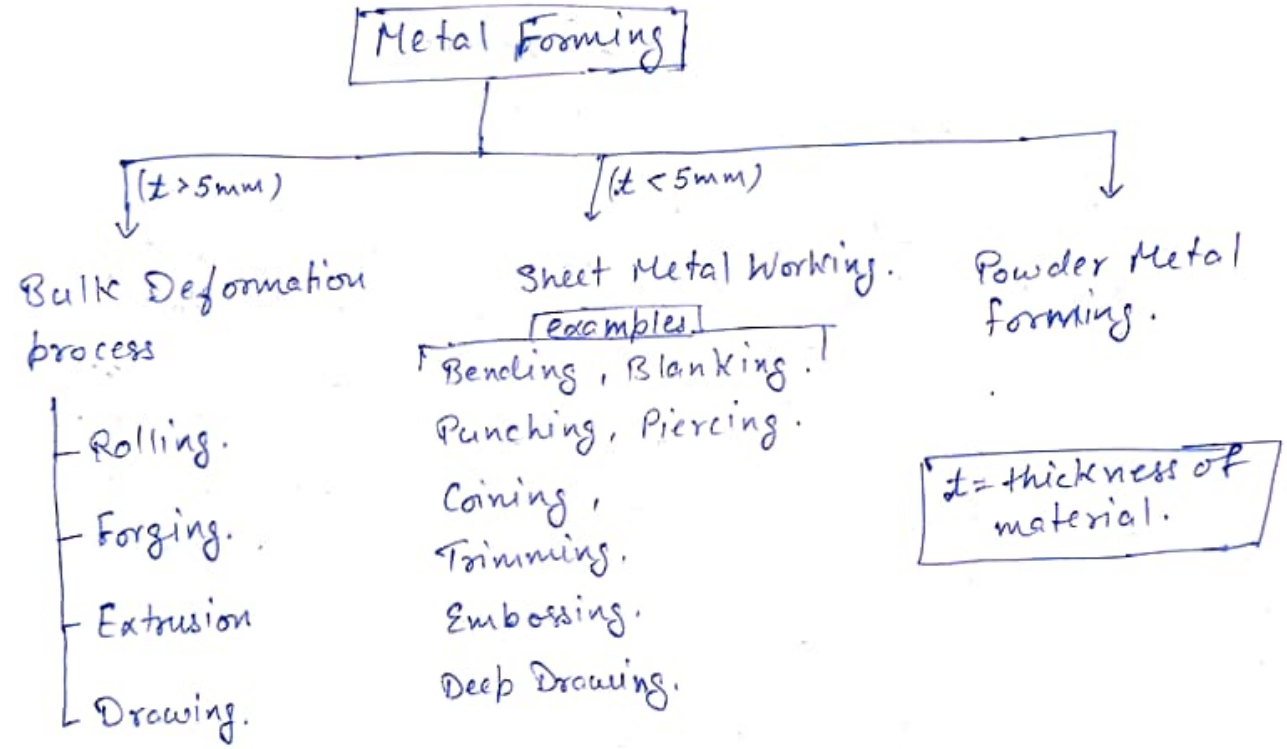
METAL FORMING PROCESS

Metal forming is a manufacturing process in which forces are applied on raw material such that stresses induced in the material are greater than yield stress and less than ultimate stress which changes the shape of the component and converted to the desired shape of the component.

CLASSIFICATION OF METAL FORMING PROCESS:



BULK DEFORMATION PROCESS:

- These process involve large amount of (plastic) deformation.
- The cross-section of workpiece changes without volume change.
- For most operations, hot or warm working conditions are preferred although some operations are carried out at room temperature.

Sheet Metal Working.

- The cross-section of workpiece does not change - the material is only subjected to shape changes.
- They are performed as cold working operations.

Metal forming can be done/performed by three ways.

1.) Cold Working.
2.) Warm Working.
3.) Hot Working.

RECRYSTALLISATION TEMPERATURE

RECRYSTALLISATION is defined as the process inwhich grains of a crystal structure come in a new structure or new crystal shape.

Recrystallisation reduces strength and hardness of a material and increase in the ductility.

Recrystallisation Temperature is a particular temperature point below the melting point of a metal or material. Usually metal (in microscopic scale) are made up of grain like particles. At recrystallisation temperature, if you impart enough force, you can easily change the size and shape of these grains. This is because the grains at this temperature, metal behave in plastic manner, allowing them to deform greatly for very less force application.

Recrystallisation temp. of Iron = 450°C

" " " Steel = 727°C

" " " Aluminium = 150°C

For Pb, Sn; Cd, Zn = Room temp.

PLASTIC DEFORMATION:

When a sufficient load is applied to a metal or other structural material, it will cause the material to change shape. This change in shape is called deformation.

A temporary shape change that is self-reversing after the force is removed, so that the objects return to its original shape, is called elastic deformation.

This type of deformation involves stretching of the bonds, but the atoms do not slip past each other.

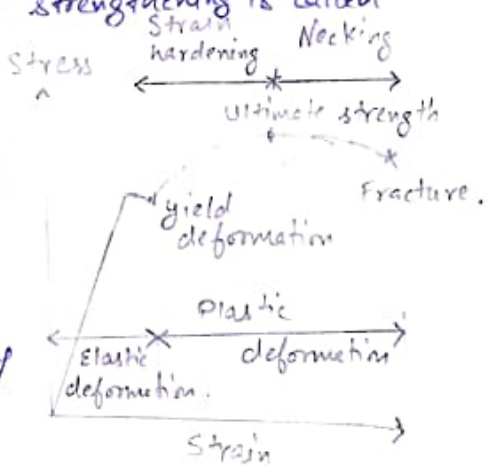
When the stress is sufficient to permanently deform the metal it is called plastic deformation.

- It involves the breaking of a limited number of atomic bonds by the movement of dislocations.
- Movement of dislocations allows atoms in crystal planes to slip past one another at a much lower stress level.

* Due to slip, grain fragmentation, moremenis of atoms and lattice distoration.

STRAIN HARDENING / WORK HARDENING:

It is the process of making a metal harder and stronger through plastic deformation. When a metal is plastically deformed, dislocations move and additional dislocations are generated. The more dislocations within a material, the more they will interact and become stronger. This will result in decreasing in the mobility of the dislocations and a strengthening of the material. This type of strengthening is called cold working.



* It is called cold working because the plastic deformation must occurs at a temp. low enough that atoms cannot rearrange themselves.
* When a metal is worked at higher temp. the dislocations can rearrange and little strengthening is achieved.

Effect of elevated temp on Materials.

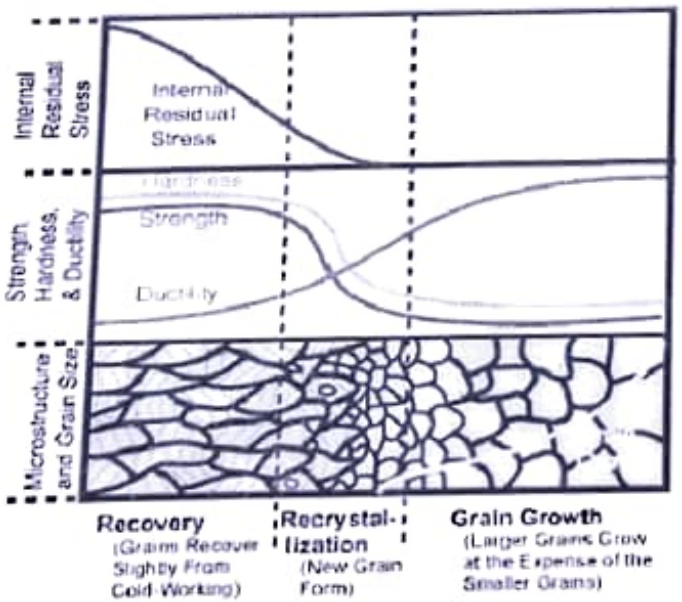
Heat treatment can be used to remove the effects of strain hardening. Three things can occur during heat treatment.

1) Recovery.
2) Recrystallization.
3) Grain growth.

Annealing:

Annealing is a heat treatment in which the metal is heated to a temperature above its recrystallisation temperature, kept at that temperature some time for homogenization of temperature followed by very slow cooling to develop equilibrium structure in the metal or alloy.

- The cooling is done in the furnace itself.
- It is used to increase the ductility.



Metal forming can be done at different temperatures.

a.) Cold Working.

b.) Warm Working.

c.) Hot Working.

(a.) COLD WORKING:

Generally done at room temperature or slightly below recrystallization temp.

Advantages:

1.) Strength and hardness increases due to strain hardening.

2.) Good surface finish and high dimensional accuracy are achieved.

3.) Grain flow during deformation provides the opportunity for desirable directional properties.

4.) No heating of the work is involved.

Disadvantages:

1.) Higher forces and power are required.

2.) Ductility decreases due to strain hardening.

3.) Annealing should be done for further deformation.
Cold forming - Annealing - cold forming.

4.) Only ductile material can be cold worked.

(b.) Warm Working:

In this case, forming is performed at temperature just above room temperature but below the recrystallization temperature. The working temperature is taken to be $0.3T_m$ where T_m = Melting point of the workpiece.

Advantages:

1.) Enhanced plastic deformation properties.

2.) Lower force required.

3.) Intricate work geometries possible.

4.) Annealing stages can be reduced.

HOT WORKING:

It involves deformation above recrystallization temperature, between $0.5T_m$ to $0.75T_m$.

Advantages

1) Significant plastic deformation can be produced.
2) Porosity of the metal is largely eliminated.
3) The grain structure of the metal is refined.
4) The impurities like slag are squeezed into fibers and distributed throughout the metal.
5) Improved mechanical properties produced such as toughness,
   percentage elongation.
   percentage elongation in area.
   Resistance to shock and vibration.
   Refined grains.

For hot working "HOT" may not be written but for Cold working "COLD" is written.

TERMINOLOGY

INGOT / STOCK: First solid form of material [Steel]

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BLOOM : It is the product of first breakdown of ingot.
[cross-sectional area > 230 cm² ; " " > 6" × 6"]

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BILLET: obtained from a further reduction by hot rolling.
[cross-sectional area > 40 × 40 mm² ; " " > 1.5" × 1.5"]

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SLAB : It obtained by hot rolling.
[cross-sectional area > 100 cm² ; width ≥ 2 × thickness]

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PLATE: thickness > 6 mm.

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SHEET : thickness < 6mm ; width > 600mm.

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STRIP : thickness < 6mm. ; width < 600 mm.

ELASTIC RECOVERY OR SPRING BACK

- Total deformation = Elastic deformation + Plastic deformation

- At the end of a metal forming process/operation, when the pressure is released, there is an elastic recovery and the total deformation will get reduced a little. This phenomenon is called as 'spring back."
- More important in cold working.
- It depends on the yield strength. Higher the yield strength, greater spring back.
- To compensate this, cold deformation be carried beyond the desired limit by an amount equal to the spring back.