MSE 440/540: Processing of Metallic Materials

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Lecture 9: Forging

Forging

Deformation process in which work is compressed between two dies

- Oldest of the metal forming operations
  - Dates from about 5000 B C
- Products: engine crankshafts, connecting rods, gears, aircraft structural components, jet engine turbine parts
  - Also, basic metals industries use forging to establish basic shape of large parts that are subsequently machined to final geometry and size

http://www.youtube.com/watch?v=x_rl-oHr3nM

http://www.youtube.com/watch?v=PXVWiGqeItM

Classification of Forging Operations

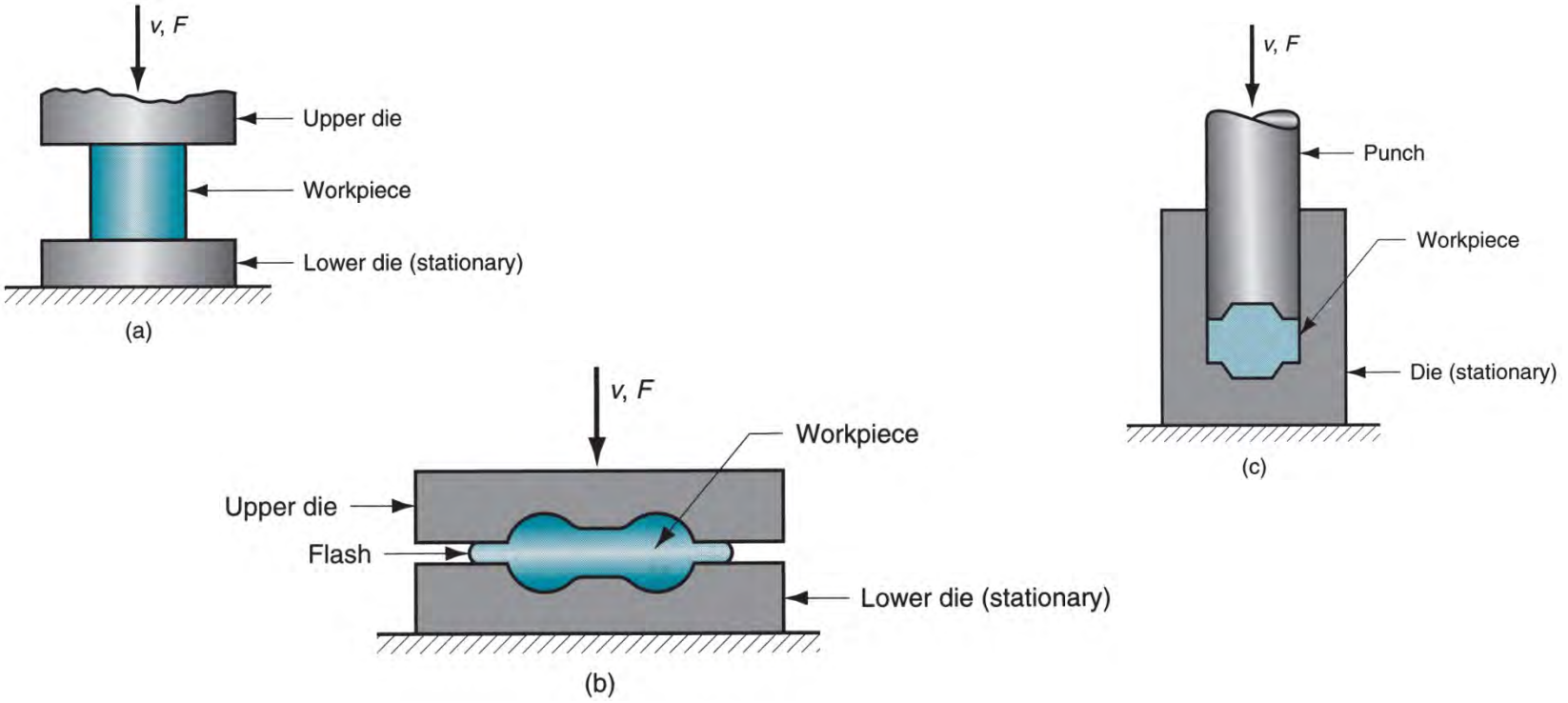
- Cold vs. hot forging:
  - Hot or warm forging – advantage: reduction in strength and increase in ductility of work metal
  - Cold forging – advantage: increased strength due to strain hardening
- Impact vs. press forging:
  - Forge hammer - applies an impact force
  - Forge press - applies gradual force

Types of Forging Operations

- Open-die forging - work is compressed between two flat dies, allowing metal to flow laterally with minimum constraint
- Impression-die forging - die contains cavity or impression that is imparted to workpart
  - Metal flow is constrained so that flash is created
- Flashless forging - workpart is completely constrained in die
  - No excess flash is created

Types of Forging Operations

- (a) Open-die forging, (b) impression-die forging, and (c) flashless forging



Open-Die Forging

Compression of workpart between two flat dies

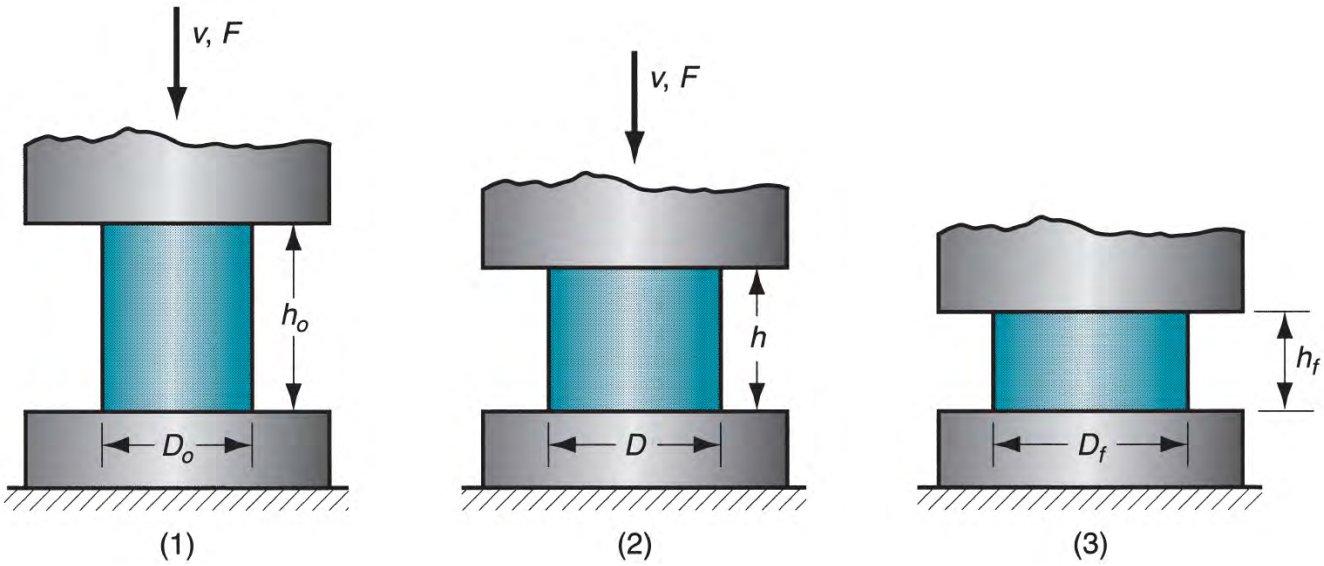
- Deformation operation reduces height and increases diameter of work
- Common names include *upsetting* or *upset forging*

http://www.youtube.com/watch?v=dK6eZGeDjZg

http://www.youtube.com/watch?v=tLRkOupbARM

Open-Die Forging with No Friction

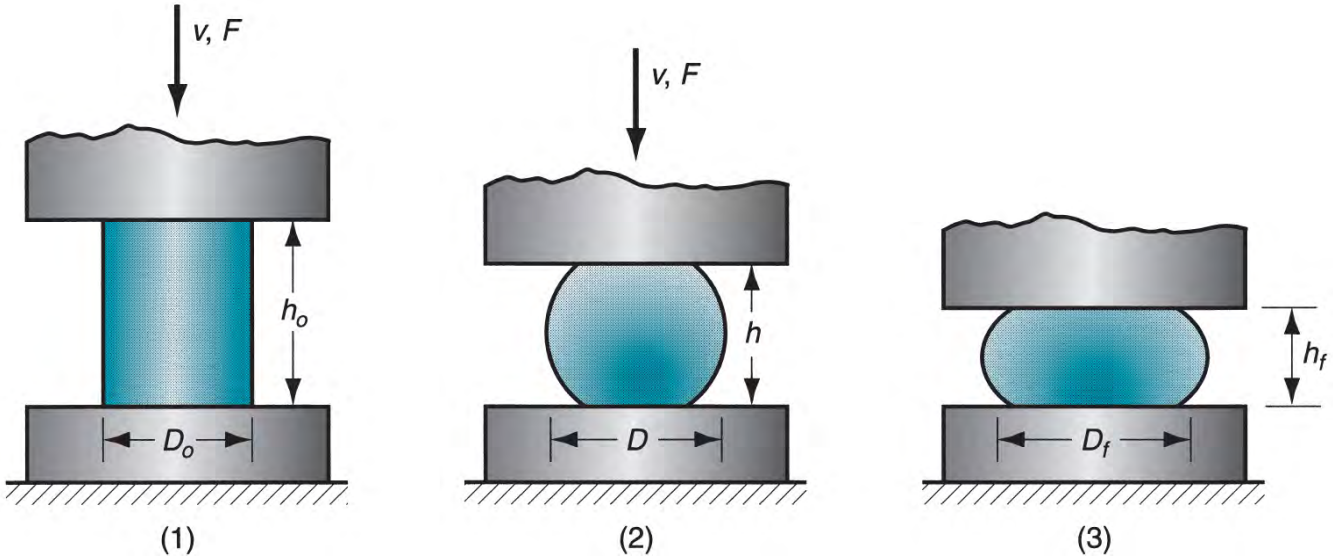
- (1) Start of process with workpiece at its original length and diameter, (2) partial compression, and (3) final size



True strain: $$\varepsilon = \ln \frac{h_o}{h}$$

Open-Die Forging with Friction

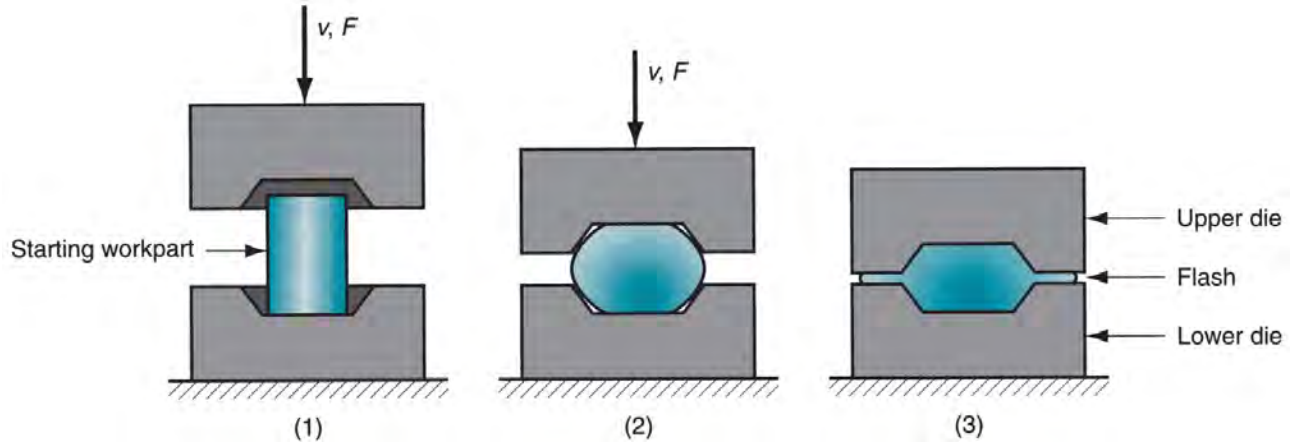
Actual deformation of a cylindrical workpart in open-die forging, showing pronounced *barreling*: (1) start of process, (2) partial deformation, and (3) final shape



Impression-Die Forging

Compression of workpart by dies with inverse of desired part shape

- Flash is formed by metal that flows beyond die cavity into small gap between die plates
- Flash must be later trimmed, but it serves an important function during compression:
  - As flash forms, friction resists continued metal flow into gap, constraining metal to fill die cavity



Impression-Die Forging Practice

- Several forming steps are often required
  - With separate die cavities for each step
    - Beginning steps redistribute metal for more uniform deformation and desired metallurgical structure in subsequent steps
    - Final steps bring the part to final geometry

http://www.youtube.com/watch?v=mySkT0Gw_X0

Advantages and Limitations of Impression-Die Forging

- Advantages compared to machining from solid stock:
  - Higher production rates
  - Less waste of metal
  - Greater strength
  - Favorable grain orientation in the metal
- Limitations:
  - Not capable of close tolerances
  - Machining is often required to achieve accuracies and features needed

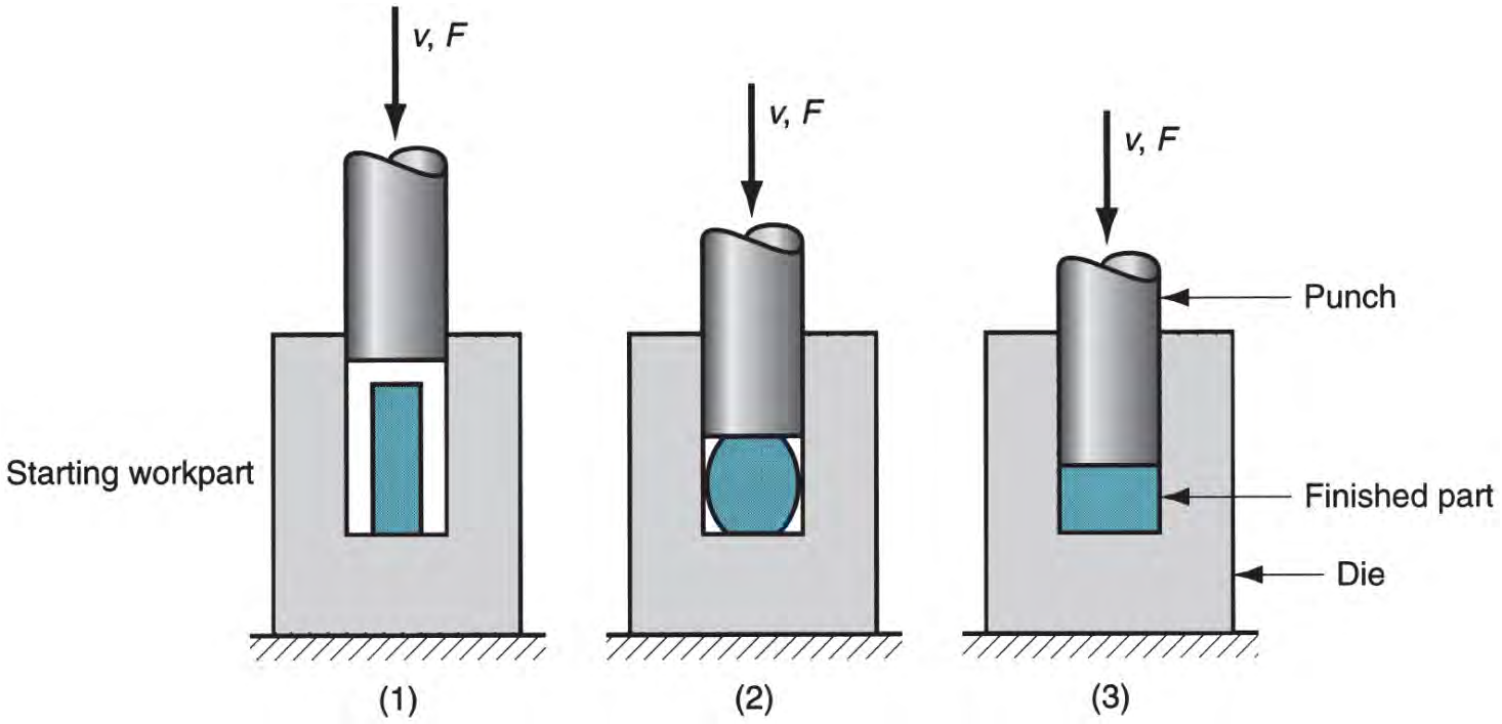
Flashless Forging

Compression of work in punch and die tooling whose cavity does not allow for flash

- Starting work volume must equal die cavity volume within very close tolerance
- Process control more demanding than impression-die forging
- Best suited to part geometries that are simple and symmetrical
- Often classified as a *precision forging* process

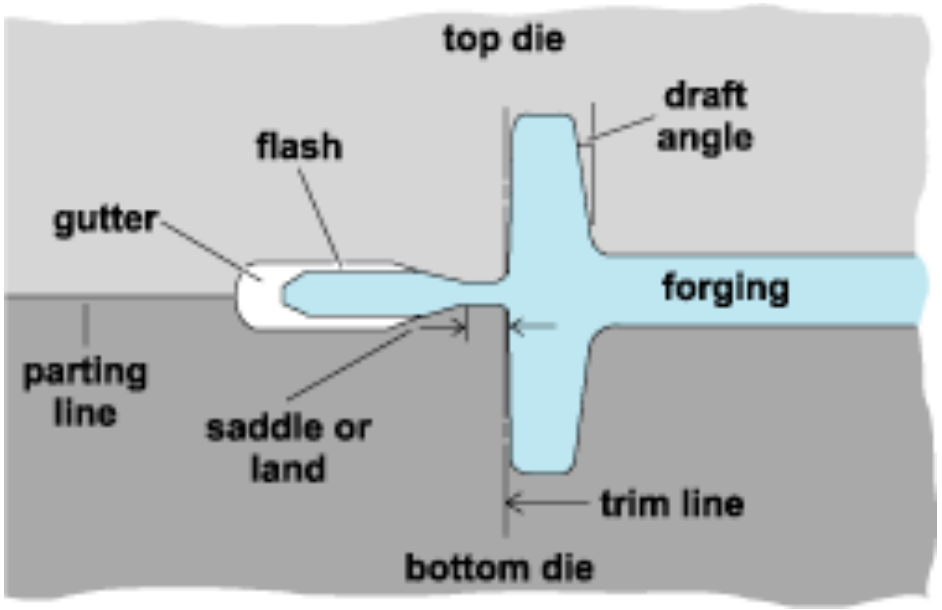
Flashless Forging (Closed Die Forging)

- (1) Just before contact with workpiece, (2) partial compression, and (3) final punch and die closure



Closed Die Forging

- Workpiece is completely trapped in the die and no flash is generated; die design and process variables must be carefully controlled



HW assignment

- Reading assignment: Chapters 13

- Review Questions: 13.10, 13.11, 13.12, 13.14,
- Problems: 13.10, 13.12, 13.14