

Manufacturing Process



Notes

Manufacturing Process III

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Part A

Unit 1 (Class1) Introduction and Concepts

Here we shall learn basic concepts, Defn of Manufacturing process,Product example,General classification of Mnf process, What is Mechanical working, Deformation,Stress, Ductile and Brittle metals, Classification of Mech Working-process,Concept of RCT, Hot ,Cold and Warm working.

Manufacturing Process contain two words:

Manufacturing and Process.

What is Manufacturing?

Manufacturing is the conversion of raw materials into a useful item called as Product.

Product is the desired or wanted material which has shape, size, colour, and moreover has Function to perform.

What is a Process?

Process is the step by operations involved in the conversion of raw material.

Ex., Coffee is the product → It is used as a drink. It is to satisfy the customer. This is its function.

Coffee Powder,Sugar,Water,Milk are the raw materials in addition a vessel and fuel is used for the purpose.

The raw materials are converted to the drink called as coffee. This is Manufacturing.

The steps involved water is taken in a vessel and heated to boiling using a heat source, then coffee powder is added and after some time it is filtered to get the decoction. To this sugar and milk are added to get the coffee. The steps involved above is the Process.

Similarly Pen is a product, Shirt is a product

Now we shall try to understand what is a product. Let us take the Pen... It has shape, size, colour and a function to perform ie.,writing on a paper leaving marks.

Manufacturing Processes can be classified as i) Casting ii) Welding iii) Machining iv) Mechanical working v) Powder Metallurgy vi) Plastic Technology etc.,

Here we shall concentrate on one of the important process ie., Mechanical working Process.

In this process the raw material is converted to a given shape by the application of external force. The metal is subjected to stress.

Stress: It is defined as the ratio of force to area of cross section of the material on which the force is acting.

The raw material undergoes change in the shape and this is referred to as Deformation.

Deformation: It is a process of changing the shape and size of the material under the influence of external force or stress.

Deformation can be Elastic or Plastic in nature.

Elastic deformation is a temporary one ie.,the metal undergoes change in shape and size under the influence of external load and regains the same once the load is removed.

Plastic deformation is a permanent one ie.,the metal undergoes change in shape and size under the influence of external load and cannot regain the original state.

Basically a Metal is used for mechanical working process. All metals which are ductile are mechanically worked.

A Ductile metal is one which undergoes increase or decrease in length when external force is applied without breaking. We have sheet or wire which are obtained due to ductility property.ex., mild steel.

There are brittle metals also. A brittle metal is one which will not undergo extension or decrease in length under the influence of external force but fracture or fail.ex., cast iron

***Classification of Metal Working Processes**

1.General classification

- i. Rolling
- ii. Forging
- iii. Extrusion
- iv. Wire Drawing
- iv. Sheet Metal Forming

2.Based on Temperature of Working

- i.Hot Working
- ii.Cold Working
- iii.Warm Working

3. Based on the applied stress

- i.Direct Compressive Stress
- ii.Indirect Compressive Stress
- iii.Tensile Stress
- iv.Bending Stress
- v)Shear Stress

Product: let us try to understand the meaning with an example.

Consider a Liter Can.....It is used to measure the volume of grains or liquid or powder.

It is having shape ..Cylindrical.

It is having size Diameter and height.

It is having colour... Based on the material.

It has function to perform.. To measure volume of materials.

Similarly one can identify many many products in our daily life and understand.

We shall know about Classification of Metal Working based on temperature first.

Hot working: It is defined as the mechanical working of metal at an elevated (higher) temperature. This temperature is referred to RCT(Re Crystallization Temperature).

Cold Working: It is defined as the mechanical working of metal below RCT.

Warm Working: It is defined as the mechanical working of metal at a temperature between that of Hot working and Cold Working.

What is RCT? It is the temperature at which all metallic materials undergo fragmentation of the grains followed by nucleation and growth, under the influence of the external force.

What is the value of RCT? The value of RCT has been arrived at by conducting large number of studies. Its value lies between 0.4-0.5 times the Melting point of the metal. It is a function of the nature of the metal.

Ex., For Aluminium the melting point is 660°C. Hence RCT is 330°C.

Books for Reference

1. Dieter, Mechanical Metallurgy ,

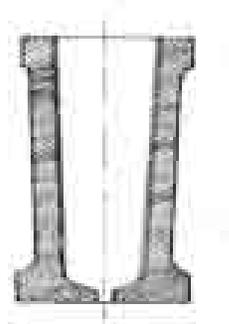
2. Dr. K. Radhakrishna, Manufacturing Process III, I Edition August 2009, Sapna Book House,

Unit 1(Class2) Introduction and Concepts

Here we shall study Types of Stresses used for Deformation, Different Mechanical Working Process, Concept of Ingot , How produced, Steps involved in Mechanical Working Process, Bloom, Billet, Bar, Slab, Plate, Sheet, Foil, Structural Shapes.

In mechanical working process the raw material is the metal in some form which is subjected to external force.

The raw material is obtained by pouring molten metal into a metallic mould and after solidification the solid metal is taken out. This will have a given cross section such as square or rectangle or circular etc., and of a given length. This is referred to as Ingot.



Typical Ingot Mould

Ingot is the starting raw metal for all metal working process.

Molten metal from the furnace is taken and poured into metal moulds and allowed to cool or solidify. The cooled solid metal mass is then taken out of the mould. This solid metal is referred to as Ingot.

This Ingot is later on converted to other forms by mechanical working.

Let us see the conversion through

Rolling and Forging

Rolling: It is a process wherein the ingot is passed between the gaps of two rotating rolls to get deformation. It is similar to sugar cane juice making Here there will be two rotating cylindrical rolls between which sugar cane is passed and crushed to get the juice. The sugar cane is getting crushed.

Forging: Here the metal is pressed between two hard surfaces to get a reduced section.

It is similar to pressing a model clay ball between two fingers or palms. The clay gets crushed to smaller thickness.

a) Rolling Route

*Molten metal → poured into metal moulds and cooled → Ingot ($\approx 250 \times 250 \text{mm}$)

*Ingot → rolled → Blooms ($\approx 200 \times 200 \text{mm}$)

*Bloom → rolled → Billets ($\approx 150 \times 150 \text{mm}$)

*Billet → rolled → Bars/Rods ($\approx 40 \times 40 \text{mm}$)

*Bar → drawn into Wires ($< 5 \text{mm}$ dia.)

*Billet → rolled → Slabs ($t < b$)

*Billet → rolled Structural shapes I, U, L, V etc.

*Slabs → Plates ($t \ll b$ and $t > 4 \text{mm}$)

*Plate → Sheets ($t < 4 \text{mm}$) → Foils (microns)

b) Forging Route

*Ingot → Open die → Blooms → Billets → Bars

*Ingot → Closed die → Shaped objects like crank shaft, spanner, connecting rod etc.,

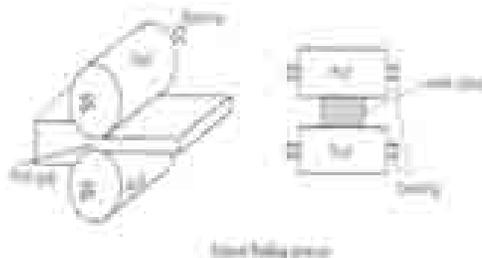
As said earlier one has to apply external force or load or stress to bring about the deformation in the metal.

We shall learn what types of stresses are present in each of the mechanical working process.

*Rolling --- Direct Compressive Stress

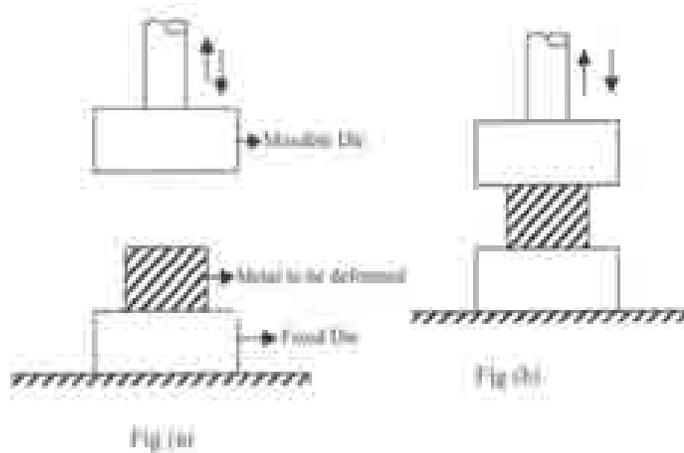
Here Plastic deformation takes place in metal when passed through a set of two rotating cylindrical rolls.

As the hot metal is passed through the gaps of two rotating rolls the metal is dragged inside and the compression of the metal takes place and the cross section is reduced. During the process there is a contact point at the start and an exit point at the other end. During these points the metal is in complete contact with the rolls and the metal experiences direct compressive stress as shown in the figure.



*Forging ----- Direct Compressive Stress

Here a simple open type forging is taken for discussion. There will be two flat hard surfaces called as dies. The gap between the dies can be adjusted and the metal is placed between the two dies and load is applied. When the dies press against the metal it gets squeezed and the cross section is reduced. The metal will experience direct compressive stress. Fig. shows this.



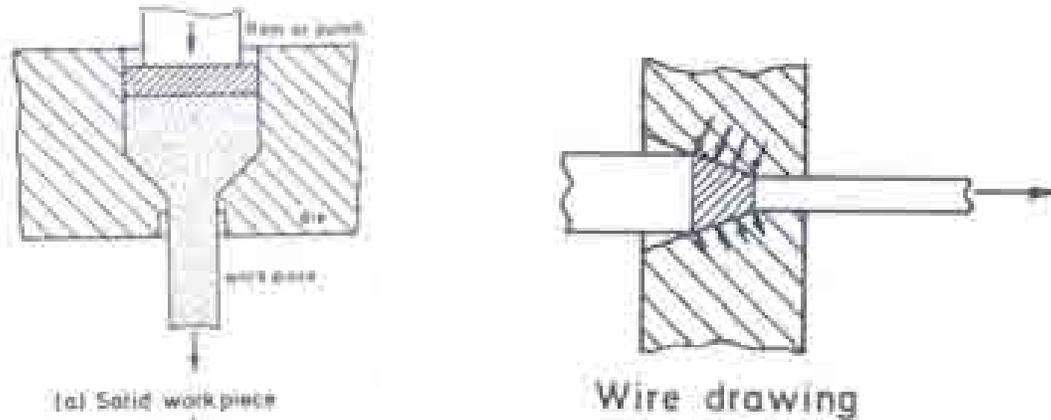
*Extrusion and Wire Drawing Indirect Compression

Here a conical die is used for deforming the metal. The die is a converging one.

In Extrusion the metal is pushed from one end towards the conical opening and the cross section is reduced.

In Wire drawing the metal is pulled from the front end of the conical end and the cross section is reduced.

In both cases the metal is subjected to indirect compressive stress. Fig. shows this.

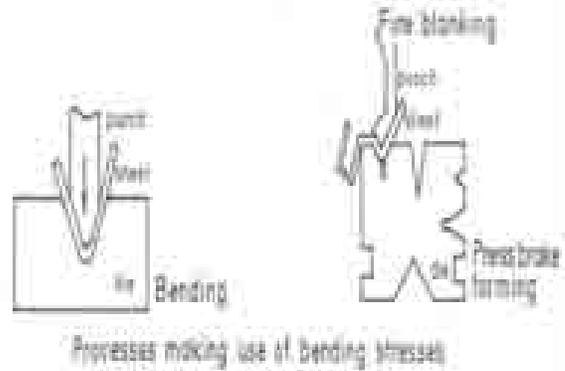


Extrusion

Wire drawing

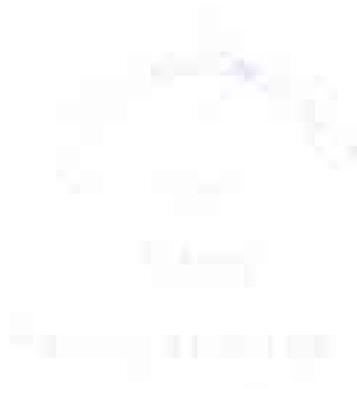
*Bending of Sheet ----Bending Stress

Two dies with matching contours are used. The metal in the form of sheet is placed on the bottom die and the top die is brought in contact with the metal and force is applied and the metal takes the contour of the dies. The metal is subjected to differential stresses on either side of the sheet resulting in bending stresses in the metal. Fig. shows this.



*Stretching of Sheet ---Tensile Stress

Here sheet metal is held between grippers and the sheet is made to press against a contoured mandrel. The process is repeated to get a permanent change in the shape. Normally this is used to deform large surfaces. The sheet is being stretched and hence experiences tensile stresses. Fig. shows this.



*Shearing of Sheet ----Shear Stress

This is used to cut the sheet into two pieces. Here two sharp edges called as shears are used(similar to scissors). The sheet metal is kept between the two shears and force is applied. The metal pieces get separated. Fig. shows this.

Unit 1 (Class3) Introduction and Concepts

What is a Cast Product?

It is a product obtained by just pouring molten metal into the mould and allowing it to solidify to the room temperature. It will have the final size and shape.

Engine block ,Piston etc.,

What is a wrought Product?

It is a product obtained by subjecting the hot ingot to mechanical working process and get a variety of products.

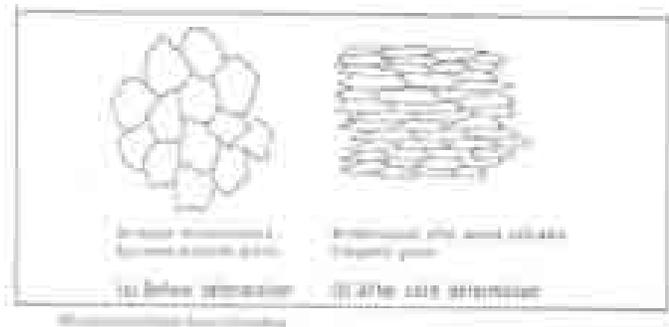
Ex., spanner, screw driver, connecting rod, etc.,

Characteristics of a Wrought Product

*Grains are oriented in a particular direction.

*The metal will show flow lines which are due to the presence of inclusions present between the metal layers.

*The Metal will shows higher properties in the direction of metal flow.*The defects get welded due to mechanical working.



Difference between Cast and Wrought product.

Cast Product	Wrought Product
1.It is obtained by conversion of liquid metal to solid state to get the required shape of the component in one step. The cast product may undergo machining operation.	1. It is obtained by subjecting the metal to external load or mechanical working to get the shape. It may be subjected to further operation.

2. The cast product will have uniform properties. The product is Isotropic in nature.	2. The wrought product will have directional properties. Properties are Enhanced. The Product is anisotropic in nature. ie., properties are different in different directions.
3. The product will have uniform grain structure.	3. The product will have directional properties and the grain structure will be oriented. Grains get altered.
4. The product will have small amount of porosity which cannot be eliminated completely.	4. Due to mechanical working the porosity level is almost zero.
5. Cast product will have any shape size and complexity. Small to very huge components can be produced easily.	5. Wrought products can also be produced with large size and moderately complex shapes with difficulty.
6. Even brittle metals can be cast easily.	6. Brittle metals cannot be mechanically worked.
7. The process does not need additional equipments. Only Regular maintenance of the equipment is required.	7. Needs additional equipments for mechanical working.

Difference between Hot Working and Cold Working

Hot Working	Cold Working
1. The metal is subjected to mechanical working above RCT	1. The metal is subjected to mechanical working below RCT.
2. Uniform fine equiaxed grains are o Properties are uniform in any direction.	2. Elongated columnar grains are fo Properties are higher in a particular direction.
3. Properties are uniform in any direction.	3. The properties are higher in a particular direction than the other.
	4. The component will be anisotropic in

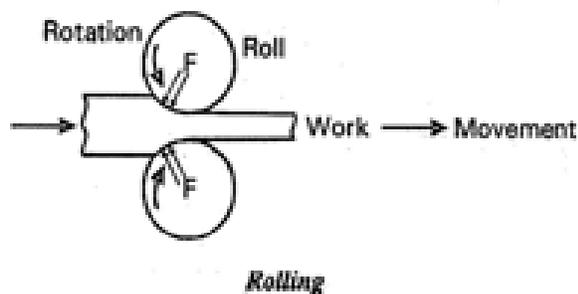
4. The components will have Isotropic properties.	nature.
5. Energy required for deformation is less.	5. Energy required for deformation is more.
6. No strain hardening takes place in the metal.	6. Strain hardening takes place in the metal.
7. Large components can be hot worked easily.	7. Only small components can be cold worked.
8. Surface oxidation occurs, scaling will be present and surface finish is poor.	8. Surface oxidation is less, scale formation is also less and surface finish is good.
9. Pores are minimized and inclusion gets redistributed.	9. Pores and inclusions cannot be taken care of to a great extent.
10. Capacity of the equipment is less.	10. The capacity of the equipment required for cold working is less.
11. Needs extra equipment for heating of the metal.	11. Does not need extra equipment as in hot working.
12. Handling of hot metal is difficult.	12. Handling of metal is not very difficult.

Classification of Metal Working Process based on Stresses

1. Direct Compressive Stress

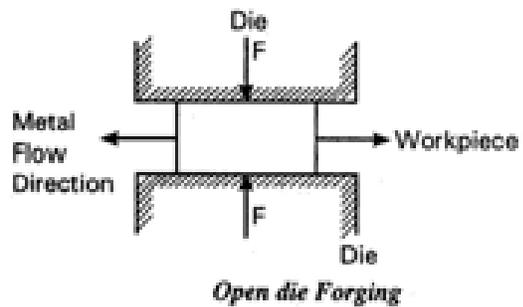
a) Rolling and b) Forging

Rolling



It consists of two rotating rolls with a gap between which the metal is passed through and the metal gets reduced in its cross section. During the process the metal experiences direct compression as shown in the figure.

Forging

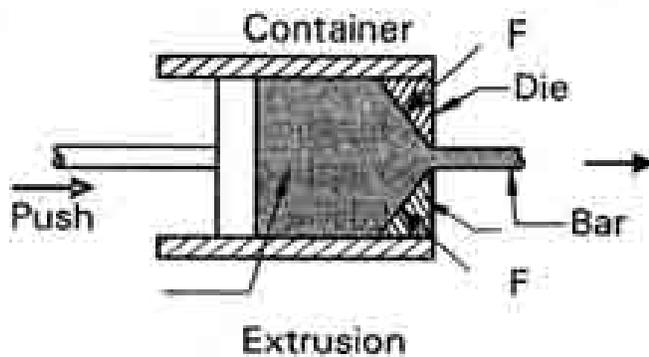


Here the metal is placed between the gap of two hard surfaces called as dies and are made to come closer and make contact with the metal. On applying the load the metal is compressed and it experiences direct compression.

2. Indirect Compression

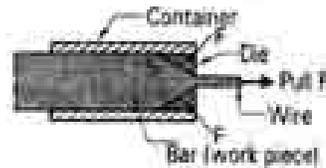
a. Extrusion and b) Wire Drawing

Extrusion



It consists of a cylindrical container in which the metal is kept and pushed out of a conical end called as die. Reduction in the cross section takes place. The metal experiences indirect compression near the die walls.

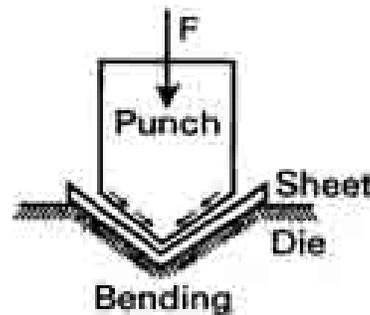
Wire drawing



Here also a cylindrical container with a conical end will be there and the metal is being pulled out of the die. The metal cross section is smaller than in extrusion.

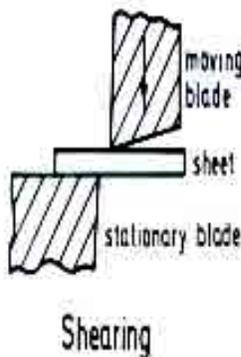
3. Bending Stress

Bending of plates and sheets



Here two dies are used with a given contour as shown in the fig. A sheet is placed on the bottom die and the upper die is made top force against the sheet and the metal undergoes bending due to tensile and compressive forces acting on it at top and bottom surfaces. The metal takes the form of the contour and bends.

4. Shear Stress



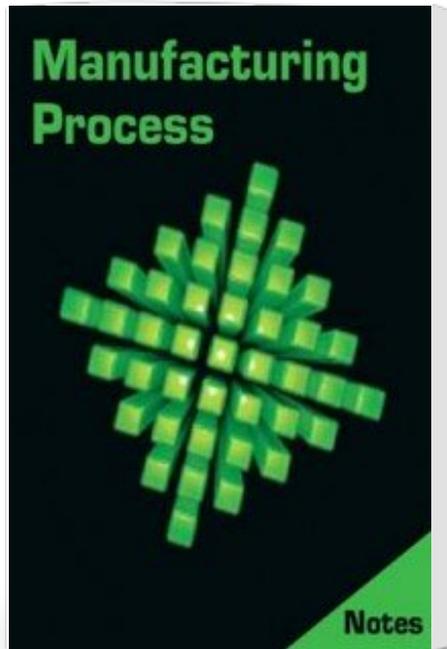
Here a sheet is cut between two sharp edges called as shear blades. The metal is placed on one of the blades and the other blade is made to force against it. The metal undergoes shear as shown in the fig. Pure shear stress will be acting on the metal.

5. Tensile Stress



A sheet metal is held between grippers and is pulled against a contoured die as shown in the fig. The sheet takes the form of the die due to tensile forces acting on it. The required contour is obtained.

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