



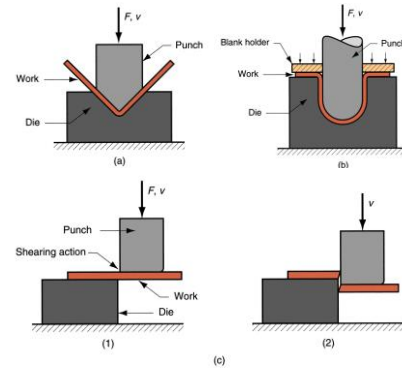
Department of Mechanical Engineering  
GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY

## WORKSHOP TECHNOLOGY

### Metal Forming - 2 Sheet Metal Forming

1

## Sheet Metal working



2

## Shearing Process

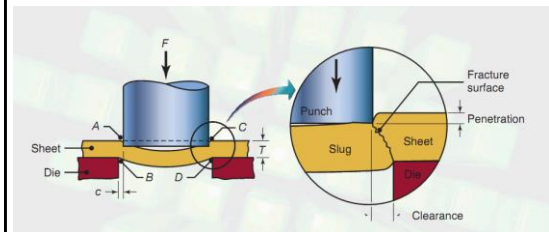
- Sheet metal subjected to shear stress developed between a punch and a die is called *shearing*.
- Shearing usually starts with formation of cracks on both the top and bottom edges of the work piece. These cracks meet each other and separation occurs.

### Process parameters :

- Shape of the material of the punch and die
- Speed of the punching
- Lubrication and clearance

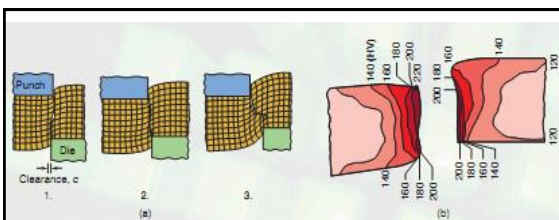
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## Shearing Process



- Illustration of the shearing process with a punch and die, indicating important process variables.

4



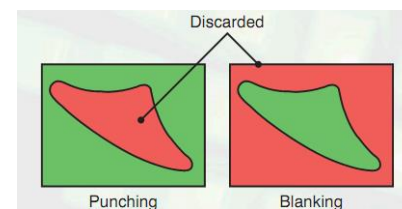
a) Effect of clearance,  $c$ , on the deformation zone in shearing. Note that, as clearance increases, the material tends to be pulled into the die, rather than being sheared.

b) Micro-hardness contours, for a 6.4 mm (0.25-in) thick AISI 1020 hot-rolled steel in the sheared region.

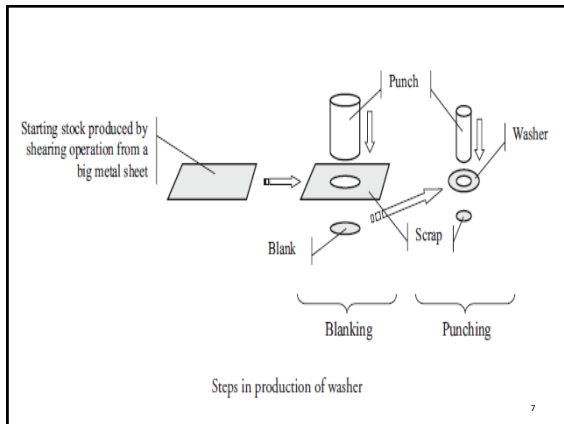
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## Shearing Operations

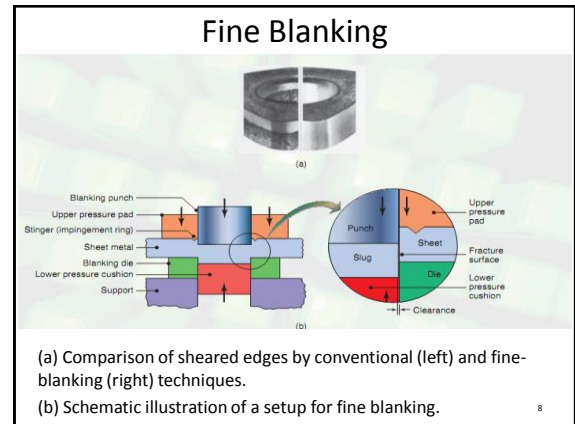
- Operations based on shearing performed  
Punching – sheared slug discarded  
Blanking – Slug is the part and the rest is scrap



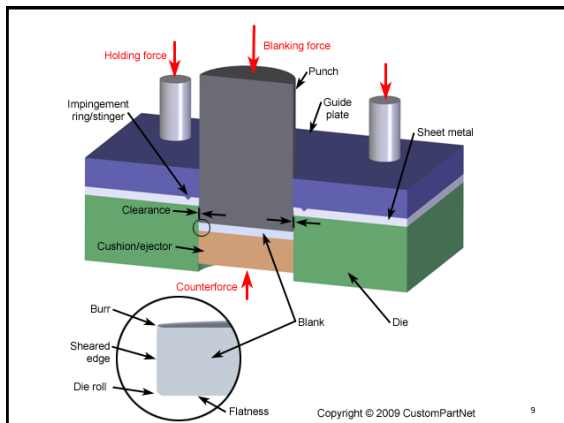
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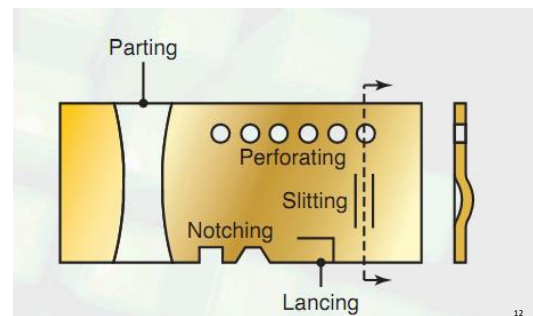
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#### Clearance :

- Function & type of material
- Its temper and its thickness
- Size of the blank and its proximity to the edges
- Clearance of soft materials are less than harder grades

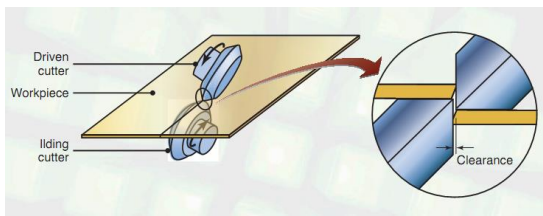
11

#### Example of Shearing Operations on Sheet Metal



12

## Rotary Shearing (Slitting)



- Slitting with rotary blades.

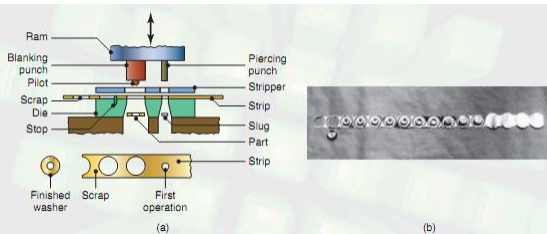
13

## Dies and Punches

- 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.

14

## Progressive Die

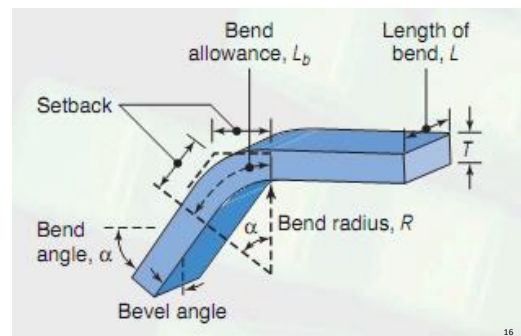


(a) Schematic illustration of producing a washer in a progressive die.

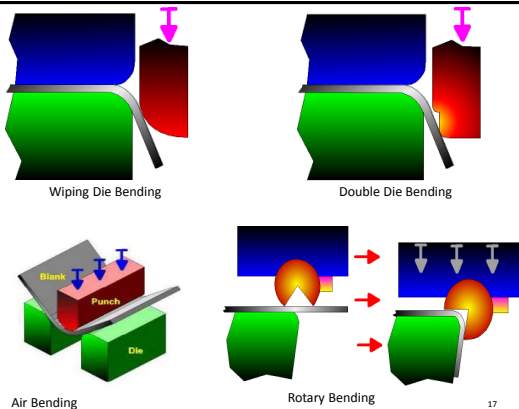
(b) Forming of the top piece of a common aerosol spray can in a progressive die. Note that the part is attached to the strip until the last operation is completed.

15

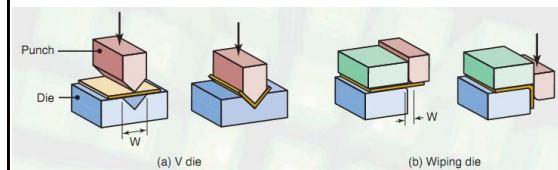
## Bending



16

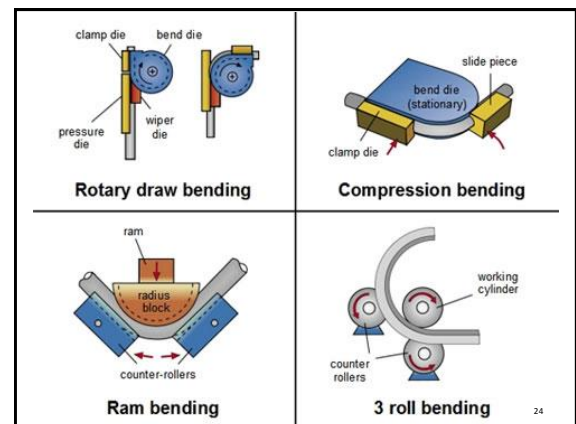
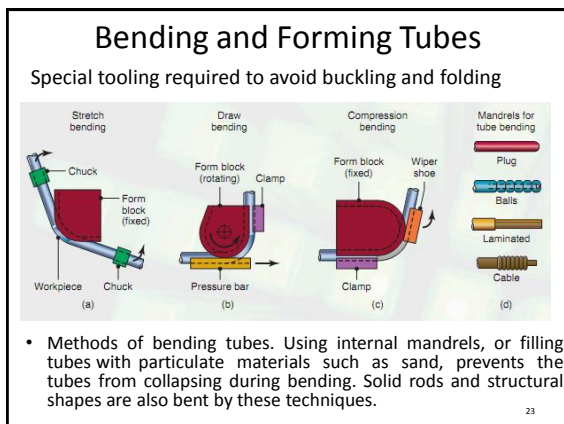
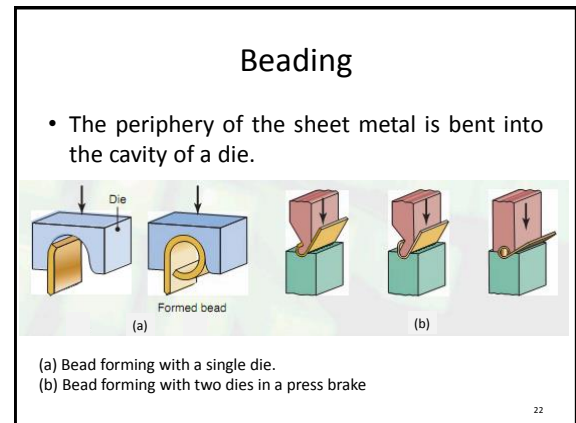
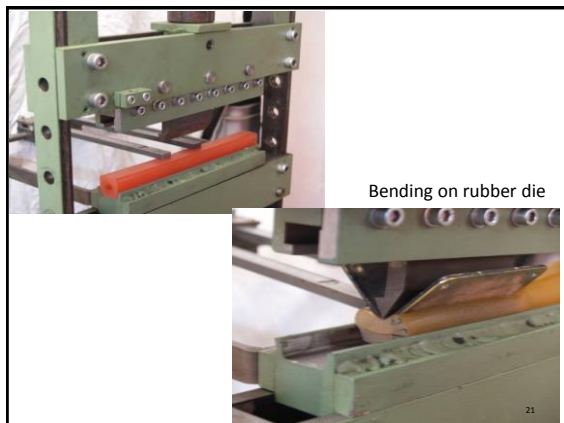
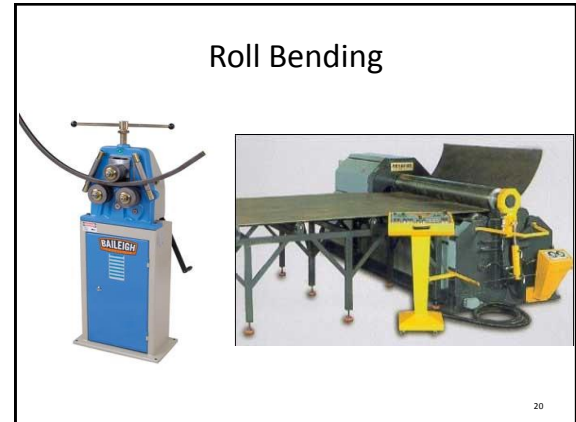
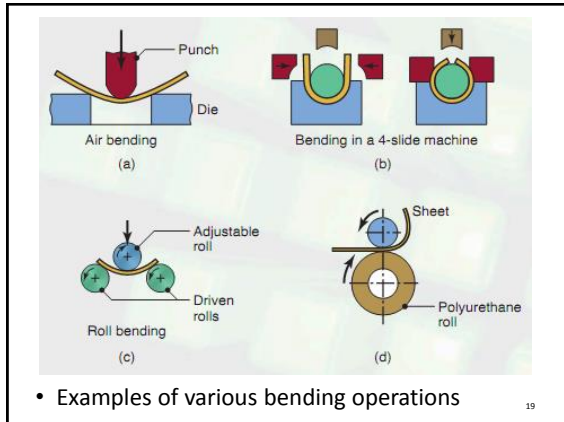


17

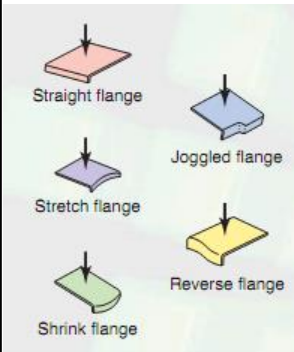


- Common die-bending operations, showing the die-opening dimension  $W$

18



## Flanging

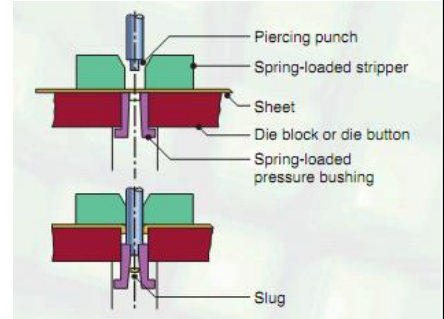


• Flanging is a process of bending the edges of sheet metals to 90°

• Illustrations of various flanging operations. Flanges formed on flat sheet.

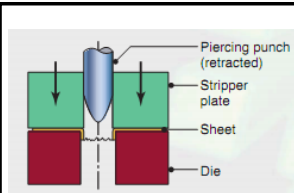
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## • Dimpling

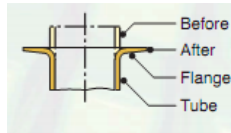


- First hole is punched and expanded into a flange
- Flanges can be produced by piercing with shaped punch

26



- Piercing sheet metal with a punch to form a circular flange. In this operation, a hole does not have to be pre-punched; note, however, work will be consisted with the rough edges along the circumference of the flange.



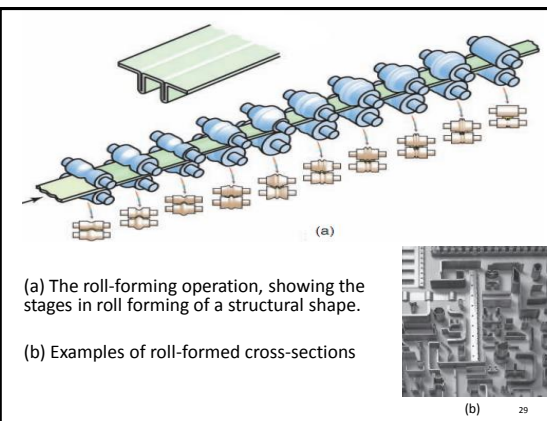
- Flanging of a tube; note the thinning of the periphery of the flange, due to its diametric expansion.

27

## Roll forming

- Roll forming is used for continuous lengths of sheet metal.
- Used for large production runs.

28



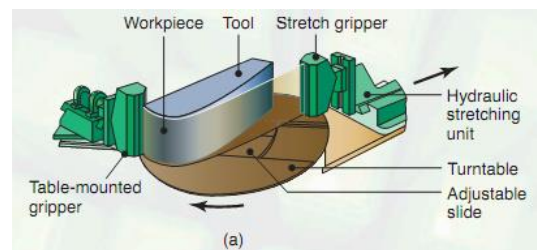
(a) The roll-forming operation, showing the stages in roll forming of a structural shape.

(b) Examples of roll-formed cross-sections

29

## Stretch-Forming

Sheet metal clamped along its edges and stretched over a die or form block in required directions.

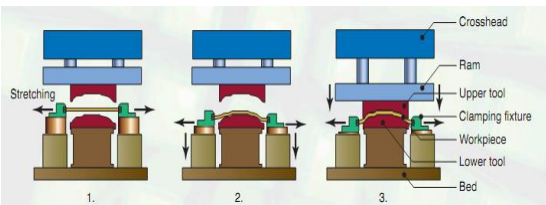


Schematic illustration of a stretch-forming operation. Aluminum skins for aircraft can be made by this process.

30



## Stretch-Forming

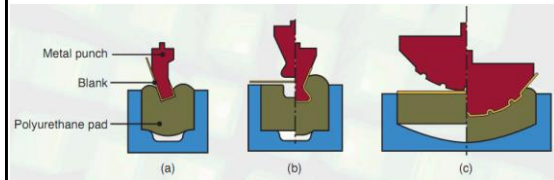


- Stretch forming in a hydraulic press

31

## Forming with a Rubber Pad

In bending and embossing of sheet metal, the female die is replaced with rubber pad



- Examples of bending and embossing sheet metal with a metal punch and a flexible pad serving as the female die.

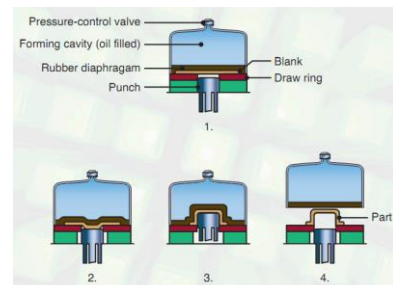
32

## Hydro-form (or) fluid forming process

- The pressure over rubber membrane is controlled through out the forming cycle, with max pressure up to 100 Mpa.
- As a result the friction at the punch-cup interface increases, this reduces the longitudinal tensile stresses in the cup and delays fracture.

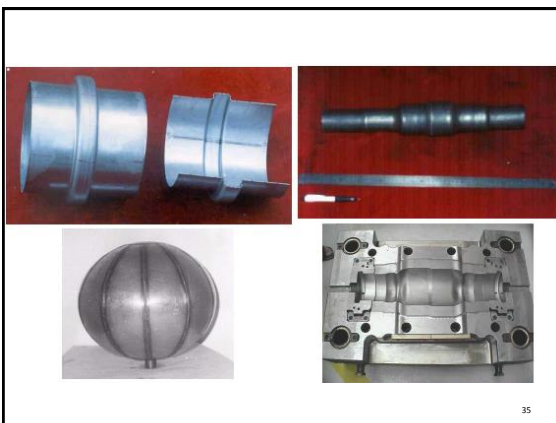
33

## Sheet Hydroforming



- The principle of the hydroform process, also called fluid forming.

34



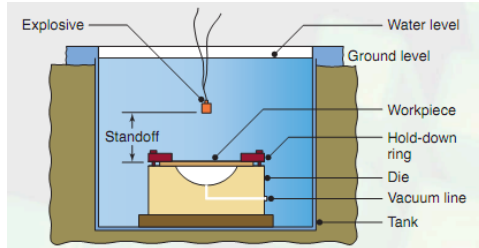
35

## Explosive Forming

- Explosive energy used for metal forming
- Sheet-metal blank is clamped over a die
- Assembly is immersed in a tank with water
- Rapid conversion of explosive charge into gas generates a shock wave. The pressure of this wave is sufficient to form sheet metals.

36

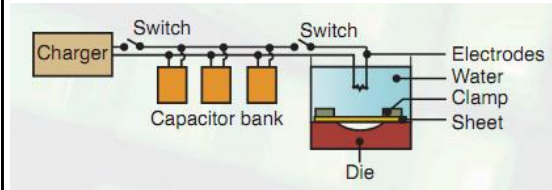
## Explosive Forming



- Schematic illustration of the explosive forming process. Although explosives are typically used for destructive purposes, their energy can be controlled and employed in forming large parts that would otherwise be difficult or expensive to produce by other methods.

37

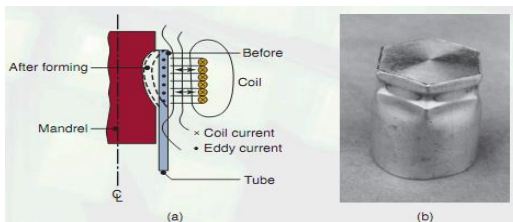
## Electro-hydraulic Forming



- Schematic illustration of the electro-hydraulic forming process

38

## Magnetic-Pulse Forming



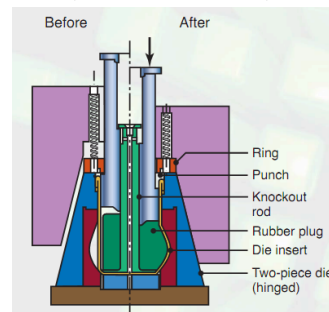
- (a) Schematic illustration of the magnetic-pulse forming process. The part is formed without physical contact with any object.

- (b) Aluminum tube collapsed over a hexagonal plug by the magnetic-pulse forming process.

39

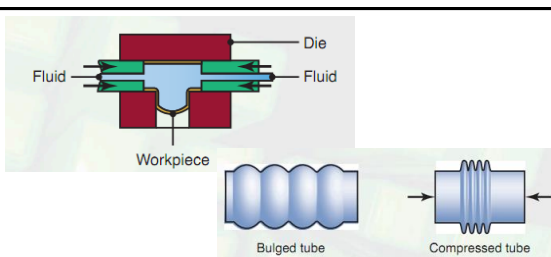
## Bulging

Process involves placing tabular, conical or curvilinear part into a split-female die and expanding it.



Bulging of a tubular part with a flexible plug. Water pitchers can be made by this method.

40



- 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" section.

41

## Spinning

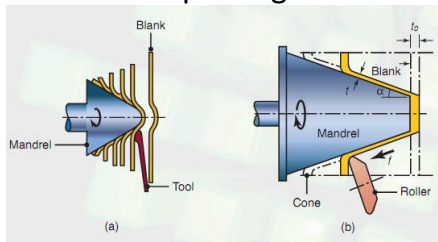
- Shaping thin sheets by pressing them against a blunt tool and to force the material into a desired form

- Conventional spinning :

A circular blank is flat or preformed sheet metal held against a mandrel and rotated, while a rigid metal (tool) is held against a mandrel.

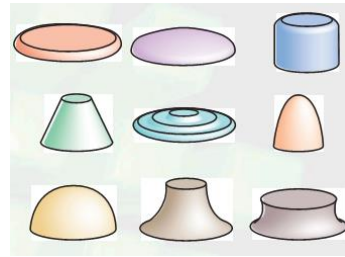
42

## Spinning



- Schematic illustration of spinning processes:
- (a) conventional spinning
- (b) shear spinning. Note that in shear spinning, the diameter of the spur part, unlike in conventional spinning, is the same as that of the blank. The quantity  $f$  is the feed (in mm/rev or in./rev).

43



- Typical shapes produced by the conventional spinning process. Circular marks on the external surfaces of components usually indicate that the parts have been made by spinning, such as aluminum kitchen utensils and light reflectors.

44

## Shear Spinning

- Known as power spinning, flow turning, hydro-spinning, and spin forging
- Produces axisymmetric conical or curvilinear shape
- Single rollers and two rollers can be used
- It has less wastage of material
- Typical products are rocket, motor casing and missile nose cones.

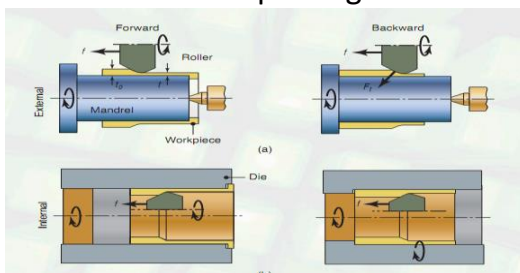
45

## Tube Spinning

- Thickness of cylindrical parts are reduced by spinning them on a cylindrical mandrel rollers
- Parts can be spun in either direction
- Large tensile elongation are obtained within certain temperature ranges and at low strain rates.

46

## Tube Spinning



Examples of

- (a) external and
- (b) internal tube spinning, and the process variables involved.

47

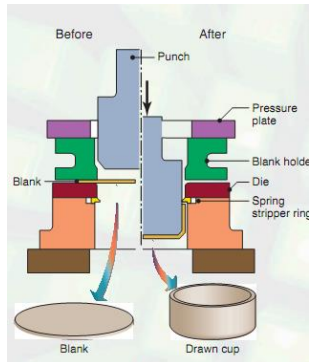
## Deep-Drawing

- Punch forces a flat sheet metal into a deep die cavity
- Round sheet metal block is placed over a circular die opening and held in a place with blank holder & punch forces down into the die cavity

48

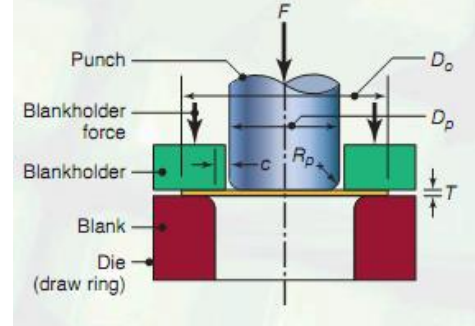


## Deep-Drawing



Schematic illustration of the deep drawing process on a circular sheet-metal blank. The stripper ring facilitates the removal of the formed cup from the punch.

49



- Variables in deep drawing of a cylindrical cup. Note that only the punch force in this illustration is a dependent variable; all others are independent variables, including the blank holder force.

50

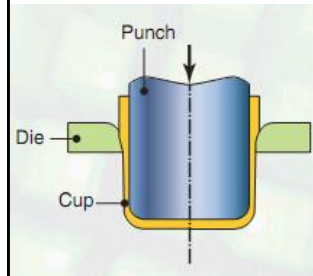
## Deep drawing Practice

- Blank holder pressure – 0.7% -1.0 % of Yield strength + UTS
- Clearance usually – 7% -14 % > sheet thickness
- Draw beads are used to control flow of blank into die cavity.
- Ironing is a process in which the thickness of a drawn cup is made constant by pushing of the cup through ironing rings.
- Redrawing** – Containers or shells which are too difficult to draw in one operation undergo redrawing

51

## Ironing

Process of thinning the walls of a drawn cylinder by passing it between a punch and die whose separation is less than the original wall thickness.

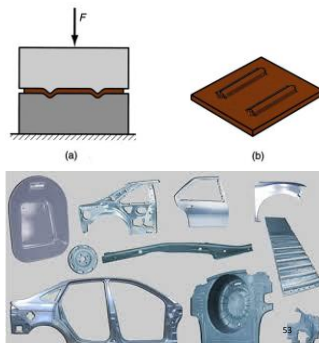


Schematic illustration of the ironing process. Note that the cup wall is thinner than its bottom. All beverage cans without seams (known as two-piece cans) are ironed, generally in three steps, after being deep drawn into a cup. Cans with separate tops and bottoms are known as three-piece cans.

52

## Embossing

Presswork process in which raised lettering or other designs are impressed in sheet materials



53

## Sheet metal working Summary

- Shearing
  - Rotary Shearing
  - Punching
  - Blanking
- Bending
  - Die bending
    - Wiping Die Bending
    - Double Die Bending
    - Air Bending
    - Rotary Bending
    - V die bending
  - Roll bending
  - Tube bending
    - Stretch bending
    - Draw bending
    - Compression bending
  - Flanging
  - Dimpling
- Forming
  - Roll forming
  - Stretch forming
  - Forming with rubber pad
  - Sheet hydroforming
  - Explosive forming
  - Electrohydraulic Forming
  - Magnetic-Pulse Forming
  - Bulging
- Spinning
  - shear spinning
  - Tube spinning
- Deep-Drawing
- Embossing

54

