Fundamentals of Manufacturing Processes

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

Lecture – 03
Manufacturing Process Specific Advantages & Limitations

Hello. I welcome you all in this presentation. This presentation relate with the subject of Fundamentals of a Manufacturing Process, this presentation is based on the Advantages and the Limitations of the Manufacturing Process, and the process is specific a advantages and limitations will be talking about here.

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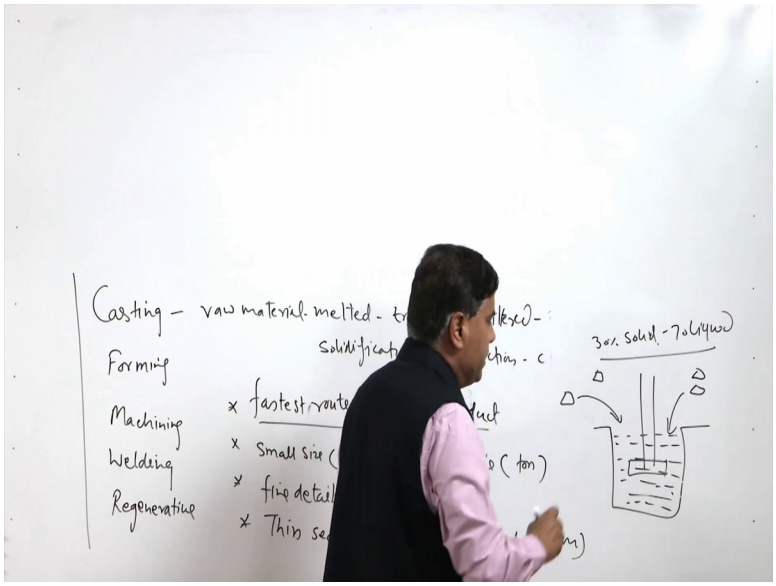

So, we know that the one of the means the most common manufacturing processes include like casting process, forming process, which are deformation based, machining processes, welding process, and a regenerative processes.

So, these are very broad group of the a processes, because in each of the category we have a large number of the a processes. These are we can say the broad group of the processes. In casting processes, what is needed to a manufacture a product? At first the raw material is melted, and then to clean the impurities from the molten metal like the treatment of the molten metal is carried out where in like degassing, fluxing, etcetera kind of treatment which are done. There after impurities are filtered if they are present. So, filtration is another step and then filtered molten metal is poured into the mould.

So, pouring of the molten metal into the mould followed by pouring into the mould, and then the solidification of the molten metal results in the casting. And once the casting is solidified it is taken out a rejection or you can say ejection; not rejection, ejection from the mould, and then cleaning and fatling etcetera as per the process which is done.

So, if we see this process these are the steps from the capability point of view of this process. This process offers the fastest route, fastest way, or fastest route for manufacturing a product or to get that desired shape, but the surface finishing the tolerance which are achieved by this process are not good .

So, this is the fastest route because we melt and we get the desired size and shape, but the finish and the tolerance which is achieved is not very good. This casting can be used for making the products of very a small size, may be of a few grams to the very large size; may be few tons also like 100 ton 2000 ton castings are also made. And very fine details can also be achieved fine details, in the products can be realized. So, the quite good aspect ratio means the height to the thickness or the width of the slots and the grooves which can be achieved is very good.

So, aspect ratio which can be achieved is also high, means we can say it can be used for the making components of very thin sections of few mm to the very heavy thick sections, may be in meters also. So these are some of the very positive sites related with this process. To see more details related with this process is offers the shortest route for manufacturing a product like shortest route to get to the complex shape, with the internal features through a holes, or the blind holes, or any other geometry of that kind.

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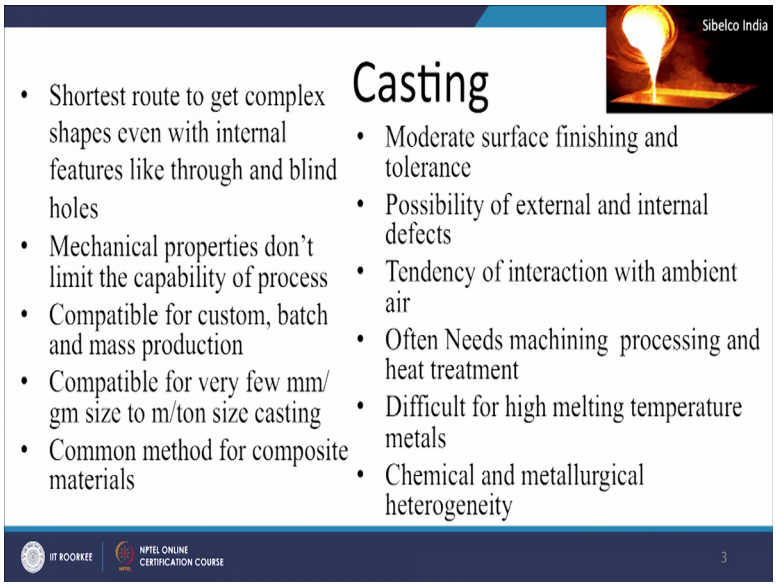

A another important thing mechanical properties of the material do not affect the success of this process the more, because whether it is material is hard or tough or very strong or very low ductility or of very high ductility, that does not affect the processing capability of the casting to get the desired size and shape. So, mechanical properties do not affect or do not limit the capability of this process, and compatible for custom batch and mass productions.

So, this is important we can make very large size casting, in a single casting of very large size, or we can make few number of components like a batch of 10 or 15 number of products can be made by the casting, economically at the same time the process can also be used for the mass production purpose. So, that is the another good feature related with the casting, that process compatible for the custom made products, or customized products, or for the batch batches of the different sizes and for mass production purpose.

Like this process is therefore, very commonly used in the casting in casting industry for making wheels, for making the piston rods, case engine blocks etcetera, and the compatible for very few of for very fine dimensions to the very large size, dimensions like say the components may be of very small size in mm or sections may be of very small size in m m, or a very large size in meters, or in tons and this is common method for making the composite materials also, like the ister casting, or Rio casting is one of

the route where the molten metal where casting is used for preparing the composite material.

So, in this method what is done basically, the molten metal is maintained at a correct temperature, so that there is a mushy zone, wherein like say 30 percent solid and a 70 percent of the liquid. So, this is the two phase own state which is normally used like 20 to 30 or 40 percent of the solid and the remaining liquid. So, in this condition the particles that we want to reinforce in the casting they are fed in with the help of ice stirrer or this molten metal is it steered, and then we feed in the ceramic the particles or any other particle which is to be reinforced.

So, that it gets distributed into the into the mass or in this semi solid metal, and then it is allowed to solidify, and that is how the this casting is also used for making the composites, all the composites can be made using other roots like the powder metallurgy, and there are various methods for making the composite materials.

Now, coming to the limitation of the process the limitation is that it is required that for this process it is necessary that the metal is brought to the molten state. So, melting of the material is mandatory, and for that purpose it is necessary that the melting point of the material must be reasonably low or if it is too high then it will make the melting of the material difficult.

And that is why the high melting point materials are for difficult to process, to be processed by the casting process, like difficult for high melting temperature metals. And at the same time the surface finish which is achieved by the casting process is not that good, it requires a secondary processing in form of the machining, and at the same time tolerance is also not good. Therefore, to achieve the close control over the dimensions to have the close control over the tolerance of the manufactured product the machining becomes important as per the requirement.

Then the possibility of the internal and external defects, we know that the molten metal will be solidifying, so if the gases remain get trapped or impurities are passed into them with along with the molten metal they get into the molt, then they will be present in form of porosity or the inclusions. So, which will be leading to the internal defects at the same time like the formation of the cracks due to the high residual tensile stresses can lead to the development of the cracks in the surface at the surface of the castings.

And another important thing tendency of the interaction with the ambient air, we know that whenever the temperature of the metal is increased it becomes active to the atmospheric gases, and with the increase in temperature it can absorb or it can dissolve more amount of the gases in the liquid is state as compared to the solid state, so the differential solubility in the liquid and solid state leads to the problem of the porosity if the gases are not they do not find enough opportunity to come out of the casting during the solidification, and these gases also sometimes react with the molten metal. And if these do not flow toward the surface of the molten metal during the solidification, and then they may get remain trapped into the castings, and that will be leading to the defective.

Often needs machining and process machining process, processing of the casting by machining and the heat treatment. We know that this is the control over the dimensions and surface finish which is achieved in a casting is not very good therefore, to achieve the desired degree of surface finish and close control over the dimensions. The machining becomes important as per the functionality or as per the requirement of the services same.

Similarly heat treatment is of the casting is also carried out to enhance the characteristics and properties of the castings because, in a scarce conditions casting offer somewhat poor mechanical properties and therefore, to enhance the properties of the casting sometimes the heat treatment is also carried out and the chemical and metallurgical heterogeneities is also exist in the castings, that is another side said more of the technological point related with the casting like whenever the solidification of any casting takes place.

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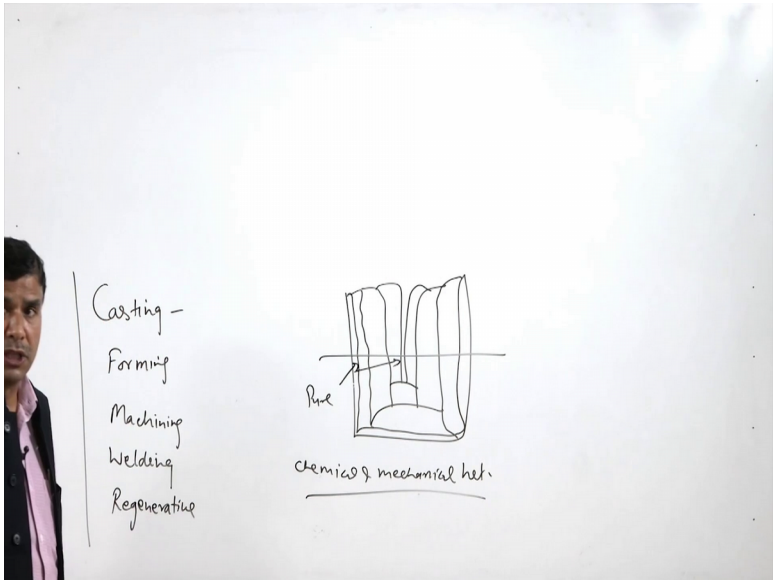

We find that the pure metal solidify solidifies first, and gracefully the impurities or the alloying elements will be segregating or will be moving towards the center, and at the end what we find that all the impurities have got segregated at the center.

So, it is starts with the purest metal at the boundary, and then impurity concentration keeps on increasing up to the center. So, more of the segregation takes place in the cast components, and that in turn leads to the chemical and mechanical heterogeneity in the properties, and the composition of the casting.

So this is the inherent feature of the casting process, where the micro level heterogeneity always exists and sometimes even macro level heterogeneity is also found in the castings. Now coming to another process which is a forming; so in case of the forming is deformation based manufacturing process.

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Deformation based manufacturing process where normally compressive force is applied for plastic deformation, and in order to achieve the desired size and shape, but since this process uses a the plastic deformation a to achieve the desired size and shape, and using though those and the nature of the application of these forces is such that it cannot really help to achieve the very complex a shape very high aspect ratio geometries, and therefore this process is found good for simple shapes, this is one this it this process offers means this category of the process offers the high volume production rate, generally the deformation is associated with the closing of the discontinuities and the defects if they are present in the material.

So, basically it eliminates impurities defects and discontinuities if they are present under the compressive plastic deformation conditions, these are eliminated from the raw material. So, elimination of the defects like pores or like, inclusions are also broken down, so these are these are made to be discontinued under the deformation forces under the plastic deformation, and at the same time this results in the plastic deformation causes the work hardening of the material, so work hardening leads to the increased a strength and the hardness of the material.

So, basically property enhancement takes place in the products which are made by the deformation based processes, and this in turn also leads to the high a strength to weight ratio, this also helps to increase the s achieve the high strength to weight ratio. And these

features are therefore, exploited in making a number of the components for automated sector.

So, if we see here the advantages the forming processes of our high volume production rate improved mechanical properties, due to the work hardening, associated with the deformation based processes in forming, and the internal discontinuity and defects are closed, under the effect of the deformation and therefore, reduce the internal defects.

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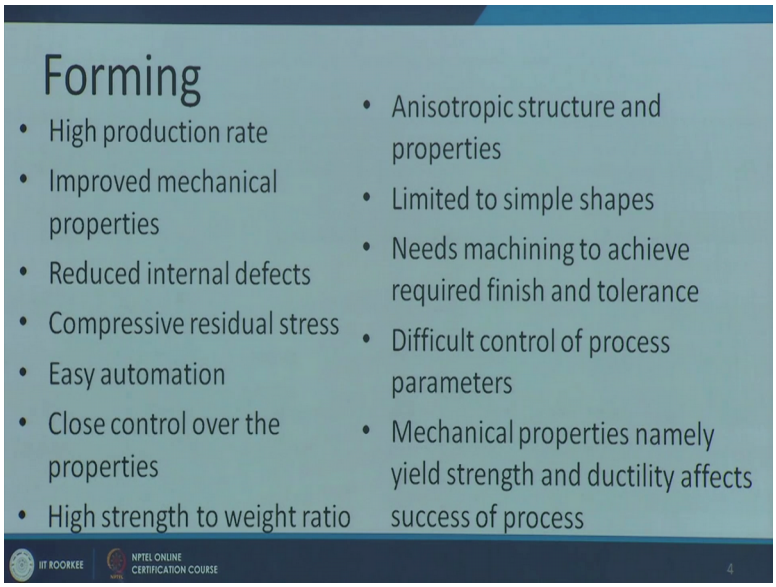

And the compressive residual stresses another advantage is the development of the compressive residual resistance this process, whenever the deformation takes place by processes like the rolling or the controlling here the surface layer deformation is more as compared to the core region, and this in turn leads to the presence of the compressive residual stresses. And these compressive residual stresses actually increase the capacity to take up the stresses, these compressive residual stresses are considered to be favorable, due to the two regions one they increase the tensile load carrying capacity of the product being made capacity, and they also improve the fatigue life of the product.

So, because of these two regions that component made by the forming process deformation based process, they will be leading to the improved fatigue life and increase it as a load carrying capacity. And that is considered to be farewell which in turn helps to make the product by the forming processes of the lighter in weight because of the high strength weight to weight ratio and increase load carrying capacity, easy automation in

these processes and close control over the properties is achieved, because we can regulate the extent of the deformation followed by we can adjust the extent of deformation that we want to in each a step. Thereafter we can use the post forming heat treatment process to adjust the structure and properties as per requirement.

So, the control over the properties is very good at the same time high strength to weight ratio is achieved, because this process through work hardening has to achieve the higher strength for the same mass of the metal. And therefore, strength to weight ratio which is achieved by the components made using the forming processes or deformation based process, that becomes quite good and, but there are certain other issues and the limitations related with the forming processes.

So, these limitations of the forming processes include like an isotropic structure, and properties limited to the simpler shapes because the deformation process really cannot help to achieve very complex shape, and very high aspect ratio a sections cannot be made with the complex geometrical features. And therefore post machining the post forming machining operations or secondary processing is needed to achieve the desired size, and the shape as well as features. And therefore, it needs machining to achieve the required finish and tolerance the finish and tolerance which is achieved with this process is also not that good, because especially when the hot forming waste processes like hot rolling cold and hot forming hot forging is used during the processing material will be expending at high temperature. And then if when it cools down the shrinkage takes place.

So, the this changing dimensions of the component due to the heating and subsequent killing cleaning, in case of the hot forming process especially makes the control over the dimensions difficult, and especially at the same time increase in temperature also leads to the increased oxidation tendency of the metal, and which they reduces the surface roughness of the metal. And therefore, the machining is needed.

So, that the required finish and the tolerance can be achieved difficult control of the process parameter since the processes deformation builds. So, we need to control the temperature of the metal which is being deformed, we need to control the rate at which it is being deformed, and in appropriate control over the temperature as well as the rate of as well as the rate of deformation, will lead to the development of the surface defects onto the surface of the component which is being made by the forming process, and

which will lead to the simply rejection or the product with the undesirable characteristics and the properties.

Another important point will be the limitation is that the mechanical properties namely yield strength, and ductility affects the success of the process. And normally whenever work hardening takes place the strength and hardness increases, but at the same time the ductility of the work hardened component comes down. So the products which are made using the forming process may be experiencing the localized loss of the ductility, as well as toughness.

So, we need to be very careful if the application needs if application of the component made by the forming processes need the toughness as well as the ductility. Then in those cases, we need to be careful to avoid any premature failure.

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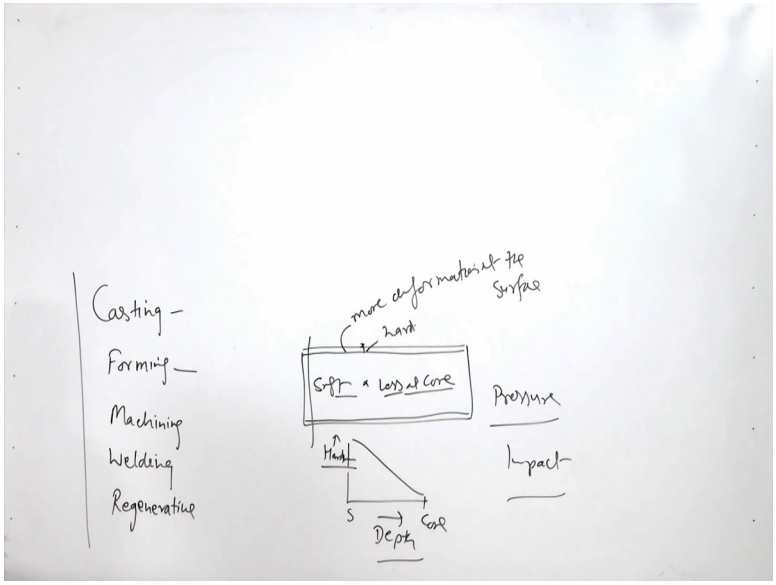

I will explain little bit more the anisotropic e x structure and the properties of the form component we know that in the deformation, we apply either we apply pressure for causing the deformation or we apply impact. So, in case of the pressure and in case of the impact, in case of the impact the deformation is not uniform throughout the section like the surface layers will be deforming more as compared to the inner core material.

Well, it is expected that deformation in case of the in those cases where pressure is applied is by enlarge uniform, but is still the deformation is more experienced that the

surface as compared to the inner core material of the component which is being deformed to get the desired size and shape, and because of this differential deformation more deformation at the surface, and less at the core. So, because of this the core remains soft and this becomes hard. And because of the increased hardness, so this simply leads to the since this simply leads to the variation in properties of the material like, if you measure the properties from the surface to the depth. So, from the surface to the core of the material, we miss we may find that there is continuous drop in the hardness, and strength of the material with the increasing depth from the surface.

So, with this kind of the trend there is the differential property very this the property variation is attributed to the difference in the work hardening behavior, another important thing which is observed is during the deformation based processes material is a force to flow in a particular direction, which is called longitudinal direction and that due to the application of the force material flows in one particular direction.

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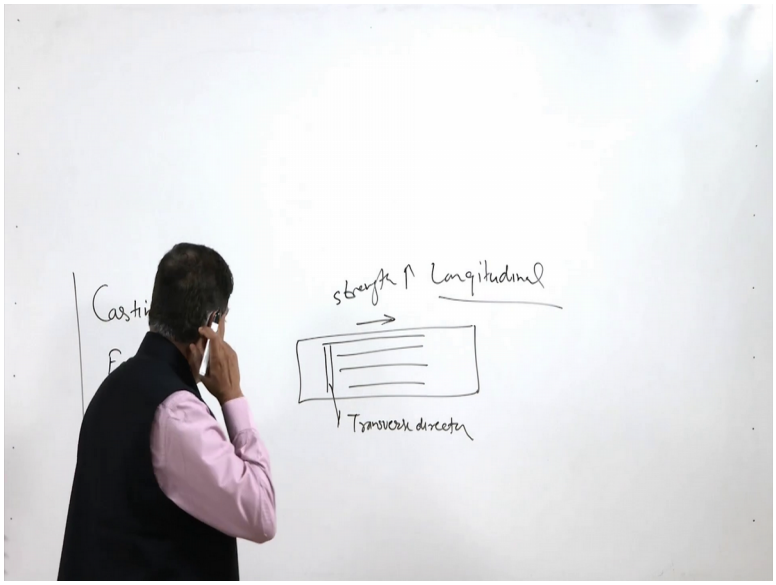

So, the direction in which material flows we find much better a strength as compared to the direction perpendicular to that, so longitudinal direction; direction, in which the grains will be flowing the strength is found to be much better as compared to the strength is high in longitudinal direction or the direction; direction, in which the flow of the grains take place during the deformation, longitudinal, and the transverse direction is this.

So, the properties in the transverse direction or means the direction perpendicular to the flow of the grains, the perpendicular the direction in which the grains have flown under the effect of the external forces, that direction is the transverse direction, and in that direction, the strength and strength is found to be a lower then the longitudinal direction.

So this is another aspect, so while designing the manufacturing process or while deciding the direction in which the flow is to be achieved, we need to consider the way by which the material will be subjected during the service, coming to the another machining process another manufacturing process is the machining one.

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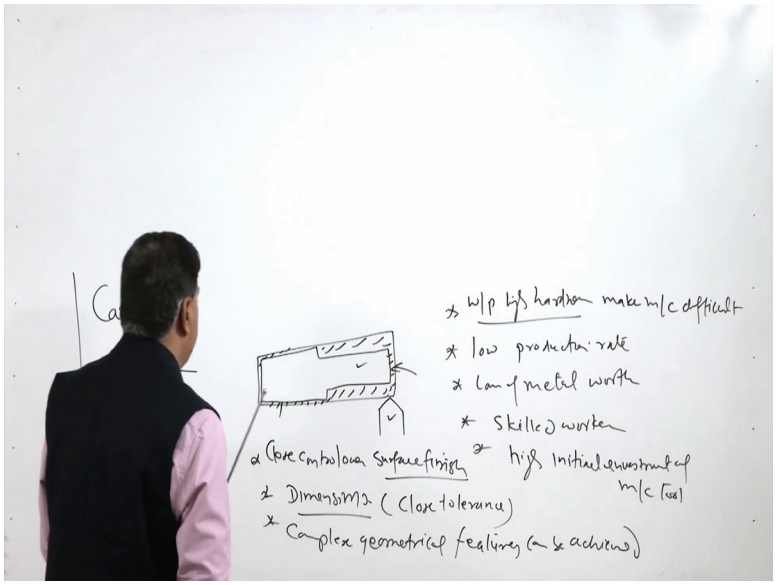

We know that in case of the machining we take the stock material like this, and using the suitable cutting tool the unwanted material or unwanted extra material, like say this is the unwanted this is a shape which is to be achieved. So, the unwanted extra material will be removed by so, this hatch the portion is the portion where from material is to be remove, say this is the turning process is where facing will be done this turning region, and this is the region where turning is to be done.

So, now, when this is applied what we get we get very close control, over surface control, over the surface finish this is one and very close control over the dimensions. So, very close tolerance can be maintained using the machining process that is another that is why most of the formed component or the cast component are processed through the machining, so that the desired control over the dimensions and the surface finish can be

achieved, at the same time very complex geometrical features can be achieved by machining, which is otherwise not so, easy to be made in case of the casting and forming, with the such a precision as well as good surface finish.

So, the complex geometries can be achieved, but the process has the limitation of the low production rate, because the material is removed the sequencely 1 by 1, so it takes long to achieve the desired size, and the shape. And there is a loss of metal work material whatever is removed is lost info is lost and cannot be used further for any other useful purpose and therefore, the metal loss takes place very skill worker or machinist is needed for machining purpose, and high initial investment on the machine tool is not high initial investment on machine tool is needed to get to perform the machining purpose.

So, these are some of the limitations at the same time, we know that to facilitate the machining of the material, it is necessary that tool penetrates into the work piece, but that penetration will be possible, only if the tool is harder than the work piece, if the work piece itself is harder than the tool, then it will not allow any kind of penetration. And that is why the work piece of high hardness, they offer resistance they make the machining difficult. So, high hardness materials make machining difficult by the conventional process, this is another one. So high harder means the materials of the very high hardness cannot be easily processed using the machining process.

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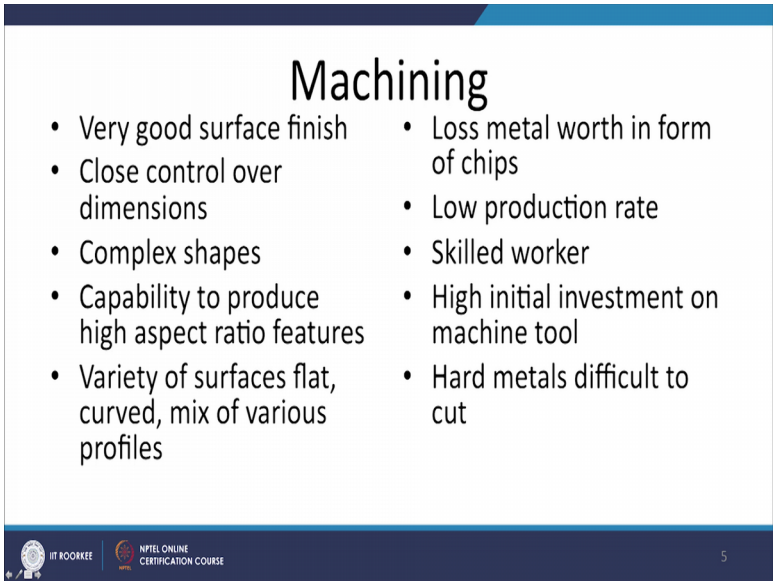

So, the advantage side very good surface finish very close control over the dimensions, and very complex shapes can be produced. And its capable to produce very high aspect ratio features which otherwise cannot be made using the like forming and the casting processes, and the variety of surface features like the flat curved or mixed of the various profiles can be easily made.

So, these are the advantages and these are the disadvantages and the limitations associated with the machining processes, coming to the welding processes welding you know the welding or you can say the joining processes.

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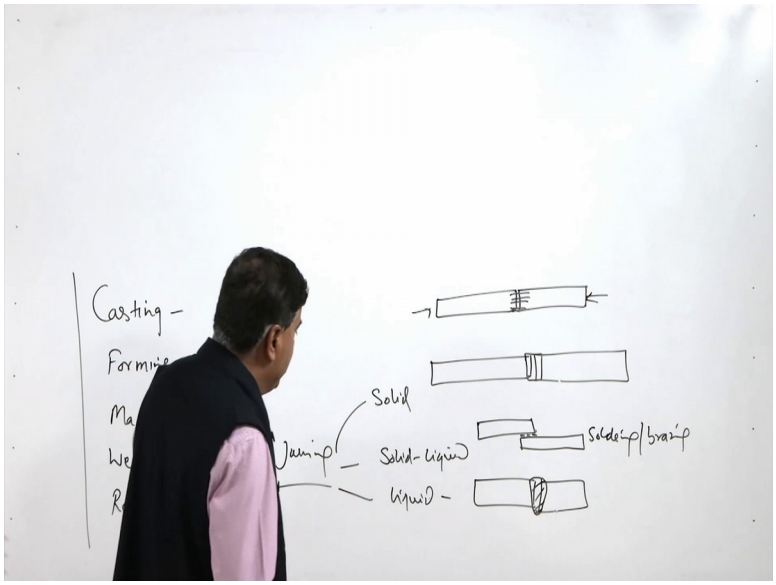

There are three variants in the joining processes like, the solid state joining processes, solid and liquid state joining processes, and the liquid state joining processes, so liquid state joining processes, where the components to be joined need to be brought to the molten state with the application of the heat. In case of the solid liquid joining processes what we do the components to be joined are just heated, so that the material low melting one material can be filled in.

So, the process is like shouldering and brazing fall in this category well in case of the solid state joining processes the components are maintained in the solid state. And the application of the force helps to make the two have the metallic continuity as well as or we can use the processes like the diffusion were clean the polished surfaces, are kept

under the pressure, at high temperature, so that the diffusion across the interface takes place to have the metallic continuity this is about the process.

So, the range is, so wide that it allows very good features to the joining. So, if you go by the advantages related with the joining processes.

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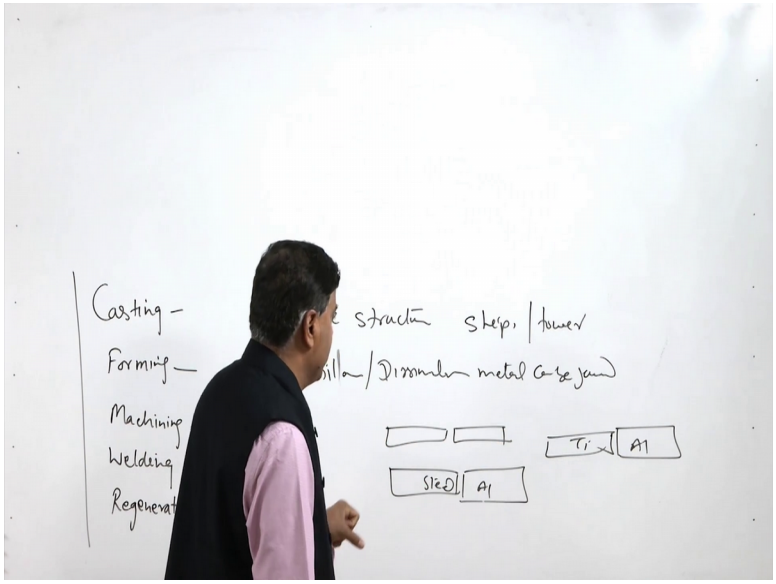

It can it helps to make very large structures, it allows to develop the large structures like, ship or big towers like, f a tower is also one of the example where simple shapes are joined together to make a big tower . So, here what we do for fabrication of the ships the simpler plates are joined together by welding to achieve the little large sized structures.

Another thing it can make it can help to develop the joining of the similar and dissimilar; both similar and the dissimilar joins can be similar and dissimilar metals can be joined, because there are examples like joining the paper with the metal, or joining the likes say a steel with the aluminium, or joining of the titanium with the aluminium. So there are very means they completely different kind of a metal systems can be joined using the suitable combination of the process, whether it is chemical based like that has use can be used or like solid state joining process or the solid and liquid state joining process can be used as for the compatibility the suitable kind of the process, joining process can be selected to have the joint between any two systems.

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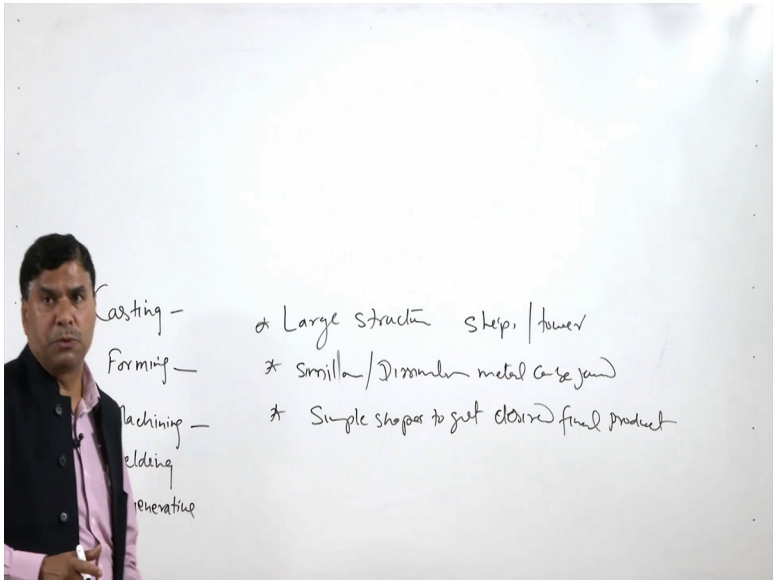

So, large structures, so the good feature is that it uses the simple shapes to get the desired final products, means this process is good for making those safes which cannot be otherwise we realized through the forming or the casting processes, or the machining will be uneconomical, so there is another side.

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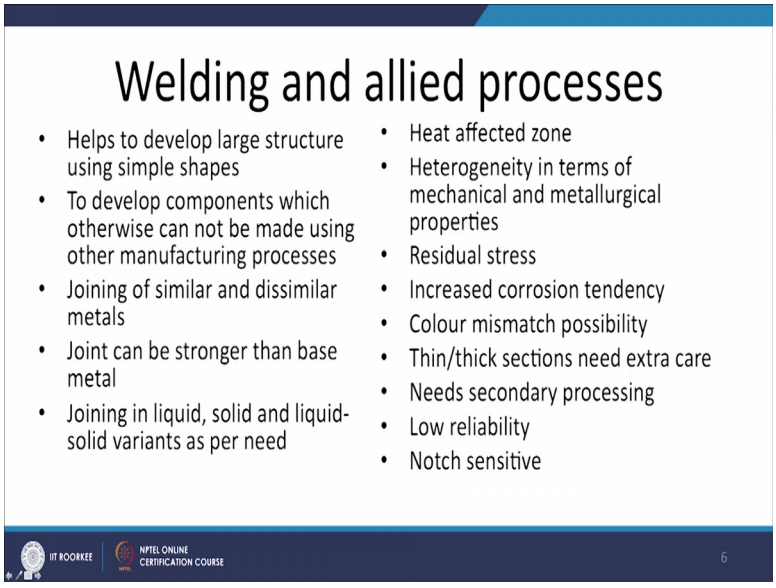

So, coming to the advantages of the welding and allied processes, if we see here it helps to develop the large the welding processes helps to develop the large structures using simple shapes like ships and towers. To develop the components which otherwise cannot

be made using the other manufacturing processes, like it using the simple steps we can make the components otherwise very easily more economically otherwise which will be difficult using the forming or casting processes, and it allows the joining of the similar as well as the dissimilar metals joints can be stronger than the base metal. This is another good feature if we are thinking that joint will be weaker then, the processes even the fusion welding processes or the solid history joining process they may allow to have the connection between the 2, which will be much even stronger than the base metal.

So, it will perform as good as the base metal except that in some cases heat affected zone is produced, so that needs to be taken care of and there are various variants of the joining processes like liquid solid, and liquids and liquid solid variants as per the requirement the suitable variant can be selected, so that the joint can be made. As far as the negative aspects are concerned especially, when we use deformation based process or the fusion based processes we find a region next to the weld joint which is called heat affected zone. This heat affected zone has the different micro structure and different mechanical properties and therefore, this sometimes this become the source of the weakness in the joint and therefore, this heat affected zone must be taken care of.

The weld joint offers the heterogeneity in terms of the mechanical properties, and the heat affected zone as I said the heat affected zone off has the different a structure, and different properties, sometimes the hardening of the heat affected zone takes place and sometimes even the softening of the heat affected zone occurs thin and thick sections need extra care in case of the welding, thick sections lead needs to the multi pass processing which results in the very wide heat affected zone as well as thin section can lead to the made through or increased distortion tendency of the thin sheets the control of the weld pool becomes very difficult in case of the thick sections.

Thin sections residual stresses which is which are integral part of then all types of the welding processes, mostly it is found residual stress are found in the fusion welding processes which are very tensile in nature. And these are promote the failure in number of adverse working conditions of the weld joints increase corrosion tendency, color mismatch possibility and the limited reliability and no sensitivity.

We know that all these features actually reduce the reliability of the weld joints regenerative processes another category of the manufacturing process. These are this is

the newer category of the manufacturing process wherein the complex ships can be very easily produced.

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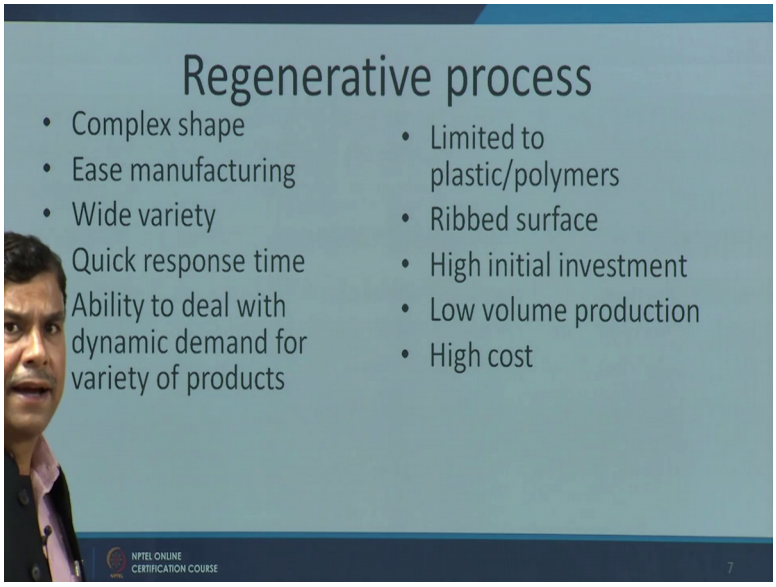

This process is very easy to use for manufacturing the simple shape products of very large in variety means the different geometrical features, the different dimensions can be easily made, because it uses the cad cam and rapid prototyping principles for making the product, and it offers very good response to the changing conditions of the market. So, as for the requirement of the demand response the requirement of the market, designs can be modified, and the volumes which are to be made, can be modified all that is used for very low volume fraction purpose ability to deal with the dynamic demand for the variety of the products.

But the limitations are like in the process these processes are not very matured as of, now this process this category of the processes are limited to the plastic, and the polymers, and the water surfaces are generated they have the rim surface feature surface finish is not that good. And the initial investment on the systems which are needed for this category of the processes are very high, the process offers were limited volume of the production and the initial cost are the cost of the product which are made using this is high.

So, here now I will summarize this presentation, in this presentation I have talked about the advantages associated with the common manufacturing processes, and their

limitations the processes about which I have talked included like casting, forming, machining, welding and regenerative processes.

Thank you for your attention.