Metal Forming Processes (ME5807)

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Metal Forming Processes−ME5807

Forging

- **Forging:** a deformation process in which the work is compressed between two dies, using either impact or gradual pressure to form the part.
  - Dates back to perhaps 5000 BCE.
  - Today, forging is an important industrial process used to make a variety of high-strength components for automotive, aerospace, and other applications.
  - These components include engine crankshafts and connecting rods, gears, aircraft structural components, and jet engine turbine parts.
  - In addition, steel and other basic metals industries use forging to establish the basic form of large components that are subsequently machined to final shape and dimensions.

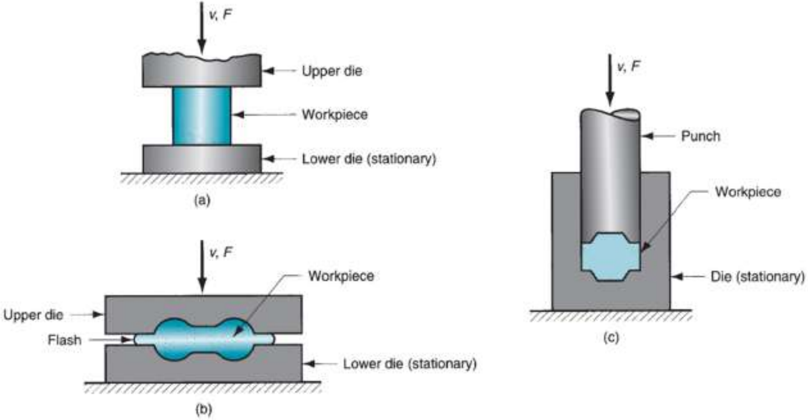
Forging

- **Forging** can be classified in many ways, one is working temperature.
  - **Hot or warm forging:** done when significant deformation is demanded by the process and when strength reduction and increase of ductility is required.
  - **Cold forging:** its advantage is the increased strength that results from strain hardening of the component.
- The other way is by the way the forging is carried out:
  - **Forging hammer:** a forging machine that applies an impact load.
  - **Forging press:** a forging machine that applies gradual load.

Forging

- **Forging** can be also classified according to the degree to which the flow of the work metal is constrained by the dies.
    - **Open-die forging:** the work is compressed between two flat dies, thus allowing the metal to flow without constraint in a lateral direction relative to the die surfaces.
    - **Impression-die forging:** the die surfaces contain a shape or impression that is imparted to the work during compression, thus constraining metal flow to a significant degree. Here, flash will form.
    - **Flashless forging:** the work is completely constrained within the die and no excess flash is produced.

Forging


v, F
Upper die
Workpiece
Lower die (stationary)
(a)
v, F
Workpiece
Upper die
Flash
Lower die (stationary)
(b)
v, F
Punch
Workpiece
Die (stationary)
(c)

Open-Die Forging

- Known as upsetting or upset forging.
- Involves compression of a workpart of cylindrical cross section between two flat dies, much in the manner of a compression test.
- It reduces the height of the work and increases the diameter.

If carried out under ideal conditions of no friction between work and die surfaces, then homogeneous deformation occurs, and the flow of the material is uniform throughout its height.

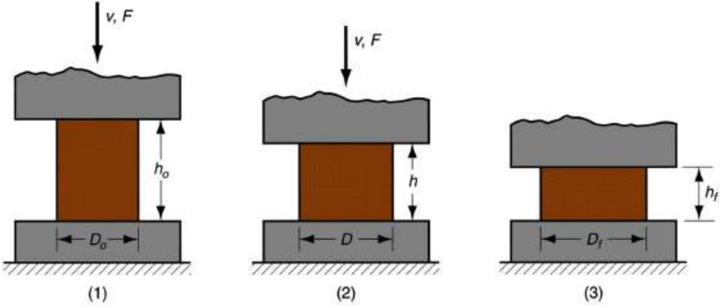


Figure: Homogeneous deformation of a cylindrical workpart under ideal conditions in an open-die forging operation: (1) start of process with workpiece at its original length and diameter, (2) partial compression, and (3) final size.

Analysis of Open-Die Forging

- Under these ideal conditions, the true strain experienced by the work during the process can be determined by:

$$\epsilon = \ln \frac{h_o}{h}$$

- The force to perform upsetting at any height is given by:

$$F = Y_f A$$

Where,
$F =$ Force, N;
$A =$ cross-sectional area, mm^2; and
$Y_f =$ flow stress, MPa.

Analysis of Open-Die Forging

If carried out under conditions where friction between work and die surfaces is accounted for, a barreling effect is created.

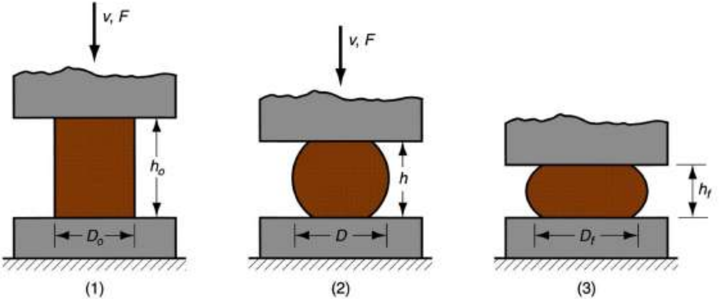


Figure: Actual deformation of a cylindrical workpart in open-die forging, showing pronounced barreling: (1) start of process, (2) partial deformation, and (3) final shape.

Analysis of Open-Die Forging

- Friction causes the actual upsetting force to be greater than what is predicted the previous equation:

$$F = K_f Y_f A$$

Where, K_f is the forging shape factor, defined as:

$$K_f = 1 + \frac{0.4\mu D}{h}$$

Where, μ = coefficient of friction; D = workpart diameter or other dimension representing contact length with die surface, mm; and h = workpart height, *mm*.

Open-Die Forging

In practice, open-die forging can be classified into:

- Fullering: a forging operation performed to reduce the cross section and redistribute the metal in a workpart in preparation for subsequent shape forging (dies have convex surfaces).
- Edging: similar to fullering, except that the dies have concave surfaces.
- Cogging: consists of a sequence of forging compressions along the length of a workpiece to reduce cross section and increase length.

Open-Die Forging

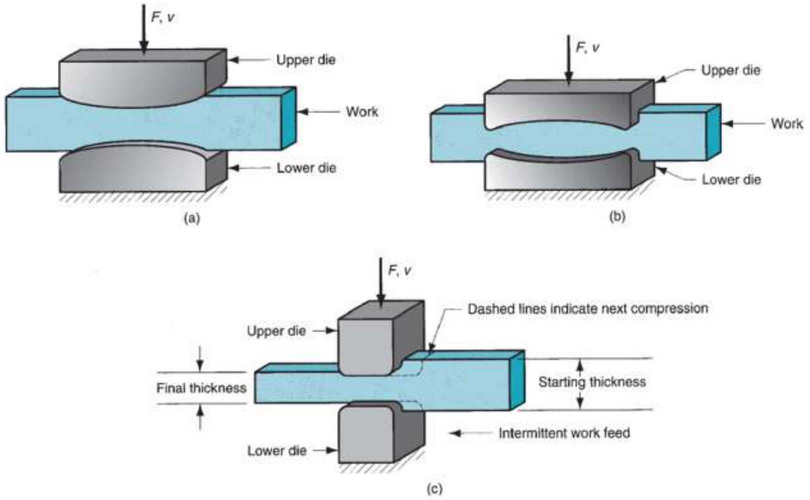


Figure: Several open-die forging operations: (a) fullering, (b) edging, and (c) cogging.

Impression-Die Forging

- Impression-die forging (sometimes called closed-die forging): performed with dies that contain the inverse of the desired shape of the part.
  - As the die closes to its final position, flash is formed by metal that flows beyond the die cavity and into the small gap between the die plates.
  - Although this flash must be finally cut away, it serves an important function during impression-die forging.
    - As the flash begins to form, friction resists continued flow of metal into the gap, thus constraining the bulk of the work material to remain in the die cavity.
    - In hot forging, metal flow is further restricted because the thin flash cools quickly against the die plates, thereby increasing its resistance to deformation.
    - Accordingly, compression pressure is increased, thus forcing the material to fill the whole cavity.

Impression-Die Forging

- Sequence in impression-die forging:

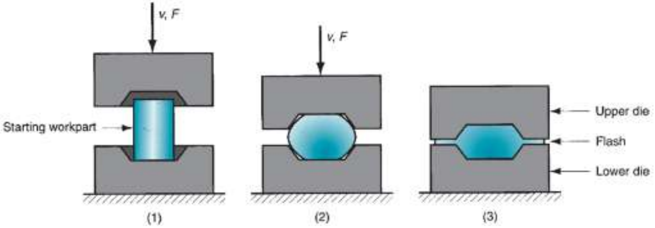


Figure: Sequence in impression-die forging: (1) just prior to initial contact with raw workpiece, (2) partial compression, and (3) final die closure, causing flash to form in gap between die plates.

Impression-Die Forging

- **Advantages**:
  - higher production rates,
  - less waste of metal,
  - greater strength and
  - favorable grain orientation in the metal.

- **Limitations:**
  - incapability of close tolerances and
  - machining is required to achieve accuracies and features needed.

Flashless Forging

- **Flashless Forging:** the raw workpiece is completely contained within the die cavity during compression, and no flash is formed.
- **Several requirements**:
    - The work volume must equal the space in the die cavity within a very close tolerance.
    - If the starting blank is too large, excessive pressures may cause damage to the die or press. If the blank is too small, the cavity will not be filled.
    - Simple geometries required.
    - Best for soft metals, such as aluminum and cupper and their alloys.
    - Sometimes classified as Precision Forging.

Flashless Forging

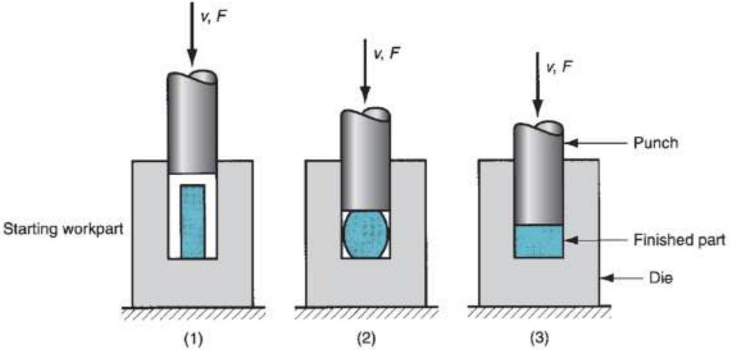


Figure: Flashless forging: (1) just before initial contact with workpiece, (2) partial compression, and (3) final punch and die closure

Flashless Forging

- **Coining:** is a type of flashless forging, in which fine details in the die are impressed into the top and bottom surfaces of the workpart. There is little flow of metal in coining.

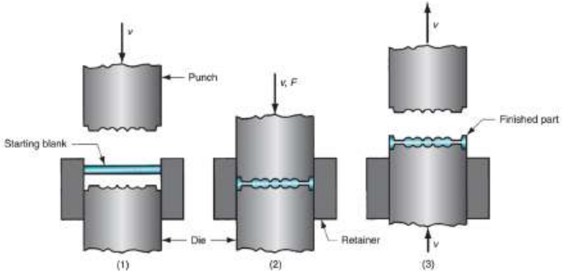


Figure: Coining operation: (1) start of cycle, (2) compression stroke, and (3) ejection of finished part.

Thank You