Fundamentals of Manufacturing Processes
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Lecture - 23
Casting: Shell Mould Casting

Hello, I welcome you all in this presentation related with the subject Fundamentals of the Manufacturing Process. And in this presentation we will be talking about some a special casting processes and these a special casting processes are slightly different from the sand mould casting process, so the special casting processes.

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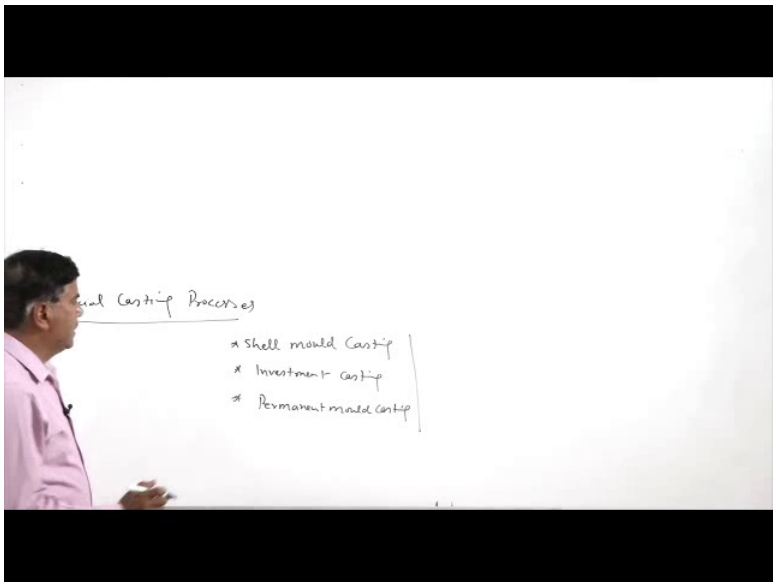

There are three casting processes a special casting process about which we will be talking about one is like shell mould casting process, then investment casting process and then permanent mould casting process. So, in this presentation basically I will be focusing in the shell mould casting process.

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So, in case of the shell mould casting process as it appears from its name the shell word, a shell is prepared using a mixture, using mixture of basically sand plus resins and plus additives.

So, a mixture of these three is used for preparing one shell which is used as a mould cavity for pouring the molten metal so that after the solidification desired casting can be achieved. Advantage of this process is that it helps to achieve very close dimensional control as well as the surface finish.

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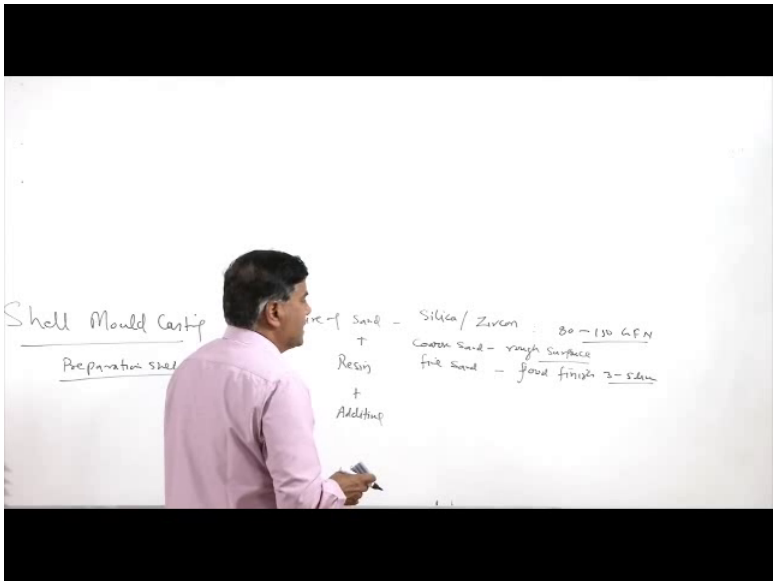

So, means the main part are related to this casting process is preparation of the shell mould. So, what we use for preparing the shell mould basically mixture of sand plus resins plus additives this mixture is first prepared. So, this sand mixture sand can be of the silica sand or zircon sand and it depending upon the metal to be processed by the casting process either silica sand or zircon sand or mixture of the two can be used. And normally the grain fineness very fine grains the sand grains of the fineness number are 80 to 150 grain fineness number sand grains are used for preparing the shell.

And these sand grains are depending upon the size you see the coarse sand is used for you can say where even rough surface of the casting is acceptable, but if high degree of the surface finish is needed then fine sand grains are used for good finish. So, the finish which can be achieved in this process is range like say 3 to 5 micrometer which can be achieved using the fine sand grains.

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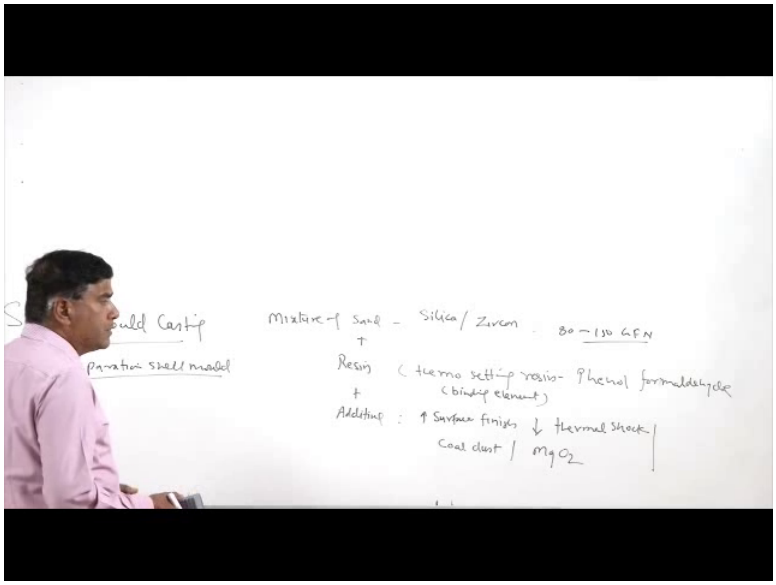

And this, then a mixture of the resins basically thermo setting resins are used thermo setting resins like Phenol formaldehyde, formaldehyde is used as a resins plus additives are these resins act as a binding element or binding member in the mixture to hold the sand as well as the additives. Additives are used basically to achieve the good surface finish and to reduce the thermal shock due to the pouring of the molten metal and for this purpose like coal; dust and the magnesium dioxide are used as additives. So, these will be helping to improve the surface finish as well as reducing the thermal shock so that the

cracking and fracture tendency of the shell can be reduced when the molten metal is poured.

So, all these mixture basically is prepared there is a particular process wherein like the sand dry sand which is free from any clay is provided with the liquid resins and it is thoroughly mixed with resins under the additives are thoroughly mixed for the use.

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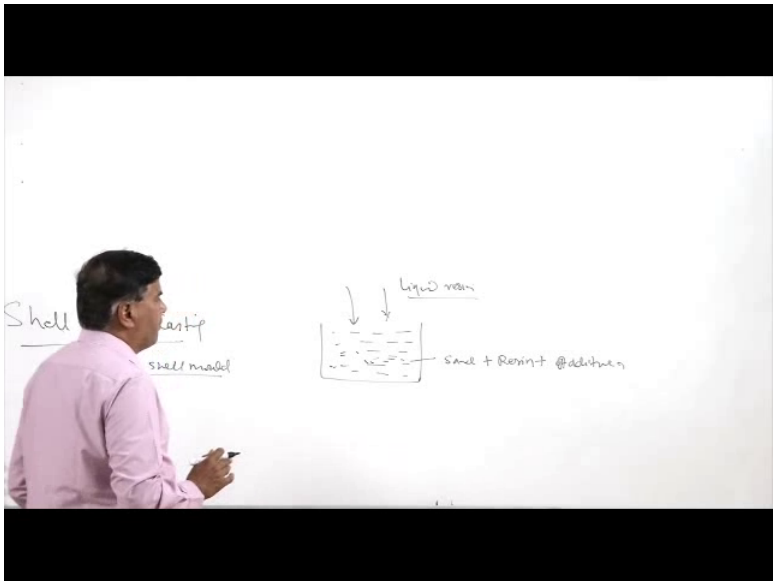

So, this mixture of the sand plus resins plus additives is prepared and then it is used for preparing the shell. So, what we will be doing basically this mixture is placed over these mixture is used for preparing the mould.

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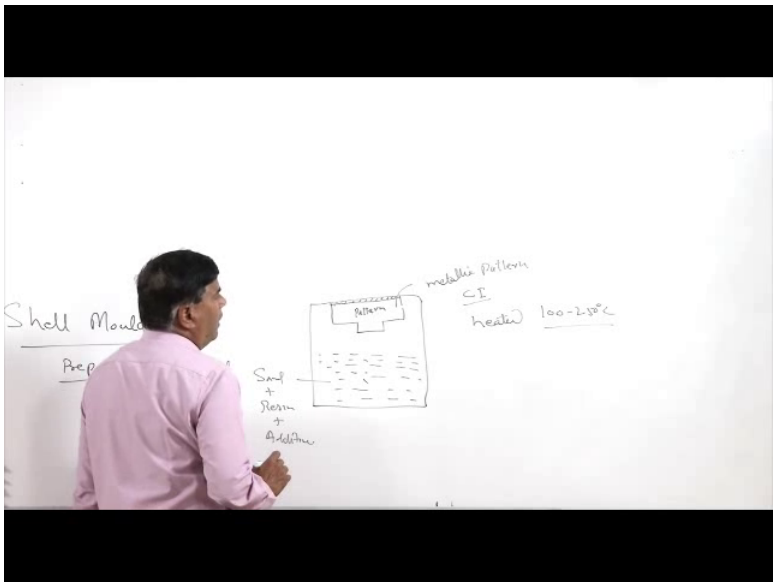

So, say this is the chamber where this mixture has been kept and in this one, one the pattern oh or pattern of a particular shape whose shell is to be prepared say this is the pattern this is attached with this cover and which can be opened and closed. So, this is the pattern which will be used for preparing the shell this is basically a metallic pattern mostly the cast iron or grey cast iron is used for preparing the pattern and this pattern is basically heated it can be heated from 100 to 250 degree centigrade. So, this heated pattern is a fitted in this box which is carrying this mixture of the sand, resins and additives.

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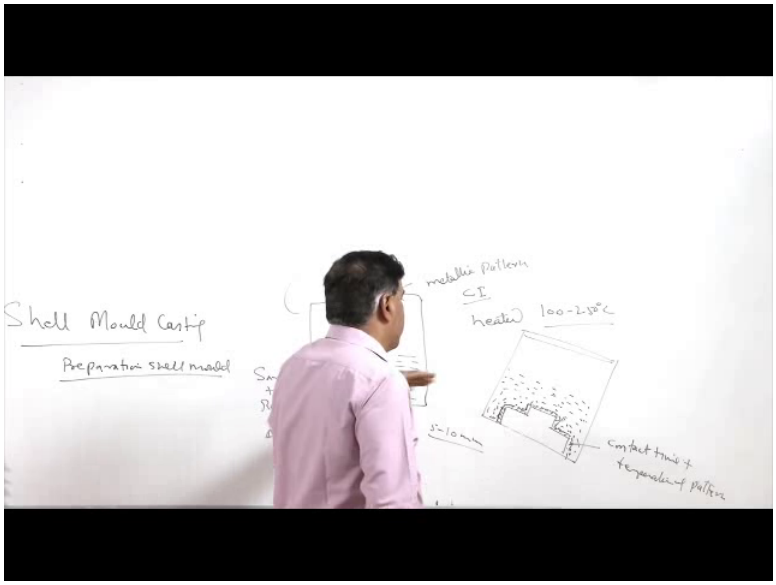

And then what we do? We try to rotate this box so that it is up and upside down. So, in this situation what will be happening say our pattern this will be the location of our pattern and hole of the sand now will be falling over the hot pattern. So, the sand with mixture with the resins and additives will be coming in contact with the pattern. So, resins will few and they will get a stick to the surface of the pattern. So, one shell is formed all around the pattern like this.

So, depending upon the contact time and the temperature of the pattern contact time of the sand mixture with the pattern and the temperature of the pattern shell of particular thickness is formed a normally it is desired that the that the 5 to 10 mm thickness of the shell is formed, so this is the situation. So, once it gets a sufficient time then it is again brought in the same position where the shell well where the pattern will be the upside and the sand mixture will be in the bottom. So, whatever is unused sand mixture is there that will be at the bottom and whatever the portion, will get a stick to the pattern that will be forming the shell.

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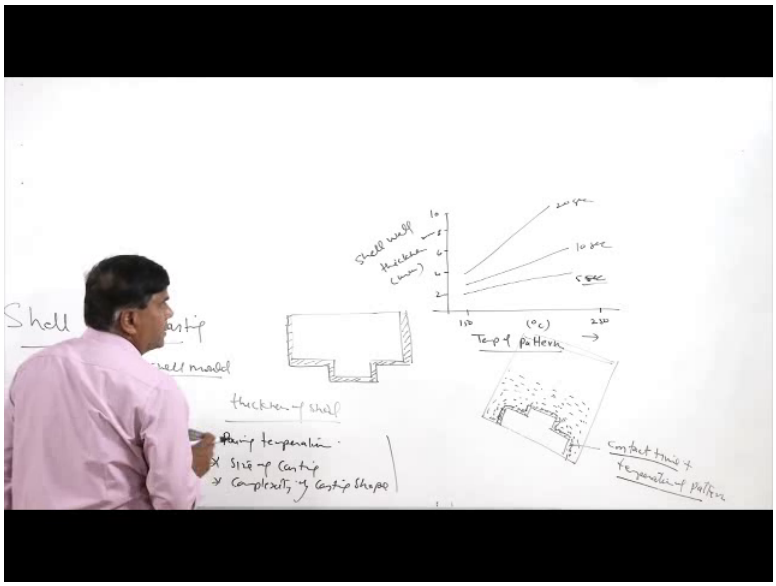

So, in that case now this pattern is a taken out. So, this pattern say here is of shape like this with the presence of the shell all around the pattern like this. So, this shell now we need to take care of. There are certain things now about which we have to talk like what are the factors that will be affecting the thickness of shell or the thickness of the shell which is to be used.

So, like say there are two factors one is pouring temperature of the molten metal and the size of casting and the complexity of casting shape these are the factors that will be governing the shell thickness which we need to use. This shell thickness as I have mentioned depends upon the contact time for which the sand mixture remains in contact with the hot pattern plate hot pattern and the temperature of the pattern. So, there is a proper relationship which has been studied and wherein like say the temperature of the pattern varying from 150 to 250 degree centigrade is the temperature of pattern in the x axis and y axis is the shell wall thickness in mm.

So, shell wall thickness say varying from 2 to 10 mm, so when 2 4 6 8 and 10 mm. So, this is what we will see that when the contact time is for 5 seconds then the rate of increase in the shell thickness with the change of temperature change there is a one definite trend that increase in temperature of the pattern increases the shell wall thickness and you see that when the time is like this 20 second or time is like this 10 second. So, there is a increase in the shell thickness with the increase in the pattern temperature. So, with the increase in pattern temperature more and more amount of the resin will be melting in it the sand mixture will be forming the cover around the pattern to increase the thickness of the shell.

So, and similarly when it gets longer time then, so increase in the shell thickness with the increase in the contact time is due to the increased availability of the time for which heat will be transferred from the pattern to the sand mixture. So, that more of and more of the sand mixture will be getting attached with the pattern and, which in turn will be increasing the thickness of the shell. Shell thickness as I mentioned is which is to be used it depends upon the pouring temperature size of the casting and as a complexity of the shape of the casting.

So, once the shell of the prepared proper thickness has been achieved which thickness is to be used from for a particular casting that is achieved through the trial and error method, so as per the casting, shape, geometry and the size the proper thickness is a identified and once the shell is made then it is required to remove the shell from the pattern.

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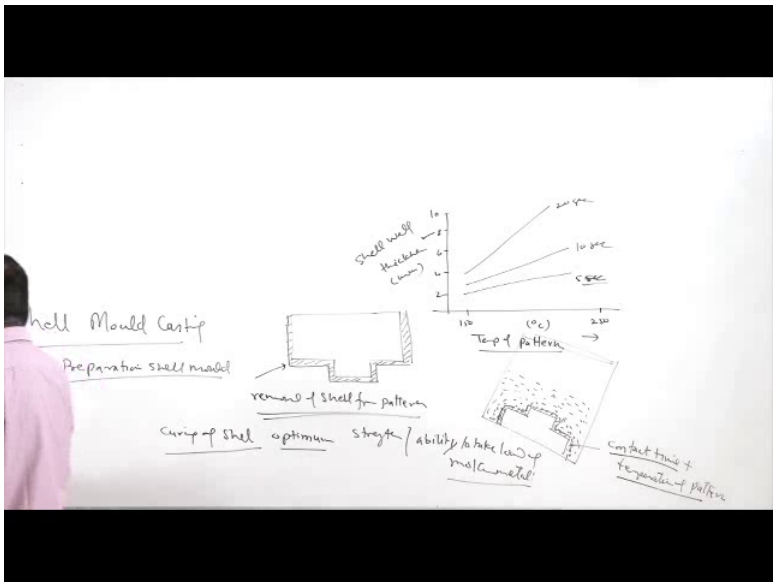

So, removal of shell from pattern this is what is achieved and in order to facilitate the easy removal of the shell from the pattern like some of the agents are spread in the over the surface of the pattern, so that the removal of the pattern becomes easier. And of once the shell has been removed once the shell has been removed, so proper curing is done. So, curing of the shell is performed in order to provide sufficient properties. So, curing of the shell is to be done in optimum manner so that it gets desired a strength and ability to take the load of the molten metal. So, means ability to handle the metal static pressure is achieved through the proper strengthening of the shell.

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In either case if the curing of the shell has not been done properly then it may lead to the over cured or under cured.

So, in case of the over curing the over curing will be reducing the lowering a strength of the shell because of the burning of the resins and in case of the under curing not just the low strength, but it also leads to the blow holes in the casting. So, it is a desire that the things are properly cured. So, you know for uniformity of the shell thickness uniformity of shell thickness, it is important that the temperature of the entire pattern is uniform say the pattern was of this type.

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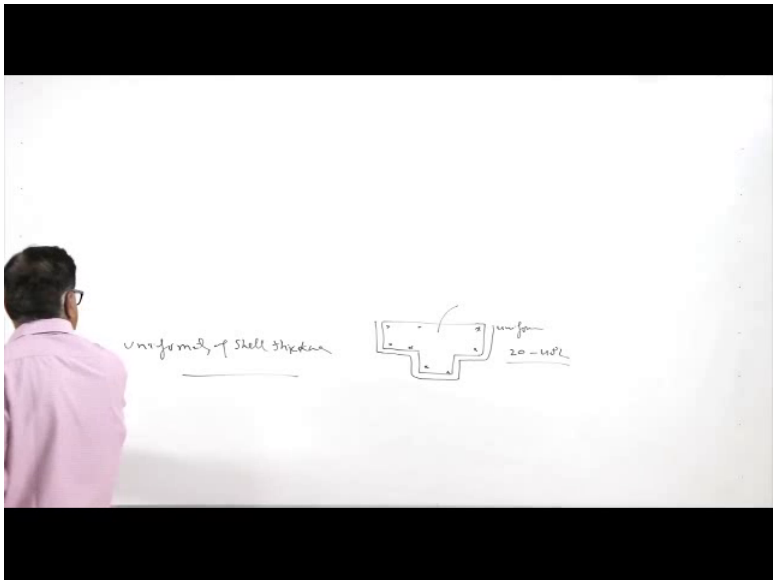

So, heating of the pattern should be done in such a way that the temperature of the pattern at almost all locations is uniform and this variation should not be more than 20 to 40 degree centigrade because the fact the temperature governs the melting of the shell resin in the mixture and which in turn affects the shell thickness. So, if the temperature is uniform then shell thickness will also be uniform too large variability will be leading to the non uniform shell thickness and which can lead to the defective casting. So, shell thickness temperature for uniformity of the shell thickness that uniformity of the plate temperature or the pattern temperature is important.

Now, we will see which for the costing the different types of the metals we have to use the different mixtures for preparing the shells.

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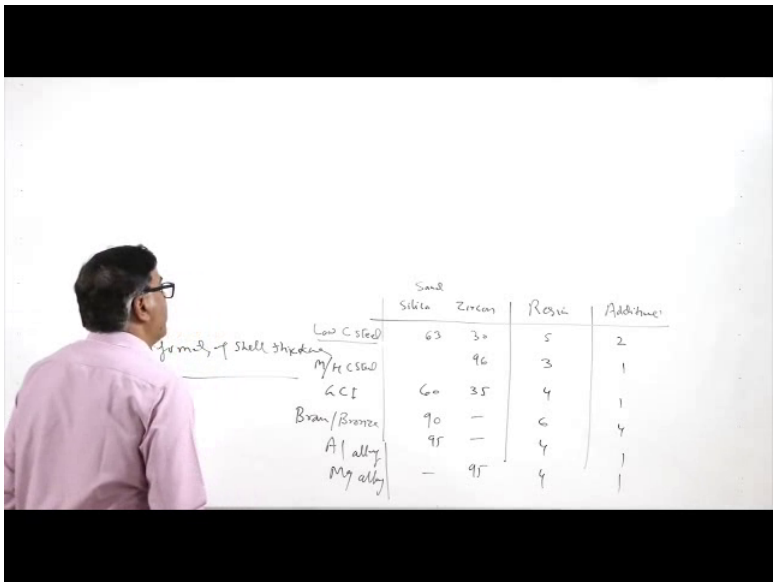

So, for example, here we will have the two types of the sand like silica sand and zircon sand then we have to use the resins and then additives.

So, what is the amount of these constituents which is to be used when the different casting processes are when the different metals are to be processed by the shell mould casting. So, say for low carbon steels what is used for low carbon steel basically 63 percent of the silica sand and 30 percent of the zircon sand, 5 percent of the resin and 2 percent of the additives are used well for the medium and high carbon steels mostly it is a zircon sand which is used, 96 percent and 3 percent and 1 percent of the additives. For the gray cast iron GCI basically 96 percent of the silica sand and the 35 percent of the zircon sand and 4 percent of the resins and 1 percent of the additives are used.

For copper alloys like brass and bronze mostly the silica sand of the 90 percent and 6 percent of the resins and 4 percent of the additives are used. For aluminium castings 95 percent of the silica sand, 4 percent are no zircon sand and 4 percent of the resins and 1 percent of the additives. For MG alloys for magnesium this is for aluminium alloy and this is for magnesium alloys mostly zircon sand is used of the 94 percent, 4 percent of the resins and 1 percent additives. So, these are the kind of mixtures which are used for preparing the sand mixture and resin additive mixture for shell mould casting process.

The shell mould casting process is used for the very simple shape, but with the much closer control over the dimensions and the surface finish.

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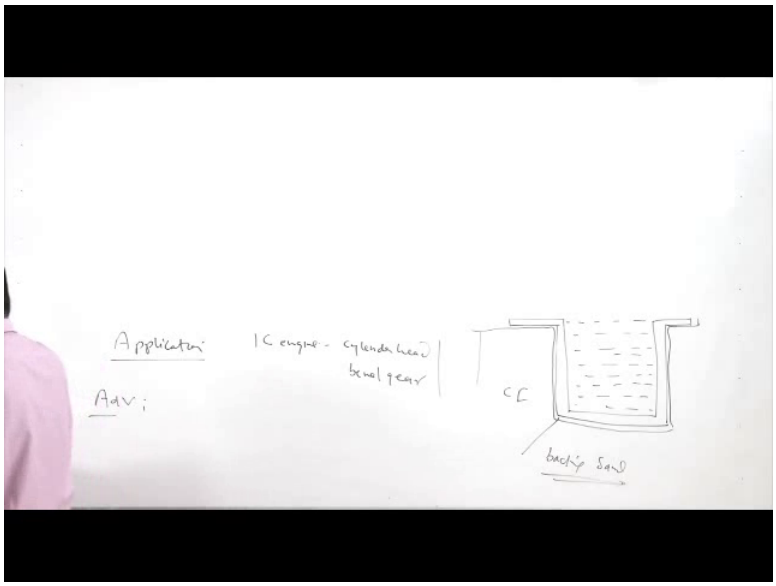

So, now if we see this process is mainly used for preparing the components like IC engines, cylinder head and bevel gears. These are the two common types of the components which are prepared apart from the many other of fine components of the auto mobiles. Advantage of this shell mould casting process is that once the shell is ready then we can pour the molten metal into the shell as per the requirement so that after the solidification we can get the casting.

But we need to consider here one point that since the shell is of the limited thickness say this is the shell of the thickness of this like say 5 mm, 6 mm or 8 mm. So, it basically provides the shape to the mould, but it may not be able to handle the pressure of the molten metal. So, in order to make it capable so that it can handle the pressure of the molten metal suitable support systems are used. So, it may be like say the grey cast iron support of there is same shape as that of the casting as the same shape as that of the mould is used or for. So, this may be of the cast iron or we may provide the backing of the sand also from the all the sides so that it can take the metal static pressure of the mould. So, suitable support to the shell need to be provided so that it can take the metal static pressure and the load of the molten metal without fracturing of the shell. So, that after the solidification suitable casting can be achieved.

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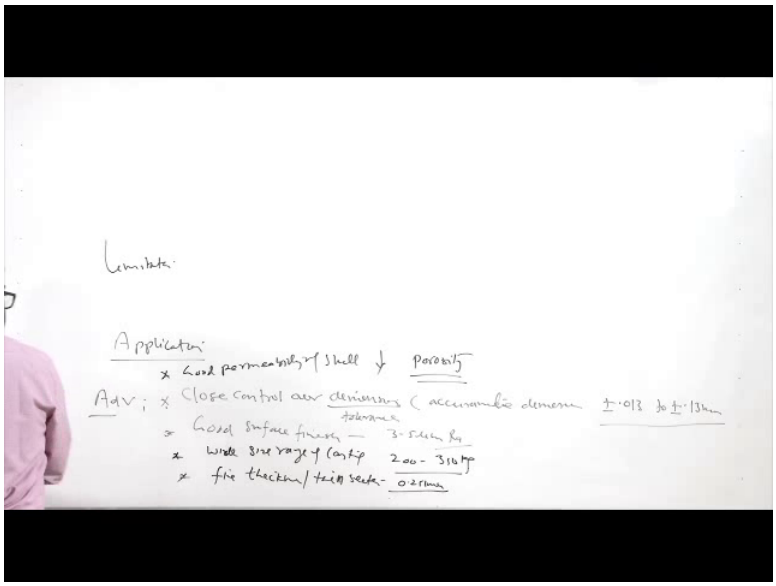

Coming to the advantage very close control over the dimensions is possible, so accurate close control over the dimensions (Refer Time: 25:23) tolerance is possible. So, accuracy accurate in the dimensions, which can vary from say 0.1013 to plus minus 0.3 mm this is the kind of the control over the dimensions is possible. And the good surface finish is achieved like say 3 to 5 micrometer are a surface roughness is realized.

Then the process is a the surface finish and the close control over the dimensions then wide size range of the castings can be made using this, may be as highest 200 to 350 kg size castings can also be made. And this process can be used for producing the very fine or thickness or thin sections thin section features as low as 0.25 mm. So, the features of the thickness of 0.25 mm can also be produced with the help of this casting process. Since the permeability of the shell is good. So, good permeability of the shell actually reduces a scope for the porosity so that casting is sound and detail is by enlarge free from the porosity.

Coming to the limitations the limitation is that since the shell for preparing the shell we need to prepare the mould. So, we need to prepare the pattern and preparation of the pattern will be justified only in case when the large volume of the castings are to be made because metallic patterns preparation of the metallic patterns is an expensive affair and that is why the metallic patterns for preparing the shell will be justified only when

the large volumes are to be produced, so, the process is economical for large volume production purpose.

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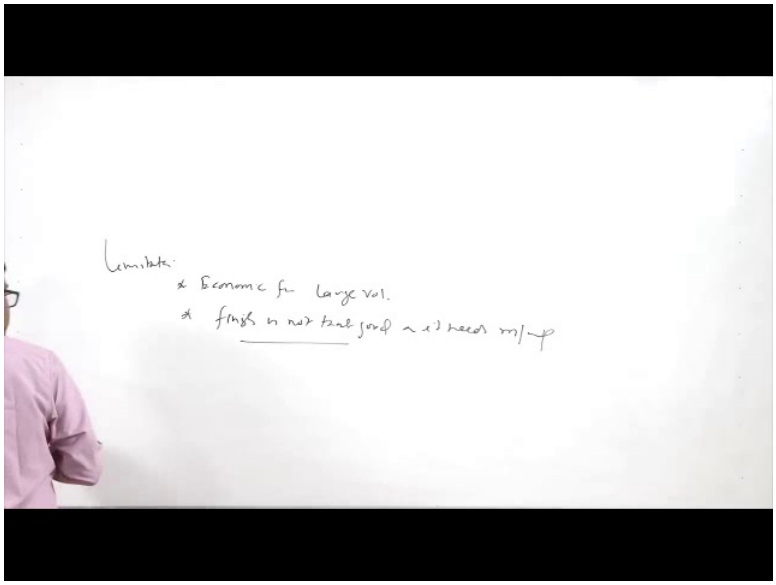

And then the another limitation it means the finish is not that good as it needs the machining, so means the components produced by this cannot directly be put into the use especially when the close control over the dimensions and the surface finish is needed. So, for those cases this process cannot be used like the investment casting process for those metals which for those components which can be directly used into the service can be produced by the investment casting process because they are for the good surface finish and the good control over the dimensions.

Now, I will summarize this presentation. In this presentation basically I have talked about the principle of the preparing the shell, in case of the shell mould casting process and also I have talked about the applications and the advantages of this process.

Thank you for your attention.