Fundamentals of Manufacturing Processes
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Lecture - 06
Selection of Manufacturing Processes

Hello, I welcome you all in this presentation related with the subject Fundamentals of the Manufacturing Process. And this particular presentation is based on the selection of the manufacturing processes. So, the topic is selection of manufacturing processes.

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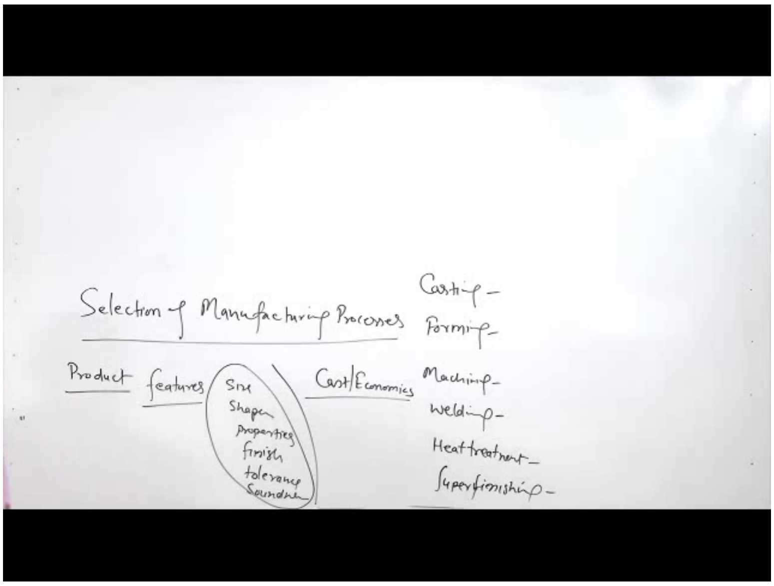

We have seen that there are wide varieties of the processes like casting, forming, machining, welding; and then you can say the property enhancing processes like heat treatment for bulk material and the coatings etcetera for a surface property enhancement, and then super finishing processes.

Since, the each process works on the different approach for achieving the desired size and shape. Therefore, the mechanical, physical and chemical properties of the material to be processed significantly affect the success of the processing by a particular process or the productivity, which will be associated with a particular process for achieving the desired size and shape. So, what are the factors that we need to consider when a selection is to be made. And of course, what we need first there are two aspects related with the selection, one is the product features which are related with the size, shape, properties, finish, tolerance, soundness or at the acceptance level.

So, the product related features are very wide, but as these will be determining how successfully, how effectively product can serve the purpose for which it has been made, but there is another category also which is related with the cost are the economics related with the manufacturing. So, under that only we need to see how it is to be made, so that a product can be made cost effectively in, so that it does not affect to the environment. It is economical and it also serves, it serves the purpose for which it has been made its life is good and so that the purpose of the manufacturing as a whole can be achieved.

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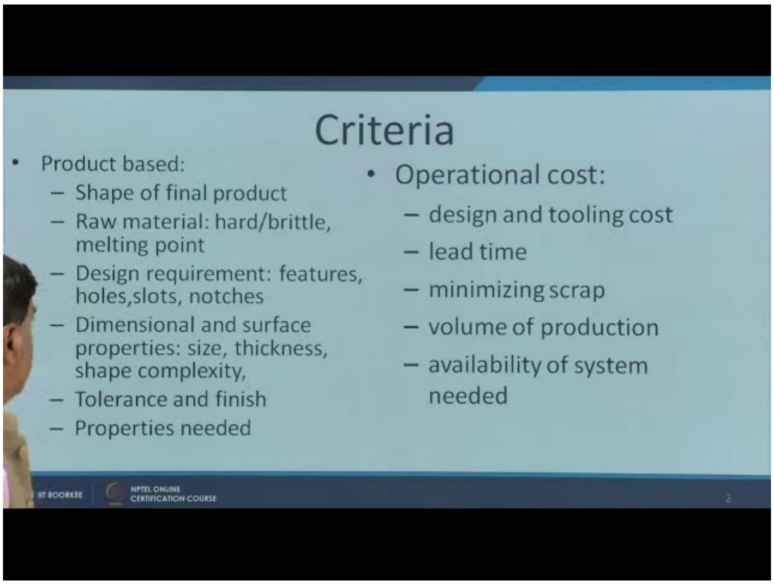

So, if we go by the different factors which are associated with the selection of the manufacturing process those which are product based and those which are operational cost or the economics based. So, if we see the shape of the final product, raw material to be processed, the design requirement like features, holes, slots, notches, etcetera to be achieved. The dimensional and the surface properties inform of the size, thickness and the shape complexity which are to be achieved; the tolerance and the finish which is to be achieved, then the properties that are needed in the components like very high strength to weight ratio or very good surface properties, interior properties may not be that a important. So, these are the properties that a we need to consider that we need to achieve in the product which can be made by any of the processes or by combination of the certain processes provided that is achieved at the minimum possible cost, and minimum harm to the environmental conditions.

And for that what we need to see how much design and tooling costs are involved for making a particular product using a process. Because either for casting, forming, machining, welding, heat treatment and super finishing, we need one or other kind of the equipment. So, if that is available it is fine if it is not then we need to make it we need to arrange it, so their costs related to the design and tooling. And then lead time, how much time it will take to get the product, so that after the placement of the order, so that the lead time is a time which is required for getting the delivery of the product after the order is a placed. So, if you have that kind of luxury where long time is available or for certain big customized products long lead time maybe as long as few months to the years also. Then we have the minimizing this scrap, the volume of the production availability of the system which is needed for manufacturing.

So, these are the factors related these are the factors which will be determining the cost at which a given product can be made. And these are the features which will be governing the casting processes in order to realize these pictures in the productive. So, here we will be going one by one through these aspects related with the processes and the product features which can be achieved.

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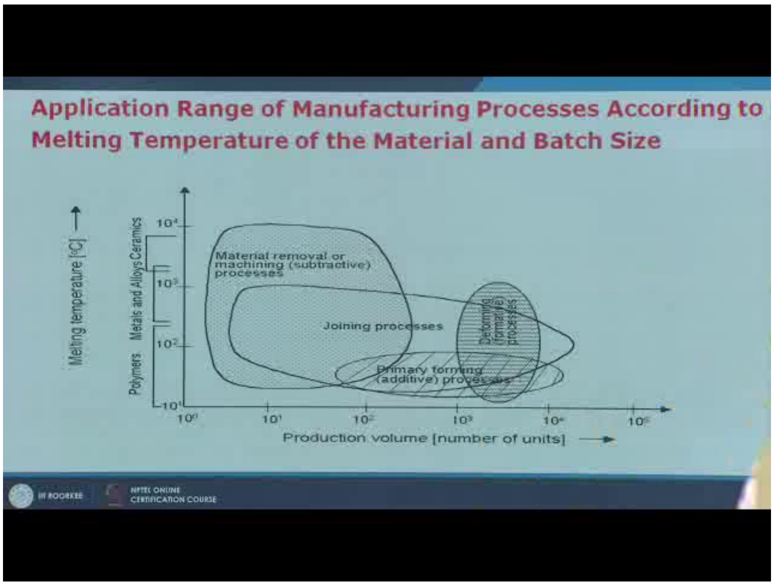

So, here this is one very basic diagram. What it shows in x-axis, what we have the volume of the production or the number of units which are to be made is starting from 1, 10, 100, 1000, 10,000, 1,00,000. And on the y-axis, we have the temperature melting point temperature of the material to be processed we know that the polymers will have the lower melting point temperature then metals and then ceramics. So, for the polymer, it is say from the 10 to 100; and then for the metals it is from say 200 to about like say 2,000 to 3,000 degree centigrade; and for ceramics about 3,000 to the higher temperature of say 7,000 or 8,000 degree centigrade.

So, the processes which will be having the lower melting point, they can be easily processed through the certain category of the processes those which have the higher melting point, they can we processes through another category of the processes. Similarly, the processes, which will be involving the lesser volume, they can be made by one category of the processes those, which will involving the larger volumes they can be made by another category of the processes.

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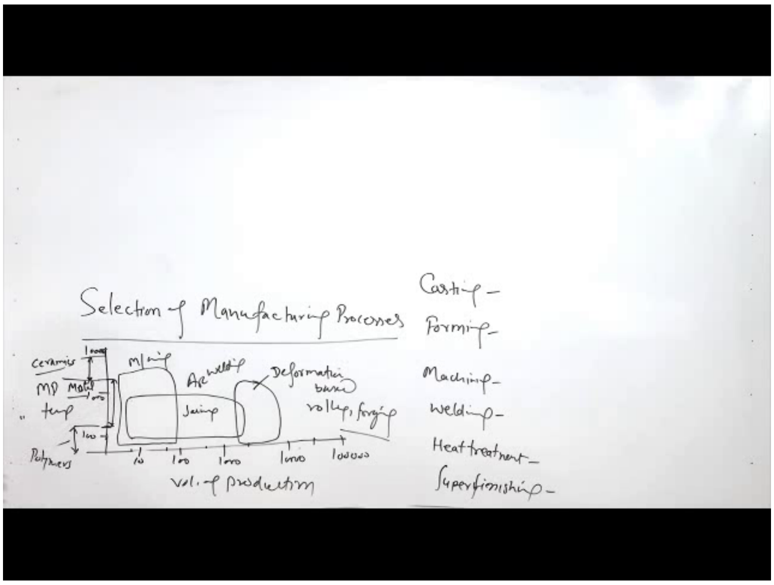

So, here if we see if you tried to put in this diagram in the x-axis we have volume starting with the say here it is a 0, 10, 100, 1,000, 10,000, 1,00,000 in the x-axis. And in the y-axis, we have the melting point temperature, so this is up to the 100, then up to say 1,000 then 10,000. So, for the metals, this is the range this is approximate range for the metals; and at this range is for the polymers; and above this it is the range say for about 3,000 to the higher or 7,000, 8,000 it is for ceramics.

So, if you see this diagram the machining processes are good for the smaller volumes like say this is the rough band for the machining processes; for joining processes, it is a slightly longer; this is for the joining processes, joining, machining and the primary forming and the deformation based processes. So, here the deformation based processes, this is the band for the deformation based processes, normally they are justified for the higher volumes like 1,000 to the 10,000. So, deformation based processes. So, here it will be involving like rolling, forging, extrusion etcetera joining will be involving like arc welding and the machining.

So, we can see for if the final size and shape of the product is to be achieved only through the machining, then the volumes are limited, for limited volume this can be done, but for even for the harder material. And if the joining is to be done to get the desired size and shape then the volumes rpt large and you can say it can be used for the metal systems or the systems having the moderate range of the melting point temperature like say 200, 2000, or 1500 degree centigrade. And then for the deformation based processes like hot forming or hot deformation based processes can be used for even higher melting point temperature metals, but these are justified only for high volume productions.

So, here if you see 10, 100, 1000 forming 1000. So, we can adjust this scale little bit on the higher side. So, here this is 10, like 100, 1,000, 10,000 and 1,00,000 like this, so volume of production. So, a high volume processes are the deformation based processes; for moderate range, it is joining; and for the very low volume it is machining. Primary forming processes like the casting this is good for the narrow range of the melting point as well as like this. So, this is the band for the primary forming or the casting based processes. So, not too high melting point and not too low or not very high the volumes for which it can be used.

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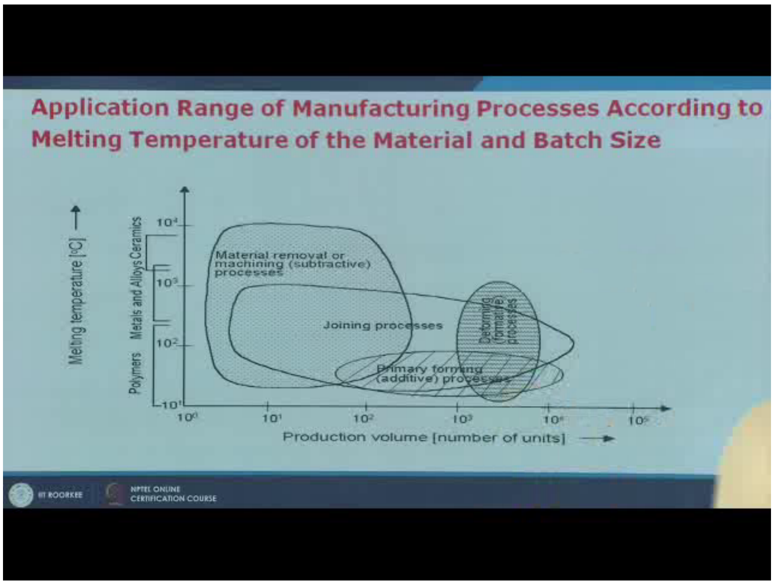

So, if you see this one, this is the primary, this is the joining, this is the material removal and this is the primary forming processes, and this is the deformation based processes. So, a for the low melting point systems and for joining, so this is how we can say the selection is based on here.

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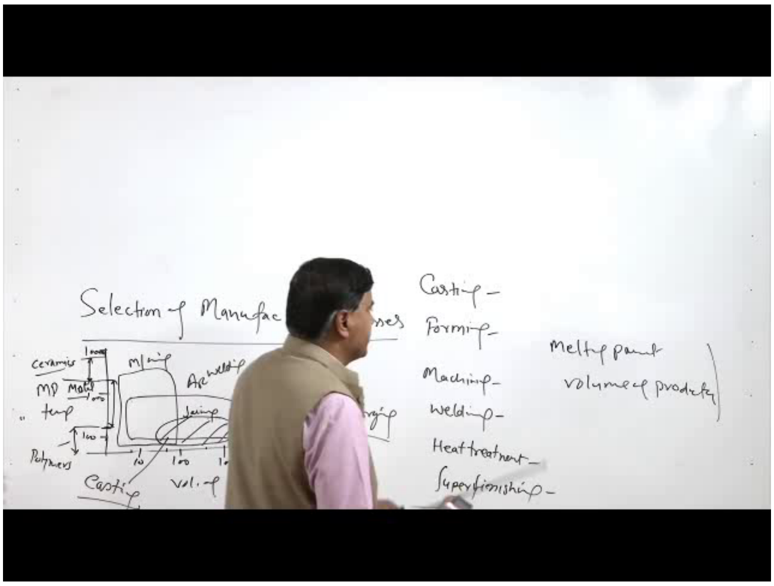

So, the properties are basically the melting point and the volume of the production these are the two things that govern the economics as well as the properties of the material help in deciding the processes to be used for manufacturing a product.

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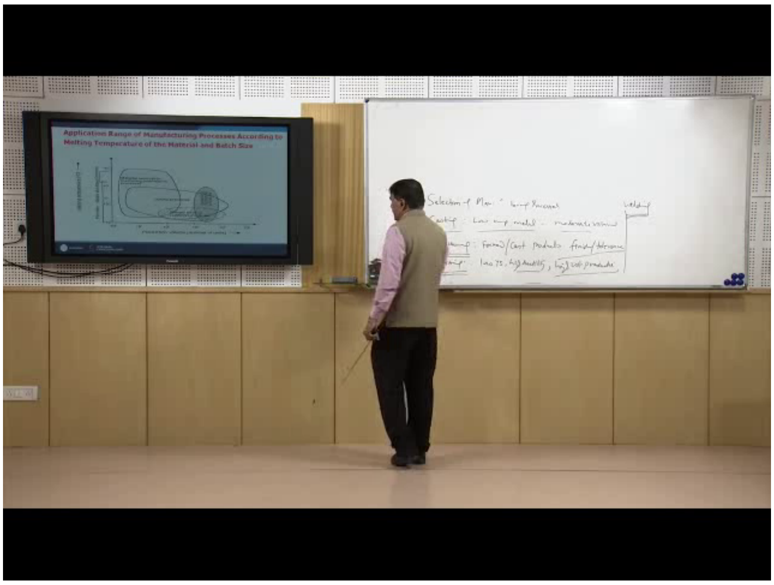

So, if we see the casting wise the casting processes are normally selected for the low melting point metals and for moderate volumes. Then the machining processes these are selected for mostly all formed and cast products are subjected to the machining, primarily for achieving the finish and the tolerance. Primary shaping is not much a done using the machining; and if it is to be done then very limited volumes are used for production purpose of the machining; otherwise mostly machine is used as a secondary a processing, so tolerance.

And then forming processes, forming processes are used for the low yield strength and the high ductility metals and for the high volume production when the volumes to be made are very large then only this high volume production processes based on the forming are justified. And the welding is used when welding is used when the desired size and shape cannot be achieved through the primary forming or primary shaping processes like casting and forming. And in that case we try to use a welding or joining processes, so that the simpler shapes can be brought together to get the desired size and the shape, but there after a frequently the machine is carried out for achieving the desired finish and the tolerance and even in case of the welded joints.

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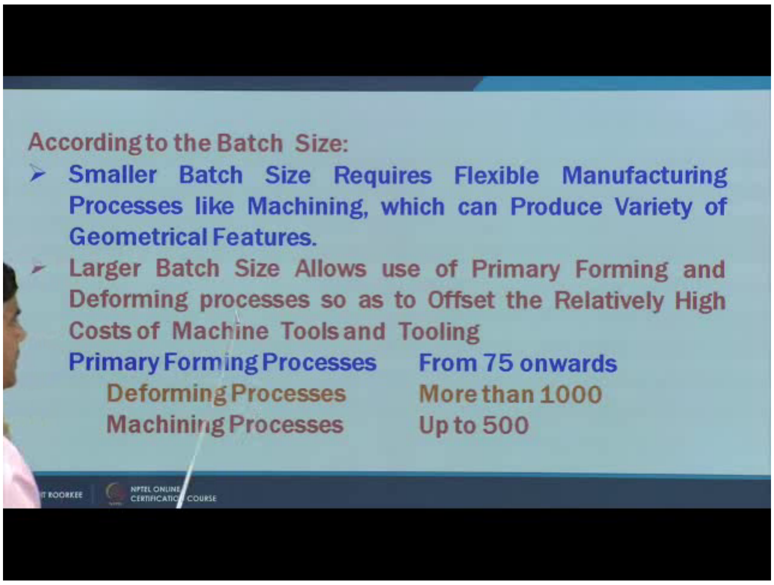

So, according to the batch size, if the product is to be made then there are three options like the small batch size requires the flexible manufacturing processes like machining, which can be used for producing the verity of the geometrical features. Well, the large batch size allows the use of the primary forming and the deformation based processes in order to offset the relatively high costs of the machining and tool. So, the primary forming processes will be used like say from the 75 number of the units were made and onwards. The deformation based processes will be used for more than 1,000; and the machine based processes maximum up to the 500, because it is not very economical to achieve their primary shape using the machining.

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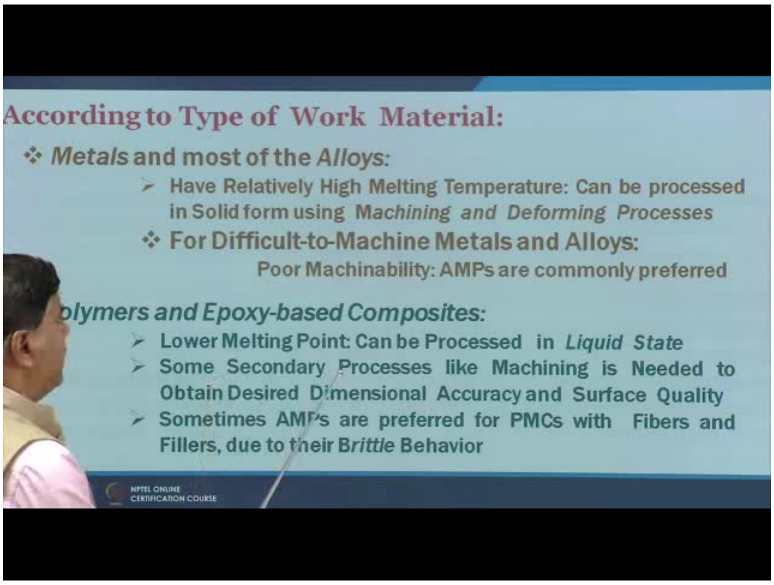

Now, based on the work piece material as I have said the material of the low melting point metals they are preferred to be processed through the casting rod, and metals of the low yield strength and high ductility metals are preferred to be processed through the formation or deformation based processes. But it still in each of the category we will see that certain unique features are there which are which will be guiding us to which will be forcing us to select a particular kind of the process for example, the metals and most of the alloys really does not metals they have the high melting point temperature

So, they can be processed in the solid form using the machining or the deformation processes because this will be making the melting of the metals difficult. And for their certain difficult to machine materials which cannot be machined because of the high hardness. Then they require they offers the poor machinability using the conventional processes, and therefore advanced manufacturing processes are used for processing up those metallic systems.

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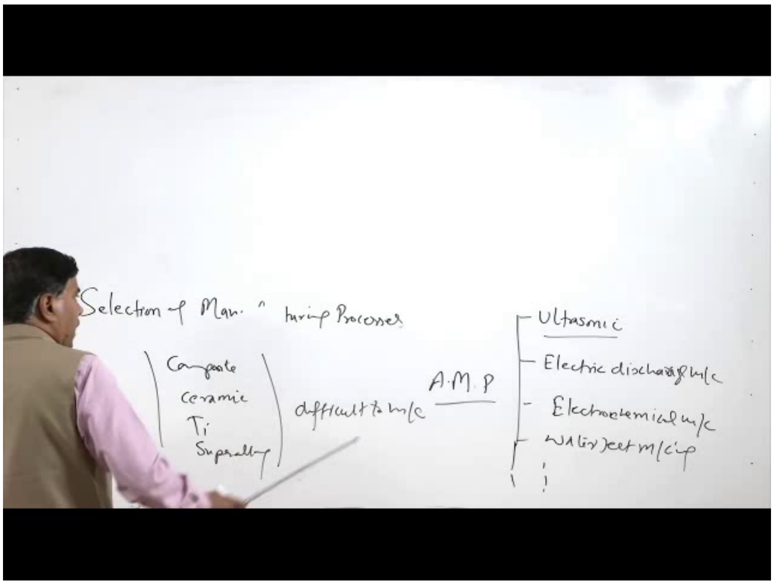

So, the metals like composites ceramics which uncertain metal systems like titanium alloys and super alloys having these are the difficult to machine materials by the conventional processes. So, it is preferred that the advance manufacturing processes AMPs are used for them. And there are number of advanced manufacturing processes like ultrasonic processes ultrasonic machining, electric discharge machining, electro chemical machining, water jet machining. So, there are further larger more number of the advanced manufacturing process; and in these processes, we are able to even remove the material in control way, so that desired size and shape can be achieved through the advanced manufacturing processes.

So, difficult to machine materials are further subjects to the advance machining processes so that the desired a dimensions and the finish can be achieved. Like the polymers approximate composers they have the low melting point and can be processed in the liquid state. Some secondary processing is like the machining is needed in order to achieve the desired finish and the quality. And sometimes advanced manufacturing processes preferred for processing the polymer matrix composites with the fibers, fillers, because of their brittle behaviour. So, certain the composite materials of the polymer base can be processed using the advanced manufacturing processes, but means especially to deal with brittle behaviour of such metal; otherwise mostly because of their low melting point liquid state processing of the polymers and the plastic is carried out.

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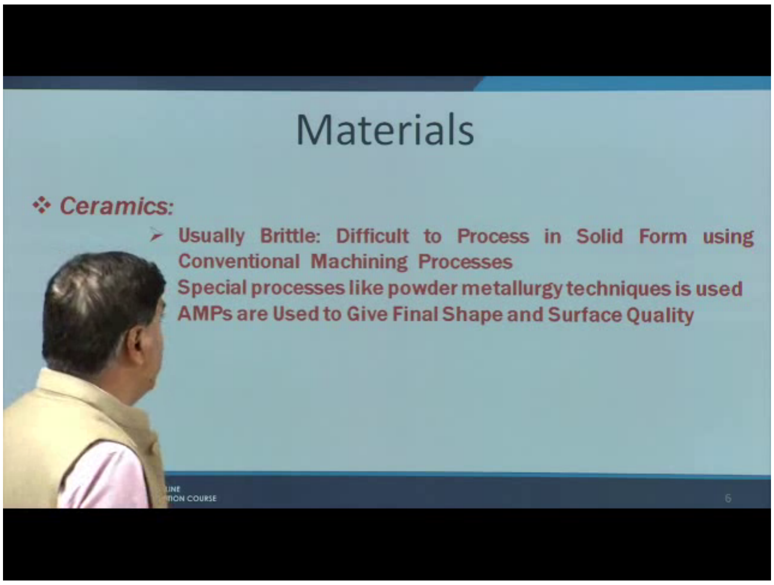

Now, you will see the ceramics, which are usually brittle and difficult to process in solid form using the conventional processes. And therefore, conventional machining processes are normally not applied even they are because of high hardness and brittleness they are difficult to be processed through the formation forming based processes and the joining based processes. Therefore, advanced machining processes are used for a processing the ceramic materials. And therefore, sometimes a special processes like powder metallurgy technique is used to get the desired size and shape or they can be advanced manufacturing process can be used to get the desired shape and the surface quality when using the ceramics.

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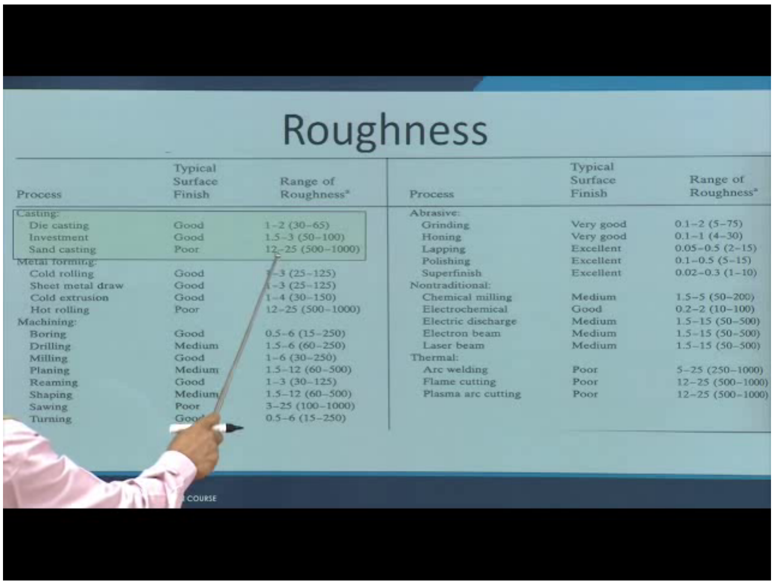

Process	Typical Surface Finish	Range of Roughness*
Casting:		
Die casting	Good	1–2 (30–65)
Investment	Good	1.5–3 (50–100)
Sand casting	Poor	12–25 (500–1000)
Metal forming:		
Cold rolling	Good	[illegible]–3 (25–125)
Sheet metal draw	Good	[illegible]–3 (25–125)
Cold extrusion	Good	1–4 (30–150)
Hot rolling	Poor	12–25 (500–1000)
Machining:		
Boring	Good	0.5–6 (15–250)
Drilling	Medium	1.5–6 (60–250)
Milling	Good	1–6 (30–250)
Planing	Medium	1.5–12 (60–500)
Reaming	Good	1–3 (30–125)
Shaping	Medium	1.5–12 (60–500)
Sawing	Poor	3–25 (100–1000)
Turning	Goo[illegible]	0.5–6 (15–250)

Process	Typical Surface Finish	Range of Roughness*
Abrasive:		
Grinding	Very good	0.1–2 (5–75)
Honing	Very good	0.1–1 (4–30)
Lapping	Excellent	0.05–0.5 (2–15)
Polishing	Excellent	0.1–0.5 (5–15)
Superfinish	Excellent	0.02–0.3 (1–10)
Nontraditional:		
Chemical milling	Medium	1.5–5 (50–200)
Electrochemical	Good	0.2–2 (10–100)
Electric discharge	Medium	1.5–15 (50–500)
Electron beam	Medium	1.5–15 (50–500)
Laser beam	Medium	1.5–15 (50–500)
Thermal:		
Arc welding	Poor	5–25 (250–1000)
Flame cutting	Poor	12–25 (500–1000)
Plasma arc cutting	Poor	12–25 (500–1000)

So, as I have said there are various processes which have the different kind of the capabilities, for example, the castings is the fastest route to get the a complex shapes, but very thin sections cannot be made. The forming is the best method for making the simpler cross section simpler shapes at a very high rate provided the volumes to be produced are high, so the forming will be good for those processes. And the machining is good for achieving the desired dimensional control and desired surface finish. The welding is used for a fabrication of the products which otherwise cannot be made by other manufacturing processes. So, the welding or the joining is to be used only under those conditions primarily in those conditions where the given shape cannot be achieved by other processes. So, but each of the process will have certain capabilities to produce the certain dimensional features, to produce the surface properties, and to offer the certain the tolerance which can be achieved by a given process and the kind of finish which can be achieved by a giving process.

So, now we will see that what kind of surface roughness can be achieved by the different kind of processes and what kind of tolerance which can be achieved by the given manufacturing process. Because among the features or the properties desired in a product the roughness and the dimensional control of the product is important which affects the functionality and the performance of the product and that is why we will be seeing one by one the kind of roughness. First of all we will talking about the roughness and there after we will see the tolerance which can be achieved by the different processes. So, it starting with the roughness.

So, if you see the casting processes in the casting process as cast component here what we can see this is like the casting process have the die casting, investment casting and sand casting. So, what we can see the range of roughness which can be achieved. So, here we can see one to two is the roughness RA in micrometer for die casting. Similarly, for investment casting roughness is 1.5 to 3 in micrometer RA in micrometer. So, here now we will the sand casting offers the poor surface finish as the roughness is high in range of the 12 to the 25 value, but the die casting offers quite good, surface finish which is in the range of 1 to 2 micrometer. If we see the machining processes boring offers the good finish ranging from 0.5 to 6.

And similarly, most of the processes we can see the turning 0.5 to 6 and the shaping 0.5 to 1.5 to the 12. So, we can see here 0.5 to 25 is the micrometer roughness in RA, which can be achieved by the different machining processes. So, these kind of machine processes are mainly used for achieving the desired shape and size. For finishing purpose, we may use another category of the processes, which are like abrasive processes. On the other hand, if you see the grinding processes offers a very closed very good surface finish ranging from 0.1 to 2 micrometer; and the honing 0.1 to 1; lapping 0.05 to 0.5; polishing 0.1 to 0.5 and super finishing 0.02 to 0.3. So, very good surface finish can be achieved through the abrasive base processes especially the super finishing processes.

On the other hand, if you see thermal cutting, thermal cutting offers very rough surfaces like 5 to 25; or a flame cutting offers 12 to 25 and plasma arc cutting offers 12 to 25. So, very rough cut surfaces are produced by thermal cutting methods. If we see the deformation based processes cold rolling offers the good finish in range of 1 to 3 micrometer; cold extrusion offers 1 to 4 micrometer. In comparison to the cold rolling hot rolling offer the poor rough surface finish and roughness is in the order of a 12 to 25. And a reason for this is that when the model is process that elevated temperature, it gets oxidized, so that oxidation adversely affects the surface roughness of the material.

So, we can see the casting, machining, abrasive base process and thermal cutting processes each of this different kind of the surface finish and the finish which will be realized. In a particular case that will depend upon the metal system which is use processed, and the process parameters that tool condition is stability and the robustness of the machine. So, there are various parameters which will be affecting the actual surface finish which can be achieved during the processing by a particular process. For example, here sand casting offers the higher surface roughness as compared to the die-casting.

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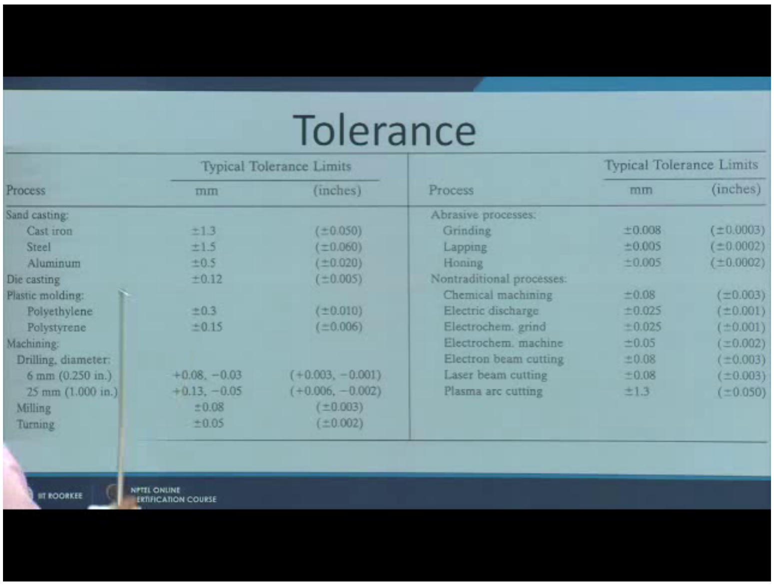

Process	Typical Tolerance Limits mm	(inches)	Process	Typical Tolerance Limits mm	(inches)
Sand casting:			Abrasive processes:		
Cast iron	±1.3	(±0.050)	Grinding	±0.008	(±0.0003)
Steel	±1.5	(±0.060)	Lapping	±0.005	(±0.0002)
Aluminum	±0.5	(±0.020)	Honing	±0.005	(±0.0002)
Die casting	±0.12	(±0.005)	Nontraditional processes:		
Plastic molding:			Chemical machining	±0.08	(±0.003)
Polyethylene	±0.3	(±0.010)	Electric discharge	±0.025	(±0.001)
Polystyrene	±0.15	(±0.006)	Electrochem. grind	±0.025	(±0.001)
Machining:			Electrochem. machine	±0.05	(±0.002)
Drilling, diameter:			Electron beam cutting	±0.08	(±0.003)
6 mm (0.250 in.)	+0.08, −0.03	(+0.003, −0.001)	Laser beam cutting	±0.08	(±0.003)
25 mm (1.000 in.)	+0.13, −0.05	(+0.006, −0.002)	Plasma arc cutting	±1.3	(±0.050)
Milling	±0.08	(±0.003)			
Turning	±0.05	(±0.002)			

Coming to the another important feature related with the important characteristics related with the manufacturing processes which we will be determining the kind of control over the dimensions which can be achieved through a particular manufacturing process. For example, for sand casting when the cast iron is processed control over the dimensions is to the tune of plus minus 1.5 mm; for a steels, it is plus minus 1.5; and for aluminium, it is a plus minus 0.5. I will just corrected; for cast iron, plus minus 1.3. In case of the die casting the dimensional control which can be achieved this plus minus 0.12, so very close dimensional control can be achieved here we can see in case of the die casting and which is much better as compared to sand casting process.

Then coming to the machining, so machining offers the dimensional control like as per the diameter or as per the size, which is being processed up to the 6 mm diameter. The dimensional control is possible in the range of like say a plus 0.08 mm to the minus 0.03, and up to say 25 mm diameter. This is possible in the range sleeve plus 0.13 to minus

0.05; for milling, it is plus minus 0.08; and for turning, it is plus minus 0.05. So, very close dimensional control can be achieved to the turning and milling processes.

Then abrasive grinding abrasive processes offer further closer control over the dimensions that is what we can see from the very close tolerance limits. For grinding, it is plus minus 0.008l for lapping, it is 0.005; and for honing it is 0.005. And the non-traditional machining offer further somewhat higher the tolerance limits like for chemical machining, it is plus minus 0.08. So, we can see that the different processes have the different capability to produce the different number of the products of the different metals having the variety of the metal systems economically.

So, there certain processes which can produce the low melting point metals in the smaller volume effectively, there is another category of the processes which can produced high melting point metals in the larger volume. There is another category having the moderate melting point and the very large volumes, which can be processed to the forming processes. So, for each kind of the material which is to be processed and the volume which is to be produced they are different. And according to the model to be processed and the volumes to be produced, we need to select a suitable process. At the same time, we can also see the each process offers the different kind of the surface finish as well as the dimensional control, which can be achieved. So, in light of the requirement of the product which is to be made we need to select the suitable process.

So, here now we will conclude in this presentation, we have talked about the various technical factors which need to be considered for selection of the manufacturing process. And there are two categories of the parameter which we need to consider one is the category of the features which are needed in the product to be manufactured, and another is a related with the cost or the economics. So, considering both the factors, we need to select the suitable process, so that the desired product can be made cost effectively without harming the environment and the entire manufacturing system is effective.

Thank you for your attention.