FUNDAMENTALS OF METAL FORMING

- Overview of Metal Forming
- Material Behavior in Metal Forming
- Temperature in Metal Forming
- Hot working and cold working operations.
- Smithy, Smithy Tools, forging operations
Metal Forming

- Large group of manufacturing processes in which plastic deformation is used to change the shape of metal workpieces
- The tool, usually called a *die*, applies stresses that exceed yield strength of metal
- The metal takes a shape determined by the geometry of the die
Stresses in Metal Forming

- Stresses to plastically deform the metal are usually compressive
  - Examples: rolling, forging, extrusion
- However, some forming processes
  - Stretch the metal (tensile stresses)
  - Others bend the metal (tensile and compressive)
  - Still others apply shear stresses
Desirable material properties:
- Low yield strength and high ductility

These properties are affected by temperature:
- Ductility increases and yield strength decreases when work temperature is raised

Other factors:
- Strain rate and friction
Temperature in Metal Forming

- Any deformation operation can be accomplished with lower forces and power at elevated temperature
- Three temperature ranges in metal forming:
  - Cold working
  - Warm working
  - Hot working
Hot Working

- Deformation at temperatures above recrystallization temperature
- Recrystallization temperature = about one-half of melting point on absolute scale
  - In practice, hot working usually performed somewhat above $0.5T_m$
  - Metal continues to soften as temperature increases above $0.5T_m$, enhancing advantage of hot working above this level
Why Hot Working?

Capability for substantial plastic deformation of the metal - far more than possible with cold working or warm working

- Why?
  - Strength coefficient is substantially less than at room temperature
  - Strain hardening exponent is zero (theoretically)
  - Ductility is significantly increased
Warm Working

- Performed at temperatures above room temperature but below recrystallization temperature
- Dividing line between cold working and warm working often expressed in terms of melting point:
  - \(0.3T_m\), where \(T_m\) = melting point (absolute temperature) for metal
Advantages of Warm Working

- Lower forces and power than in cold working
- More intricate work geometries possible
- Need for annealing may be reduced or eliminated
Advantages of Hot Working vs. Cold Working

- Workpart shape can be significantly altered
- Lower forces and power required
- Metals that usually fracture in cold working can be hot formed
- Strength properties of product are generally isotropic
- No strengthening of part occurs from work hardening
  - Advantageous in cases when part is to be subsequently processed by cold forming
Disadvantages of Hot Working

- Lower dimensional accuracy
- Higher total energy required (due to the thermal energy to heat the workpiece)
- Work surface oxidation (scale), poorer surface finish
- Shorter tool life
Cold Working

- Performed at room temperature or slightly above
- Many cold forming processes are important mass production operations
- Minimum or no machining usually required
  - These operations are *near net shape* or *net shape* processes
HOT WORKING OPERATIONS

- FORGING
- ROLLING
- WELDING
- EXTRUSION
- SPINNING
- HOT PIERCING AND ROLLING
COLD WORKING OPERATIONS

- COLD ROLLING
- EXTRUSION
- PRESSING
- DEEP DRAWING
- SQUEEZING
- BENDING
- SHEAR ING
Figure 18.2 – Basic bulk deformation processes: (a) rolling
Figure 18.2 – Basic bulk deformation processes: (b) forging
Figure 18.2 – Basic bulk deformation processes: (c) extrusion
Figure 18.2 – Basic bulk deformation processes: (d) drawing
Sheet Metalworking

- Forming and related operations performed on metal sheets, strips, and coils
- High surface area-to-volume ratio of starting metal, which distinguishes these from bulk deformation
- Often called *pressworking* because presses perform these operations
  - Parts are called *stampings*
  - Usual tooling: *punch* and *die*
Figure 18.3 - Basic sheet metalworking operations: (a) bending
Figure 18.3 - Basic sheet metalworking operations: (b) drawing
Figure 18.3 - Basic sheet metalworking operations: (c) shearing
SMITHY & FORGING

- DIFFERENCES BETWEEN SMITHY AND FORGING

- SMITHY – HAND OPERATED - METAL IS DEFORMED INTO THE DESIRED SHAPE BY HAMMERING, PRESSING AND BENDING USING HAND OPERATED TOOLS.

- FORGING – MACHINE OPERATED – METAL IS DEFORMED INTO THE DESIRED SHAPE BY HAMMERING, PRESSING AND BENDING USING POWER OPERATED MACHINES.
FORGING AND SMITHY

- SMITHY PROCESS IS CARRIED BY HAND OPERATED TOOLS
- FORGING IS CARRIED BY POWER OPERATED TOOLS.
- SMITHY IS CARRIED FOR SMALL JOBS AND FORGING IS FOR HEAVY WORK AND MASS PRODUCTION
- FOR FORGING, SHAPES ARE ALSO PRE DEFINED IN FORM OF DIES, WHERE AS FOR SMITHY, REQUISTE SHAPES ARE GENERATED BY THE REPETITIVE PROCESS REPETITIVE USE OF HAND TOOLS.
Black smith tools

- Anvil
- Swage block
- Hammers
- Tongs
- Chisels
- Swages
- Fullers
- Flatters
- Punches
BLACK SMITH FORGE

- Heating of metal is done in hearth or furnace
- It is shallow dish or tray of Mild steel with lining of fire clay or refractory material to withstand heat during combustion of fuel.
- Open hearth and closed hearth (open fire & stock fire)
- Smoke or gas are escaped through hood or chimney
WORKING OF FURNANCE

- Air at pressure for combustion of fuel.
- Centrifugal fan is driven by electrical motor.
- It draws air from atmosphere and delivers at high pressure to furnace.
- It is mainly used for maintaining combustion of fuel in furnace.
ANVIL

- It is made of solid wrought iron or cast steel.
- It is a supporting the hot metal pieces to be forged.
- Tools like swages or fullers are inserted into the holes
- Bick or horn of the anvil is used for bending
- Forging operations are carried out on the face of the anvil
SWAGE BLOCK

- Solid or rectangular block cast steel or forged steel.
- Used for swaging, bending, finishing various workpieces.
- Workpiece is given rough shape on anvil, reheated placed in a similar shaped recess in the side of the swage block.
TONGS

- Tongs are used for gripping and turning hot metal workpieces during forging.
- Tong length: 475 – 600 mm length
- Bit length: 75-120 mm
- Material: 0.4% carbon
- Types: Pick up tong, square tong, round tong flat tong, 16 types of tongs used to accommodate different sized and shaped workpieces.
HAMMER

- Hammer used by smith for striking and to give required shape to hot metal work piece.
- Hand hammer – small and light components.
- Types:
  - Ball pein hand hammer: Face: general striking, ball pien is used for riveting or burring over work.
  - Cross pein hammer: cross: hammering stretching, bending into inside shape of component.
  - Straight peen hammer: It is used for stretching the metal
  - Sledge hammer: Heavier hammer, used for flattening
Ball Peen hammer
Straight Peen hammer
CROSS PIN HAMMER
Pneumatic hammer

- Small parts by hand hammers
- Heavy machine parts require great degree of deformation
- Hand forging lengthy process
- Machines which works on the principle of repeated blows - power or forging hammers.
- Spring Hammer
- Air Hammer
- Steam hammer
Steam hammer
swages

- They are used in pairs.
- Employed to reduce and finish the job to size or shape, round or hexagonal.
- Small jobs, swages are used, large work, swage blocks are used.
- During swaging, hot metal is rotated between the swages.
FULLERS

• It is set of two tools
• Top tool is provided with handle and bottom has a square shank. Fits into square hole.
• Fullers are used to form grooves, stretch or draw the metal and reduce the thickness of the workpiece.
FORGING OPERATIONS

- Upsetting
- Drawing
- Cutting
- Bending
- Punching
- Welding
- Setting down
UPSETTING OPERATION

- It is carried out to increase the thickness of bar and reduce its length.
- Ex: Bolt Head
- Blow of the hammer must be in line with the bar to prevent bending of the bar.
- Hot bar must be in line with the bar to prevent
UPSETTING
DRAWING OPERATION

• To reduce thickness and increase its thickness.
• It is carried out by working the metal over the horn of the anvil then hammering on the anvil face.
• For heavy work, fullers are used.
PUNCHING

• The punch is driven part way through the workpiece with hammer blows.
• The Work is turned over and the hole is completed from the other side.

PUNCHING OPERATION
BENDING OPERATION

• Bending is a common forging operation.

• Simple process is the bending a piece of metal, is to support it on the anvil/Die and to strike its free end with a hammer.

• When bent, workpiece thins out round bend causing weakness.
Flatting and Setting Down

- Flattening leaves the a corrugated surface on the job.
- The marks of the hammer remains on the surface, and the removal of its is called flatter.
- Flatting and setting down used to finish off to a good smooth surface.
- Flatter is used for smoothening flat surfaces,
- Set hammer is used in restricted areas, such as corners and bends.
FORGE WELDING

- Low carbon and wrought steel can satisfactorily forge welded.
- Welding possible above 30mm thickness.
- Parts are heated to stage of plastic and placed end to end and hammered manually or by power hammer.
IMPORTANT QUESTIONS

• Define metal forming operations?
• What is difference between Hot working and cold working operations?
• Name the various processes of metal forming operations.
• What is the difference between smithy and forging?
IMPORTANT QUESTIONS

• What is the significance of hammers in forging?
• Explain the major tools used in smithy?
• What is the application difference between fuller and swage?
• What are the major forging operations?
• What is the difference between Upsetting and drawing operations?