Principles of Casting Technology
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Lecture - 28
Special Casting Processes
Centrifugal, Investment and Continuous Casting

Welcome to the lecture on Special Casting Processes, in this lecture we will discuss about few casting processes like centrifugal casting, investment casting and continuous casting. So, why we need to discuss these kinds of special casting process because otherwise if you use the conventional methods for producing certain shape of castings or for producing castings for in a certain quantity, the otherwise other conventional methods of casting processes will be quite uneconomical and also from the quality aspect, it will not be up to the standard.

So, these are the special kind of casting processes which we need to study and we need to also know about it.

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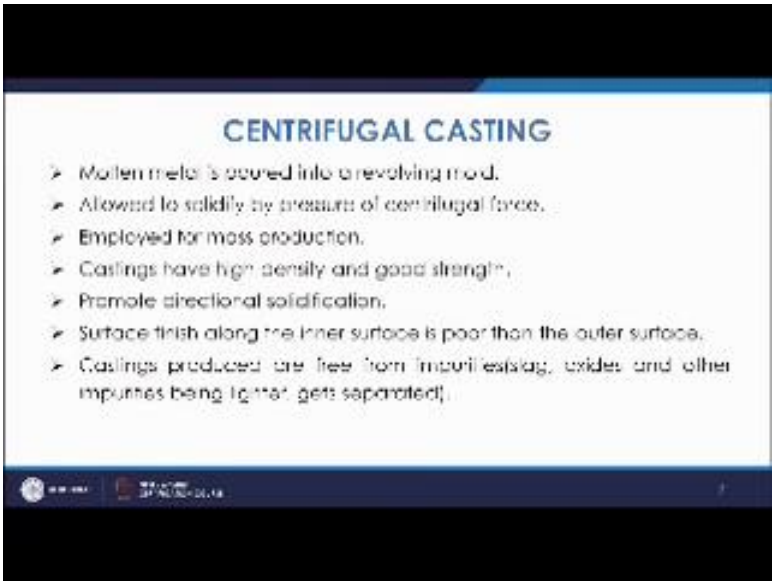

One of them is centrifugal casting; centrifugal casting uses the centrifugal forces because of the rotation of the mold. So, it is normally used to make symmetric types of pipes or

may be the casting of smaller size and you have to make large number of casting in one go. So, you can have the liquid metal board in a common runner and the runner is attached to the different casting through gates and then this runner is rotated. So, all these castings are rotated and because of the centrifugal force, the liquid metal goes into the cavity towards the extreme ends and it will show that the cavity is filled and in certain cases certainly it will go towards the outer side. So, this way you get the desired shape of the cavity or the casting.

In general in the centrifugal casting, the molten metal is poured into a revolving mold. So, the main characteristic is that the mold is rotated about certain axis and the molten metal is poured into it and then once it rotates, there will be a centrifugal force acting on the molten metal because molten metal will try to go away from the axis of the mold and then under that pressure condition and also because of the cooling condition at the mold surface. The liquid metal will solidify and since there is extra pressure like centrifugal force or the liquid metal so the density is higher, the chances of impurity or suppose gaseous holes or row holes these are less because of the pressure it is experiencing.

Employed for mass production certainly because once you have to go for mass production this methods are more helpful, because of the force which it experiences because of the centrifugal action, the density is higher and you get a good strength of the cast material. Promotes directional solidification in the sense that once we keep the molten metal inside the mold and once we rotate, in that case the first metal is going towards the mold wall and the last metal will be away from the mold wall and mold wall will be at a lower surface lower temperature. So, in that case there will be directional solidification from the mold wall towards the inner surface and this way directionality in the solidification is also achieved, and there will be minimum chances of shrinkages that will produce a sound casting, so that type of directional solidification is achieved.

Surface finish along the inner surface is poor than the outer surface. So, what happens in few cases when we talk about the two centrifugal casting or so what happens that, once we provide the liquid metal into the mold and we rotate it, the whole metal is experiencing the centrifugal force. Now the thing is that the heavier particles they are

thrown away, so they experience the force in such a manner that they are towards the mold wall, we can see that if you have a circular mold.

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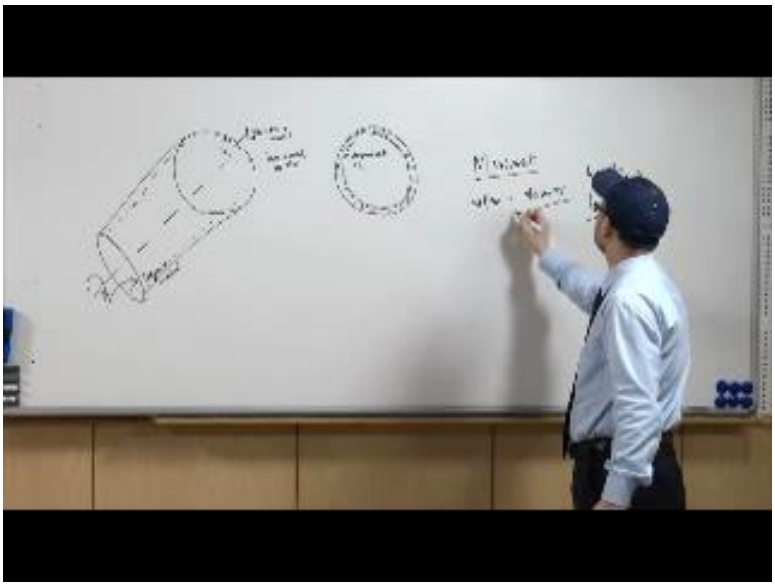

So, what happens on this side you have the higher density metals go and cling to the mold surface whereas, the lower density of oxides or impurities. So, this will be higher density metal and in the inner portion you have lower density oxides or impurities. So, what happens that these impurities and the pure metals basically have the different regimes, where they are deposited they come towards the inner side which can be removed later on by some machining processes or so, that is why you will have the inner surface will be poor because you will have the oxides or so which has to be removed and the outer surface will be confirming to the surfaces of the mold. So, it will be basically quite finished.

Castings produced are free from impurities, slag oxides and other impurities being lighter. So, that is what we discussed that these inner portions they are basically lighter slag or oxides or impurities, they can be removed by machining. So, your cast metal which you get, ultimately you get a rim of this type; the rim which you get this rim you get and here you are machining, the machine surface is taken out and this is your liquid

metal which is solidified. So, this type of structure you are getting which is pure and free from impurities.

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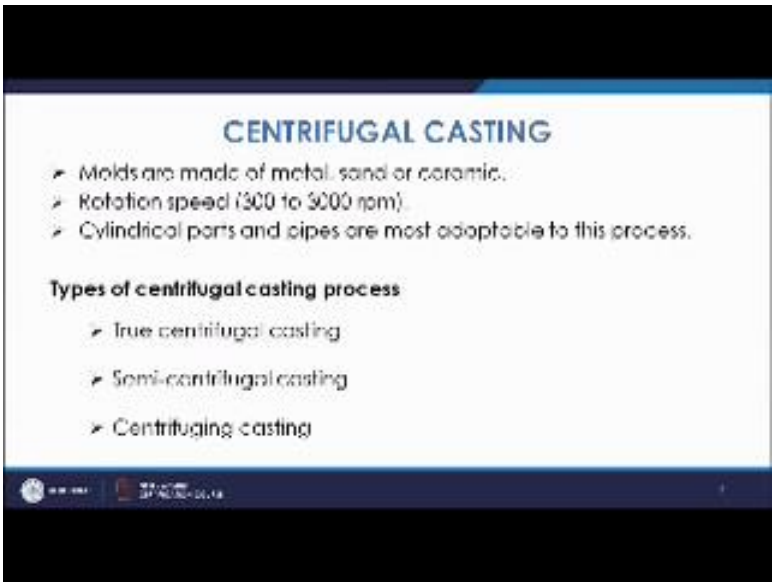

Molds are made of metals and or ceramic. So, the mold may be made of either metals or ceramic which is rotated at a speed, which is ranging generally from 300 to 3000 rpm, cylindrical parts and pipes most adaptable to this process. So, these cylindrical parts and pipes are normally manufactured using these processes. The different varieties of the centrifugal casting are true centrifugal casting, semi-centrifugal casting and centrifuging casting.

So, let us discuss one by one to these three different types of or different varieties of the centrifugal casting. So, first is true centrifugal casting, so this is used for casting as a symmetric type of cast with a concentric whole that is hollow pipes or tubes or hollow bushes. So, you have to make some axis symmetric type of product which has a concentric hole like the pipe having certain inner and outer diameter, those types of casting pipe tubes hollow bushes, this kind of products are basically cast using this true centrifugal casting.

Axis of rotation can be horizontal, vertical or inclined. So, normally it is horizontal the pipe is horizontal, the mold is horizontal supported on the (Refer Time: 09:22) and then it is rotated, so liquid metal is poured into it and it is rotated so that the liquid metal goes and clings along mold of mold and gets solidified. So, for longer pipes we go for horizontal axis and for vertical axis; in the vertical axis we go for short pipes because of the limitation of spaces if we have to produce larger length of pipes you go for horizontal axis and then rotate it.

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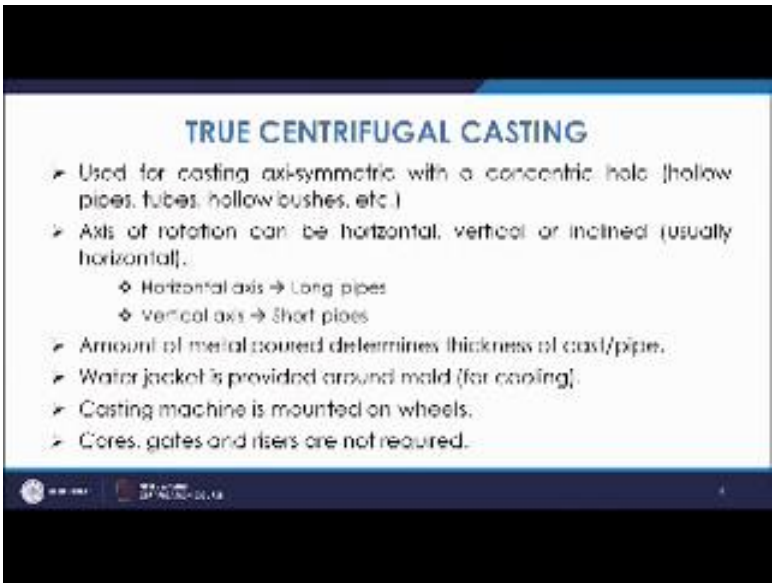

Now, amount of metal poured will determine the thickness of caster pipe. So, once you have a mold, if you have a mold like that it is coming and in that you are basically pouring the liquid metal. So, liquid metal which will go and once it is rotated. So, once it is rotated, this liquid from here it will go and basically that liquid metal is poured all along its length, so there it will rotate. So, the thickness which is formed here this thickness is dependent upon how much metal we are pouring. So, based on that calculation what will be the inner diameter of the pipe and what will be outer diameter of the pipe, you will have to pour the required amount of liquid metal into it and then you have to rotate it.

Water jacket is provided around the mold for cooling. So, may be for a better life as well as for better cooling rate we provide that, casting machine is mounted on wheels and certainty was they have to rotate and then cores gates and risers are not required in this case because we are pouring the liquid metal into it and we are rotating. So, simply we are getting an annulus type of casting where you have the inside surface as well as the outside surface, we may need to machine the inside surface because the lighter oxide or impurities are likely to be deposited towards the inner surface.

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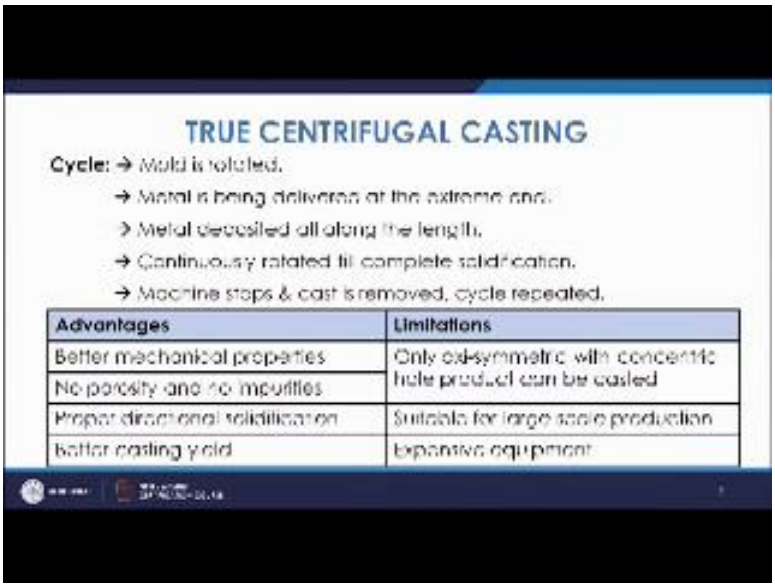

So, the cycle starts like this, mold is rotated. Metal will be delivered at the extreme end, so metal will be deposited all along its length; continuously it is rotated till it is ensured that the solidification process is complete, then machine stops and cast is removed and cycle is complete. So, again once you remove the material, again you put another molten metal in the required quantity and this cycle continues.

The advantage is that it has better mechanical properties, no porosity and impurities, proper directional solidification and better casting yield these are advantages which we discussed earlier because of the traits of this process you have better mechanical properties, good density, no porosity, rational solidification starts from this side and moves like this. The limitation is that only axi-symmetric with concentric hole product

can be casted, here suitable for large scale production and certainly the equipment is expensive because you need to have a good support for the machine, that you have to have the roll facilities, you will have to rotate it, you need good motor to rotate the whole mold which is heavier.

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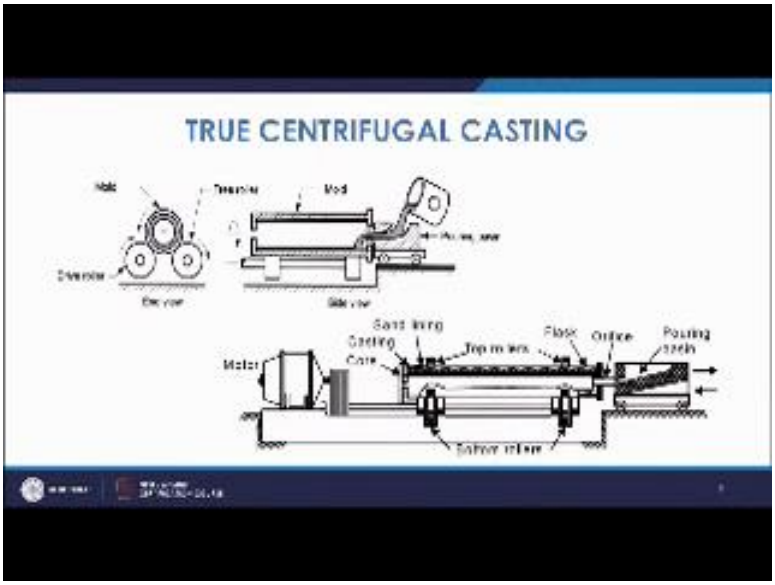

So, if you look at the figure, this figure talks about this kind of true centrifugal casting processes or machines, where you pour the liquid metal into the mold, this mold is the mold which will rotate, this rotates on this mechanism here you have rollers, on this it rolls at a higher speed, which you give the required amount of metal into it, then it rolls rotates and then after sometime you take it out and you get the required cast product.

The other variety is the semi-centrifugal casting, it is similar to centrifugal casting, true centrifugal casting, but in this case we provide a central core into it from the inner surface. To form the inner surface, sand or metal is will rotate in vertical axis, you will have the vertical axis, you will have core, liquid metal go and you have to rotate it should be asymmetric the cast metal, rotation is speed is lower than true centrifugal casting, metal enter in the mold through central pouring basin and may be the mold can be stacked one over other for increasing the productivity and the metal is poured from a single pouring machine.

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So, in that basically the advantage is that you can produce more complicated shapes because in this case the shape is very much simple you can produce, but if the shape is going like this and this. So, in that case that cannot be produced by the normal centrifugal or true centrifugal casting. So, in this case those complex shapes also can be produced for axi-symmetric castings.

Particular shape is being produced by mold and core not by centrifugal force. So, basically because of the mold and core this type of particular shape is produced, centrifugal force is proper feeding because of centrifugal force the metal goes, it is shown that the metal goes into that cavity, producing the castings free from porosity and we can have the objects like flywheel gears casted using this method.

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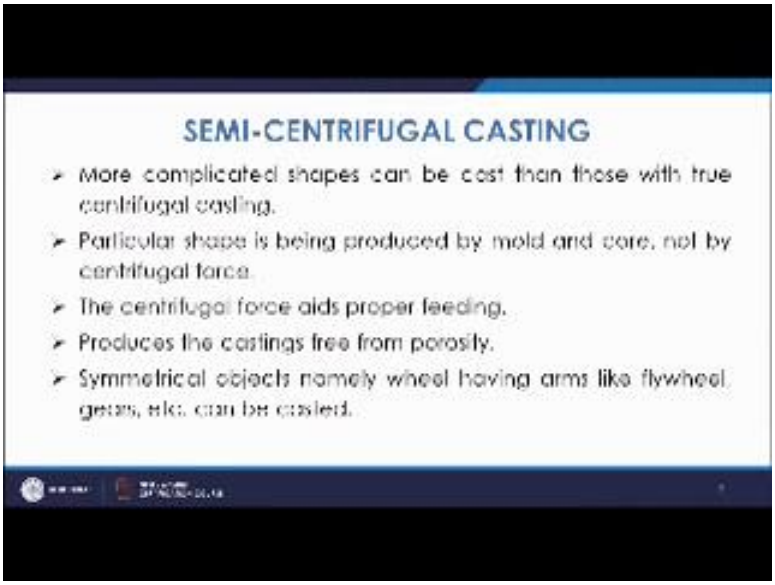

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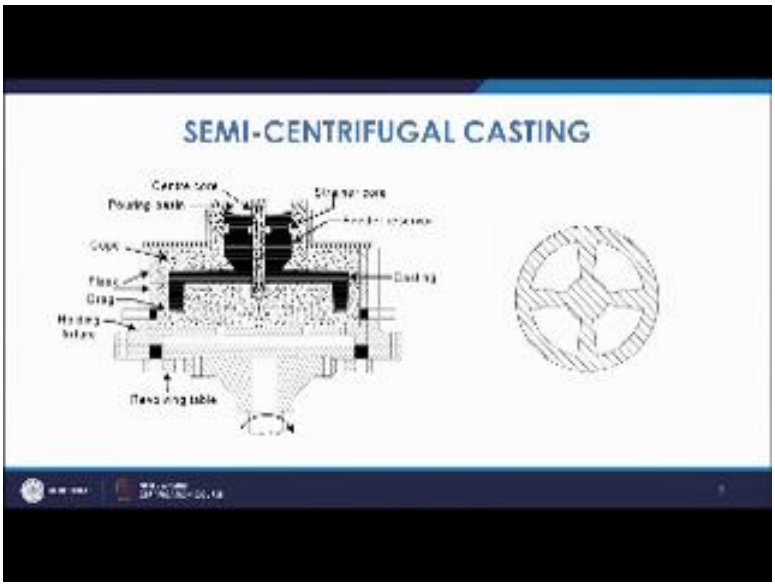

So, this is the example of semi-centrifugal casting where you see the core the pouring machine that will go that will rotate and because of that the metal will go into the cavity, so you will get these kinds of cast product. So, this is the example of semi-centrifugal casting.

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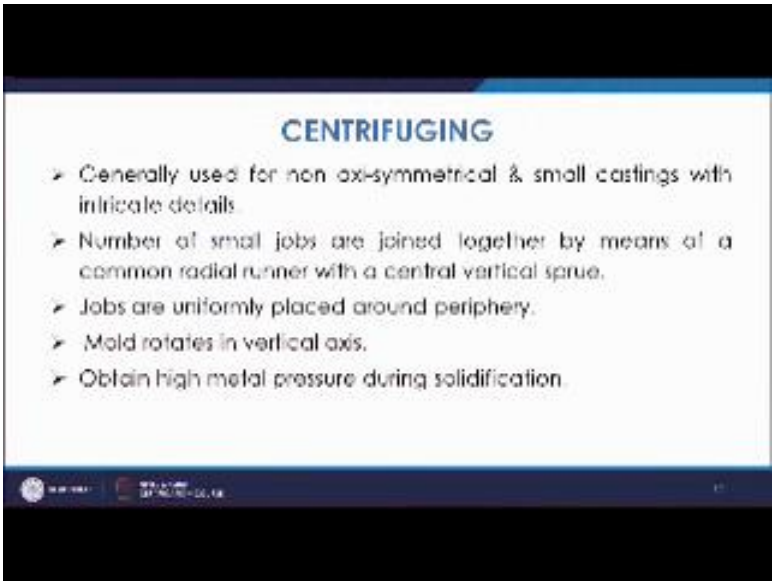

Then next is centrifuging, in that basically the use is for non axi-symmetrical type of (Refer Time: 16:36) and small casting. So, what happens in this not required that is symmetric axi-symmetric and also you have a common runner and there will be many parts attached to it, so number of a small jobs are joined together by means of common radial runner, which is central vertical screw from that you add and then that is rotated about the vertical axis and the metal is under pressure solidifies. So, this is like this where you have many parts attached which required to axi-symmetric.

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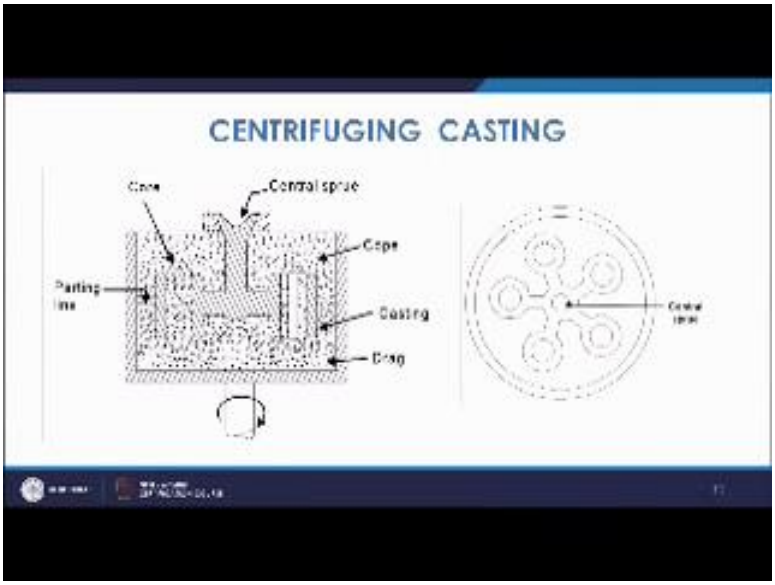

And then the metal will go and get feeded to all the portions. So, it is not required that there are having the same length here, there is also a symmetry may be there are at the different heights also it may be there, different length may be there so this may be larger this will be smaller, depending upon situation you may have and then it is rotated and because of the force, the metal goes and gets feeded.

So, these are the three varieties of centrifugal casting; next is investment casting, in this case for making very intricate shape of castings, we use this process investment casting. So, this is also known as the last wax casting when we use the wax as the material. So, this is basically based on a fact that in this the pattern material will be moving out. So, what happens normally the pattern material may be wax or even polystyrene is also used as the pattern material, now what the concept is that you use the wax as the pattern material. So, a pattern will be made by injecting the wax under the pressure in a machine you make the pattern. Now this is basically coated with ceramic slurries and then stuccoing is also done with a ceramic particles and this process is repeated drying and then further dipping in the slurry, further stuccoing the ceramic particles, so that a hard ceramic surface is basically achieved.

So, what you see is you have a hard ceramic coating with certain surface thickness so, thickness we have to see that the required thickness of the ceramic cell is achieved. So, till that time you go on doing this process of dipping and stuccoing and then what you do is the whole process, you have basically the wax pattern will have all that runners, screws and gates. So, there are always normally more than one casting are attached to the common runner and then they are heated. So, because of the heat, this wax material comes out and then a cavity is generated, in that cavity molten metal is poured and the gravity.

So, this is known as the investment casting. So, you have the preparation of metal pattern in a die may be made of metal or may be of silicon rubber also, after solidification pattern is ejected.

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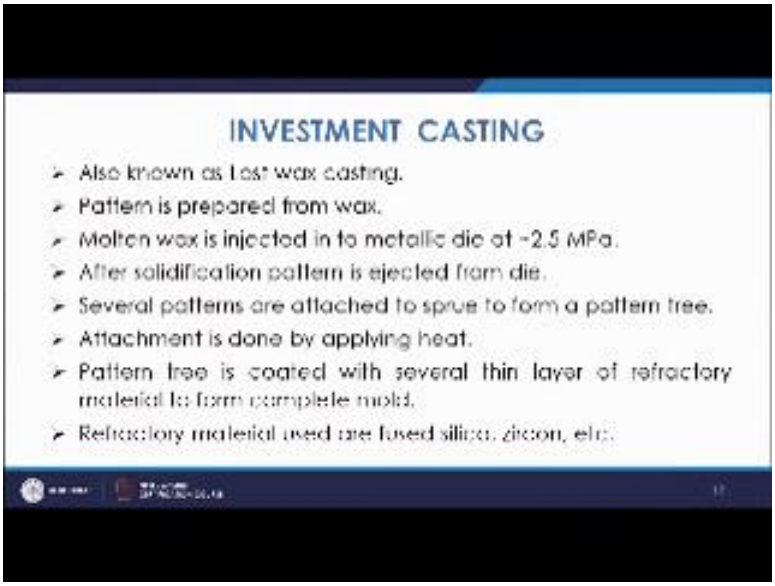

Several patterns are attached to sprue to form a pattern tree, that is known as investment tree then you apply the heat, so attachment is done by applying heat. So, you are basically adding the different patterns to that tree and then you are wiring the thin layer of the refractive material from complete mold and then you are using the different kinds of flows and the particles, ceramic particles to make that refractory coating.

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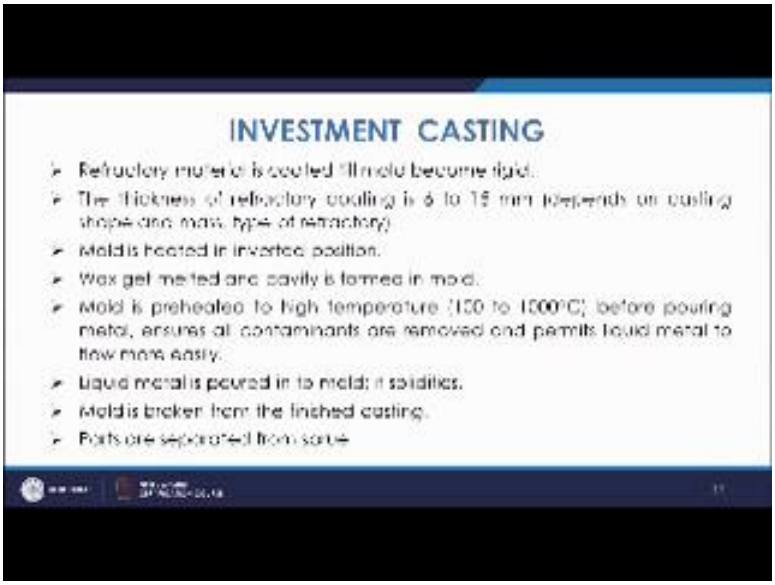

And you do this process till it becomes rigid and once this coating is of certain thickness depending upon kind of the weight or mass of the casting, it will be heated in an inverted position so that all the wax comes out and then further it is pre heated or firing is done up to 1000 degree C. So, that you ensure that all the vapor is removed moisture is removed, and then and also at higher temperature the purity will be higher or the liquid metal it will go into all the finer cavity or finer details can be produced, then liquid metal is poured if it is solidifies and then further finally, you will break the mold and get the product. So, this way you get.

In this case the pattern is removed by heating and then further again you can use, different kinds of wax are used you have macro crystalline, canova. So, there are many canova type of wax, there are many kinds of wax, the thing is that you have to take proper quality of wax which should provide you good tensile strength, good harness also minimum residue should be there. So, loss on ignition will be minimum, as contents will be minimum, otherwise it will stuck to the inner surface.

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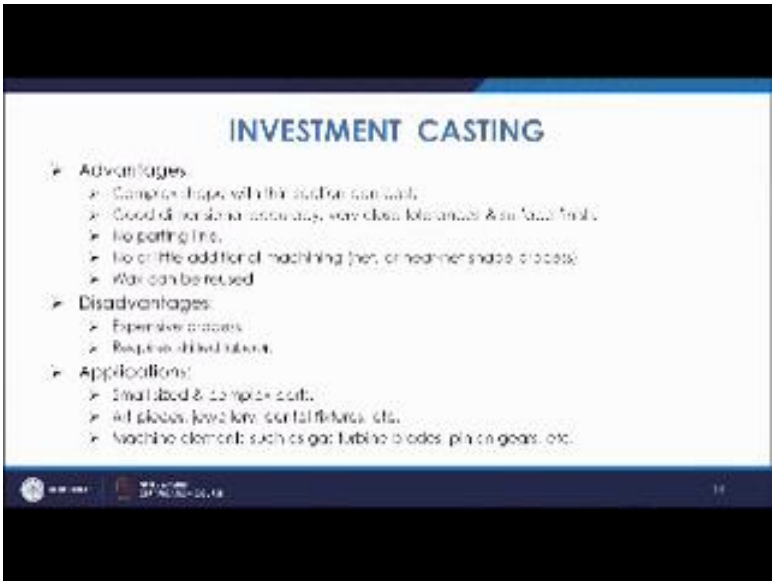

Advantage is that you can cast complex shapes, good dimensional accuracy, close tolerance finish, there is no parting line kind of things in this kind of casting, this is a near net shape process and the wax can be further used and used, it is expensive process and it requires skilled labor that is the disadvantage and normally it is used for very small sized components like jewelries, dental fixtures, turbine blades where it is lot of you know accuracy is required. So, in those cases you can go for such kind of process.

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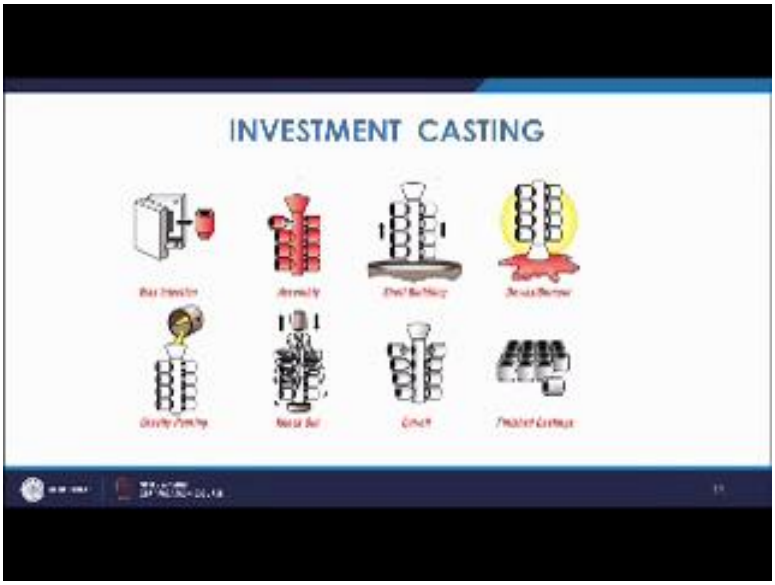

So, this is the process where you have wax injection, you get the mold you assemble the different patterns by hitting and joining, then you are dipping in the slury and you are dipping and stuccoing, that process goes on then you go for dewaxing. So, once you go for shell building, then after that you are dewaxing in the converter process, through this portion all this wax which is their inside, these waxes come out. So, this process is known as dewaxing.

So, you have to remove all the traces of the waxes, then you start the pouring that is gravity pouring and once the pouring is done, you have to remove the old material and then basically you are taking all the castings out putting as your finish casting. So, what we see is in this case very intricate type of castings can be achieved depending upon the fineness of or the use of these stuccoing particles and the different kinds of slurries prepared, the properties of the material or the finish of the material will be depending and there are large amount of additives which are available to give the strength to this mold and the desired properties also to the mold like fability, collapsibility, strength.

So, there are many kinds of additives. So, that may be ranging from the corn flour or may be the extreme molasses, these are the different kinds of you know the additives we can have coke needles. So, there are many kinds of additives which are added while

preparing this slurries, coating and this coatings are to be dried also you have to see that they get dried up properly. So, they need to be dried properly, they need to be fired properly, so that there is no trace of moisture, no trace of wax remaining inside, so that is investment casting.

There is another variety of this process that is mercast process. So, in the mercast process, the pattern is mercury. So, what happens mercury is it is the pattern material will be made below minus 5 6 degree centigrade because otherwise it cannot be put in a solid state and then on that you do the shell preparation and may be close to minus 34 degree C also it basically melts. So, at that lower temperature you would shell is built, all the mercury will come out of that cavity, then cavity is there, in the cavity further firing will be done and then you can use that cavity. So, this is a variety of investment casting that is mercast process where pattern used is mercury.

Similarly, there is one process known as CLA process that is Stanley and lamb, they had developed this process in which the vacuum is created and the metal, so from the bottom the screw portion will be inverted into the molten metal and a vacuum is created inside the cavity. So, that way it comes the metal is sucked into it. So, under the vacuum metal is sucked that is CLA process. So, there are varieties of these kinds of processes.

The next is continuous casting; now continuous casting is the latest casting process which is used in the steel making industries and even in non ferrous sections also where the name indicates that, you can have the products continuously cast without interruption.

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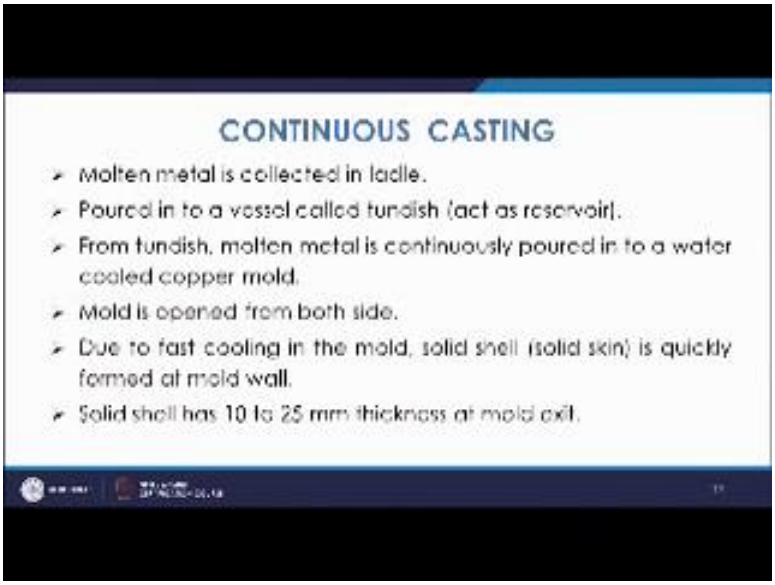

So, in this case the metal will be poured into the mold by bringing it from the furnace through a ladle and then through an intermitted reservoir like tundish, it will go into the mold. So, mold is normally water cooled copper mold, which gives a very good heat extraction rate to the mold and as the metal goes into the mold because of the large thermal conductivity of the mold, the metal starts solidifying there itself and the skin of metal, so there will be skin formed or shell thickness is achieved as the metal leaves the mold. So, at that time there will be some thickness of shell or some thickness of cast metal will be formed and then it will further go through the process of cooling in the secondary zone like cooling by moist air or water sprays and then further goes and then ultimately once it goes on a horizontal kind of platform where it will be cut in suitable length. So, it may be vertical or horizontal, but horizontal ultimately it comes in the horizontal manner in the sense that when you need to have a continuous production of larger length, only horizontal sections can be cast.

So, due to fast cooling in the mold or a shell is quickly formed and then it has certain thickness at the mold exit and basically that is able to sustain the Ferro static pressure, once it comes out and then, so that it does not dulls further, and then you can get the product finished in the finished form. So, that is normally in the form of blooms or billets.

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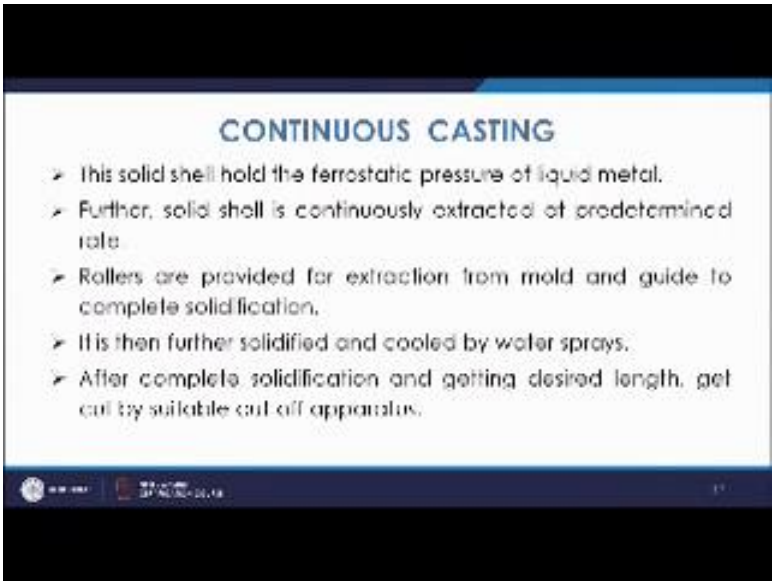

So, solid shell holds the Ferro static pressure of the liquid metal, and then it is continuously extracted at predetermined rate. Rollers are provided for extraction of from mold and guide to complete solidification and then it is further solidified and cooled by water sprays and after certain length it is getting cut.

So, the advantage is that you have 100 percent casting it is nothing no loss, if your output is in the form of billets or slurs, you are completely getting what you are melting.

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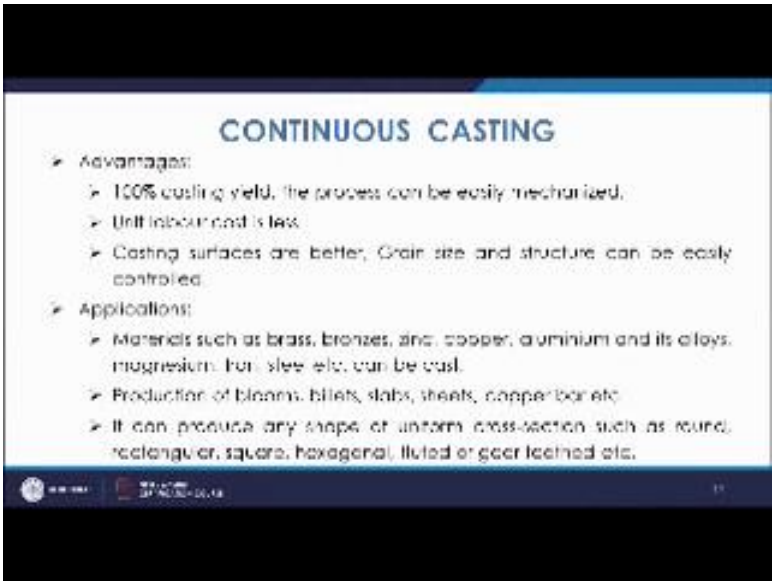

So, it is 100 percent yield completely mechanized process it is possible, the unit cost labor is less, surfaces are better good grain size fine finish will be there, fine grains will be there because of the large cooling rate and you have applications in for all the materials mostly can be cast in the form of blooms, billets or slabs or sheets, then you can make even uniform cross section or the different cross section of product.

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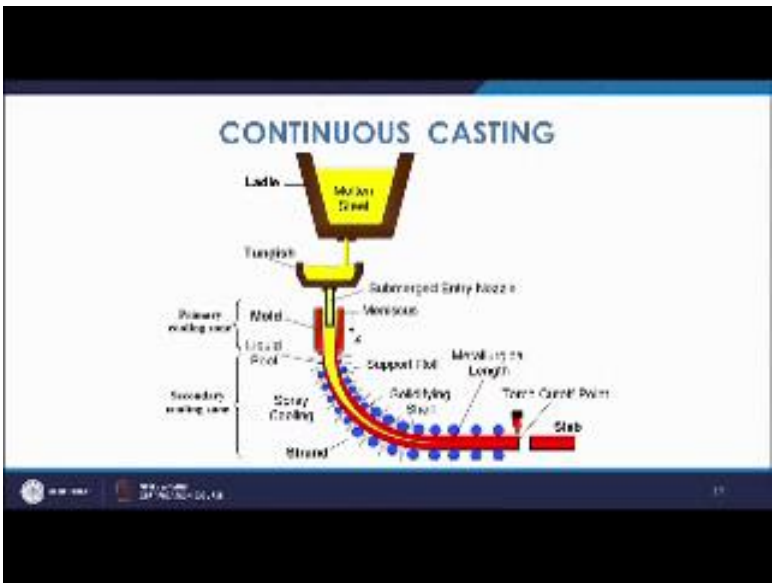

So, if you look at this schematic of this process, you see the molten steel proof comes from here and through this intermediate reservoir tundish will go into the mold, from here because of this mold being copper cooled the solid shell is formed here itself, and you have yellow portion still liquid. So, this will be liquid up to this stage and after that stage is cut in the midway they are moving on the support roles. So, that it does not bulge because of the large amount of the liquid metal available here, they are given enough support and then also it is also getting cooled at this potion. So, getting cooling from all that sides, the solidification proceeds further and at this point it is basically the complete solidification takes place known as metallurgical length or solidification length and then you cut it.

So, because of this you are (Refer Time: 31:23) of getting a slab of this form or depending upon the size of the mold, you get the output product whatever you need. So, this is the continuous casting, which is normally used most of the steel industries or the non ferrous industry of larger size, they use this process to make the slabs blooms or billets of any material using this process.

So, these are the special casting processes, apart from that there may be even more so you may be, you are advised to read more and more, which is basically based on the different kinds of cooling mechanism, different kinds of molting mechanism and so on.

Thank you.