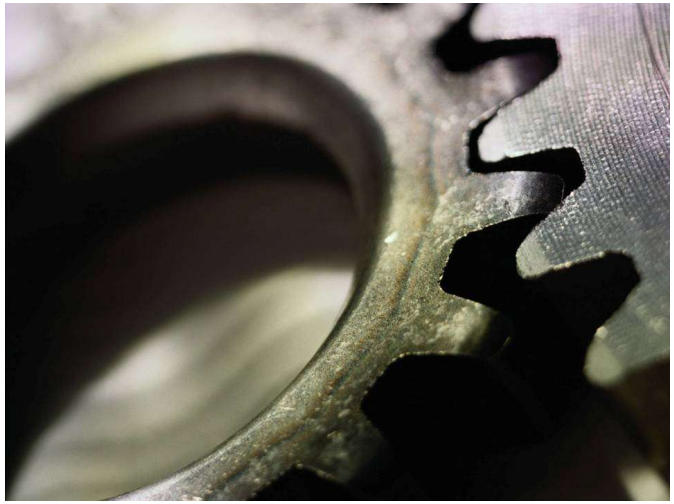
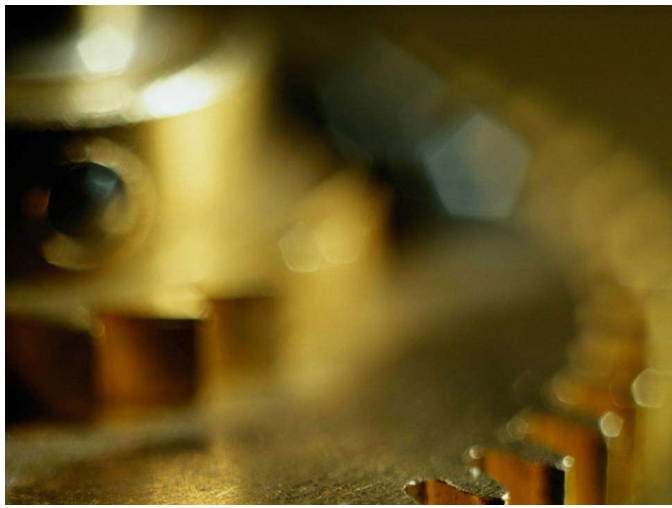
Metal Forming





Sheet Metalworking Defined

Cutting and forming operations performed on relatively thin sheets of metal

Thickness of sheet metal = 0.4 mm (1/64 in) to 6 mm (1/4 in)

Thickness of plate stock > 6 mm

Operations usually performed as cold working

Sheet Metalworking Terminology

1. "Punch-and-die"

   Tooling to perform cutting, bending, and drawing

2. "Stamping press"

   Machine tool that performs most sheet metal operations

3. "Stampings"

   Sheet metal products

Press Machine Tool

Press machine is a metal forming machine tool. Which is designed to form or cut metal by applying mechanical force or pressure.

With the help of press machine, we can form a metal in any desired shape without removal of chips. The presses are exclusively intended for mass production work.

Types of Presses

Types of presses for sheet metal working can be classified by one or a combination of characteristics, such as

a. source of power,
b. number of slides,
c. type of frame and construction,
d. type of drive, and
e. intended applications.

Types of Presses

According to source of power

Manual Presses

These are either hand or foot operated through levers, screws or gears. Most of manually operated presses are hand press, ball press or fly press.

Mechanical presses

These presses utilize flywheel energy which is transferred to the work piece by gears, cranks, eccentrics, or levers.

Hydraulic Presses

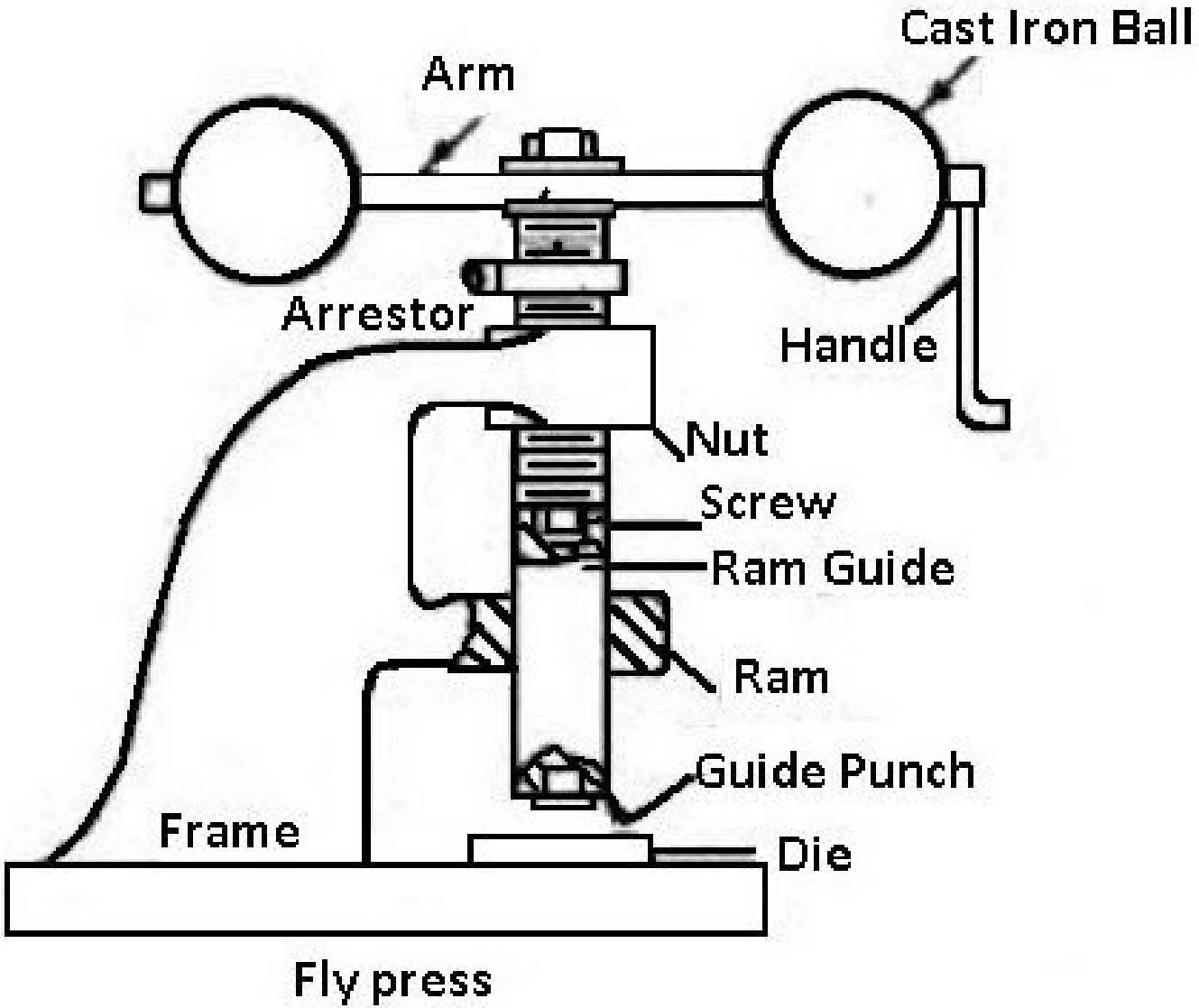
These presses provide working force through the application of fluid pressure on a piston by means of pumps, valves, intensifiers, and accumulators. These presses have better performance and reliability than mechanical presses.

Pneumatic Presses

These presses utilize air cylinders to exert the required force. These are generally smaller in size and capacity than hydraulic or mechanical presses, and therefore find use for light duty operations only.

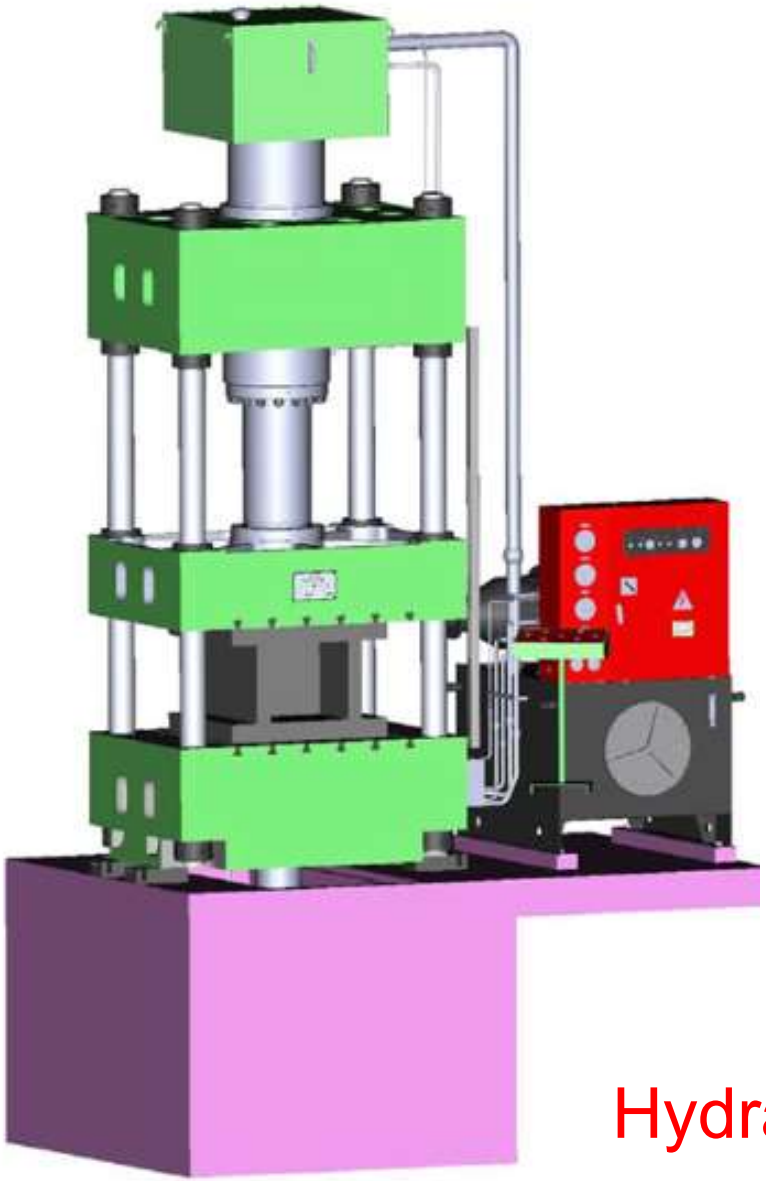
Types of Presses

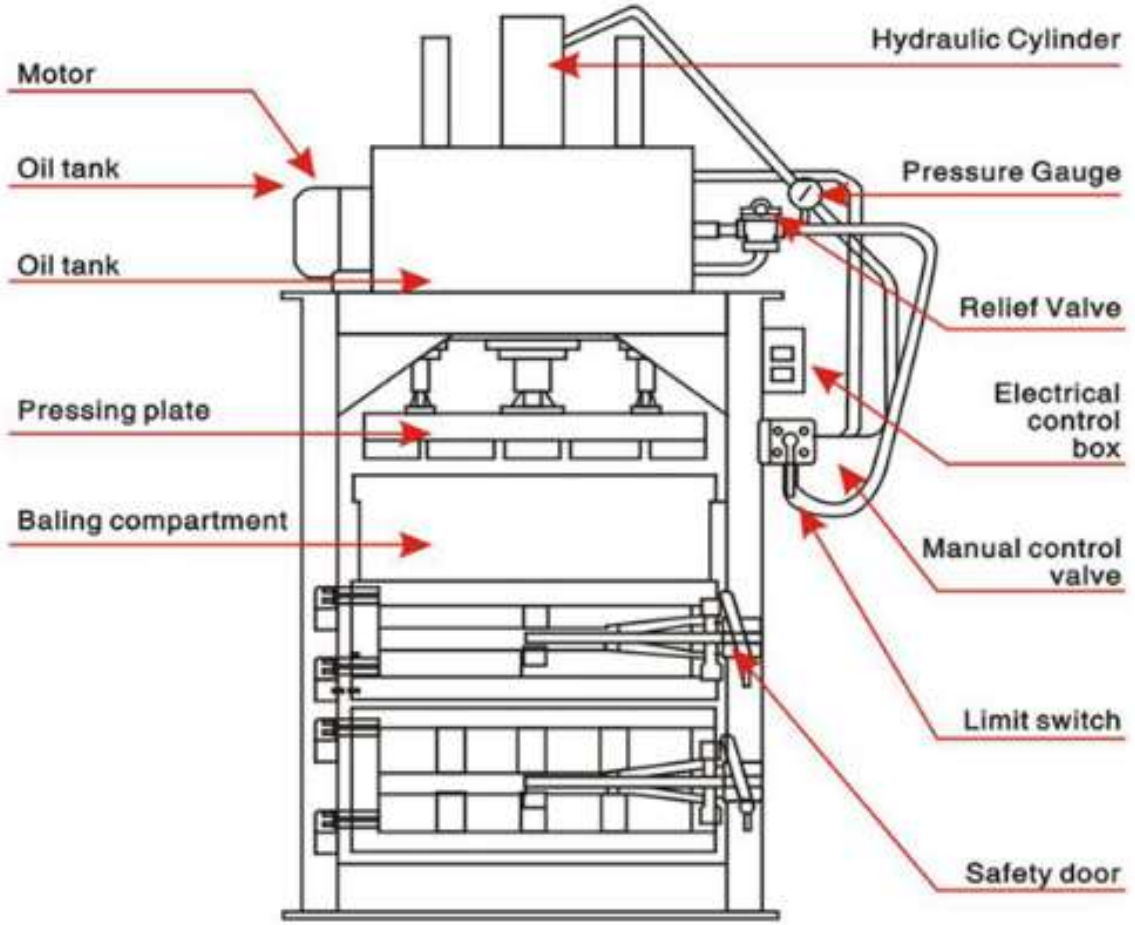
According to source of power



Types of Presses

According to source of power





Hydraulic Power Press

Types of Presses

According to number of slides

•**Single Action Presses.** A single action press has one reciprocation slide that carries the tool for the metal forming operation. The press has a fixed bed. It is the most widely used press for operations like blanking, coining, embossing, and drawing.

•**Double Action Presses**. A double action press has two slides moving in the same direction against a fixed bed. It is more suitable for drawing operations, especially deep drawing, than single action press.

•**Triple Action Presses.** A triple action press has three moving slides. Two slides (the blank holder and the inner slide) move in the same direction as in a double – action press and the third or lower slide moves upward through the fixed bed in a direction opposite to that of the other two slides. This action allows reverse – drawing, forming or bending operations against the inner slide while both upper actions are dwelling.

Types of Presses

Double Action Presses

Types of Presses

According to Frame and Constructions

Arch – Frame Presses. These presses have their frame in the shape of an arch. These are not common.

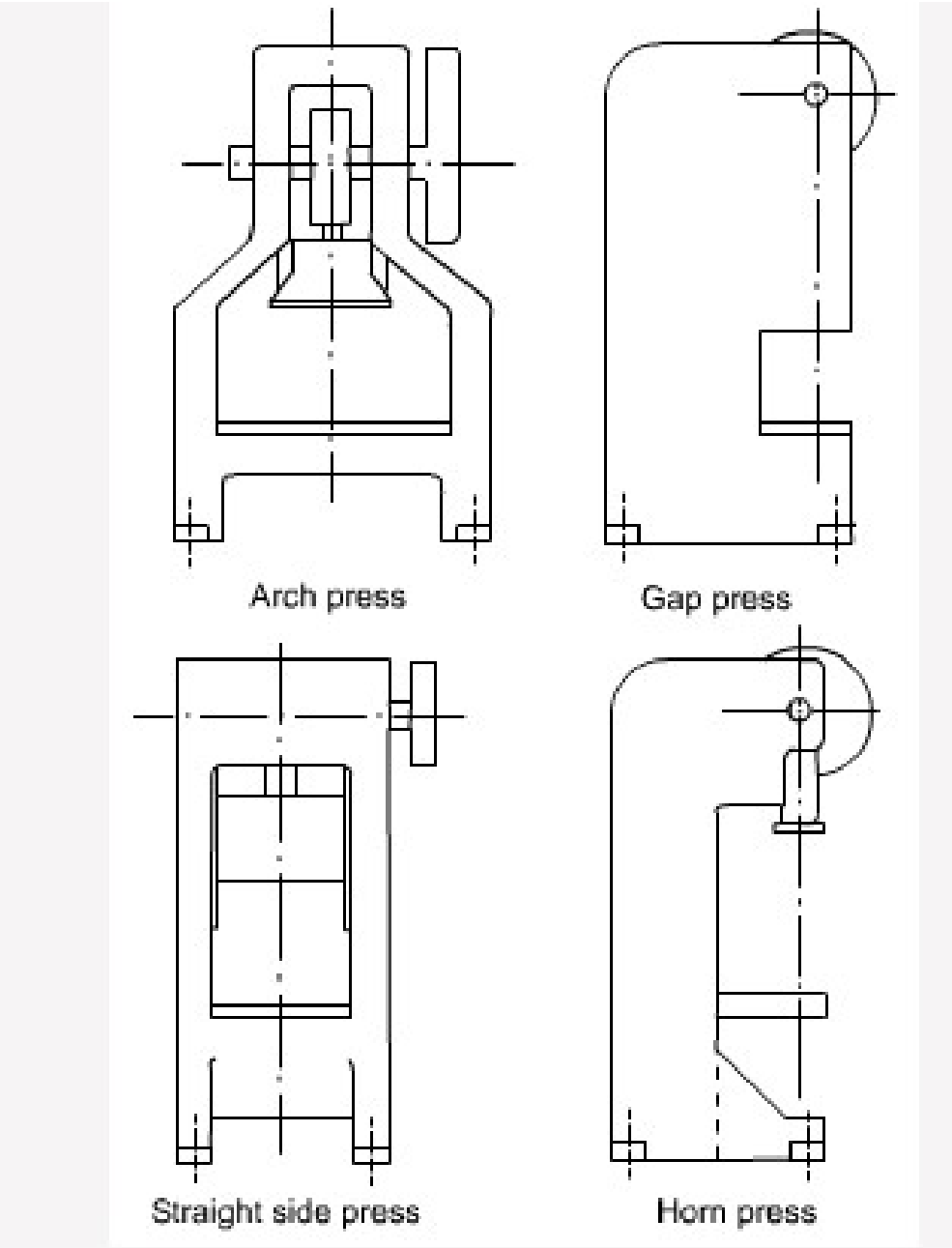
Gap Frame Presses. These presses have a C-shaped frame. These are most versatile and common in use, as they provide un – obstructed access to the dies from three sides and their backs are usually open for the ejection of stampings and / or scrap.

Straight Side Presses. These presses are stronger since the heavy loads can be taken in a vertical direction by the massive side frame and there is little tendency for the punch and die alignment to be affected by the strain. The capacity of these presses is usually greater than 10 MN.

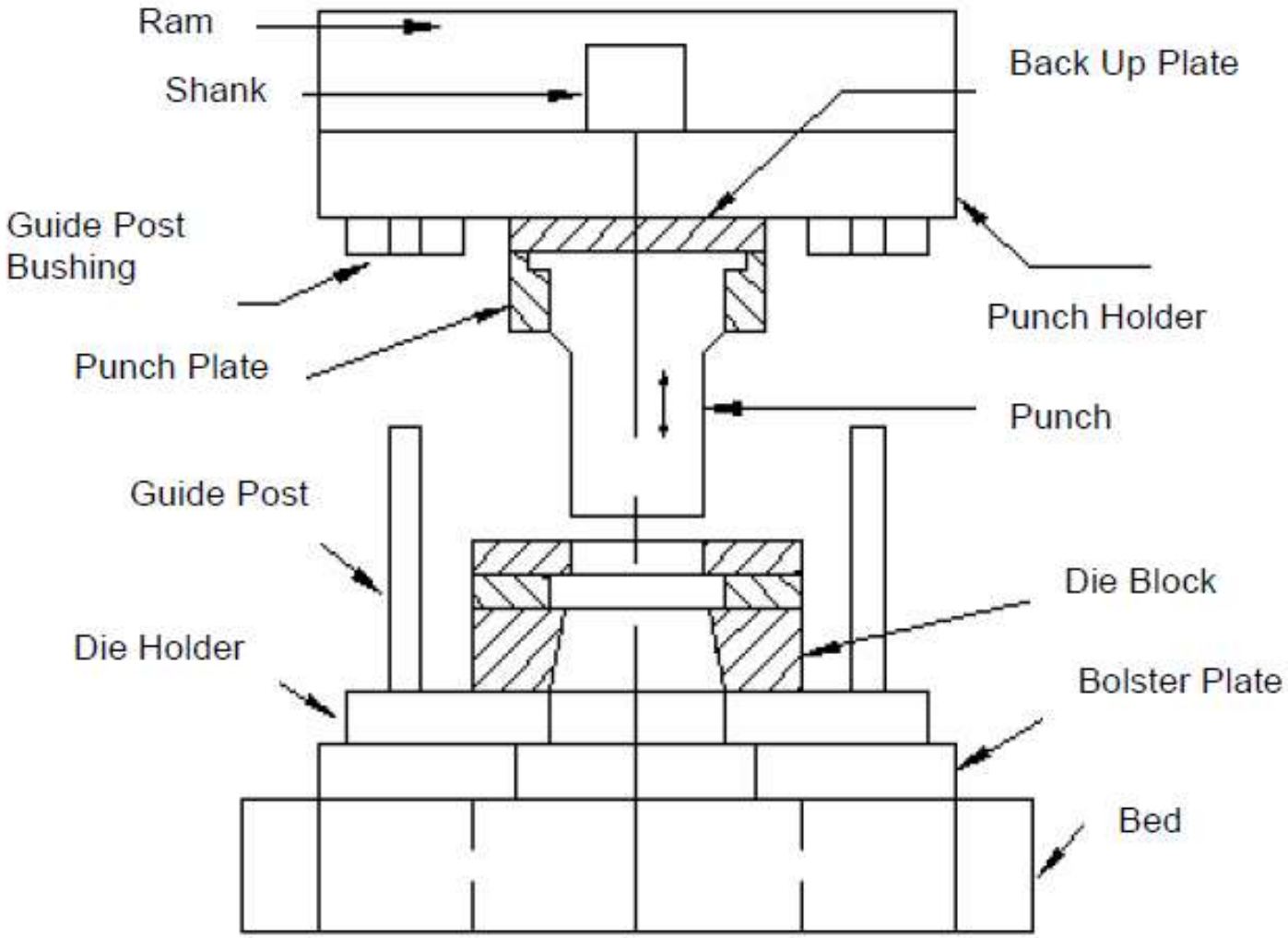
Horn Presses. These presses generally have a heavy shaft projecting from the machine frame instead of the usual bed. This press is used mainly on cylindrical parts involving punching, riveting, embossing, and flanging edges.

Types of Presses

According to Frame and Constructions



Press Working Terminology



Simple cutting Die

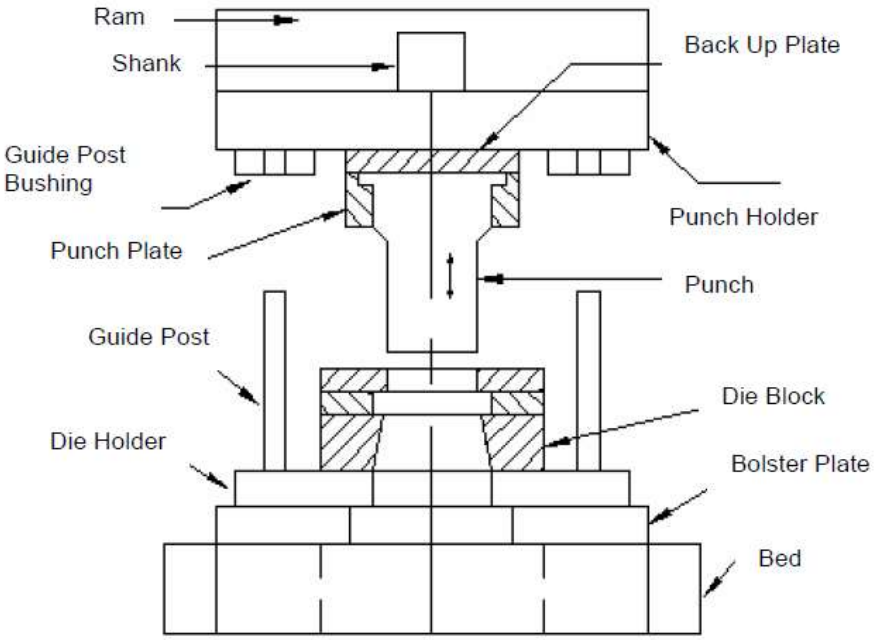
Press Working Terminology

Bed

The bed is lower part of press frame that serves as a table on which a bolster plate is mounted.

Bolster Plate

Bolster plate is a thick plate secured to the press bed, which is used for locating and supporting the die assembly. Its thickness is usually 5 to 12.5 cm.



Die Set

Die set is unit assembly which incorporates a lower and upper shoe, two or more guide posts and guide post bushings

Press Working Terminology

Die

Die is the female part of a complete tool for producing work in a press. It is also referred to a complete tool consisting of pair of mating members for producing work in press

Die Block

It is the block or a plate which contains the die cavity.

Lower Shoe

The lower shoe of a die set is generally mounted on the upper plate of a press. The die block is mounted on the lower shoe. The guide posts are also mounted in it.

Punch

Punch is the male component of the die assembly which is directly or indirectly moved by or fastened to the press ram or slide.

Upper Shoe

It is the upper part of the die set which contain die post bushings.

Press Working Terminology

Punch Plate

The punch plate or punch retainer fits closely over the body of the punch and holds it in proper relative position.

Back Up Plate

It is also called pressure plate. It is placed so that the intensity of pressure does not become excessive on punch holder. The plate distributes the pressure over a wide area and intensity of pressure on the punch holder is reduced to avoid crushing.

Stripper

Stripper is a plate which is used to strip the metal strip from a cutting or non-cutting punch or die. It may also guide the strip.

Knock Out

Knock out mechanism is used to remove the workpiece from a die. It is connected to and operated by the press ram.

Pitman

Pitman is a connecting rod which is used to transmit the motion from the main drive shaft to the press slide.

Three Major Categories of Sheet Metal Processes

1. Cutting

Shearing to separate large sheets; or cut part perimeters or make holes in sheets

2. Bending

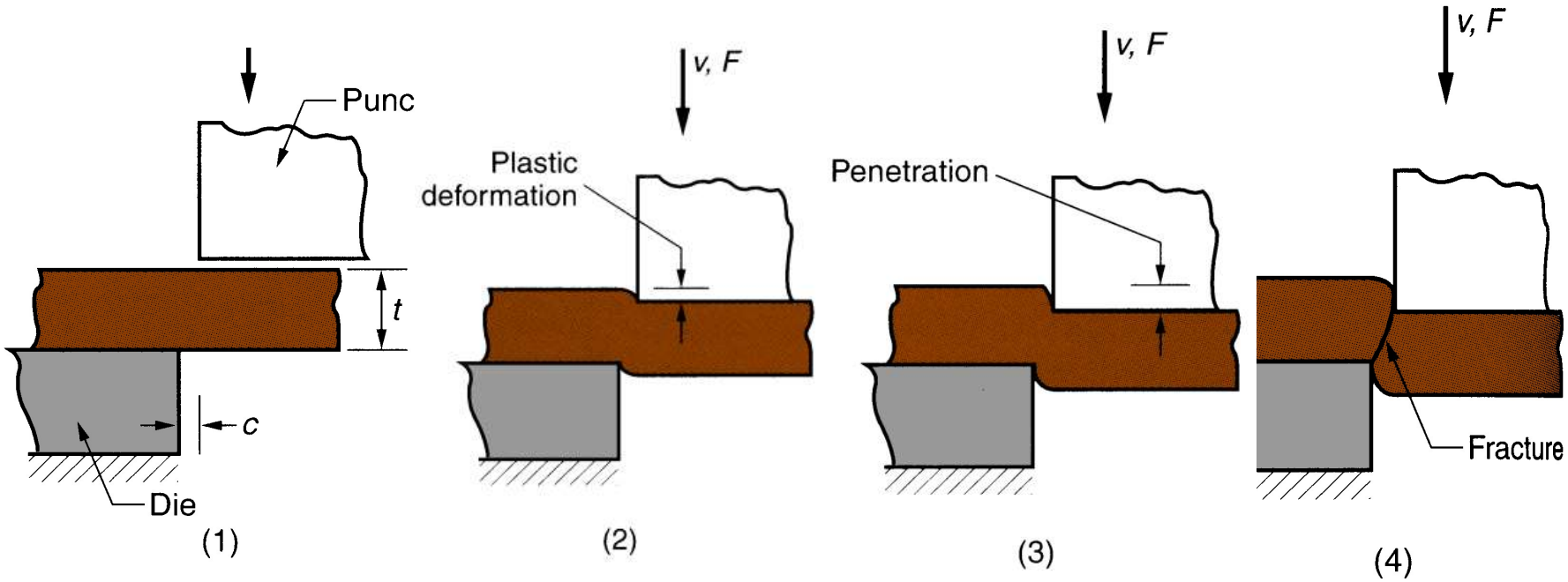
Straining sheet around a straight axis

3. Drawing

Forming of sheet into convex or concave shapes

Three Major Categories of Sheet Metal Processes

1. Cutting



Shearing between two sharp cutting edges

Cutting

Shearing, Blanking, and Punching

Three principal operations in press working that cut sheet metal:

Shearing

Blanking

Punching

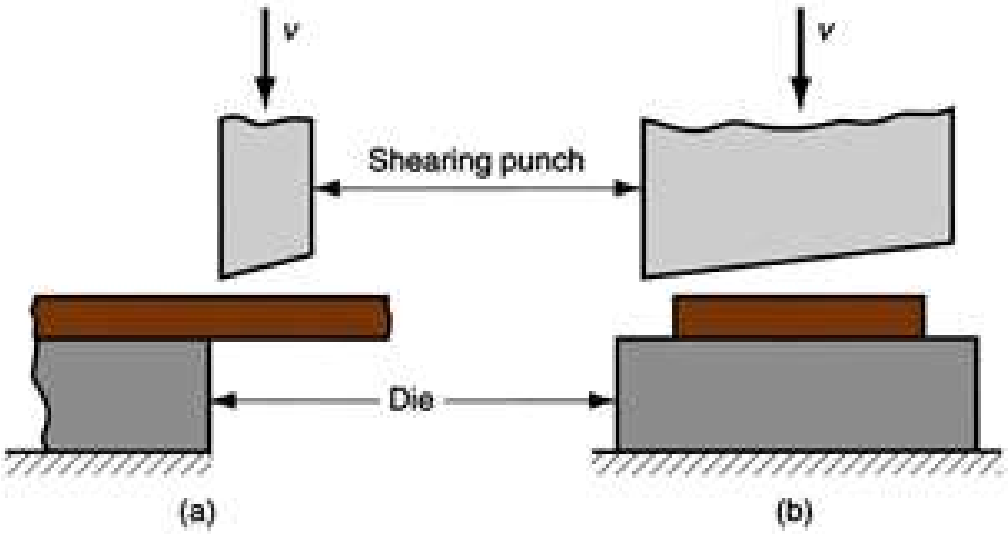
Shearing is practiced in several ways:
Shearing – cutting a sheet along a straight line
Blanking – cutting a contoured part (whether circular or more complex shape) between a punch and die in a press
Punching – removing unwanted parts of a sheet (punching a hole)
Notching – cutting out a part of the sheet edge

Cutting

Shearing

Sheet metal cutting operation along a straight line between two cutting edges

- Typically used to cut large sheets into smaller sections for subsequent operations



Cutting

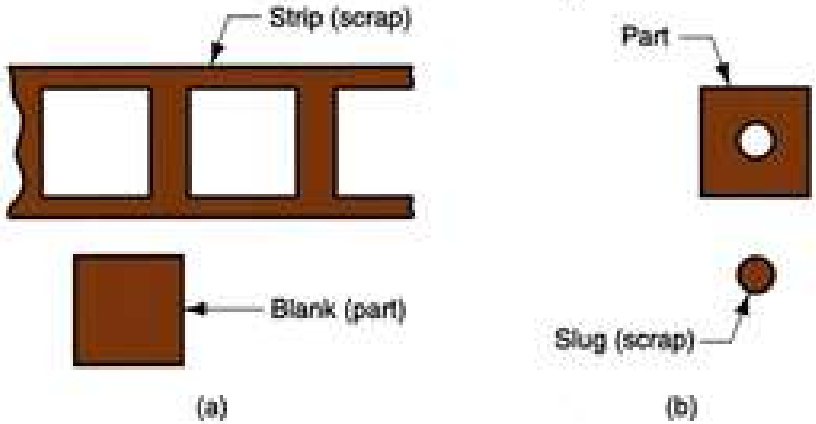
Blanking and Punching

Blanking - sheet metal cutting to separate piece from surrounding stock

- Cut piece is the desired part, called a *blank*

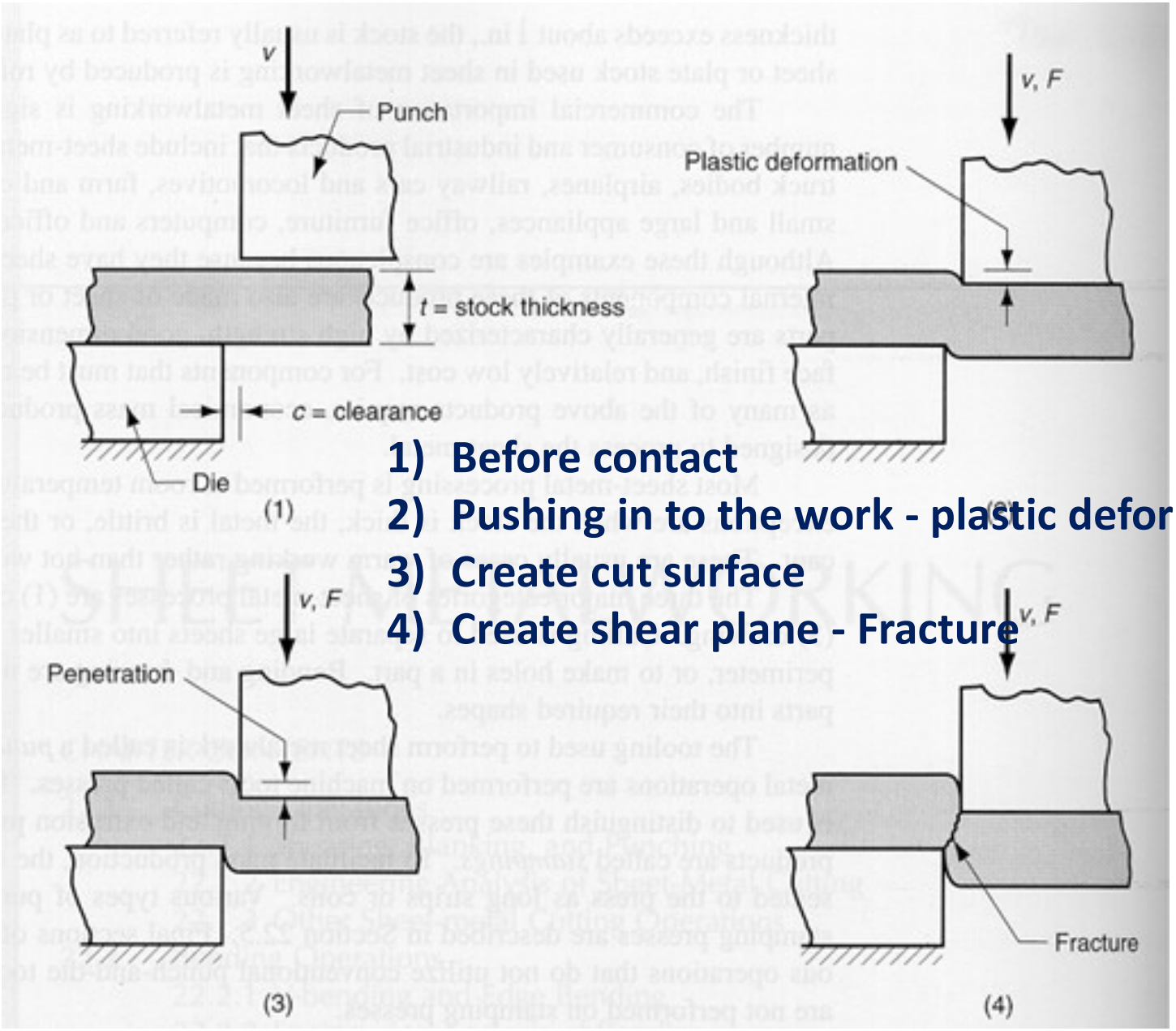
Punching - sheet metal cutting similar to blanking except cut piece is scrap, called a *slug*

- Remaining stock is the desired part



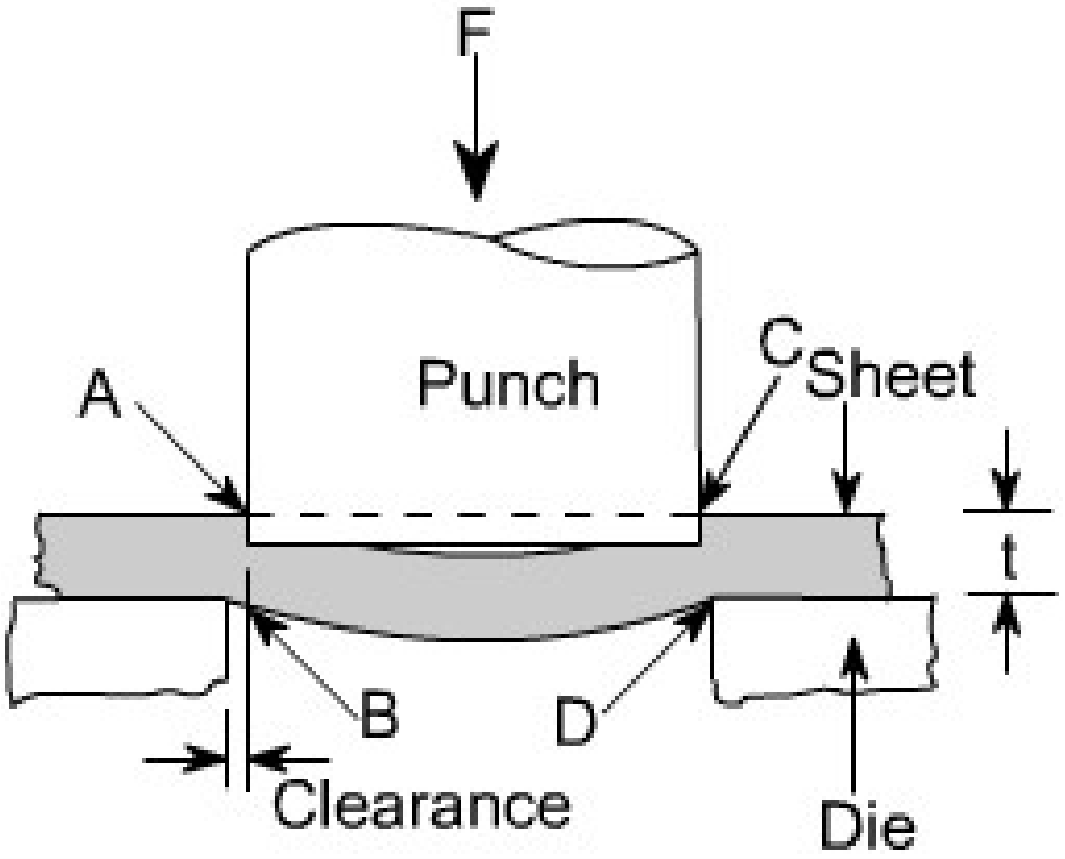
(a) Blanking and (b) punching

Shearing



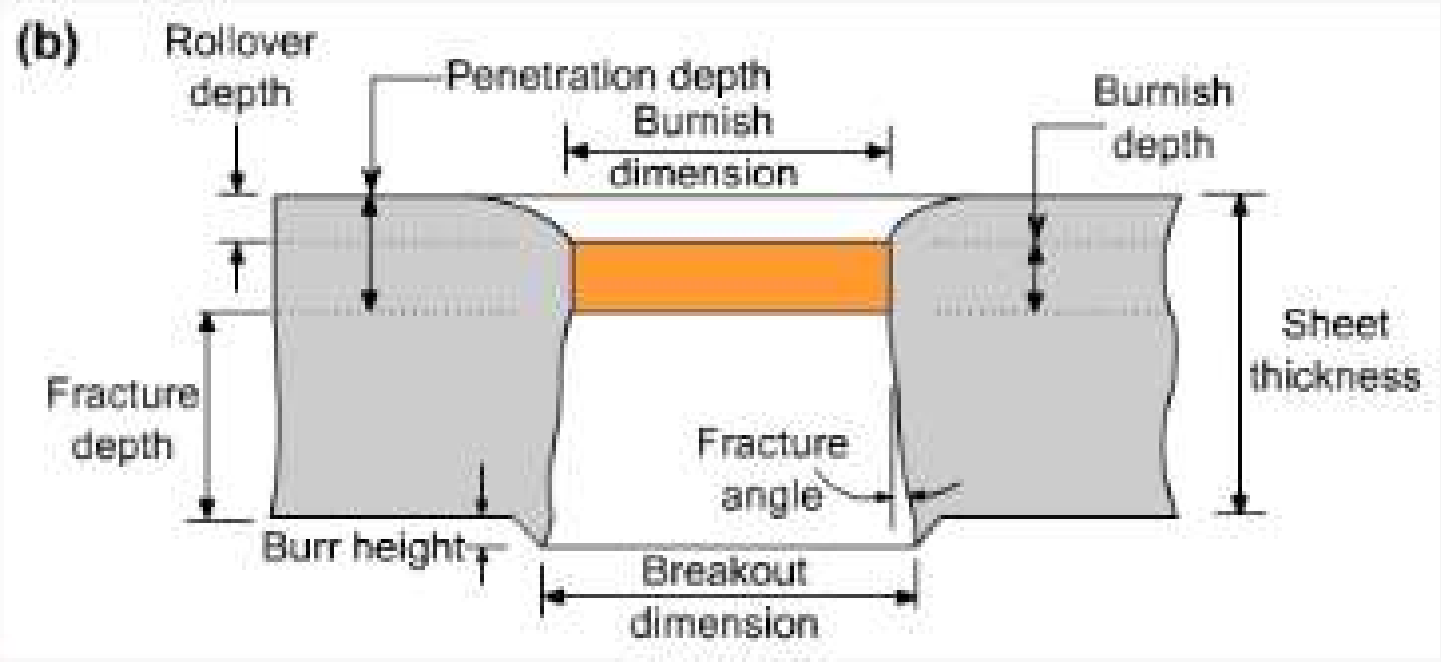
1) **Before contact**
2) **Pushing in to the work - plastic deformation**
3) **Create cut surface**
4) **Create shear plane - Fracture**

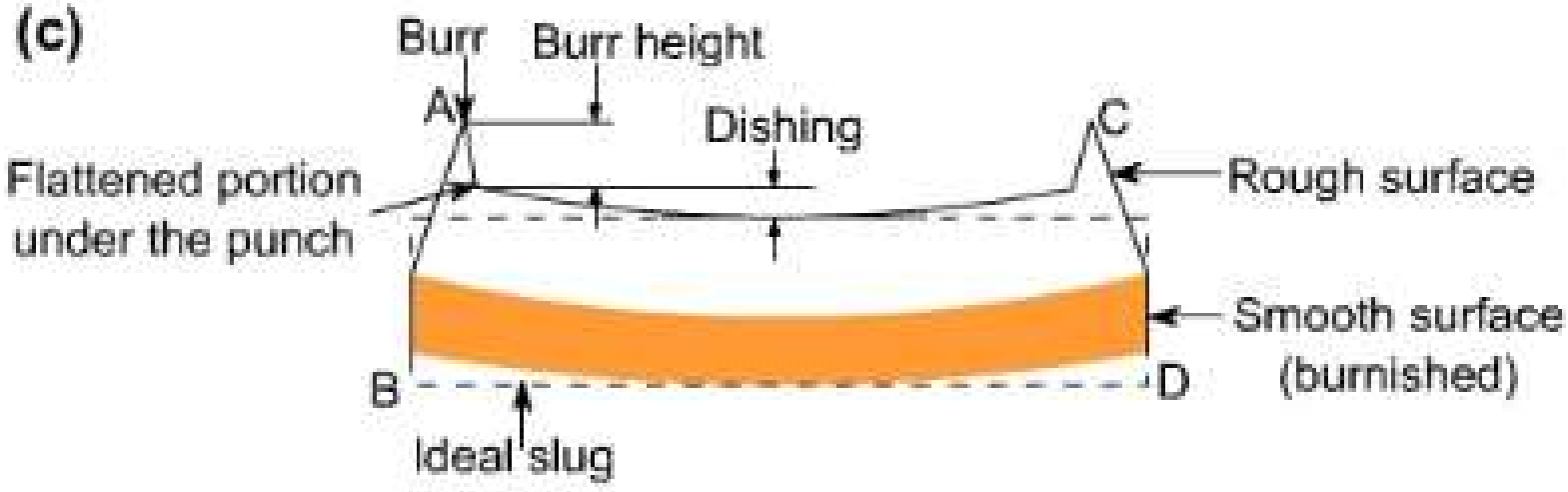
Cutting



Shearing with punch

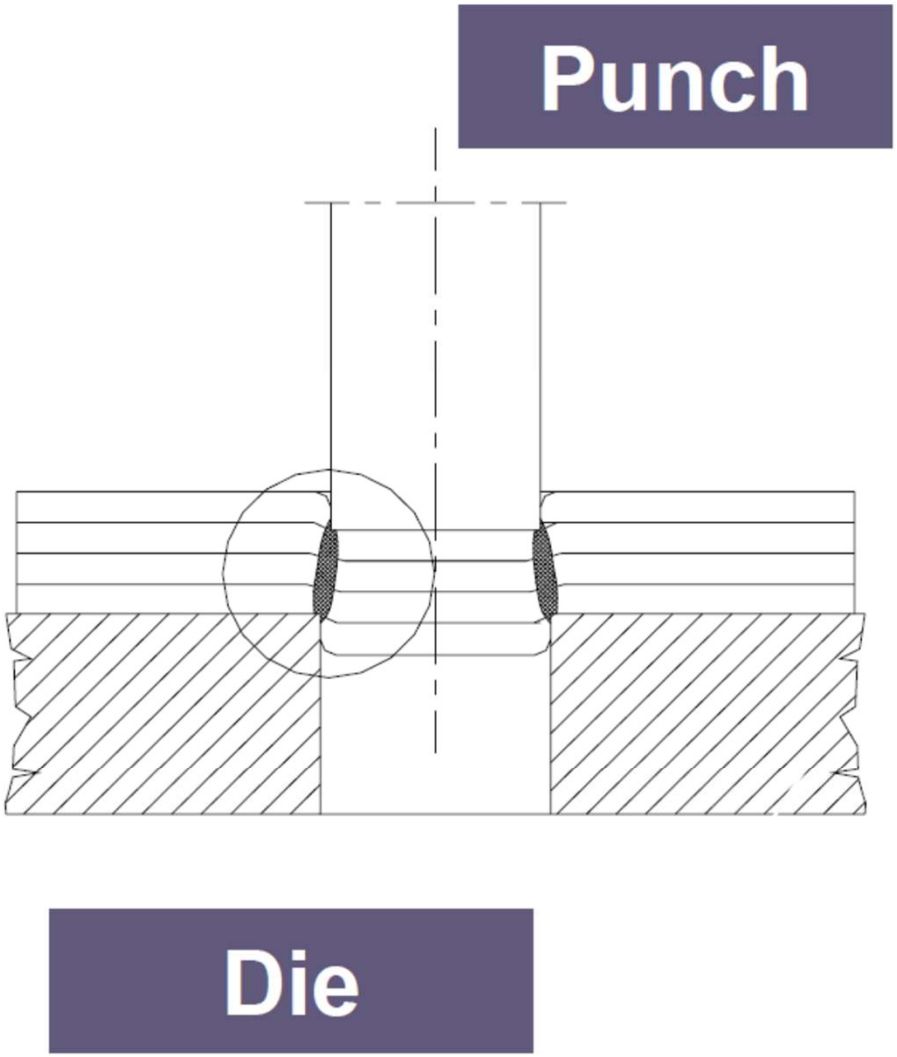
Cutting

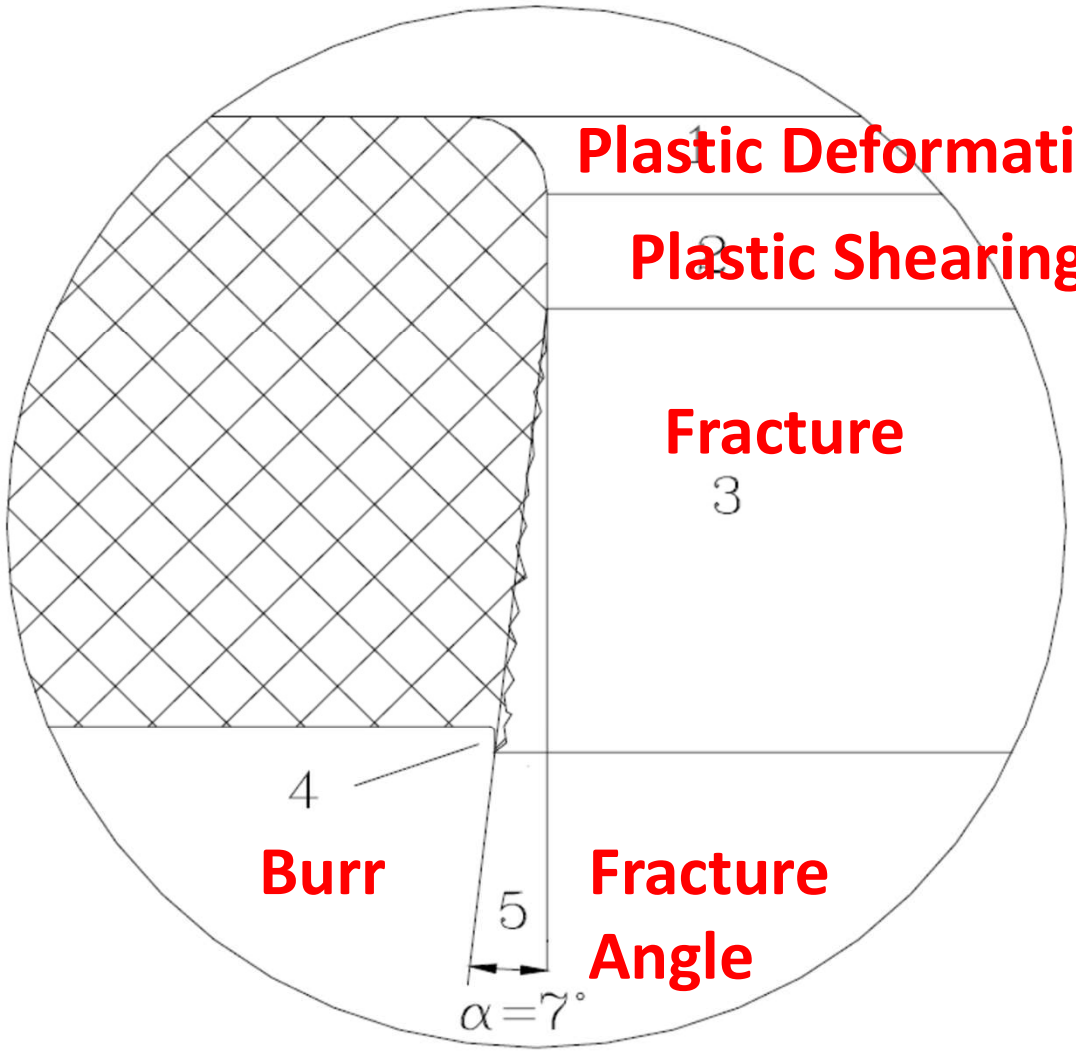




Shearing with punch

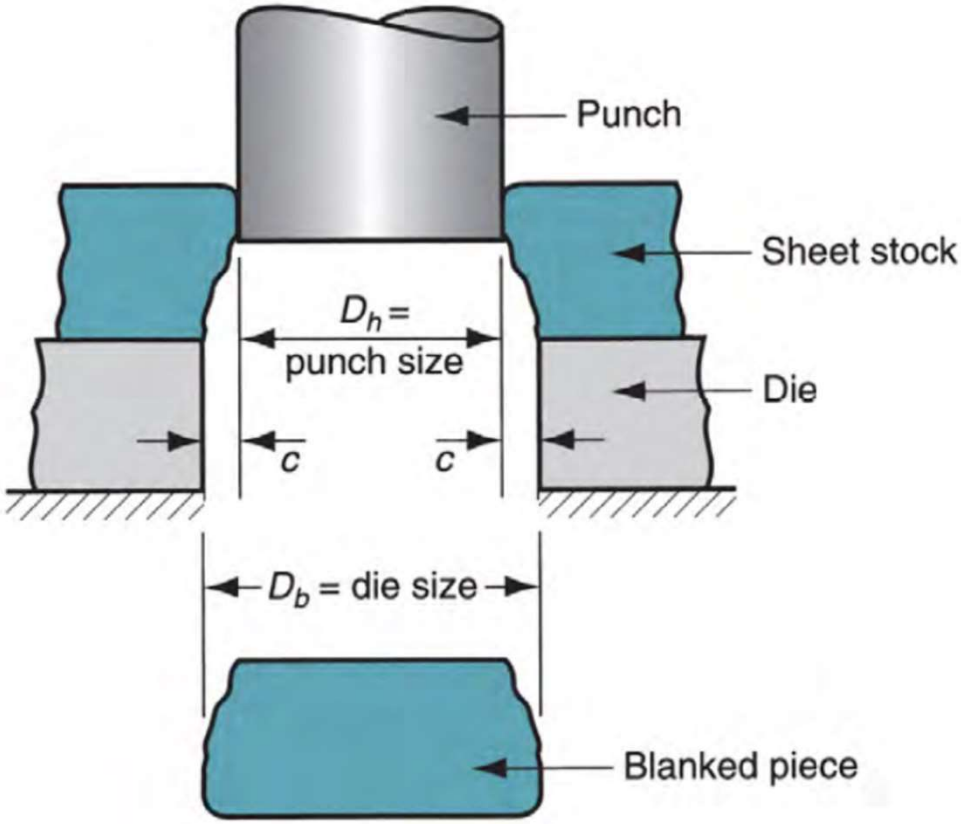
Shearing


Punch
Die


1
Plastic Deformation
2
Plastic Shearing
Fracture
3
4
Burr
5
Fracture
Angle
α=7°

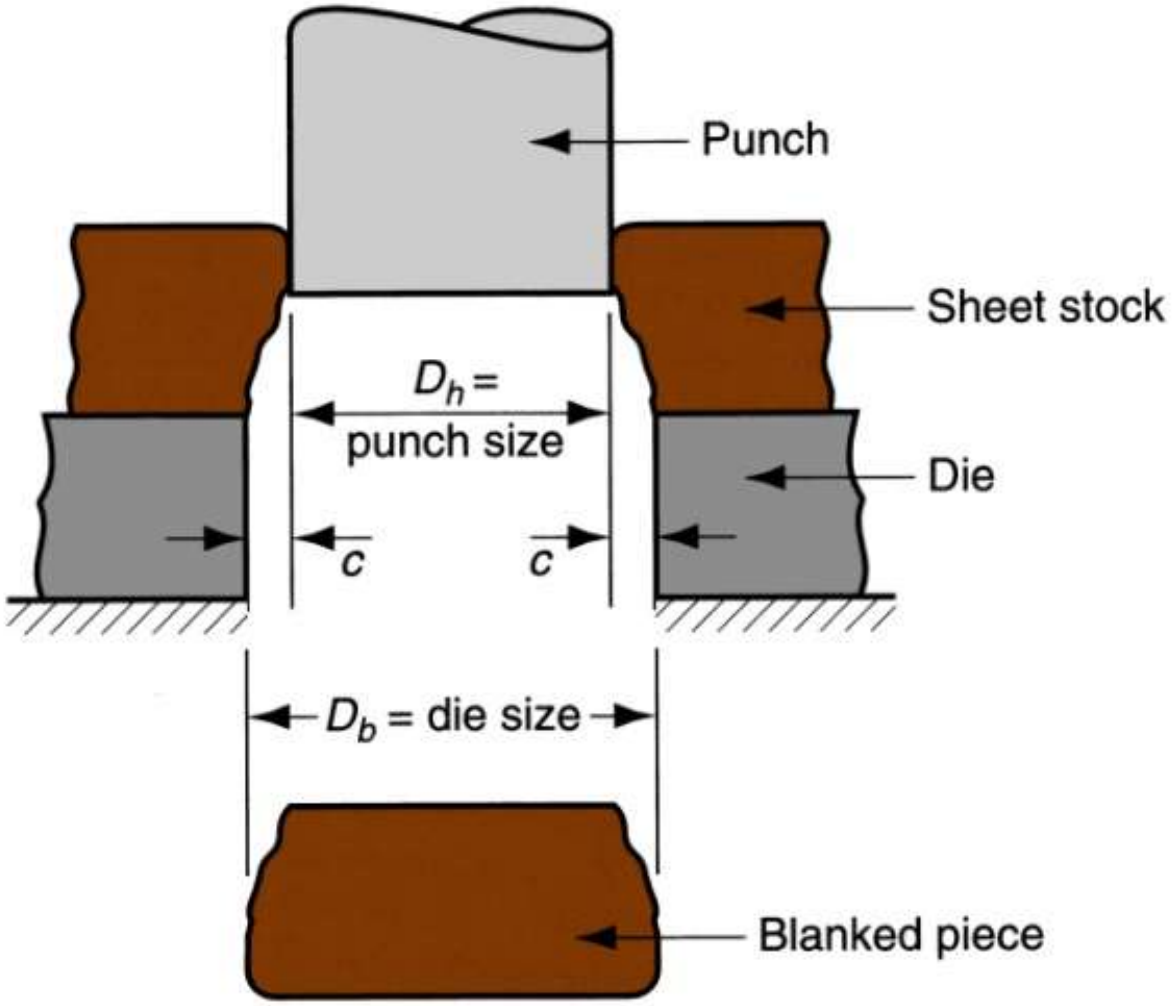
Punch-Die Clearance

- Reliable Operation of the Blanking Tools
- **Quality and Type of Cutting Edges**
- **Life of punch and die (wear)**
- **Tool Forces**
- Typically, 4 to 8 % of the sheet thickness
- Small clearance needs large force
- Large clearance will lead to more scrap

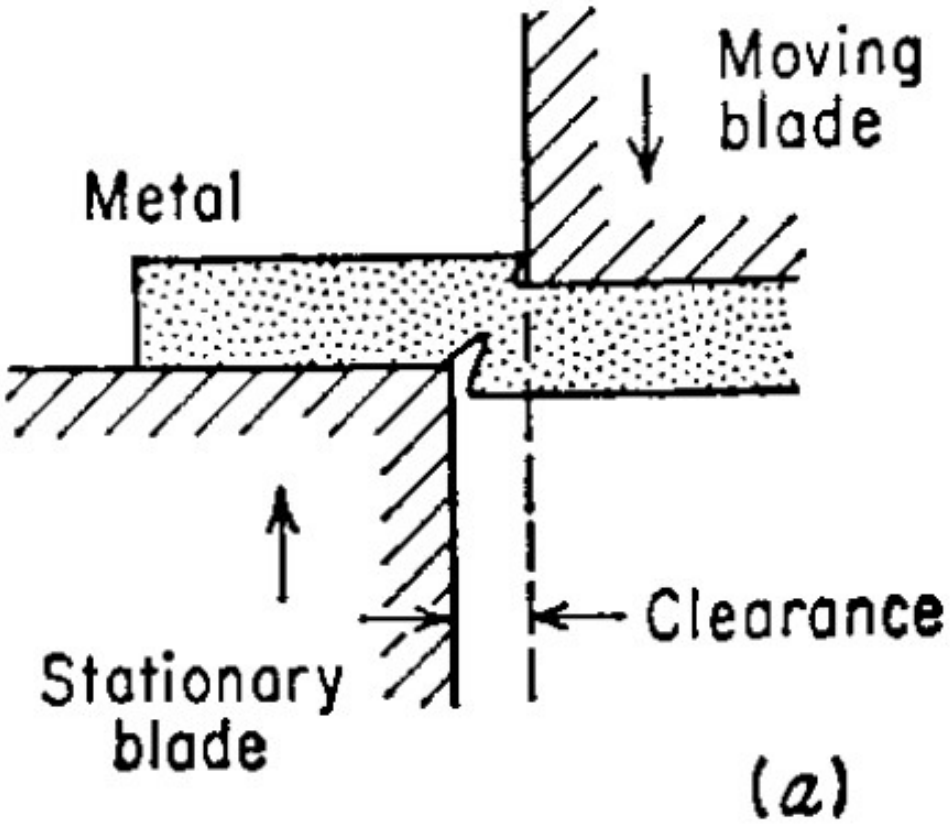


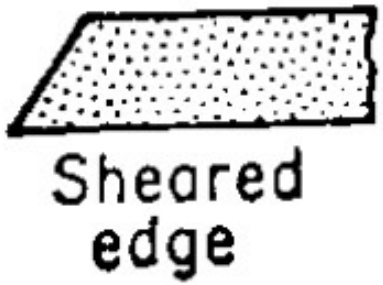
Cutting

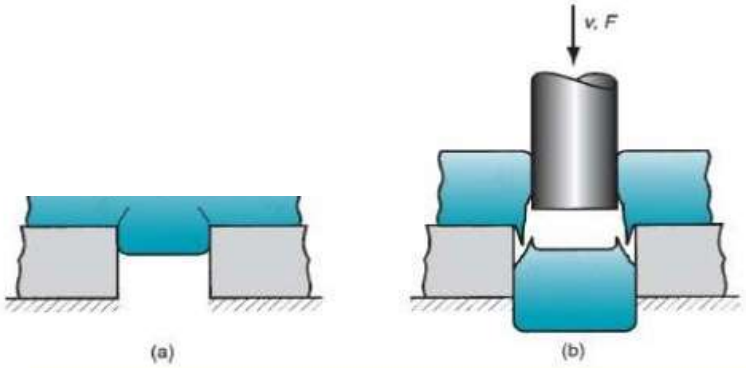
Clearance in Sheet Metal Cutting



Effect of Clearance

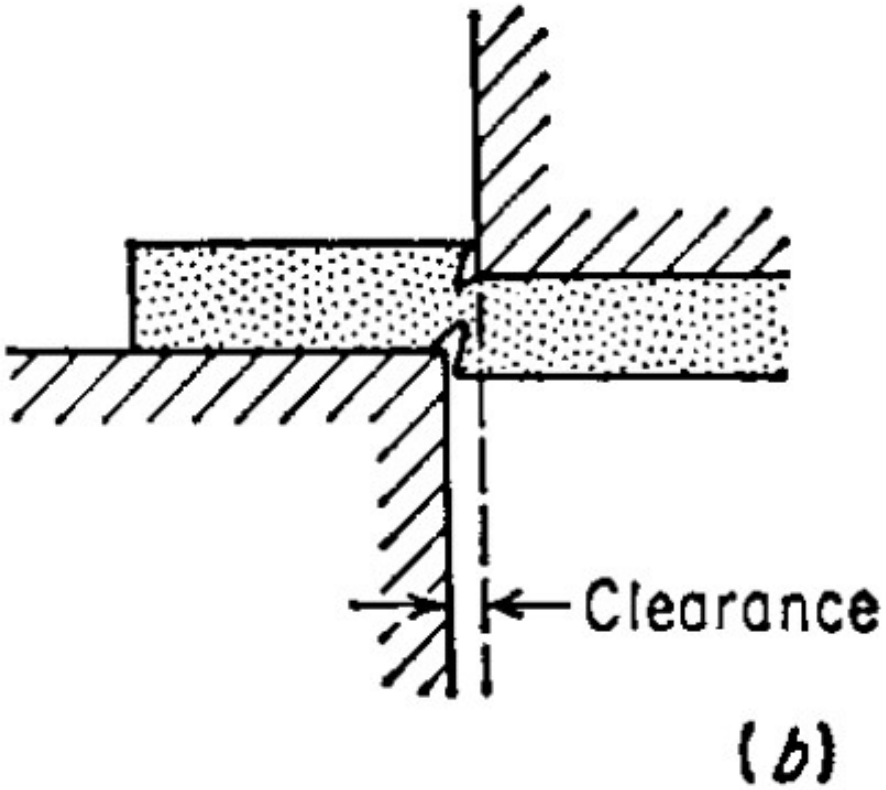


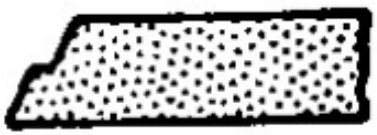


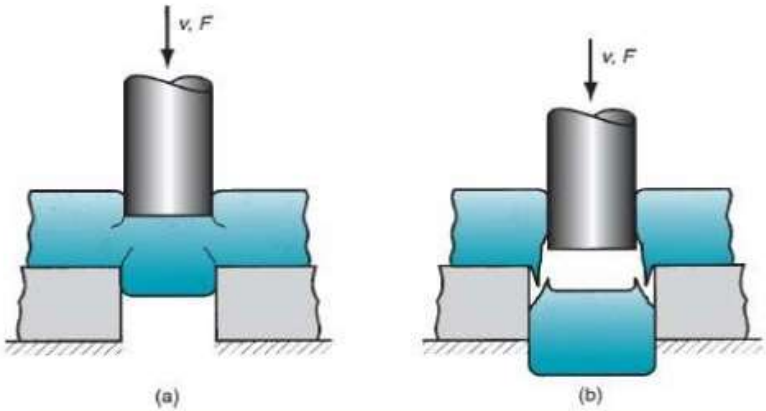


Effects of clearance:
(a) Clearance too small causes less than optimal fracture and excessive forces
(b) Clearance too large causes oversized burr

Effect of Clearance







Effects of clearance:
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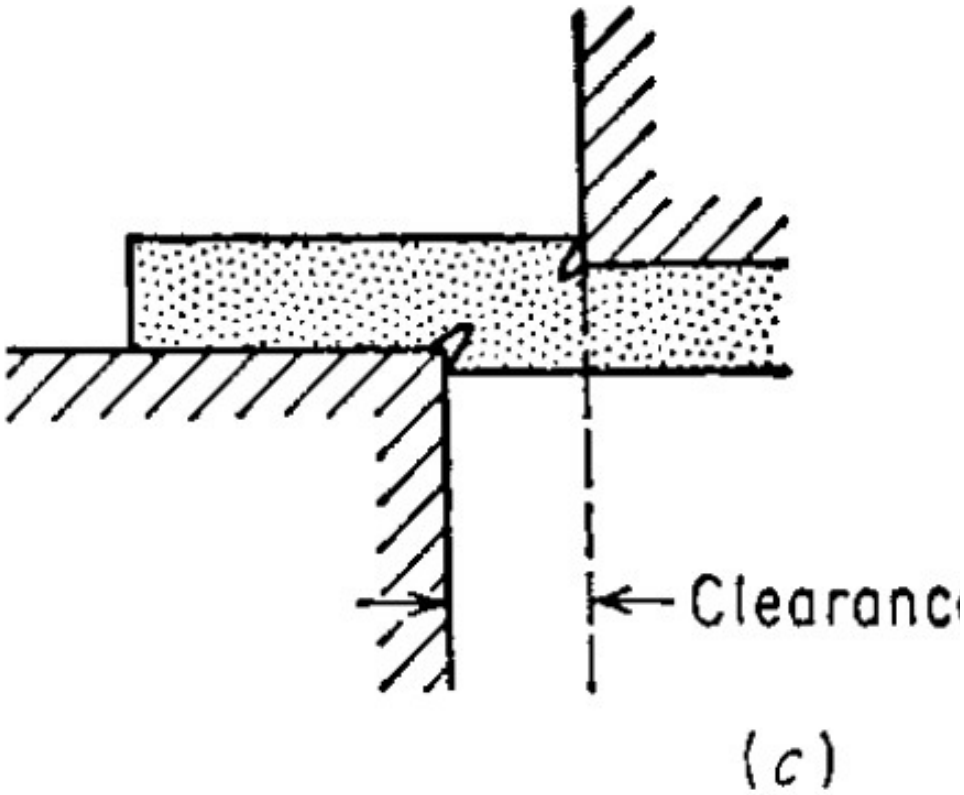
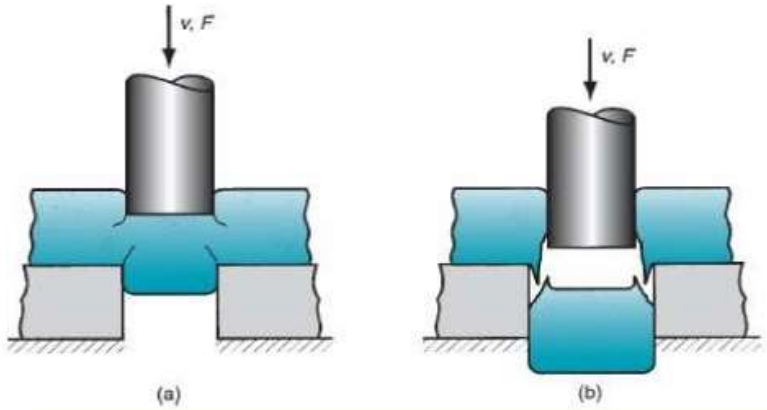
Effect of Clearance



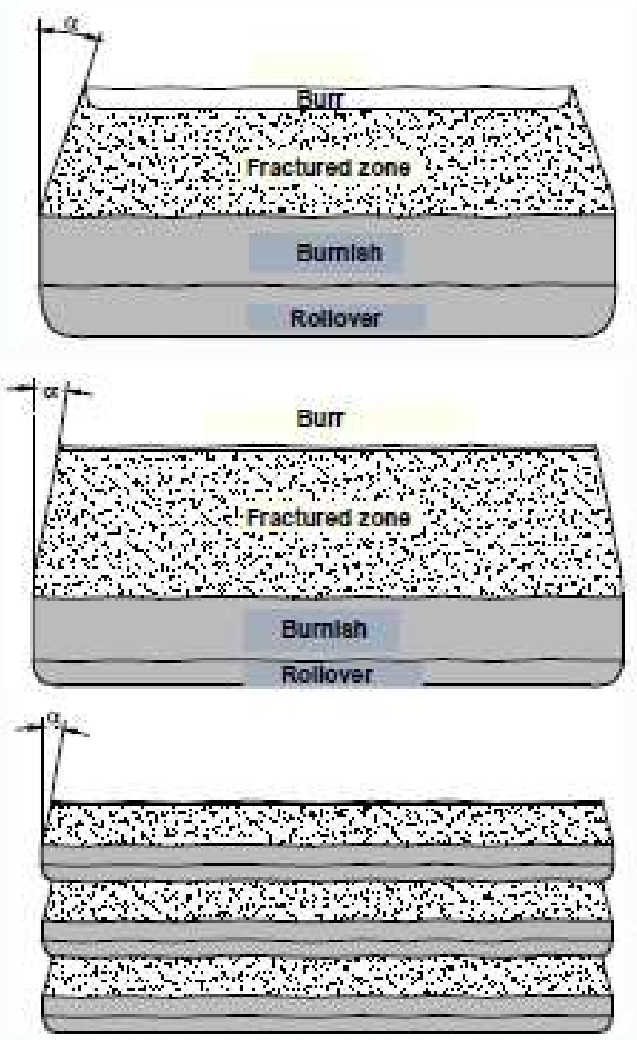


Effects of clearance:
(a) Clearance too small causes less than optimal fracture and excessive forces
(b) Clearance too large causes oversized burr

Effect of Clearance

Clearance vs. morphology of the fractured surface

The fracture surface is not perfectly perpendicular to the sheet surface.
Its quality is greatly influenced by the clearance between the punch and die.

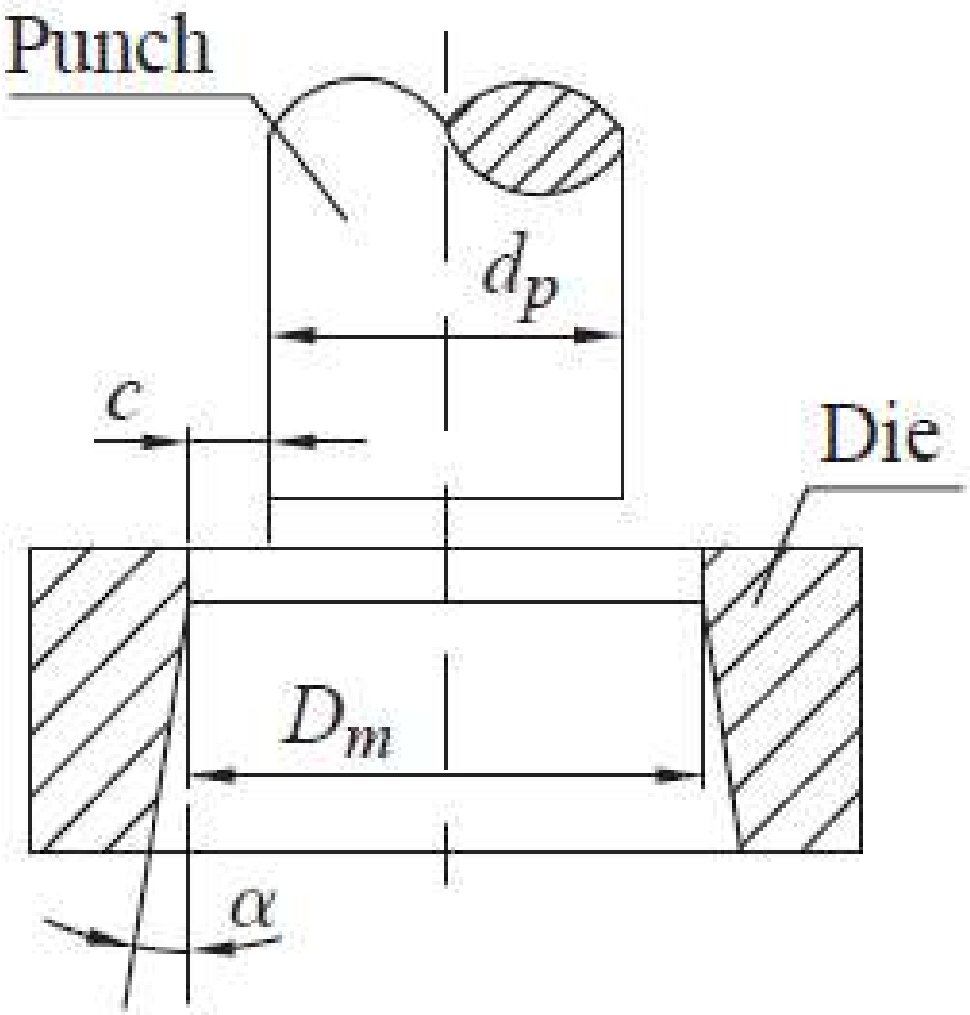


Type I
Excessive clearance allows extensive plastic deformation, separation is delayed and a long burr is pulled out at the upper surface. (this type of fracture surface is also obtained when the punch and die are used beyond their tool life)

Type III
Ideal clearance.

Type V
With a very tight clearance, the cracks – originating from the tool edges – miss each other and the cut is then completed by a secondary tearing process, producing a jagged edge roughly midway in the sheet thickness.
(this type of clearance leads to more rapid tool wear and to smaller tool life).

Effect of Clearance



Shearing Force

Neglecting friction, the force required to shear a metal sheet is the product of the length cut, the sheet thickness, and the shearing strength of the metal. Empirically, the maximum punch force to produce shearing is given by

$$P_{\max} \approx 0.7\sigma_u hL \qquad (20\text{-}1)$$

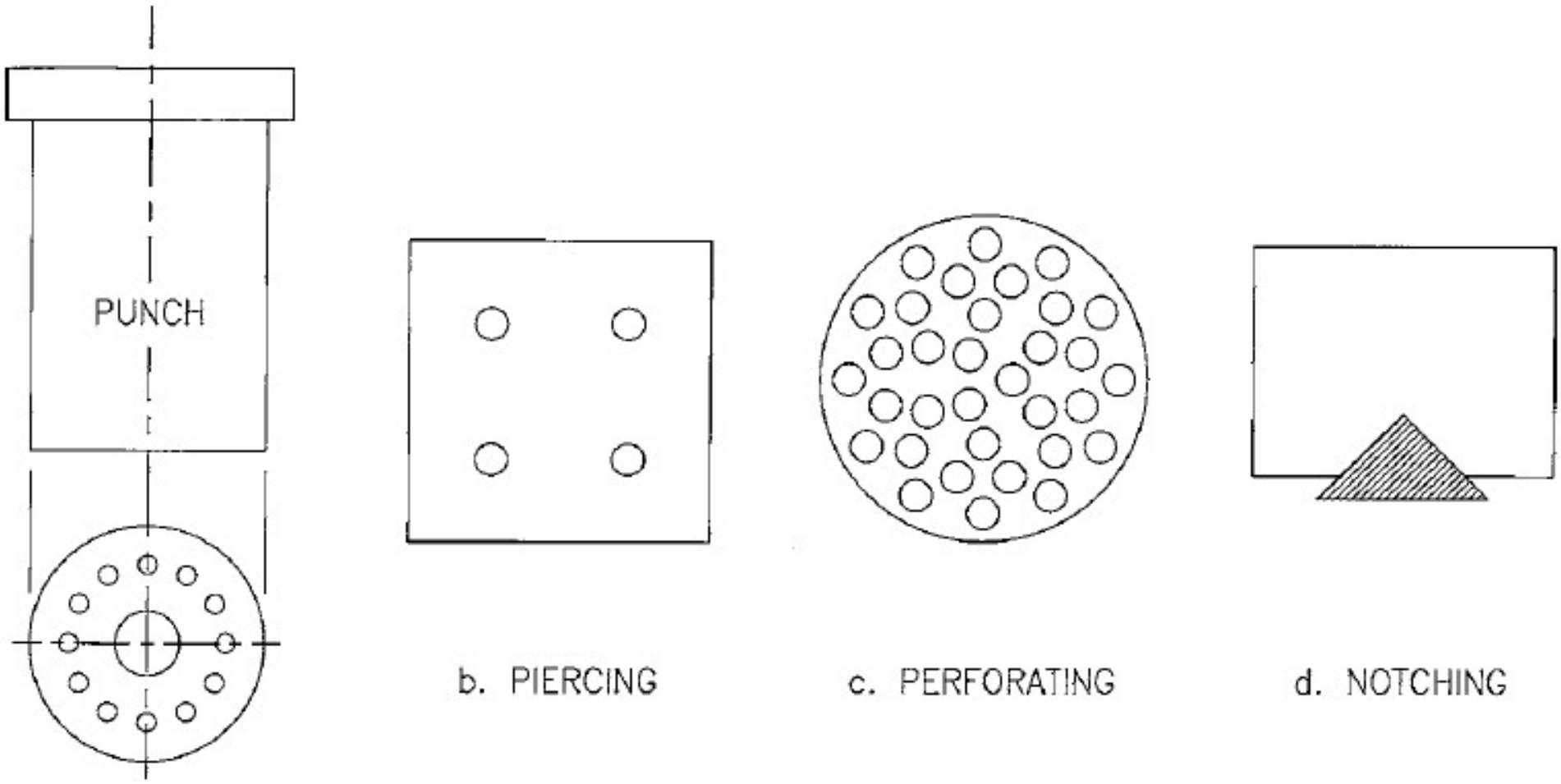
where σ_u = the ultimate tensile strength
h = sheet thickness
L = total length of the sheared edge

Types of Dies

1. Based on Types of Press Operations
   i. Cutting Dies → Examples. blanking dies, piercing dies, perforating dies, notching dies, trimming dies, shaving dies and nibbling dies
   ii. Bending Dies → Examples. V-Bending dies, U-Bending, Wipe/Edge Bending, Rotary Bending
   iii. Drawing Dies → Examples. drawing, redrawing, ironing, reducing, and bulging dies
2. Based on Methods of Operation
   i. Progressive Dies
   ii. Compound Dies
   iii. Combination Dies
   iv. Transfer Dies
   v. Inverted Dies

Types of Dies

1. Based on Types of Press Operations
   i. Cutting Dies → Examples. blanking dies, piercing dies, perforating dies, notching dies, trimming dies, shaving dies and nibbling dies



Types of Dies

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   i. Cutting Dies → Examples. blanking dies, piercing dies, perforating dies, notching dies, trimming dies, shaving dies and nibbling dies

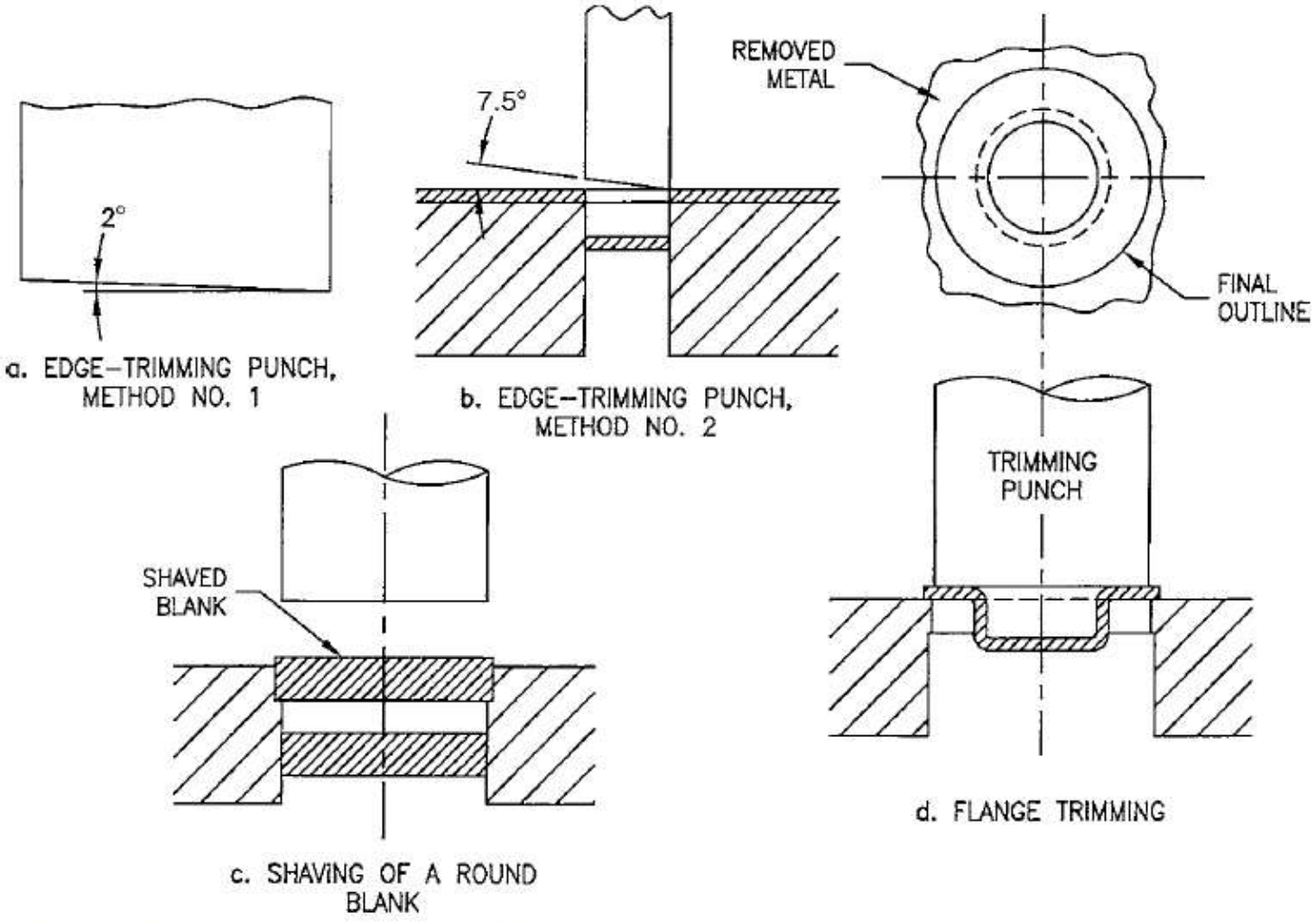


FIGURE 3-30 Trimming and shaving dies.

Types of Dies

1. Based on Types of Press Operations

   Bending Dies → Examples. Bending dies, drawing dies and squeezing dies

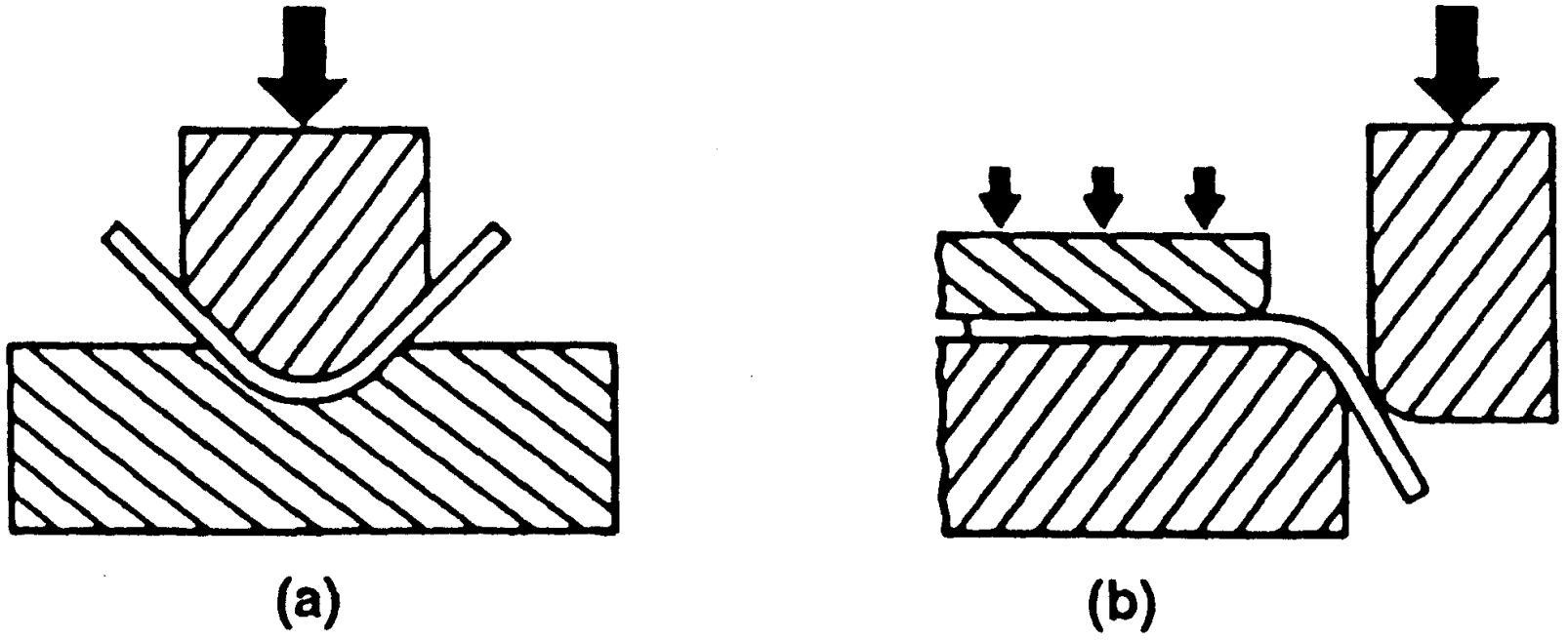


FIG. 9.14 Basic bending tools (a) v-die. (b) Wiper die.

Types of Dies

1. Based on Types of Press Operations

   Bending Dies → Examples. Bending dies, drawing dies and squeezing dies

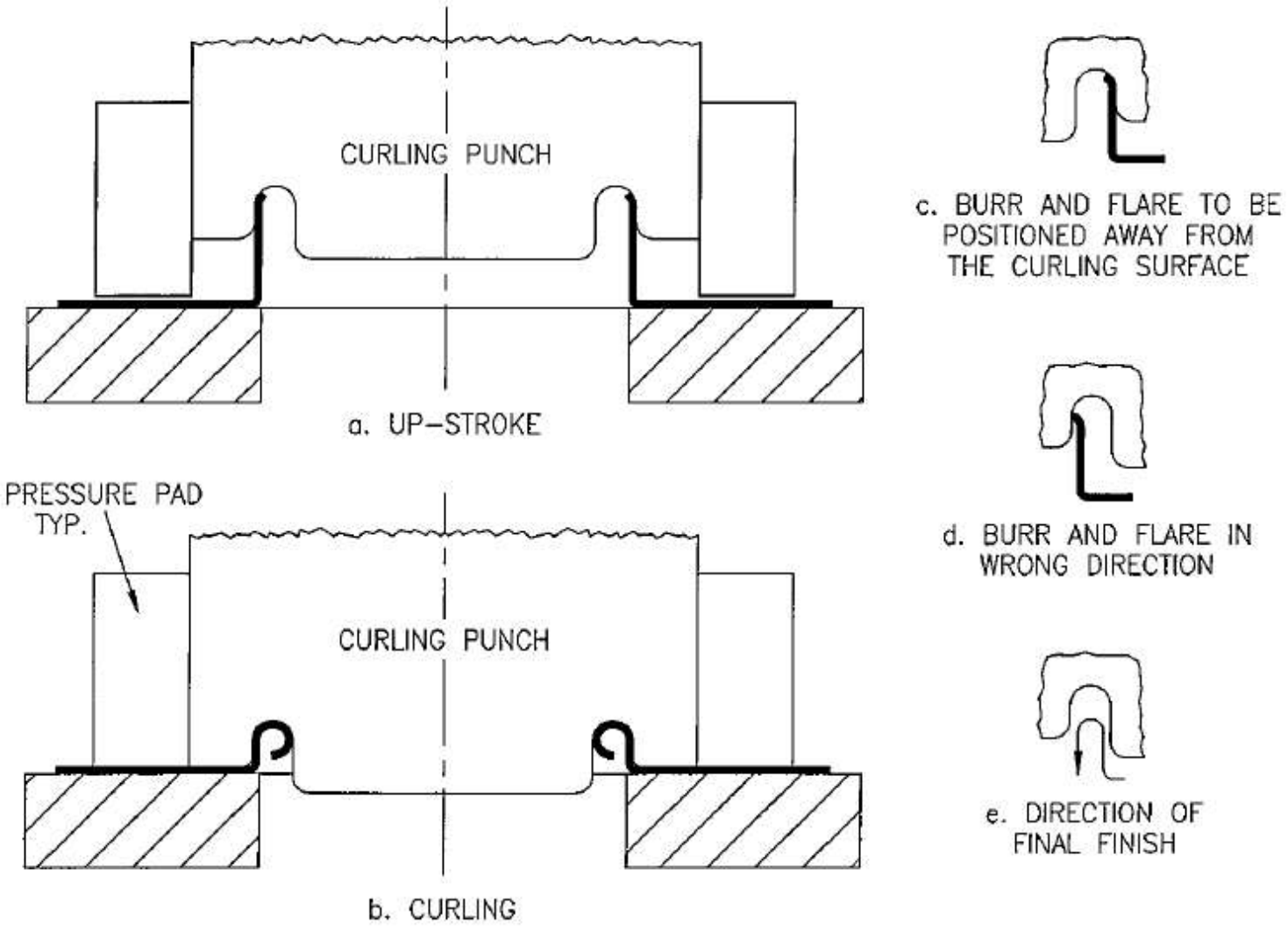


FIGURE 3-37 Curling operation, the first type.

Types of Dies

1. Based on Types of Press Operations

   Bending Dies → Examples. Bending dies, drawing dies and squeezing dies

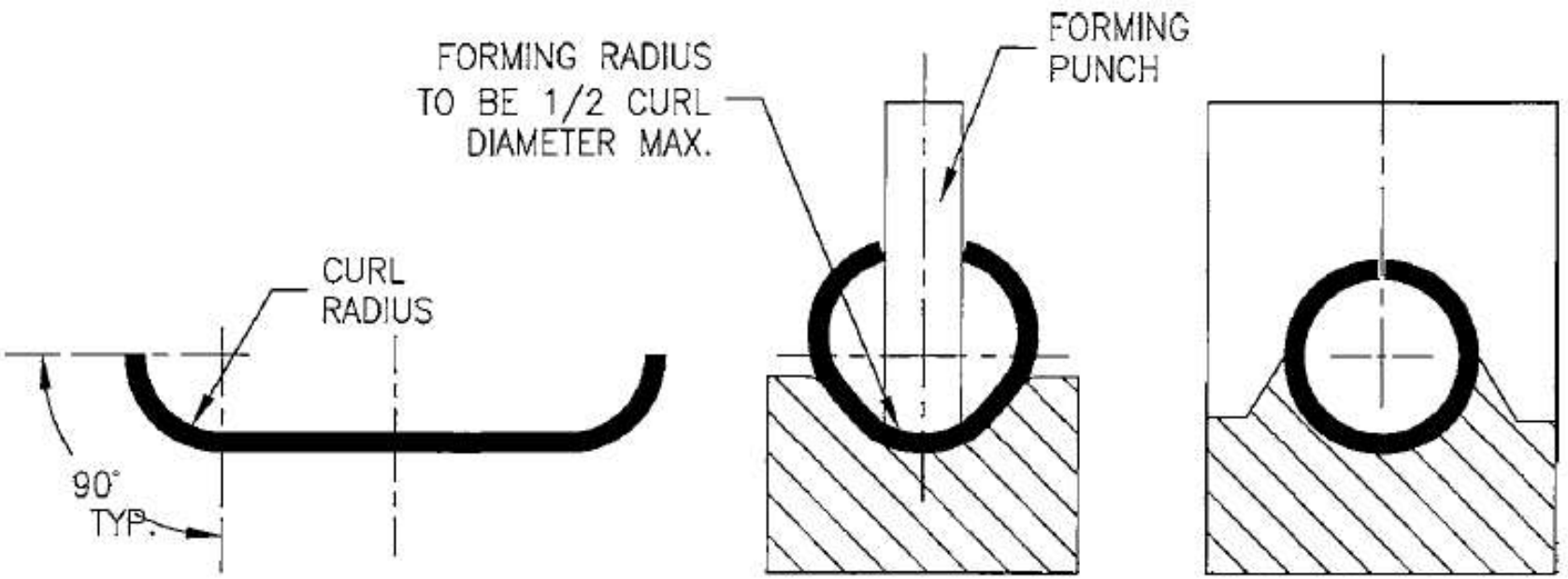
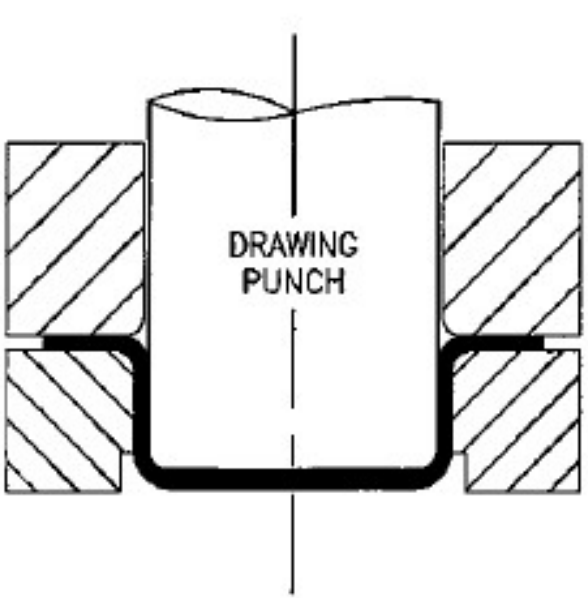


FIGURE 3-38 Three-stage curling operation.

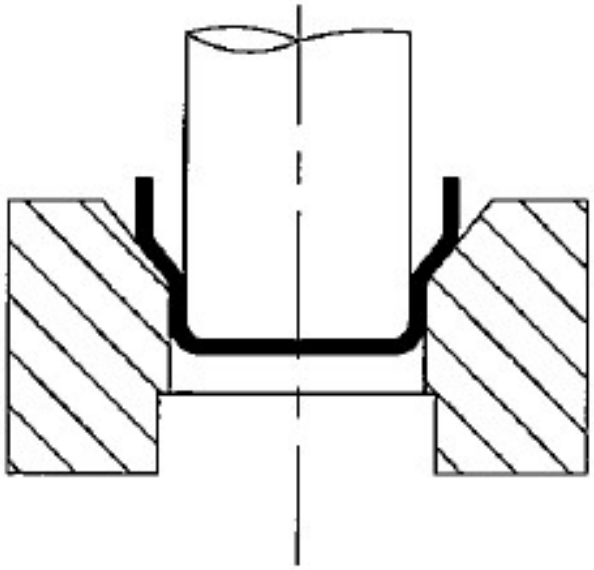
Types of Dies

1. Based on Types of Press Operations

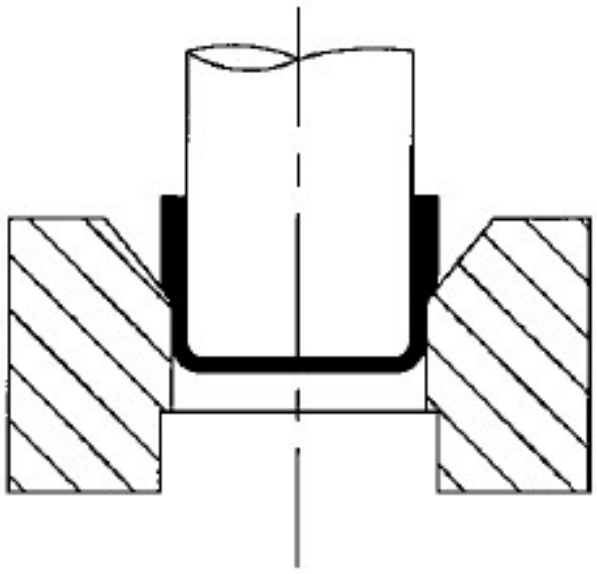
   Drawing Dies → Examples. drawing, redrawing, ironing, reducing, and bulging dies



a. DRAWING

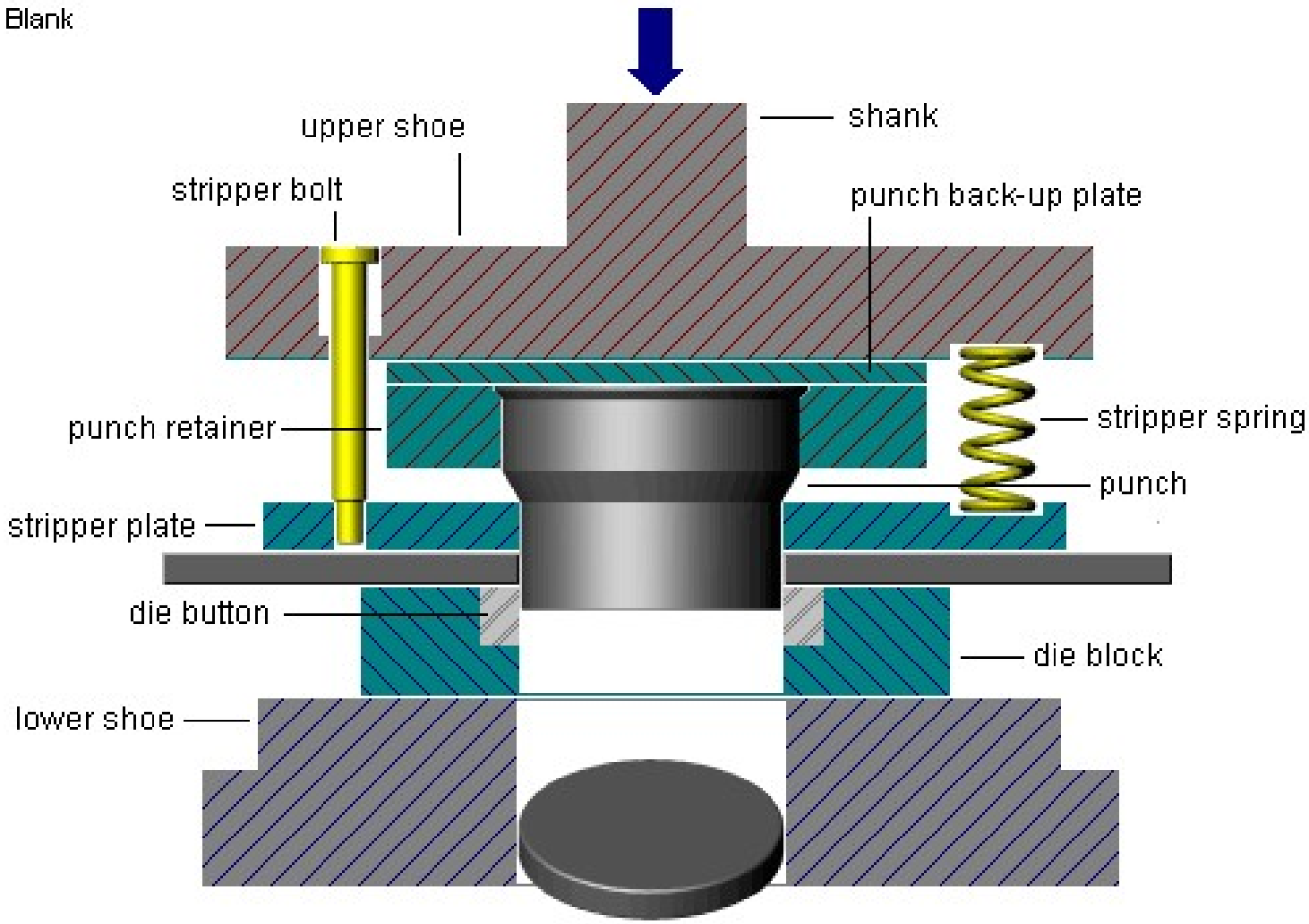


b. REDRAWING
WITHOUT BLANKHOLDER



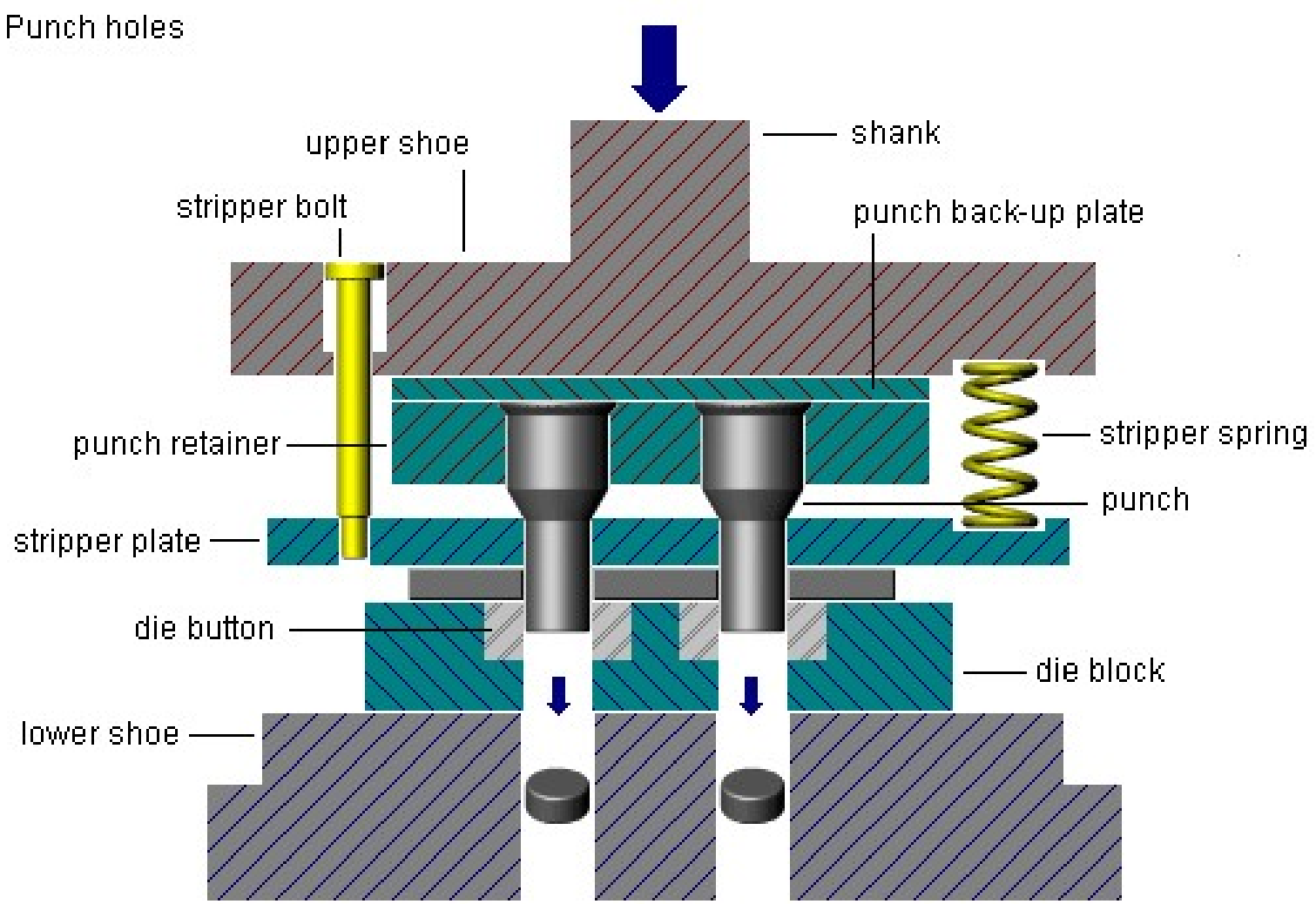
c. IRONING

Cutting Dies



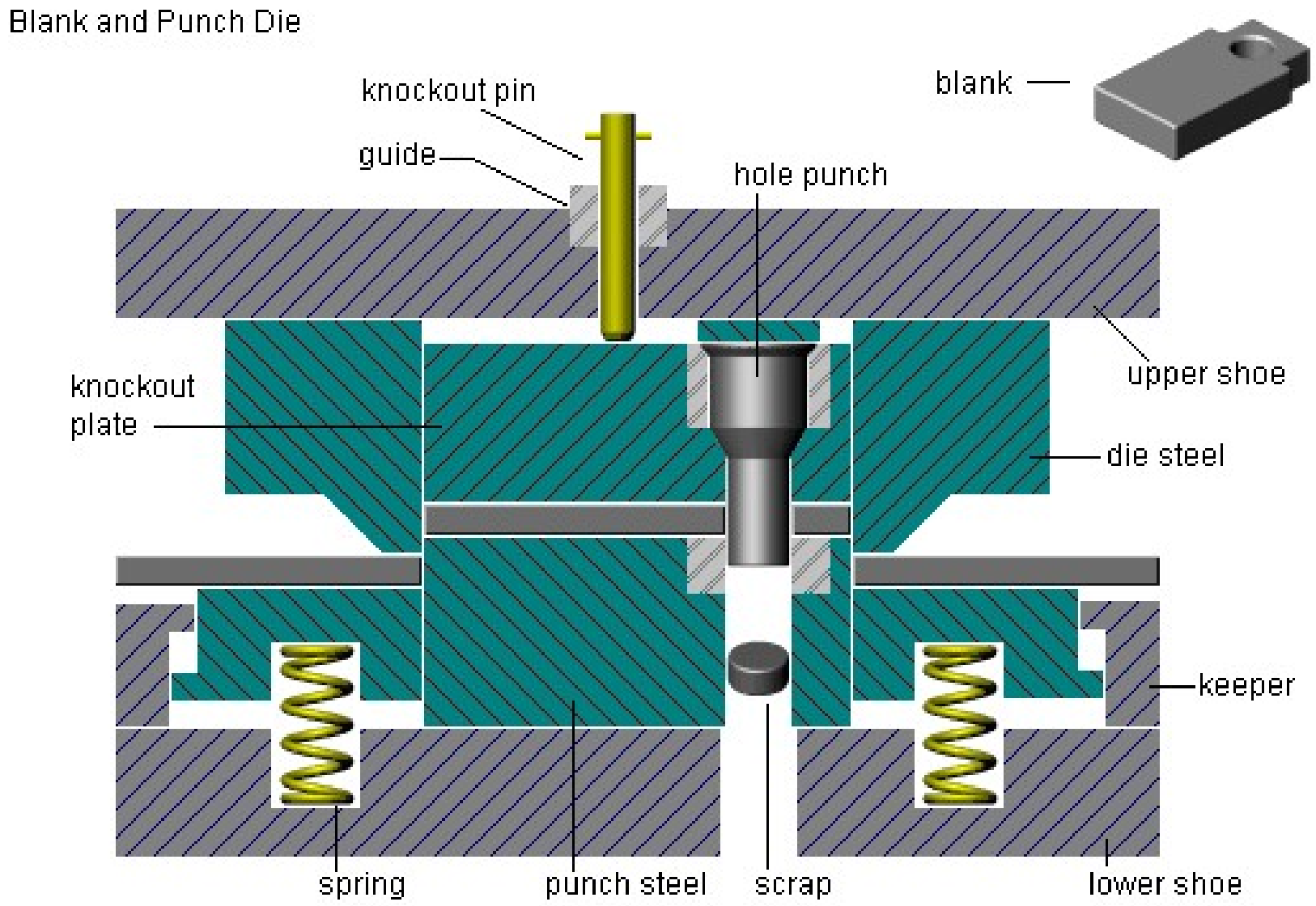
Blanking Dies

Cutting Dies



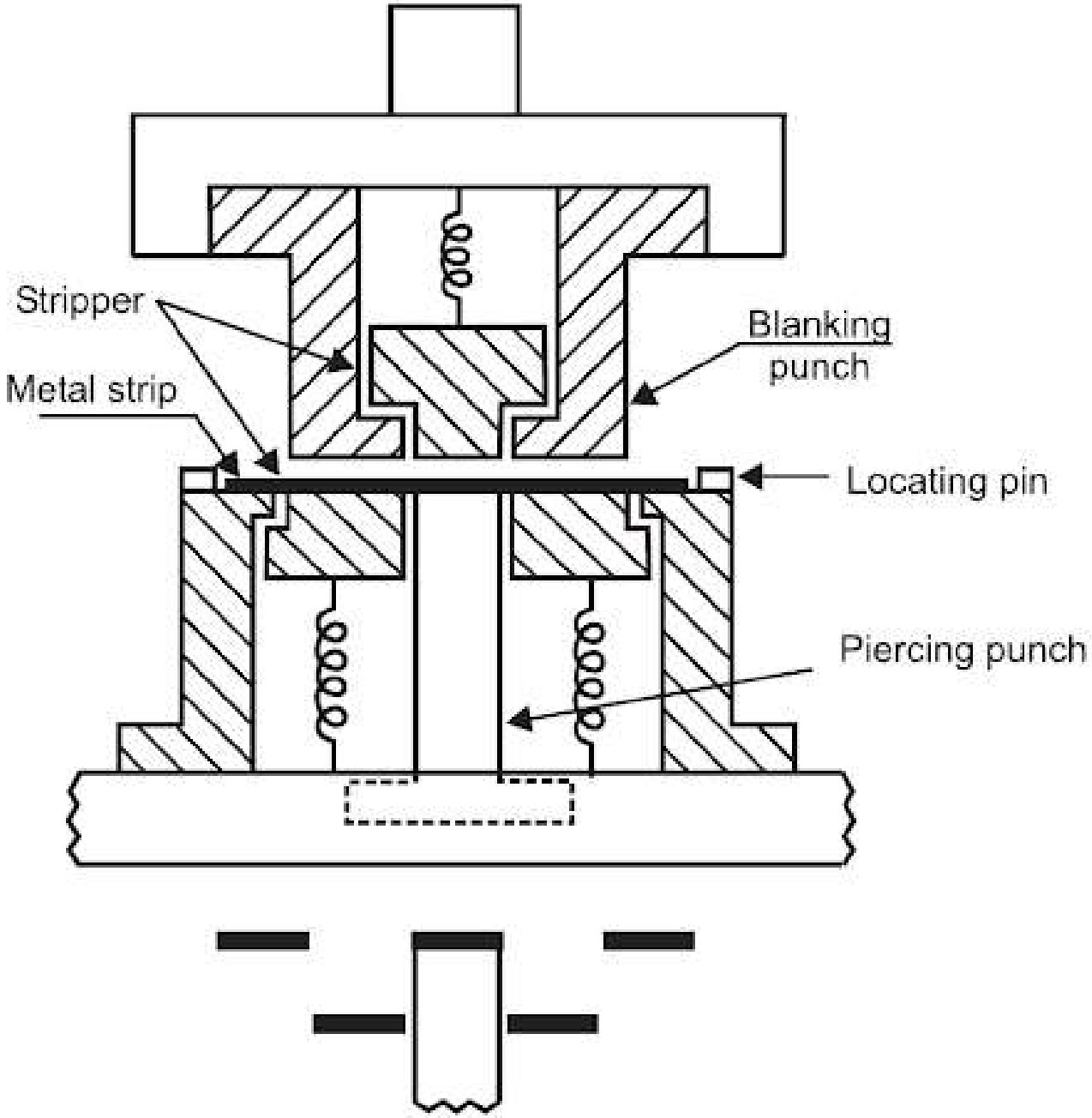
Hole Punching Dies

Compound Dies



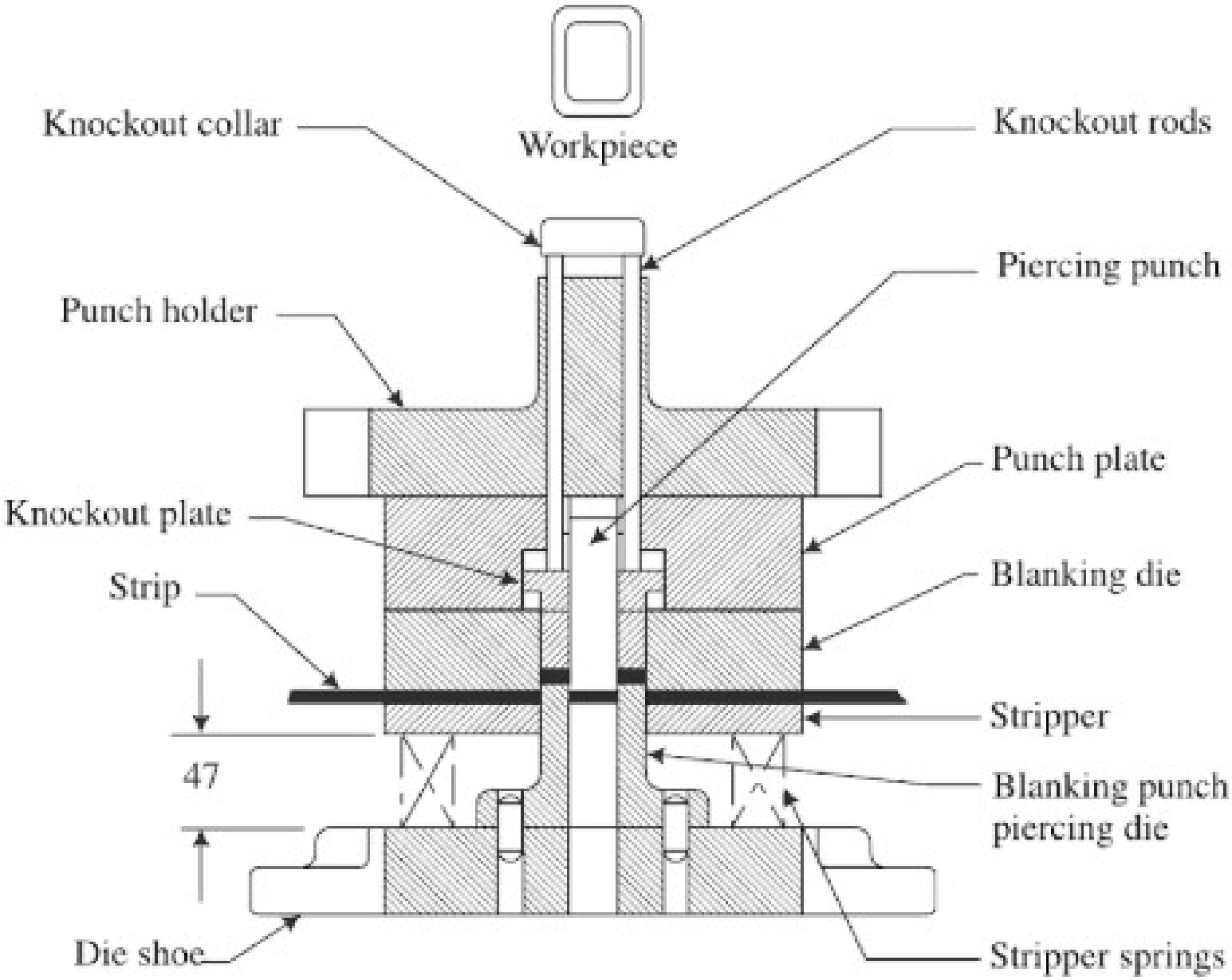
Blank and punching Dies

Compound Dies



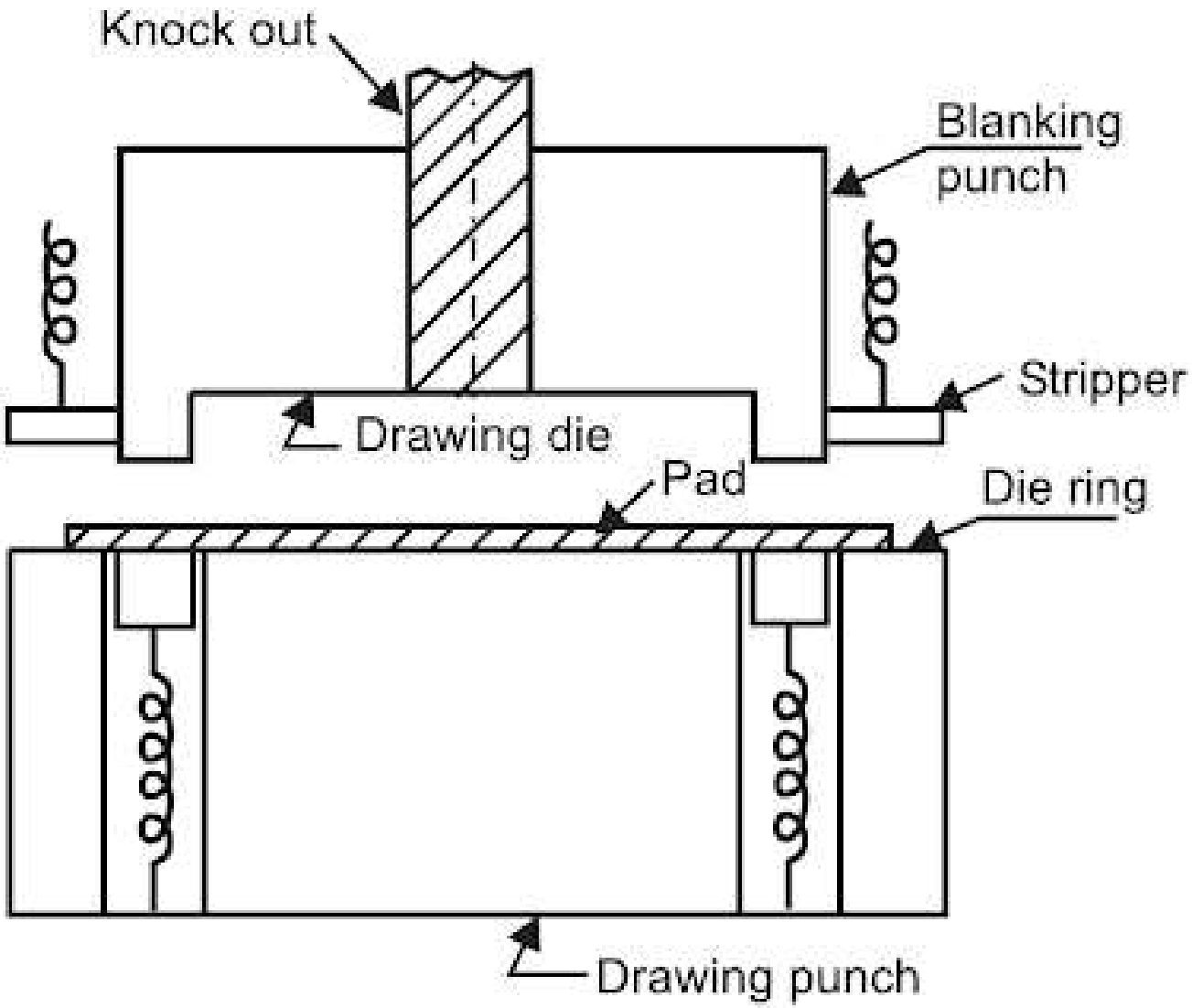
Blank and punching Dies

Compound Dies



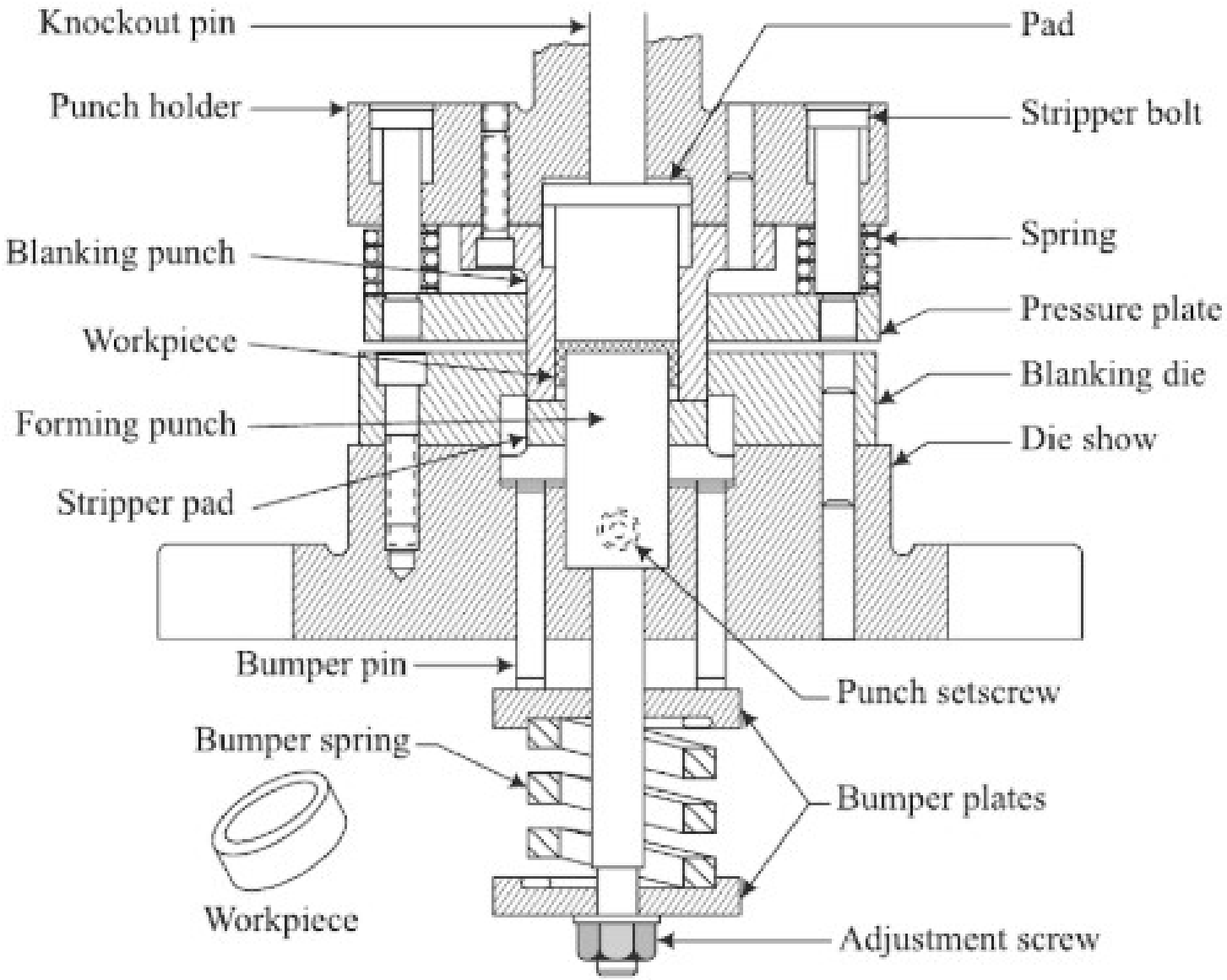
Blank and punching Dies

Combination Dies



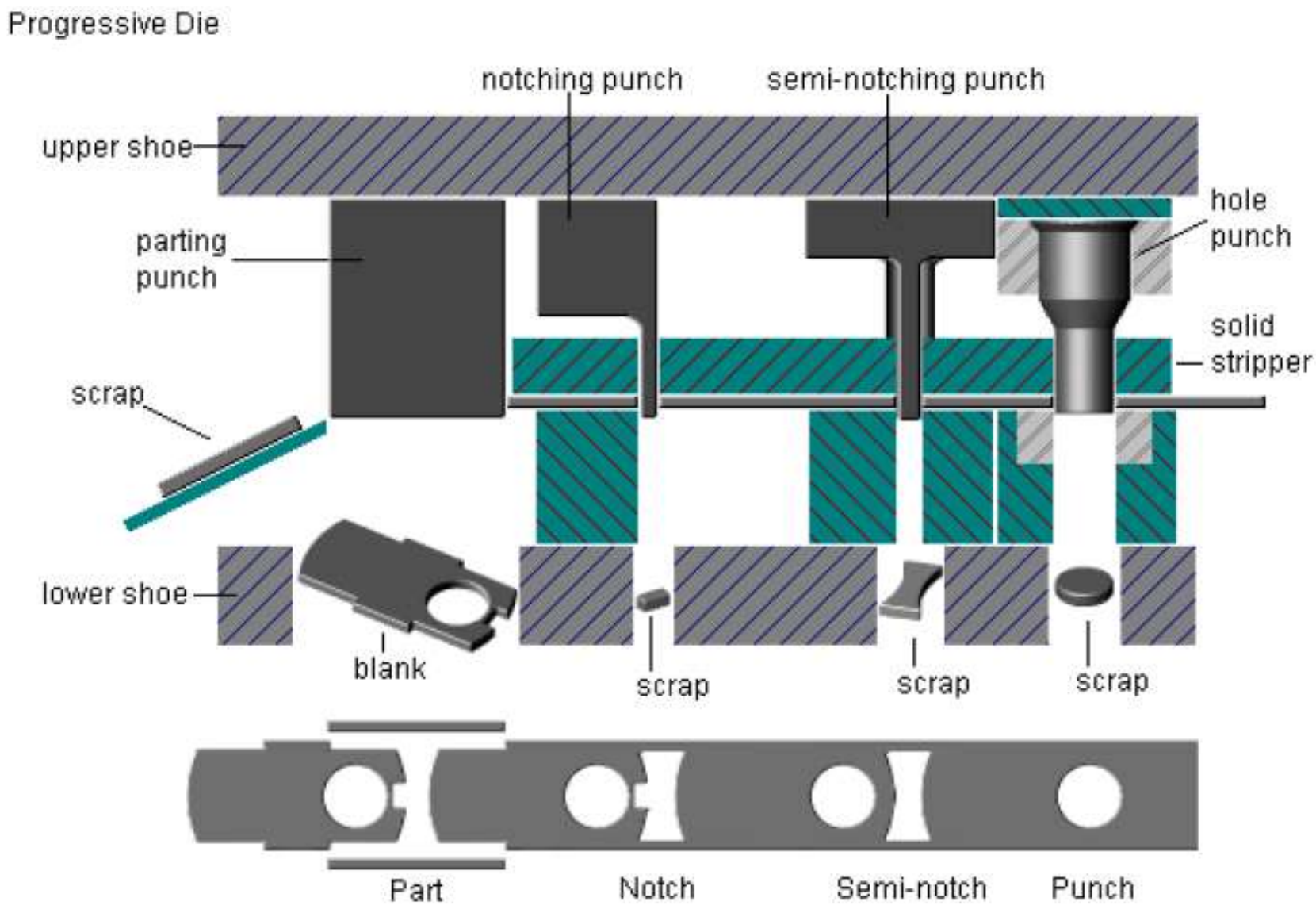
Blanking and Forming Dies

Combination Dies



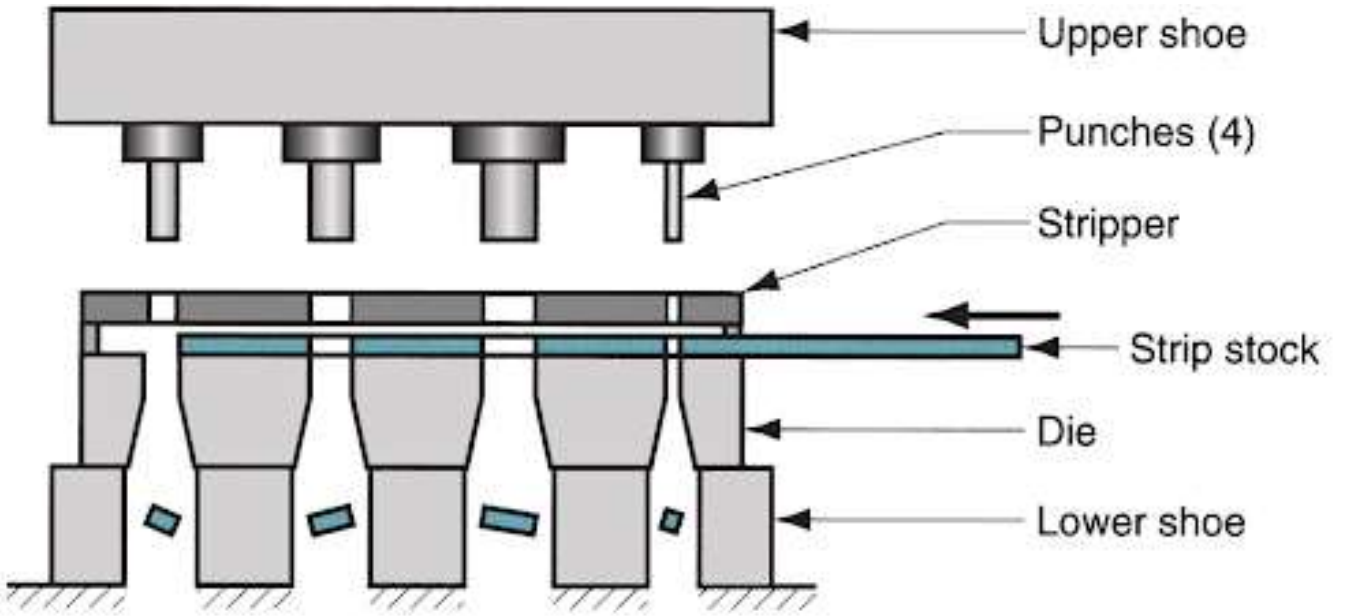
Blanking and Forming Dies

Progressive Dies

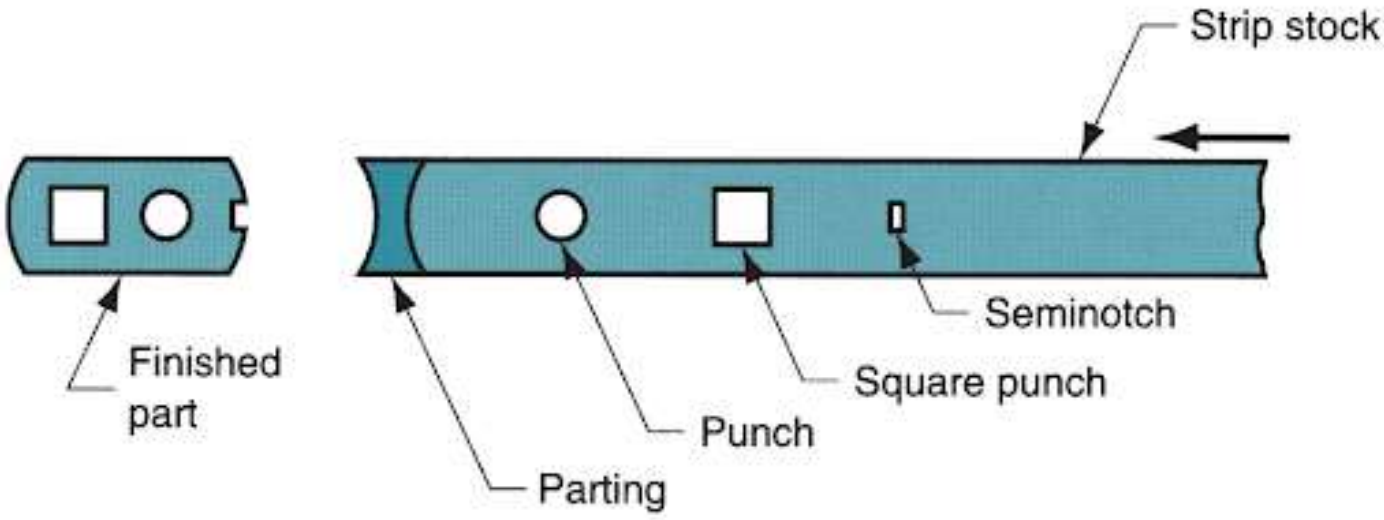


Progressive Dies

Multi Station



(a)

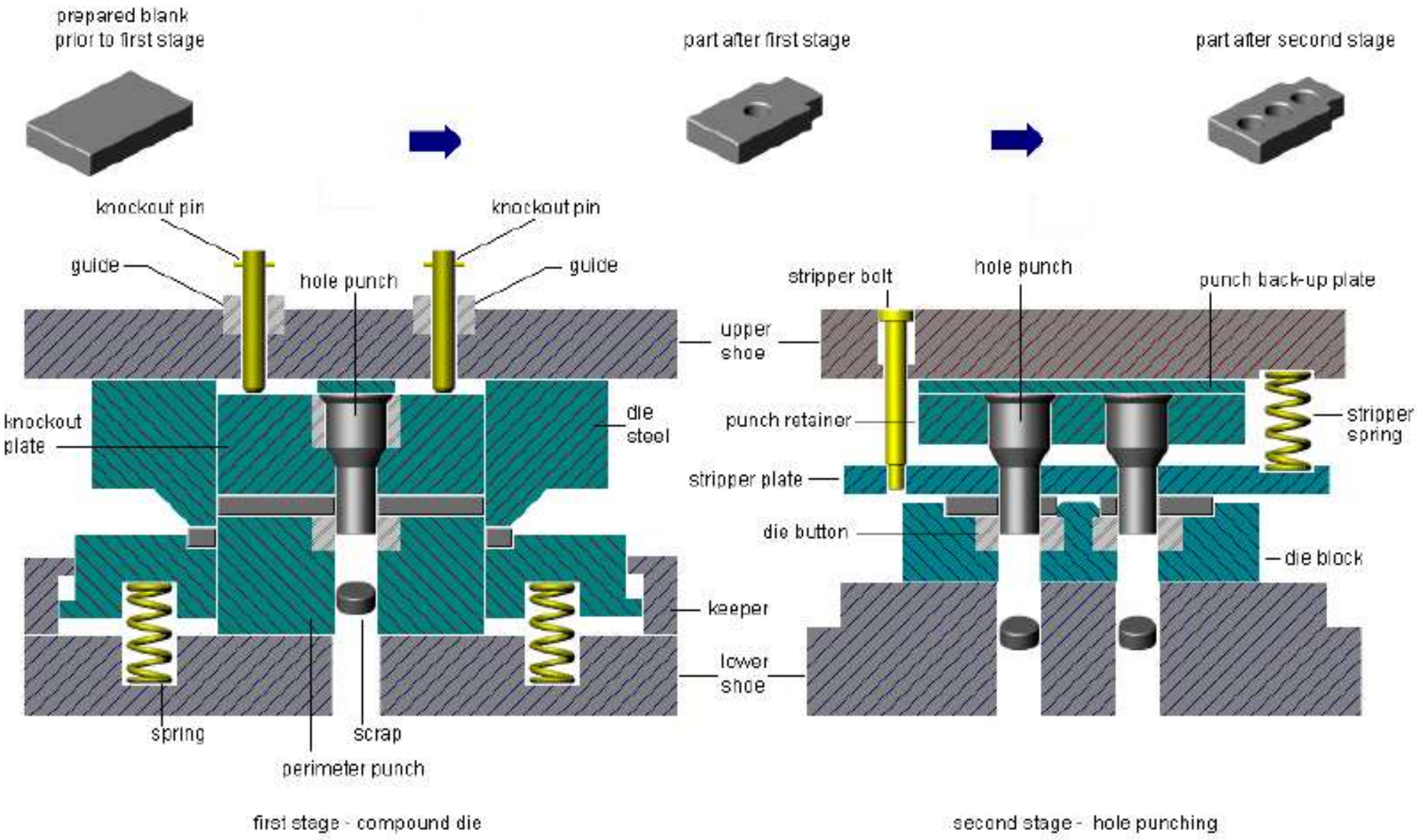


(b)

Multi Station

Transfer Dies

Multi-stage tool



first stage - compound die

second stage - hole punching

PROGRESSIVE DIE vs. TRANSFER DIE STAMPING

Which Die Stamping Process Is Right For Me?

PROGRESSIVE DIE STAMPING

- Metal is fed through a machine where a series of stamping stations perform simultaneous operations
- Produces many small pieces quickly
- Can save on costs, depending on the quantity created
- Allows you to maintain close tolerances

TRANSFER DIE STAMPING

- Mechanical transport system moves the part from station to station
- Can be a single die or several dies lined up in a row
- Tends to be more economical than progressive die stamping
- Can incorporate cut-outs, pierced holes, ribs, knurls or threading directly into the process
- Well suited for large parts that must be transferred between multiple presses

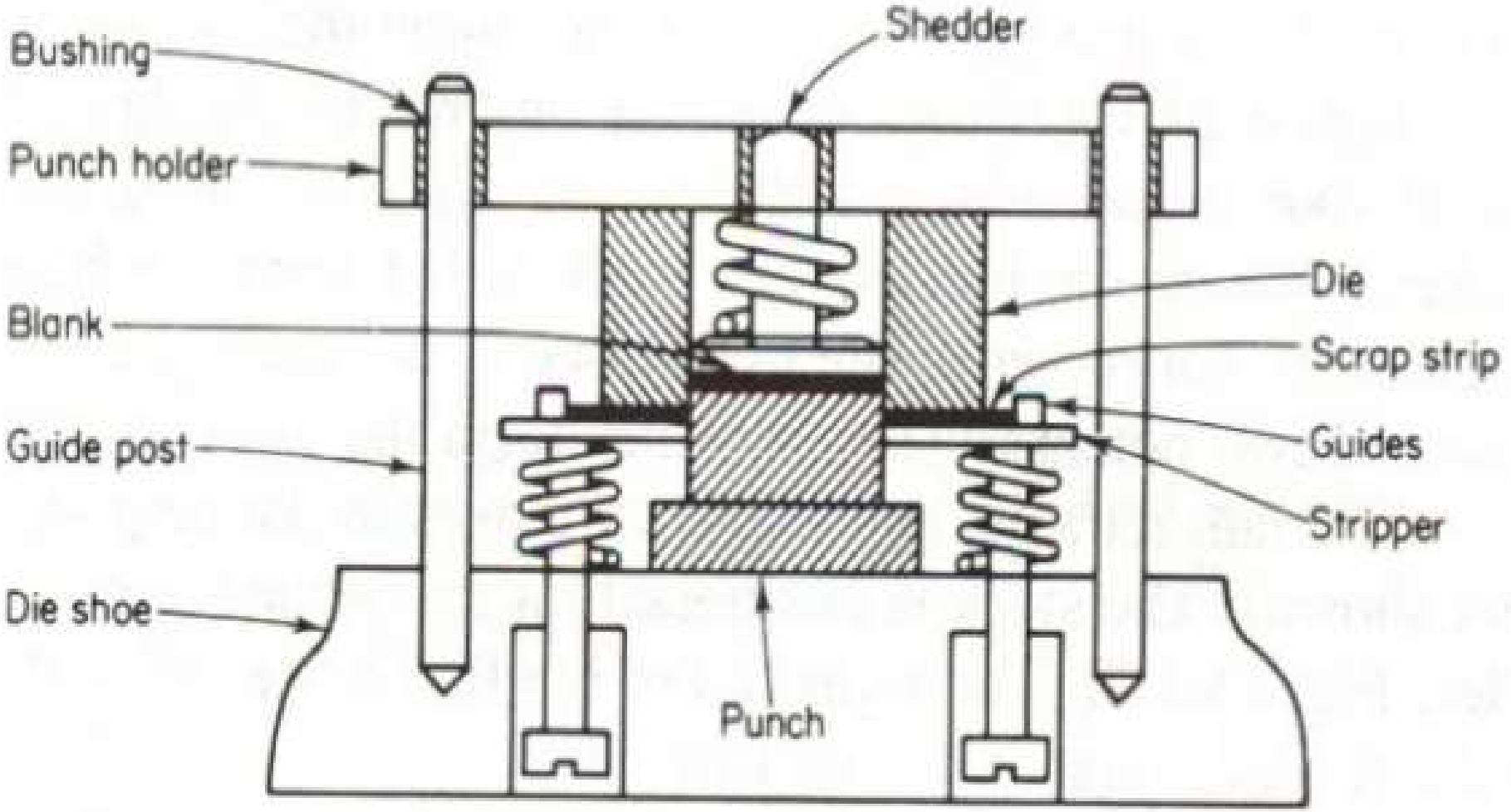
INVERTED DIES

- Punch and die positions are interchanged
- Reason: The opening in the bolster plate is too small to permit the finished part to pass through bolster opening
- Die block fastened to the punch holder and punch fastened to the die shoe
- As the ram descends the blank is sheared from the strip

INVERTED DIES

- The punch is forced through the scarp strip and a spring attached to the stripper is compressed and loaded
- On the upstroke of the ram the shedder pushes the blank out of the die opening
- Stripper forces the scrap strip off the punch

INVERTED DIES



- Q.1 Estimate the force required for punching a 25-mm Diameter hole through a 3.2-mm thick annealed titanium alloy Ti-6Al-4V sheet at room temperature.

$$F = 0.7TL(\text{UTS})$$

Sol. UTS = 1000 MPa

$$F = 0.7(32)(\pi)(25)(1000) = 0.18 \text{ MN}.$$

where T is the sheet thickness, L is the total length sheared (such as the perimeter of a hole), and UTS is the ultimate tensile strength of the material.