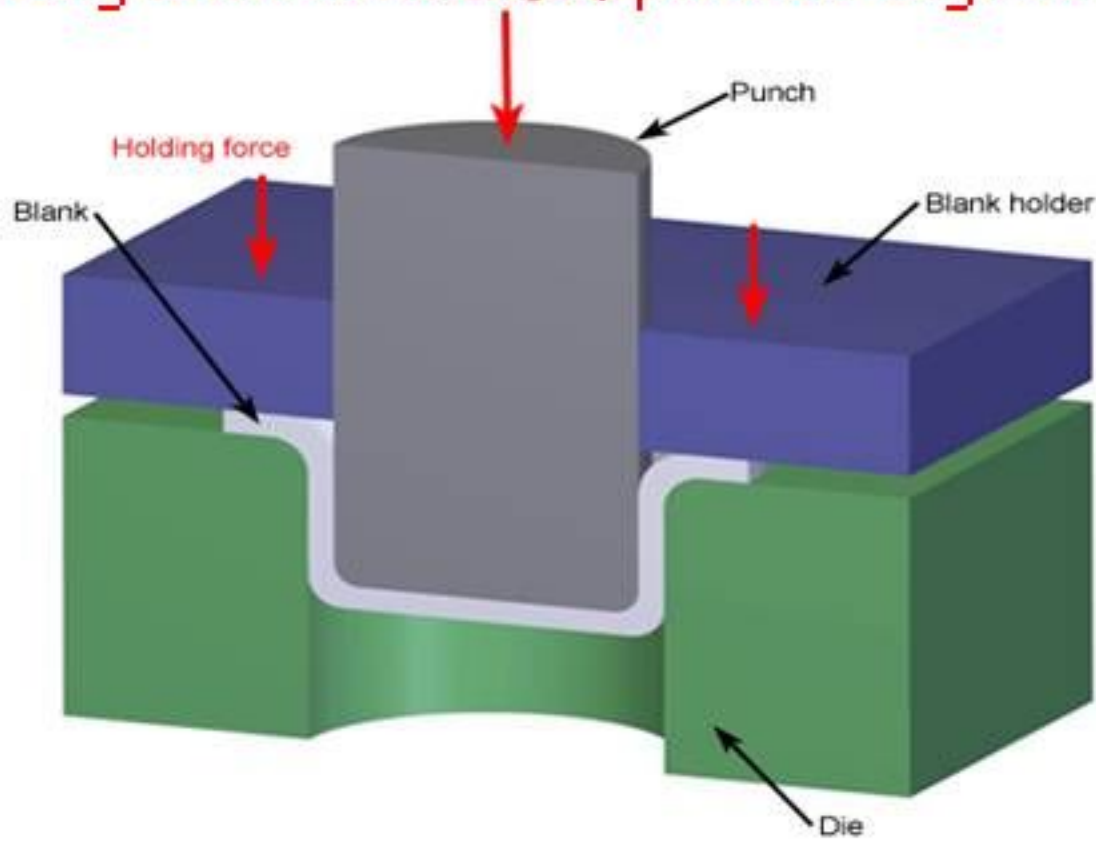
Example: a $3T$ bend radius means the metal can be bend without cracking though a radius equal to three times to the sheet thickness T .

Use notches to avoid tearing and wrinkling in right-angle bends

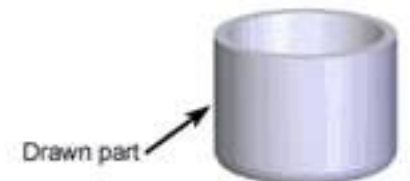
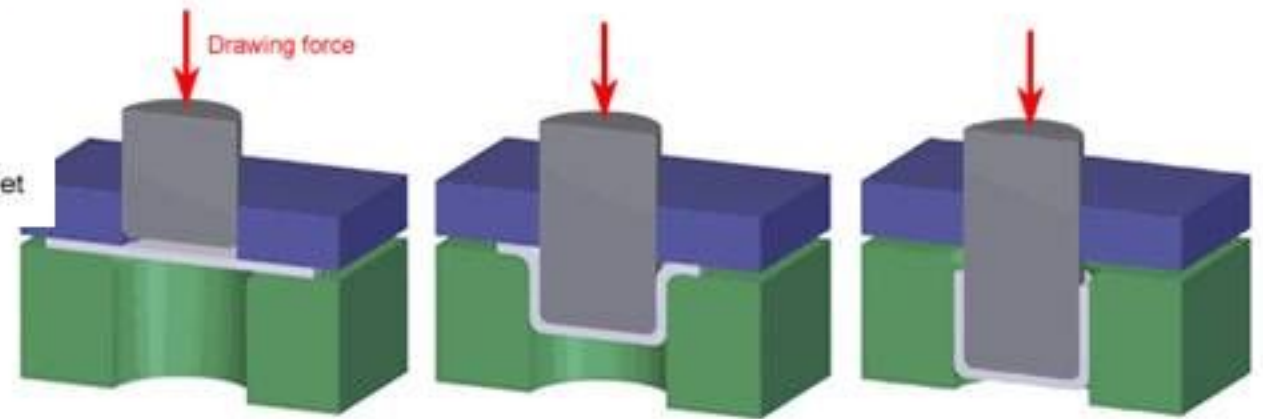


Deep drawing (3D)

- The metal working process used for shaping flat sheets into cup-shaped articles (cold).
- Deep drawing is most effective with ductile metals, such as aluminum, brass, copper, and mild steel.
- Examples; automotive bodies, fuel tanks, cans, cups, kitchen sinks, pots and pans.

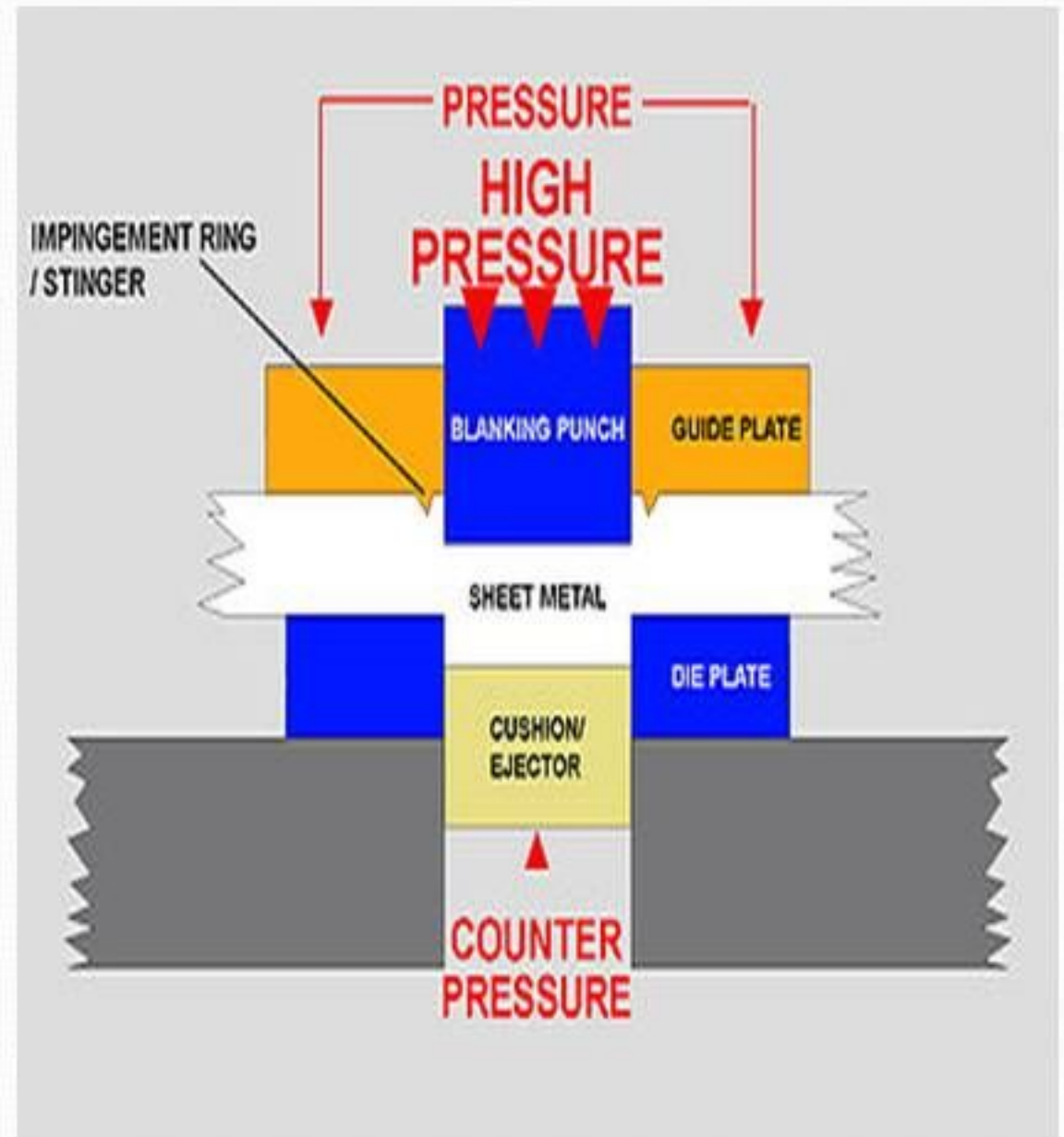


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Fine Blanking

- Fine blanking is a specialized form of blanking where there is no fracture zone when shearing. This is achieved by compressing the whole part and then an upper and lower punch extract the blank. This allows the process to hold very tight tolerances.



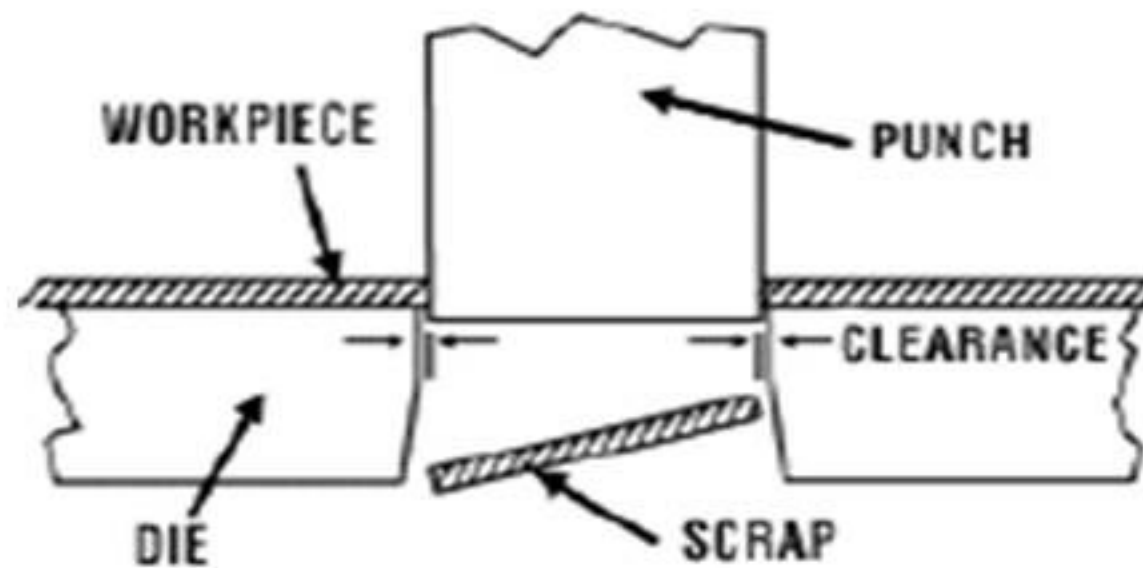
Fine Blanking

- Parts made with fine blanking include automotive parts, electronic components, cutlery, and power tools.



Punching

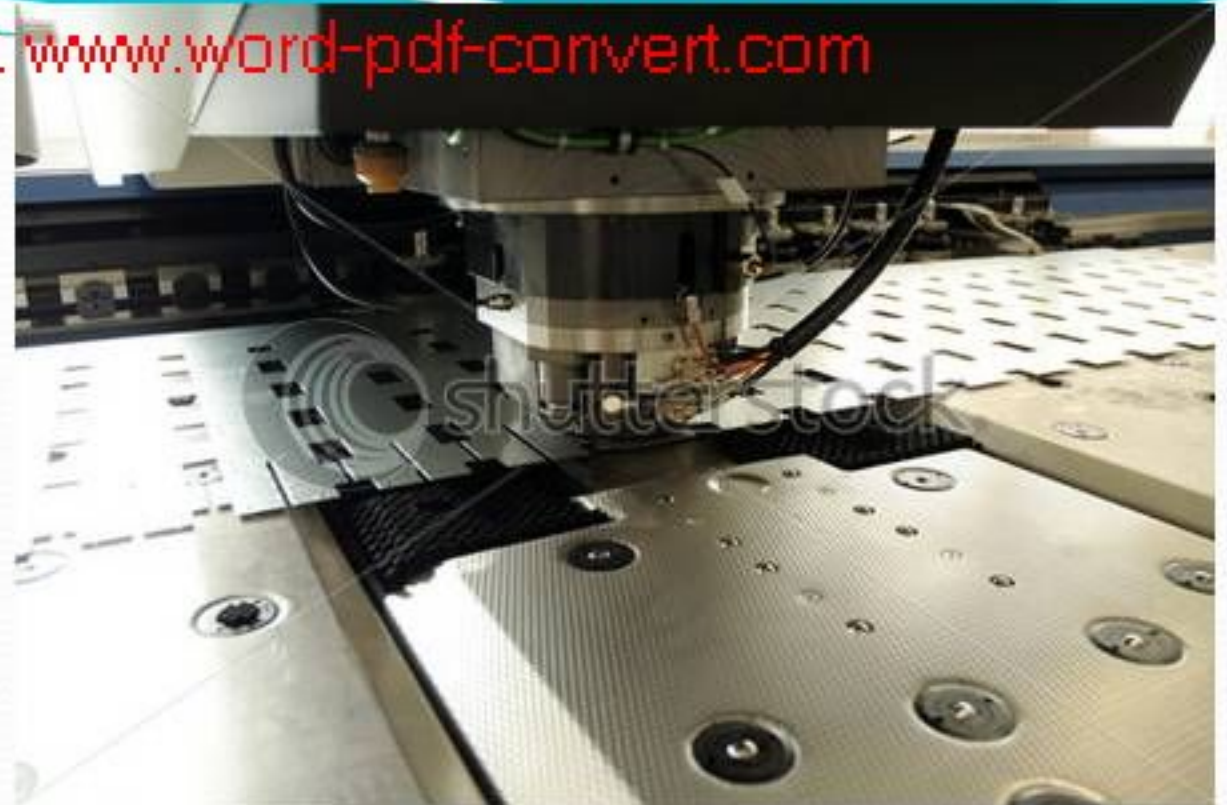
- Punching is the process of forming metal components using a punch.
- The punch is usually the upper member of the complete die assembly and is mounted on the slide or in a die set for alignment (except in the inverted die).



Punching Characteristics

- Punching is the most cost effective process of making holes in strip or sheet metal for average to high fabrication
- It is able to create multiple shaped holes
- Punches and dies are usually fabricated from conventional tool steel or carbides
- Creates a burnished region roll-over, and die break on sidewall of the resulting hole

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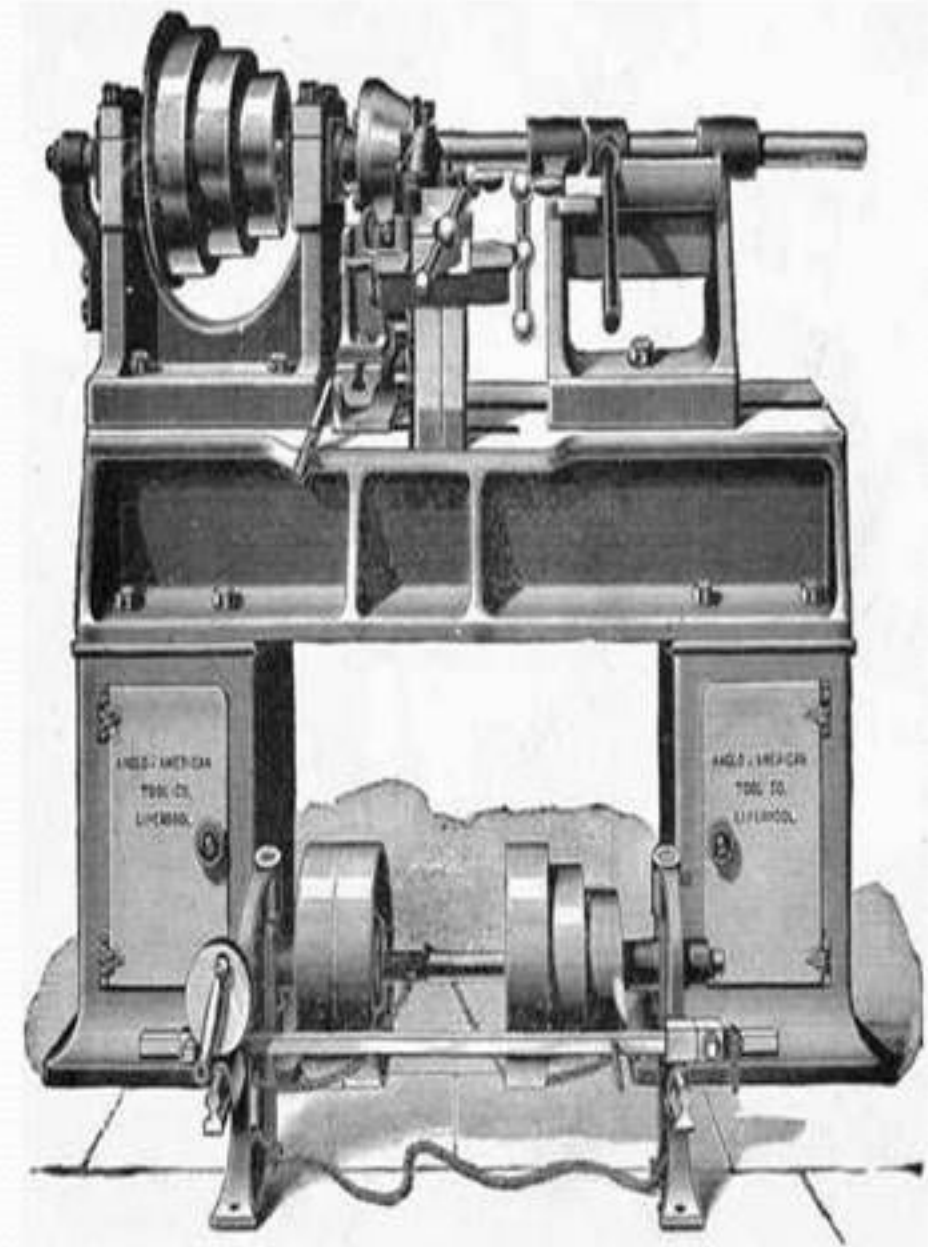
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CNC Punching



Spinning

- Spinning is used to make tubular(axis-symmetric) parts by fixing a piece of sheet stock to a rotating form. Rollers or rigid tools press the stock against the form, stretching it, until the stock takes the shape of the form. Spinning is used to make rocket motor casings, missile nose cones, satellite dishes and metal kitchen funnels.



Spinning

- Ideal for
- Lower production volumes
- Large parts
- Inexpensive tooling
- For small quantities, spinning is more economical



Piercing

- It is most fascinating work to do, and is creating much interest among all craft-workers. It is not as difficult as it looks, and a good deal of very decorative work can be done with a simple equipment at a comparatively low cost.



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Notching

- **Notching** is a metal-cutting process used on sheetmetal or thin barstock, sometimes on angle sections or tube. A shearing or punching process is used in a press, so as to cut vertically down and perpendicular to the surface, working from the edge of a workpiece. Sometimes the goal is merely the notch itself, but usually this is a precursor to some other process: such as bending a corner in sheet or joining two tubes at a tee joint, notching one to fit closely to the other.

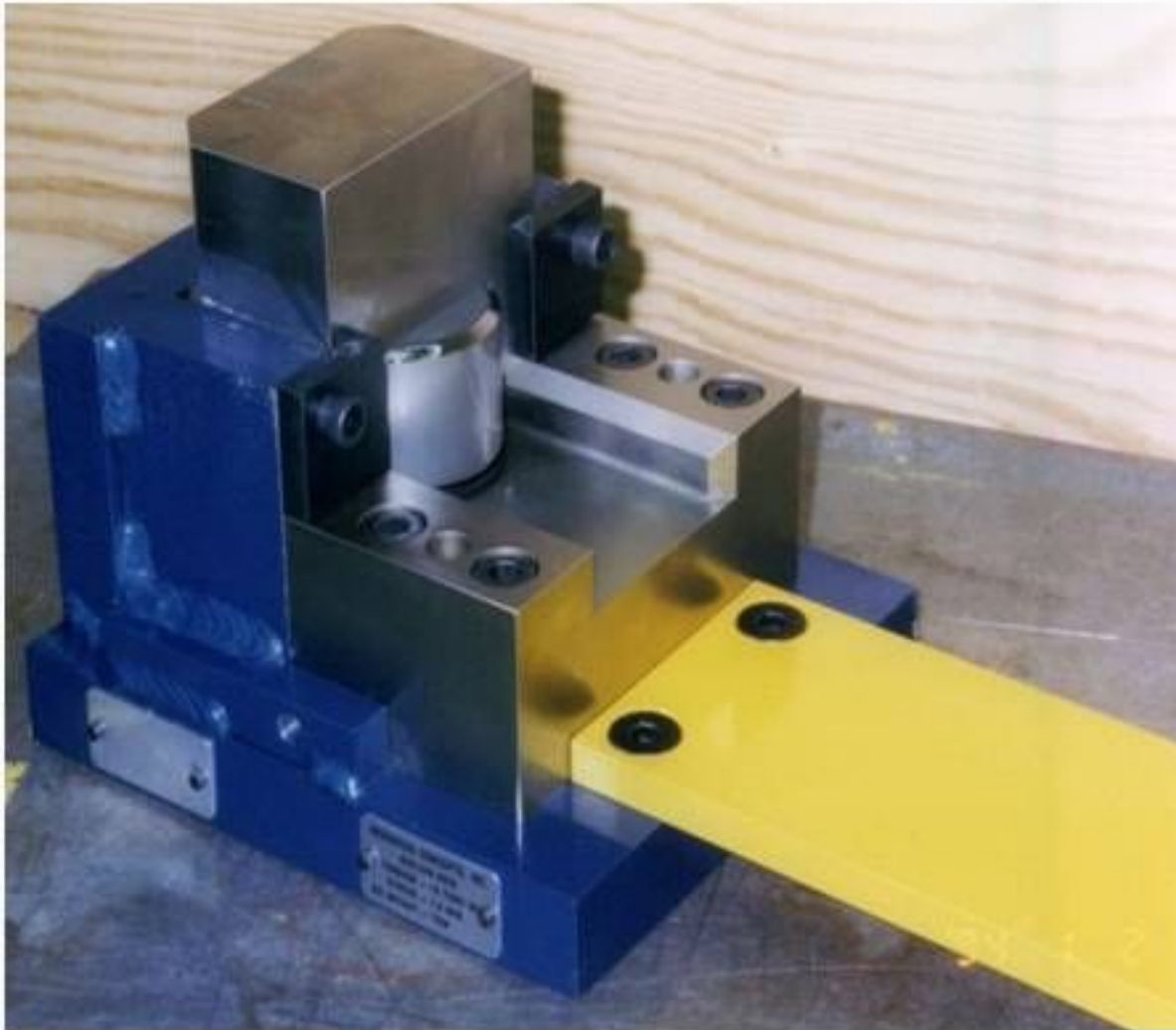
Notching

- Punching the edge of a sheet, forming a notch in the shape of a portion of the punch.



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Notching



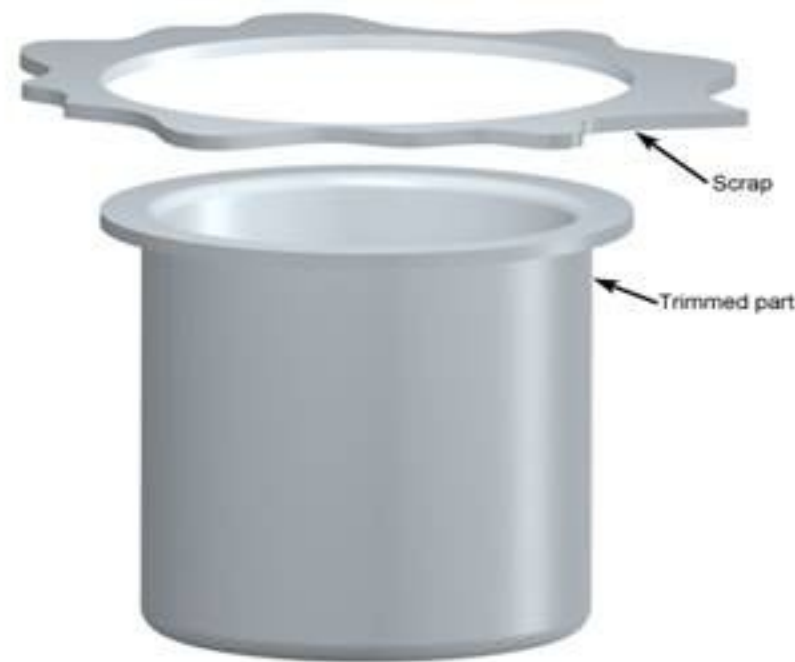
Nibbling

Punching a series of small overlapping slits or holes along a path to cutout a larger contoured shape. This eliminates the need for a custom punch and die but will require secondary operations to improve the accuracy and finish of the feature



Trimming

Punching away excess material from the perimeter of a part, such as trimming the flange from a drawn cup



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Embossing

Embossing is a metal forming process for producing raised or sunken designs or relief in sheet material by means of matched male and female roller dies, theoretically with no change in metal thickness, or by passing sheet or a strip of metal between rolls of the desired pattern.

Metal sheet is drawn through the male and female roller dies producing a pattern or design on the metal sheet. Depending on the roller dies used, different patterns can be produced on the metal sheet.

Characteristics of the metal embossing process include:

- Its ability to form ductile metals,
- Its use in medium to high production runs,
- The ability to maintain the same metal thickness before and after embossing,
- The ability to produce unlimited patterns, depending on the roll dies, and
- The ability to reproduce product with no variation



Coining

The process consists of the work piece being made to undergo a high level of stress which the plastic flow inside sufficiently on the metal's surface. In certain kinds of metals, the plastic flow system works to lessen the grains sizes on the surface, sometimes, resulting in hardening of the work surface, and the metal inside the work piece remains ductile and tougher. The coining procedure is used basically to create coins, money, badges for the police, and buttons for fire fighters.

Advantages and Disadvantages

1. Roll Forming

This process is for long parts with constant complex cross-sections. It produces good surface finish and has high production rates. However, this process has high tool costs.

2. Stretch Forming

Stretch forming can be used to produce large parts with shallow contours but it is only suitable for low-quantity production. The cons are high labor costs, although tooling and equipment costs vary depending on part size.

3. Drawing

Drawing process is for production of shallow or deep parts with relatively simple shapes. The pros are its high production rates. The cons are its high tooling and equipment costs.

4. Stamping

Stamping process actually includes a variety of operations, such as punching, blanking, embossing, bending, flanging, and coining. Drawing can be used to produce simple or complex shapes. This process has high production rates and low labor costs and is very suitable for large volume production. On the other side, its tooling and equipment costs can be pretty high.

5. Rubber-pad Forming

Rubber-pad forming is being used for drawing and embossing of simple or complex shapes. This process produces sheet surface protected by rubber membranes. High flexibility of operation and low tooling costs are its main selling points.

6. Spinning

Spinning process is used to produce small or large axisymmetric parts. This process produces good surface finish and has low tooling costs. However, labor costs can be high unless operations are automated.

7. Superplastic Forming

Superplastic forming is being used to produce complex shapes with fine detail and close tolerances. However, the disadvantages are that forming times are long, production rates are low, and the parts are not suitable for high-temperature use.

8. Peen Forming

Peen forming is suitable for shallow contours on large sheets. This process is also used for straightening parts. Its operation has high flexibility but equipment costs can be high.

9. Explosive Forming

Explosive forming is being used to produce very large sheets with relatively complex shapes but the shape is usually axisymmetric. This process is suitable for low-quantity production because of its high labor costs and long cycle times. The main selling point is its low tooling costs.

10. Magnetic-pulse forming

Magnetic-pulse forming can be used for shallow forming, bulging, and embossing operations on relatively low strength sheets. This process is most suitable for tubular shapes. It has high production rates, although it requires special tooling.

Summary

- Sheet metal is simply metal formed into thin and flat pieces.
- The applied force stresses the metal beyond its yield strength, causing the material to plastically deform, but not to fail. By doing so, the sheet can be bent or stretched into a variety of complex shapes.
- Only mechanical force is used.

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