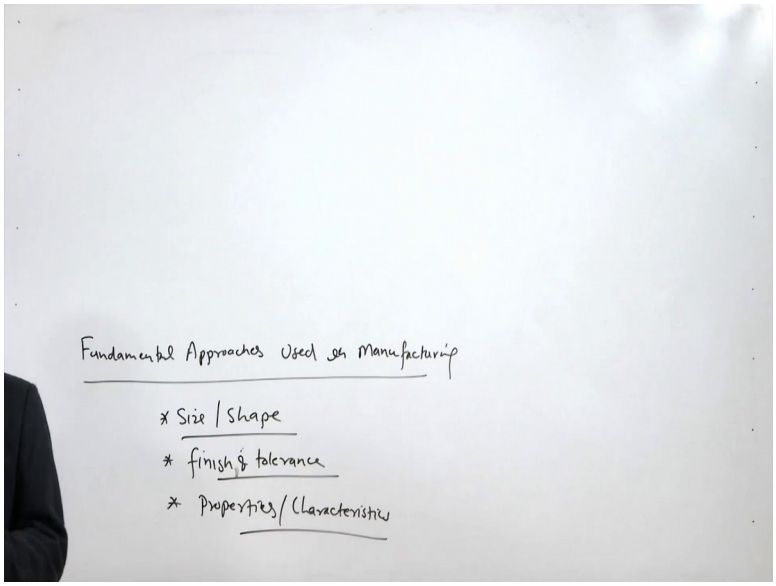
Fundamentals of Manufacturing Processes

Dr. D. K. Dwivedi
Department of Mechanical & Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture - 02
Fundamental Approaches of Manufacturing

Hello, I welcome you all in this presentation relate with the subject Fundamentals of Manufacturing Processes.

(Refer Slide Time: 00:28)

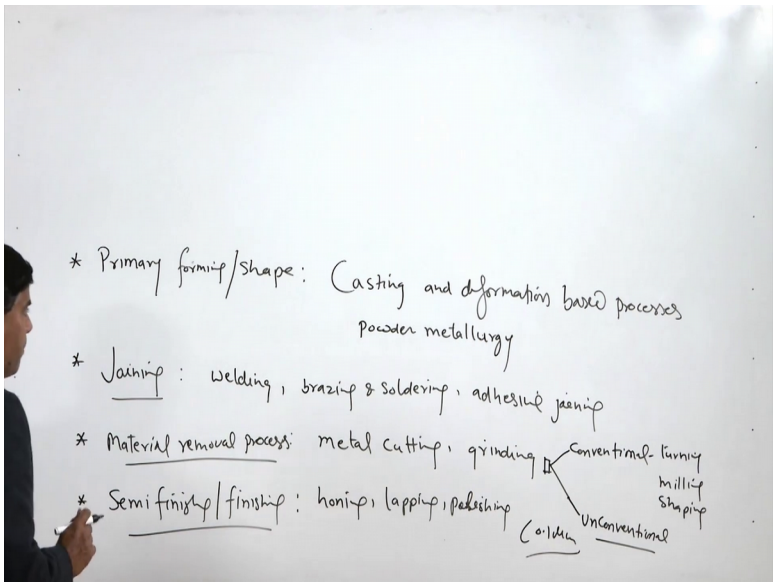


So, here today we will talk about the fundamental approaches used in manufacturing. We know that the manufacturing is used for making the goods products which can be used by the human being; and for that purpose, it is necessary that they are produced of the desired size and the shape, they are produced with the desired finish, and close control of the tolerance, and here with the desired properties. So, these are the three aspects desired properties or characteristics.

So, for realizing the desired size and shape, their finish and close control over the tolerance, and desired properties it is required that a wide range of the processes are used. So, the processes which are used in the manufacturing are very wide in range, they are very different in nature, but there are some of the basic approaches are used which helps to achieve the desired size and shape. Then they are certain other processes which are used for achieving the desired control over the dimensions and the surface finish, and

another set of the a processes which are used for achieving the desired properties and characteristics in the product being made, so that the goods and the products being made can perform the desired function. So, these processes actually can we grouped in certain categories these.

(Refer Slide Time: 03:01)



And these categories are like this the processes, which are used for primary forming or shaping. So, the major shape and size is achieved through this category of the processes; under this category of the means this kind of the objective is achieved through certain processes like the casting and deformation based processes like a rolling, extrusion, forging, etcetera. And there is another one which is powder metallurgy, this is another route which helps us to achieve the desired size and shape, but it uses the powders as a raw material in primary forming processes.

Then we have the joining processes. When the shape is complex, and it is not a economically while we will to make the product using the primary forming processes then what is done the simpler shapes simpler shapes are brought together by joining, so that the desired size and shape can be achieved. And for this purpose we use the wedding, brazing, soldering and even adhesives joining, these are under this category the simpler shapes are brought together, so that the desired size and shape is achieved.

Then we have the material removal processes. Material removal processes, in this category, the unwanted material from the undesired material or unwanted material from

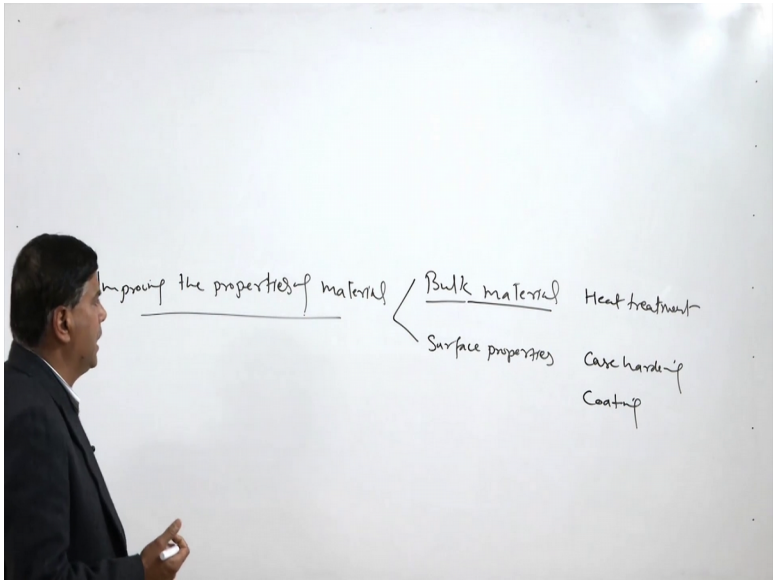
the raw or stock material is removed to get the desired size and shape, so that material is removed from the raw material to get the desired size and shape. In this category, primarily there is metal cutting and then we can say grinding all the close control over the dimensions as well as finish is achieved through the grinding.

And under the material removal category, there are two broad groups, one is conventional machining processes conventional machining where the material is removed at macro scale. Like in your turning on the lathe or the milling on the milling machine, shaping these are the conventional machining processes, which are used for the materials having the moderate properties. But if it is about the exotic materials which are difficult to machine by the conventional metal removal processes, then you can see newer machining processes or unconventional machining processes are used. And they are based on the different approaches like use of the heat, use of the impacts, use of a spark or use of the laser radiations, use of chemical interactions and chemical reactions.

So, the various principles are used in unconventional machining processes to remove the undesired material from their stock or from the raw material, so that the desired size and shape and features can be produced. So, this is the category of the material removal processes, here macro scale material is removed and very fine and little quantity of the material is removed in the grinding. And then we have in the metal cutting, there are two broad categories conventional machining and unconventional machining. In conventional machining like turning, milling, shaping; and on the unconventional machining processes, there are number of the newer machining process which have been developed like electric discharge machining, electro chemical machining, water jet machining, ultrasonic machining, abrasive finishing based processes etcetera. So, those are the unconventional machining processes.

Now, we have another category where in like semi finishing or finishing processes. In this category very close control over the dimensions as well as the surface finish is achieved using processes like honing, lapping, polishing, these processes help to achieve the very good degree of the finish like less than 0.1 micrometer or even the finer 1 in terms of the RA.

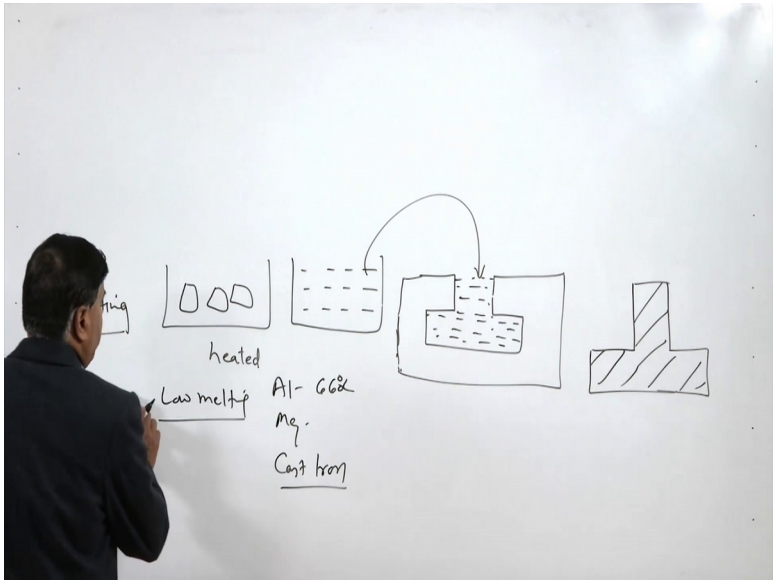
(Refer Slide Time: 09:40)



So, then improving the properties of the material and so for that we have another two categories. So, another point is improving the properties of material. There are two categories in this one where in the bulk material properties are modified, properties of the entire component is modified. For this purpose like the heat treatment, various types of the heat treatments are there, like annealing, normalizing, hardening, and tempering, martempering, austempering for their steel precipitation-hardening etcetera. So, they will be helping us to improve the properties of the entire component or as a whole entire component and there are certain methods, which are used for improving the surface properties only, so that desired functionalities and prolong life can be achieved. And in this category, we have the case hardening process where in either just a structure is modified or the chemical composition near the surface layers is modified, so that the desired set of the properties and near the surface can be achieved.

There is another method where in the coatings are applied at the surface, so that the desired properties can be achieved. So, we will try to talk about all these aspects in the subject. And in this presentation basically I will talk about the approaches which are used for these five categories.

(Refer Slide Time: 11:47)



So, we starting with the casting which is a primary a shaping or the forming process; in case of the casting, it is very simple process wherein the raw material is basically heated in crucible or in suitable furnace then so that it can be brought to the molten state. And then this molten metal is poured in to the mould, mould is a cavity which is prepared either using the sand or the metallic mould, and this molten metal is poured into the cavity, so that this cavity is filled in. Subsequently on solidification of the molten metal, we get the desired solidified casting in this form. So, this is how we get the desired shape.

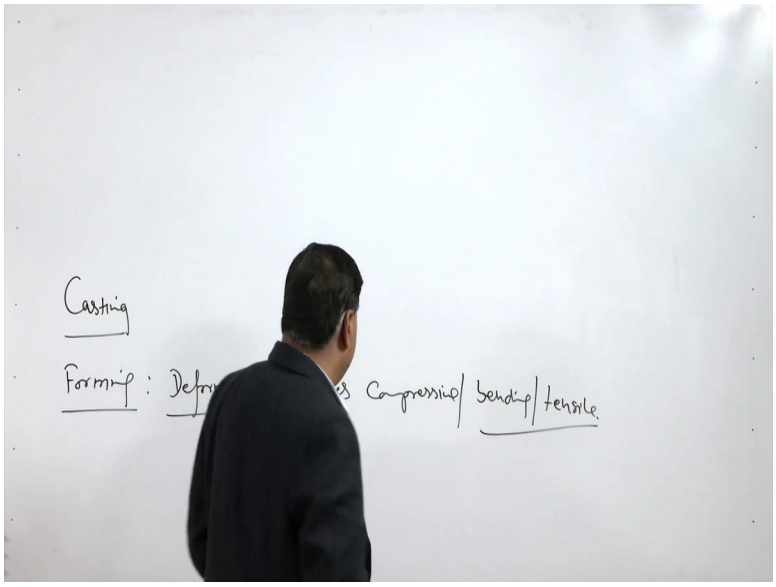
But the product which is made by the casting is usually rough and not very close to the dimensions desired. So, roughness is high and the dimensions or not actually dimensions are not very close to that required ones. So, what is needed, we need further processing for achieving the desired finish and achieving the desired dimensions. And for this purpose, mostly machining processes are used grinding processes or the finishing processes are used, so that desired finish can be achieved.

So, depending upon the function of the product made by the casting, the different dimensional different degree of that control over the dimensions and the different surface roughness or surface finish is desired, so this is what is there in the costing approach. But for this purpose what is needed your molten metal melting point of the metal to be processed must be low. That is why aluminium having like say 660 degree centigrade

melting point, magnesium and a cast irons so those having the low melting point they are easy to melt and it is easy to process them to get the desired product through the casting route. In this case, the hardness a strength of the material does not play any role.

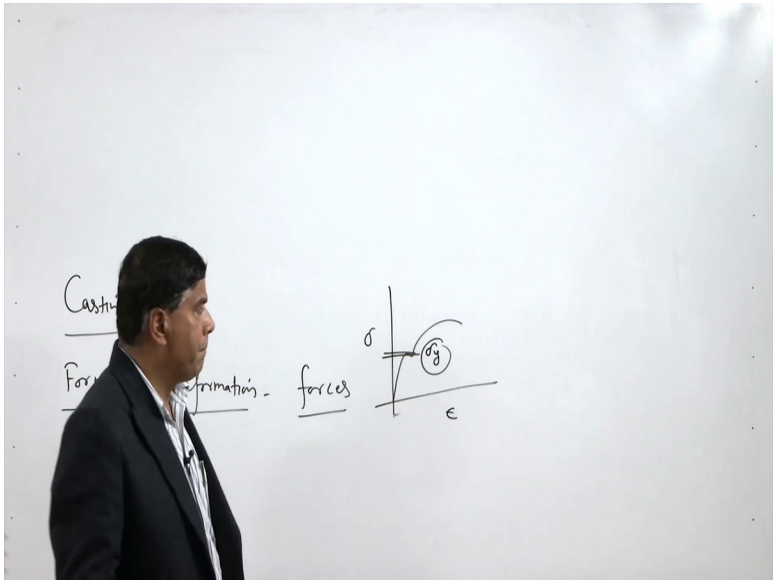
What is important it should not interact much with the gases and the atmospheric ambient air, which otherwise can lead to the formation of the inclusion say impurities or it can lead to the porosity in the cast products. So, this is one approach, this is good for the low melting point systems and it is commonly used by the jewellers for making the jewellery. Similarly, it is extensively used for making the products of the plastics, and products of the cast iron, products of the made of the aluminium, magnesium, even copper like in form of brass and bronzes. So, those low melting point systems can be easily processed through the casting route, this is the primary forming and shaping process.

(Refer Slide Time: 15:49)



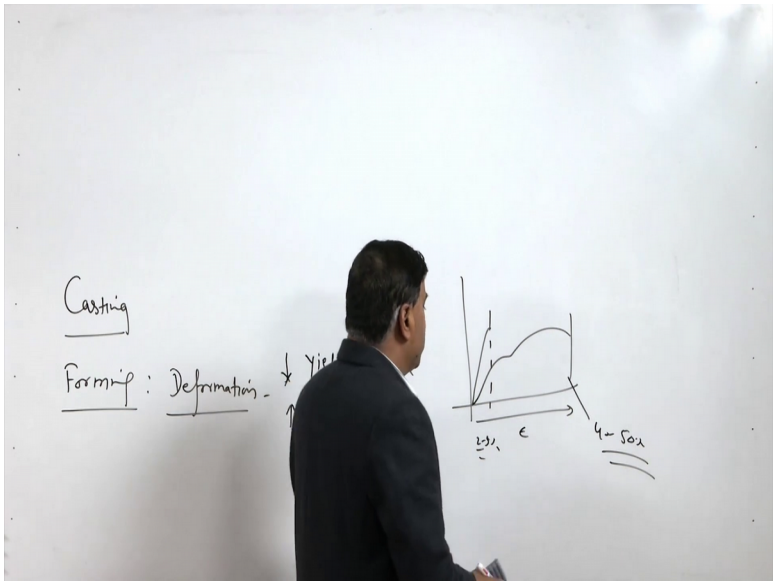
Another is forming process. Forming is basically based on the deformation based approach. So, for achieving the deformation; obviously, we need to apply the force mostly it is compressive force, but it can be of the bending type or tensile type also, but that is very not very common in the processes compressive force is normally applied.

(Refer Slide Time: 16:36)



So, for achieving the deformation, we know that from the engineering stress-strain diagram what we know that like say for typical steel products the plastic deformation sets in after the elastic limit. So, for causing the plastic deformation it is necessary that the applied force develops their stresses which are greater than the yield strength of the material, so that the plastic deformation is realized. So, what is important that material should have it is good to for this process to get the desired size and shape by the deformation approach is that the material has the low yield strength.

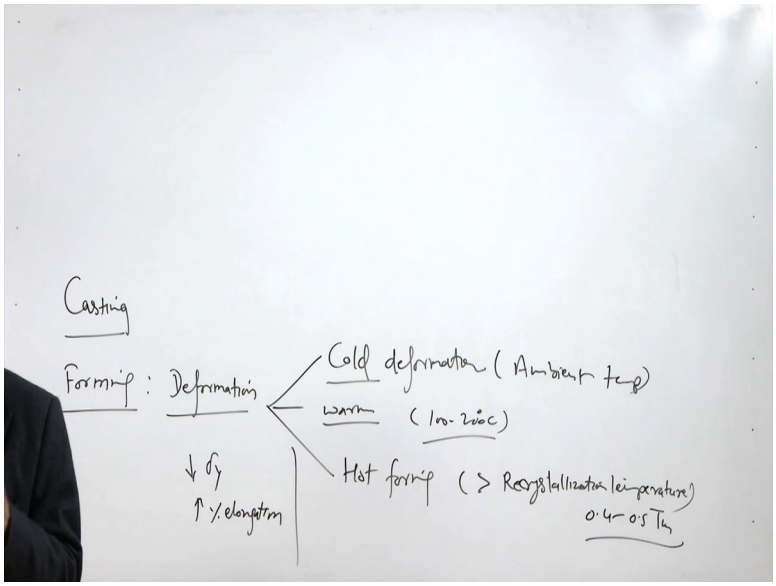
(Refer Slide Time: 17:19)



So, that you can deform it easily, so the strength of the metal to be processed; if it is low, then it is good and easy to deform. And another one is elongation, elongation or the ductility of the material is high. This is also we can see low ductility metals like they break like this. And if the metal is of the high ductility then it will be deforming a lot prior to the fracture. So, this is the strain at the fracture which is used to quantify the elongation. Like say for the low carbon steel are very like say 0.1 or 0.05 percent carbon is steel this may be as a highest 40 to 50 percent, but like say for the cast iron once it may be very low might may be 2 to 3 percent. So, if the ductility is very limited you cannot deform it much plastically; if the ductility is high, the deformation is easier under the percentage elongation is one of the very common criteria or the parameter to check the ductility of the material.

So, for the deformation based approaches, it is necessary it is good that the yield strength of the material is low and ductility is high. And to facilitate this, it walks on the two approaches like the deformation, there are two approaches of the deformation based processes.

(Refer Slide Time: 19:02)

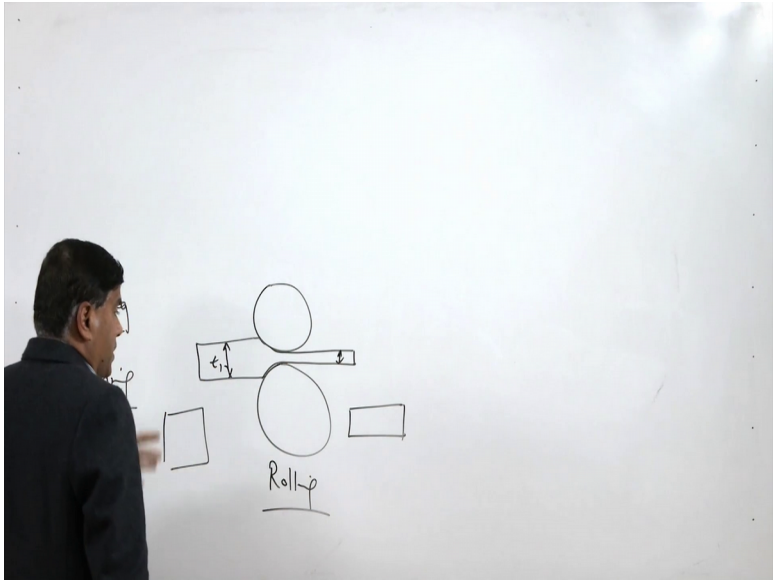


One is the cold deformation based approaches and the hot this is just cold forming or hot forming; cold deformation processor or hot deformation based processor. So, there is one more warm also where depending upon the temperature. So, this is normally carried out under the ambient condition, and this is above the recrystallization temperature, so which

is about 0.4 to 0.5 times of the melting point of the material in Kelvin that is the recrystallization 0.4 to 0.5 times of the melting point of the material in Kelvin and this is under the ambient temperature conditions.

Well may be warm forming is carried out at low very below the re crystallization temperature and above the ambient temperature may be like 100 to 200 degree centigrade heating is carried out for their steels, but certainly it is a that the below the re crystallization temperature of the material for the warm forming. So, when the hot forming is applied, temperature is high and that helps in so increase in temperature during the deformation or during the forming helps to reduce the yield strength of the material. At the same time, it helps to increase the percentage elongation. So, composition of both these characteristics is variation in both these properties like reduction in yield strength and increase in ductility helps to deform the material under the effect of external forces easily so that the desired shape and size can be achieved easily.

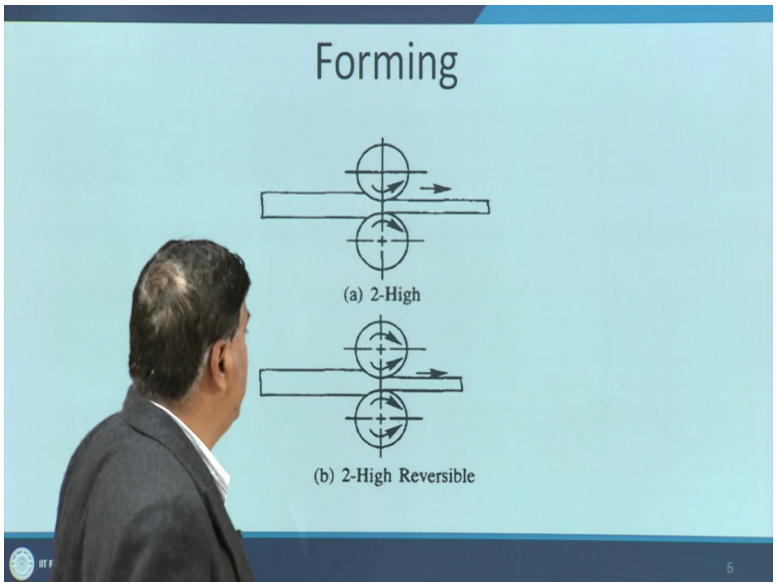
(Refer Slide Time: 21:17)



So, there are certain processes like the rolling is one process where in like there two roles like this and the material is force to pass through these roles, so that its cross section can be reduced. So, here like see initially thickness is this much and thereafter its thickness is reduced from the t 1 to t 2. So, basically the cross section size is reduced in this particular cases in the rolling processes. Similarly, so here material is being basically

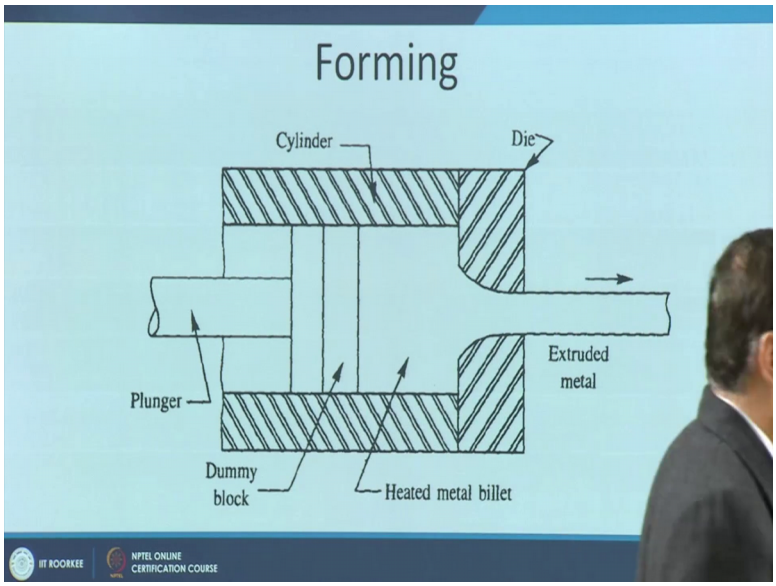
force to deform and take some other cross section like say earlier it was like this then after the deformation the thickness will be reduced under the constant the width conditions actually length increases the width remains constant. So, here likewise there are various deformation which processes that is what we can see from this diagram.

(Refer Slide Time: 22:34)



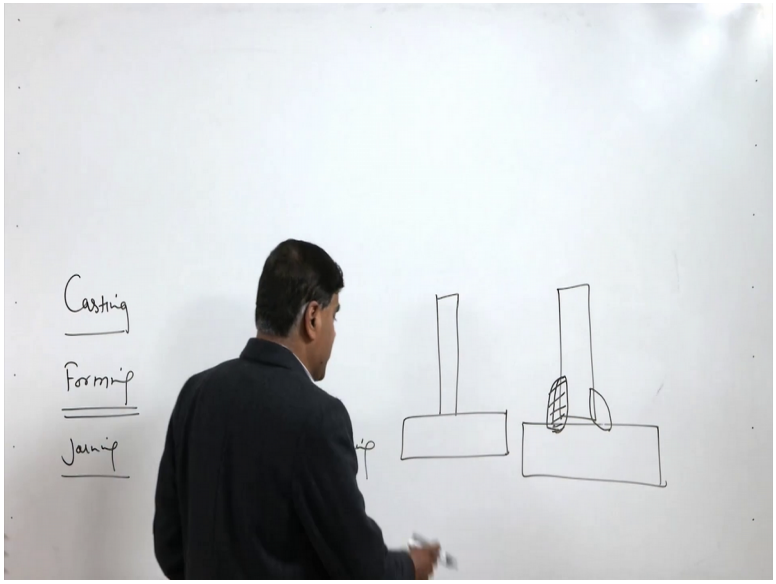
Here this is the rolling process where the stock is fed through the rollers. And other the effect of the compressive forces, its cross section its thickness is reduced. So, in this case the rotation the movement of the stock is in one direction and in this case it reverses movement is in the both the directions. So, that every time, there is a reduction in the thickness of the plates.

(Refer Slide Time: 22:58)



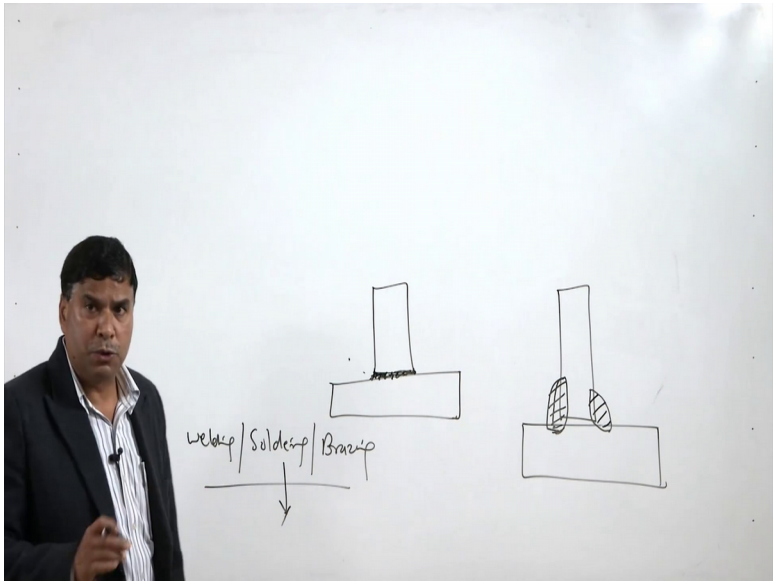
This is another deformation based process where within the under the constraint conditions of this a structure the hot the material is a force to pass through this die, so that the cross section is reduced from such a large size to a smaller size. This is the extrusion process, which is used for making the long cylinder shape jobs of the uniform cross sectional area along the length. So, these are the formation or the deformation based processes.

(Refer Slide Time: 23:45)



Then coming to the joining. In case of the joining, you know there are the processes like welding, soldering and brazing. So, here what we do since making the complex products in one go of such kind of the geometry is difficult. So, what is done we take two simple shapes like this and another one like this and the two are joined together by fusing the components partially along so this is how the joint is developed. So, otherwise it is not that easy to make such kind of the shape using the deformation based process of course, it can be done using the casting. But if the material is not a favourable for the casting due to thermal properties or due to its melting point, the way by which it responds to the heat, so it is better that it is made in simple shapes and then they are joined together. So, this is the case when fusion is possible.

(Refer Slide Time: 25:07)

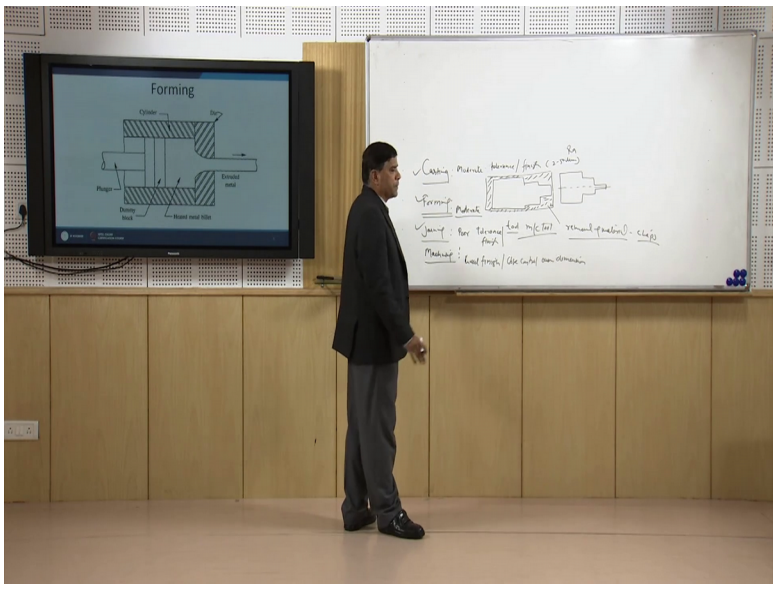


If we find that, no, even a fusion is not possible then in that case what we can do we can apply just brazing alloy. So, we heat it up and then the components are heated and then the brazing alloy is brazing material is applied or it is filled in the interfusion on solidification it produces the joint. Similarly, for the soldering; soldering is not used for load carrying joints. It is mainly used for making electrical connections, so that desired connectivity between the components being joined can be achieved.

So, in the case of the joining, it is like the simpler shapes are brought together, so that the desired size and shape can be achieved like the ships structure ship are very lengthy very heavy in its structures. So, they cannot be made by any of the conventional processes like

forming or casting, the simpler shapes simpler plates of the different geometries need to be brought together by joining processes, so that the largest structures can be created.

(Refer Slide Time: 26:22)



And then coming to the machining processes; machining processes a work on the approach of removing the unwanted extra material. So, say this is the raw material and we want to make the component having the final dimensions like this. So, what we will be doing. So, this is component to be made using this stock or raw material. So, what we will be doing, we will be just removing all that which is extra. So, this, this, this is the material that we want and the remaining things we do not want, so all this hashed section the material of the hashed dissection section need to be removed and for this purpose the material is removed with the help of suitable tools or machine tools.

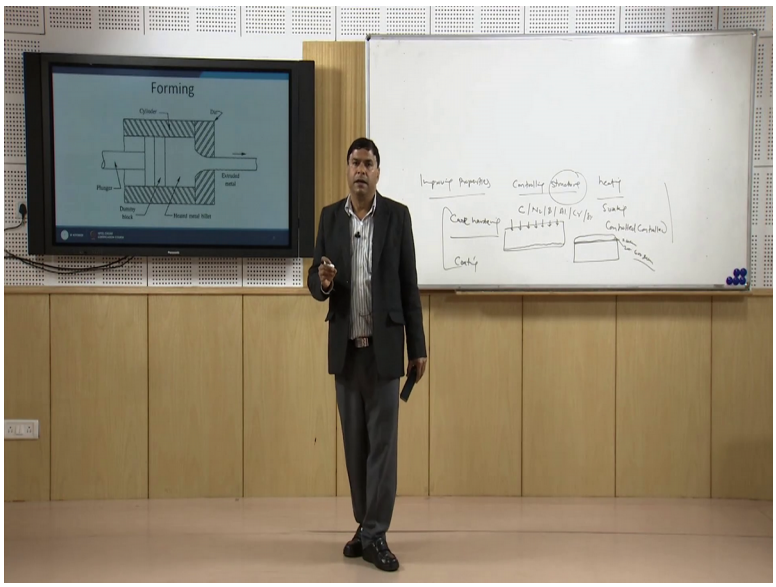
So, controlled motion of the work piece and tool helps to just remove all these unwanted extra material. So, this is called removal of material, material is removed in form of fine chips. These chips are of no use so it is wastage of the material. So, if you see this process is a negative in that way in the sense that we take the stock material and unwanted extra material is taken off or it is removed, so that is the desired size and shape can be achieved.

Coming to the capabilities of the process the process is moderate in terms of the in terms of the tolerance, which can be achieved and the finish it is not very good. Like say finish may be vary from 2 to 50 micrometer in terms of the RA and the tolerance is also not

very good. Similarly forming processes, we can achieve really good finish for the cold forming, but not for the hot forming. So, here it is also the moderate in the sense of surface finish and the dimensions or the tolerance, the joining is poor in terms of the control over the tolerance and the finish we need definitely the good the post machining or the secondary processing and the machining it offers very good finish, and very close control over dimensions. So, in that way the machining is good, because it helps to achieve the close control over the dimensions.

But this is a secondary process most of the time whatever is made by the casting, forming or even joining need to be machined, so that the desired finish and desired control over dimensions can be achieved. I will talk about, so this is the general approach which is used in case of the four major manufacturing processes likewise there are other processes heat treatment, case hardening etcetera and the semi finishing and the finishing processes.

(Refer Slide Time: 30:30)



So, improving the surface properties improving the properties and the surface properties both these actually work on the controlling the structure or microstructure of the material, so that the desired combination of the properties is achieved. And for this purpose what is done basically we will follow heating, soaking and then very controlled cooling, this is what is done in case of the heat treatment and for the case hardening

purpose. So, basically try to control the microstructure of the material so that the properties are incorporated or imparted as per the requirement.

And other properties like for the case hardening case hardening purpose like the mat surface properties the surface whose properties need to be improved we try to adjust either apply heat, so that the near surface layers are structure of the near surface layers is modified. Or we introduce carbon, nitrogen, boron, aluminium, chromium, silicon all these elements can be incorporated or introduced near the surface layer, so that the properties near the surface layers get modified. So, in this case, the chemistry is modified besides the changing in the structure.

And third approach is development of the coating. In this case, what we do basically the component whose surface properties need to be improved. So, these are the two categories where only surface properties are improved; while in case of the heat treatment, the bulk material properties are improved. So, for when we applied coatings for application of the coating, the coating maybe of thin in dimensions like say 5 to 10 micrometer or it may be very thick like say 200 to 600 or even 1000 micrometer. So, depending upon the hardness of the material thickness of the coating is influenced softer the material thicker can be the coating harder the material thinner coating need to be used. So, as per the purpose as per the requirement either hard or the soft coatings need to be developed, so that desired functionality in the product can be achieved.

So, I will conclude this presentation now. In this presentation, I have talked about the fundamental mechanisms and the approaches, which are used in the manufacturing processes; and in detail, I have talked about the ma approaches used in the casting, farming, welding and the machining or the metal removal processes.

Thank you for your attention.