PART 2
BASIC PROCESSES

Forging
Open die forging
Open-die forging.
1 – top die  2 – billet  3 – forging  4 – bottom die
(a) Ideal deformation of a solid cylindrical specimen compressed between flat frictionless dies. This process is known as *upsetting*. 
(b) Deformation in upsetting with friction at the die-workpiece interfaces.
(a) Ideal deformation of a solid cylindrical specimen compressed between flat frictionless dies. This process is known as *upsetting*. 
(b) Deformation in upsetting with friction at the die-workpiece interfaces.
Grain flow lines in upsetting a solid steel cylinder at elevated temperatures. Note the highly inhomogenous deformation and barreling. The different shape of the bottom, section of the specimen (as compared with the top) results from the hot specimen resting on the lower, cool die before deformation proceeded. The bottom surface was chilled; thus it exhibits greater strength and hence deforms less than the top surface.
Changes in the grain structure of cast or large-grain wrought metals during hot rolling. Hot rolling is an effective way to reduce grain size in metals for improved strength and ductility. Cast structures of ingots or continuous castings are converted to a wrought structure by hot working.
Ingot with nonuniform grains
(b) Hot rolling

- Deformed elongated grains
- New grains forming
- Recrystallization complete

Wrought product with large grains

Wrought product with small, uniform grains
Upsetting

Drawing out
Punch expending.
1 - expanding punch, 2 - workblank, 3 - pad ring
Mandrel expanding:
(left) Setup for saddle forging a ring; (right) Saddle forging process
Close die forging
Closed - die forging with flash.
1 – upper die  2 – lower die  3 – flash  4 – flash land
Closed - die forging without flash
1 – punch 2 – split die 3 – billet 4 – forging
Comparison of Forging With and Without Flash

Forging with flash

Flashless forging

Upper die

Upper punch

Billet

Die

Lower die

Lower punch

(a) Start of stroke

Forging

Flash

(b) End of stroke
Impression-Die Forging

(a) (b) (c)

Stages in impression-die forging of a solid round billet. Note the formation of flash, which is excess metal that is subsequently trimmed off.
Die block forging
Forging stages of a connecting rod in die block;
(a) Each operations; (b) Fullering operation and (c) edging operations
to distribute the material when preforming the blank
Forging a Connecting Rod

Blank (bar stock) → Edging → Blocking → Finishing → Trimming

Stages in forging a connecting rod for an internal combustion engine. Note the amount of flash that is necessary to fill the die cavities properly.
(a) Stages in forging a connecting rod for an internal combustion engine. Note the amount of flash required to ensure proper filling of the die cavities.
Forging a Connecting Rod

(b) Fullering, and (c) edging operations to distribute the material when preshaping the blank for forging.
Trimming flash from a forged part. Note that the thin material at the center is removed by punching.
Extrusion
Extrusion model:
(a) Backward extrusion. (b) Forward extrusion.
(c) Combined backward and forward extrusion
Extrusion model: (a) Backward extrusion.  
(b) Forward extrusion.
model:

(a) Counterpunch and ejector
(b) Forming punch

Work metal

Die

Ejector

(b) Forward extrusion.
Extrusion model:
(a) Backward extrusion.
(b) Forward extrusion.
(c) Combined backward and forward extrusion.
THANK YOU!