Principles of Casting Technology

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Lecture - 26
Special Casting Process
Permanent Mold Casting, Hot and cold chamber die casting

Welcome to the lecture on Special Casting Processes. So, in this lecture we will discuss about permanent mold casting and die casting in that we will discuss about hot and cold chamber die casting. Now what is the permanent mold casting and why its need is felt, so that is required to be understood. What we have understood by studying the different molds, when we use the sand molds; the sand molds are to be broken every time the solidified cast metal or cast component has to be taken out.

So, basically using the fettling processes or shake out processes, you are removing all the sand from the cast metal. So, in that case that takes a lot of time and lot of labor is involved and the productivity is certainly less. So, when the product is not on mass basis when your production is only for a small quantities or may be for the cases when the size is too big in that case that is preferred, but coming to the era of competition, when the mass production of component is required, in that case you will have to see a method by which you can make the molds in such a way that it has not to be broken. In fact, you must use it many number of times. So, in that case the concept of permanent mold casting came up.

Another advantage is or another point for which it has to be thought was that for obtaining a better mechanical property, you need to have a mold whose thermal conductivity should be higher. So, in the thermal conductivity is higher the heat extraction rate from the mold will be higher and if the heat const extraction rate will be higher from the mold, then depending upon the degree of under cooling and depending upon the process of nucleation and an growth, you are suppose to have a better final macro structure and so better mechanical properties. So, there this way you have 2 or 3 way you are having the advantage over the sand casting processes.

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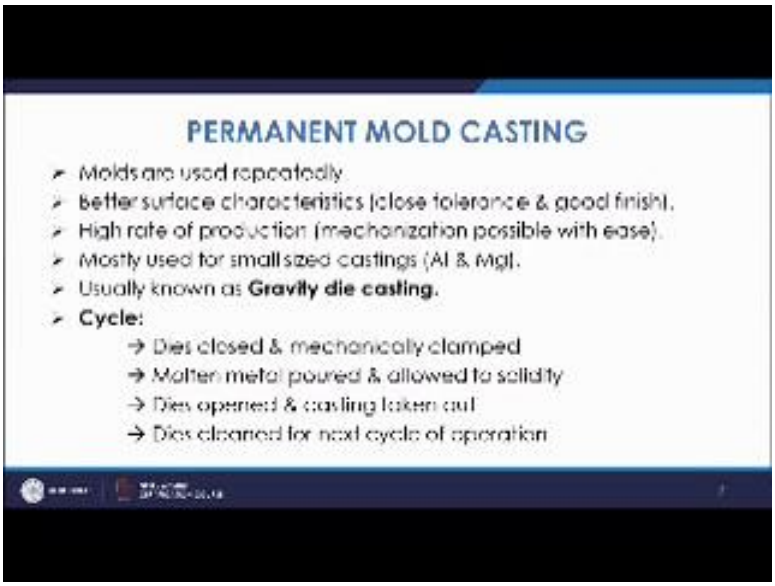

So, in that case what we see is in the permanent mold casting molds are used repeatedly. So, you have the mold which is not to be broken every time, you have to use it repeatedly you can use it repeatedly and being the metal the mold being the metal, the metal has a better finish as compared to that of this sand. So, the surface finish will be better in these components and the machine allowance which is required to be provided will be less. So, in that case the loss of metal in terms of that machine amount that will be less. So, again you are saving some amount or you are you are saving some cost, closed allowance components you can achieve because once you have the object coming to the exact dimension you can achieve the closed allowances.

High rate of production because mechanization is possible with ease, mostly it is mechanized you have the methods by which you have the dies and you have to open the die and put the metal and you have to press it. So, mostly it is a mechanized process with ease, that is why do you have higher rate of production and mostly used for the mass production of components, mostly used for small size casting this is basically one of the disadvantage we can say that will discuss later that because of other difficulties like making of dies handling of the unit, the problem will be there if the casting size is quite large.

So, mostly it is confined to metals with lower melting points and also the sizes are confined, so mostly we go for smaller size components. Now the term gravity die

casting, when we use the metallic mold or permanent mold this molds are known as dies so their term is die. Now in the die the metal can be fed by gravity. So, if you have two metallic die and if there is cavity in that and if you are feeding the metal through gravity, then it is known as gravity die casting. So, whenever we talk about permanent mold casting, then by default we think of the term gravity die casting because the metal can be fed even under pressure and in that case we call it as pressure die casting.

So, the die casting means gravity die casting or permanent mold casting, where the metal is going into the cavity because of the gravitational forces. So, you are pouring the liquid metal from the top and this metal goes in the bottom under the action of gravitational force that is why it is known as gravity die casting. What is the process of doing that? So, you have two dies, dies are closed and mechanically cramped. So, you have two parts of die they will be closed in between there is a cavity, they will be closed and clamped so that they are tied together, then molten metal will be poured and allowed to solidify there will be proper passage of the molten metal like screw, gates and runners, through that molten metal will go and form the cavity. So, it will go into the cavity space and then it will be allowed to solidify.

The difference is that in this case instead of sand mass you have the metallic mold. So, metal will go inside and then they it will solidify in certain time, then you open the die which was clamped earlier and the casting will be taken out. So, then die will be further cleaned for the next cycle, this is the very simple cycle and which goes on repeatedly you open close the die have the cavity space in that you poured the metal, then after solidification you extract it so that is how it goes again and again and this is one cycle.

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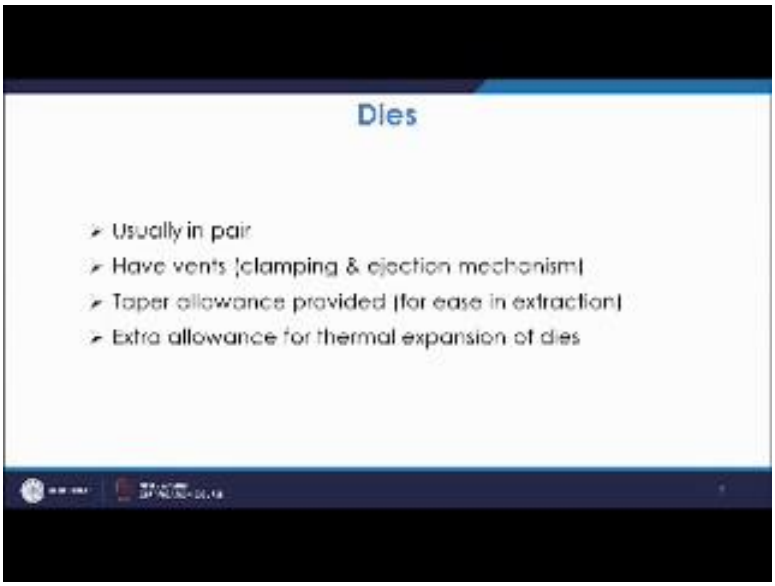

The dies are usually in pair, may be more than that even, but normally they are in pair. They have also vents normally at the parting line and also you have clamping and ejection mechanism, so that you clamp when you have to put the molten metal inside the cavity and then further you have the mechanism of ejecting it out you have to take it out. So, you have to separates these two halves of the die so that you can take the metal cast out. Taper allowance is provided for the ease of extraction of the casting from the cavity. So some taper allowance is always given. Then in that case, there is extra allowance that is given is thermal expansion of the die because once you are pouring the liquid metal into the die, the die is at higher temperature and it expands. So, an allowance of for the thermal expansion of die is also provided in these cases.

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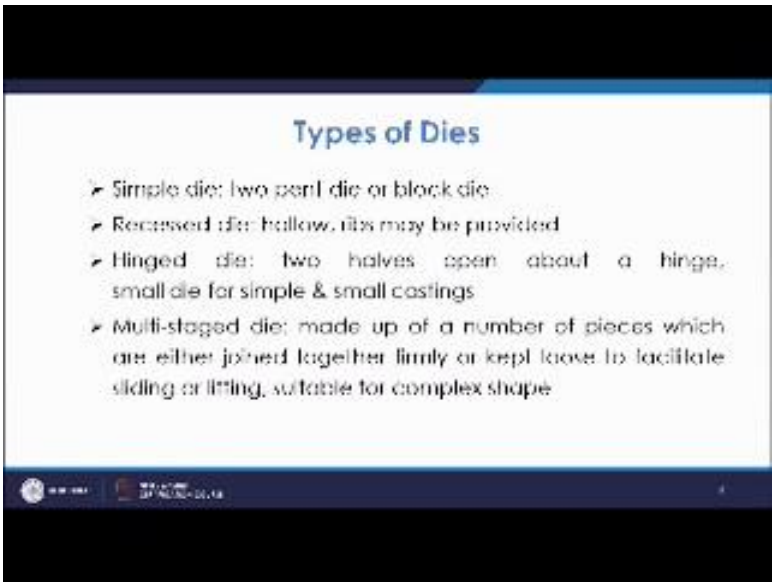

What are the types of dies? Now the types are dies are one is simple die that is two part die, this is mistake this is two part die or block die which is known as, then you have recessed die. So, this is die hollow or ribs. So, this is hollow normally, this is dies they are normally hollow and ribs are provided for strengthening. So, they are recess dies then huge die. So, basically the two halves are opening about a hinge, you close it and then you can open, will be hinge this will be not completely separate, but about a hinge it can open it and take the part out normally for simple and small castings, then multi stage die. So, this is a die made of number of pieces which are either joint together firmly or kept loose to facilitate sliding or lifting suitable for complex.

So, in these three types of dies are normally for simple shapes, but when you have a complex shaped of casting, in that case you need to have a die which are basically of number of number pieces so that you can take them out one by one and take the complex casting out. So, this way you have a multi staged die also, these are different types of dies which are used in such cases.

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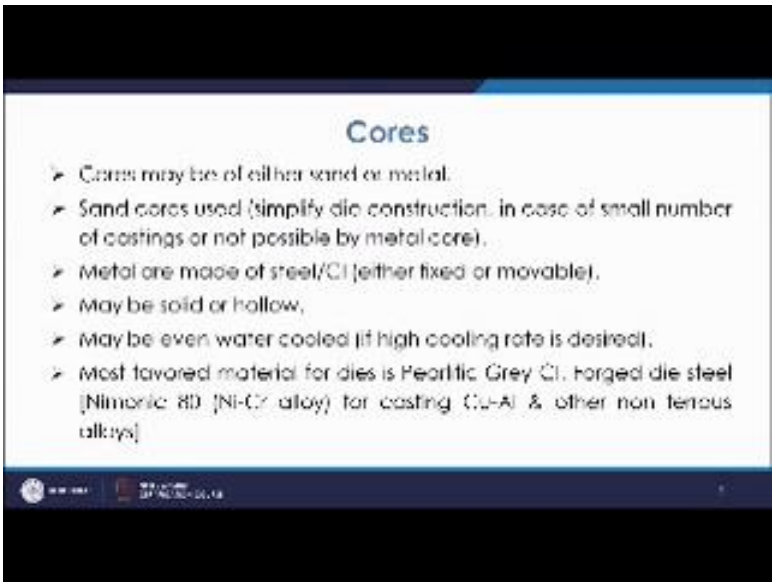

Then you can also provide the course in these permanent mold castings. Now this course may be either of the sand or the metal. So, metallic codes if you are proving then certainly it will not be easy to take it out, it has to be fixed some normally or you have to put it at some place and they have to take out.

But normally sand course are used because that is simplifying the die construction and usually in case of small number of castings you are using these sand course, and you are also using the sand course whenever it is not possible to get the work done by a metallic core. So, either you can put a sand core or a metallic core. Metal are made of steel or cast iron that is the core metal is core is made of either steel or cast iron, which can be fixed or movable, it may be made solid or hollow, it may be even water cooled. So, if you need the larger heat extraction rate at that particular location, you can even make this core water cooled.

Now, most favored material for die is pearlitic grey cast iron, force die steel mnemonic 80 that is nickel chromium alloy for casting of copper aluminum and other non ferrous alloys, so normally these are the die materials which are used for making the dies. What are the types of metal which are being cast? Normally the dies are made of steel or casting iron, certainly it is not advisable to cast the metals which are the melting point close to these. So, normally in the case of these permanent mold castings, we confine our

work to the non ferrous components or non ferrous materials because their melting point is normally lesser.

So, for aluminum or zinc, they are preferred zinc having less than 400 degrees centigrade aluminum less than 700 degree centigrade. So, they are normally preferred.

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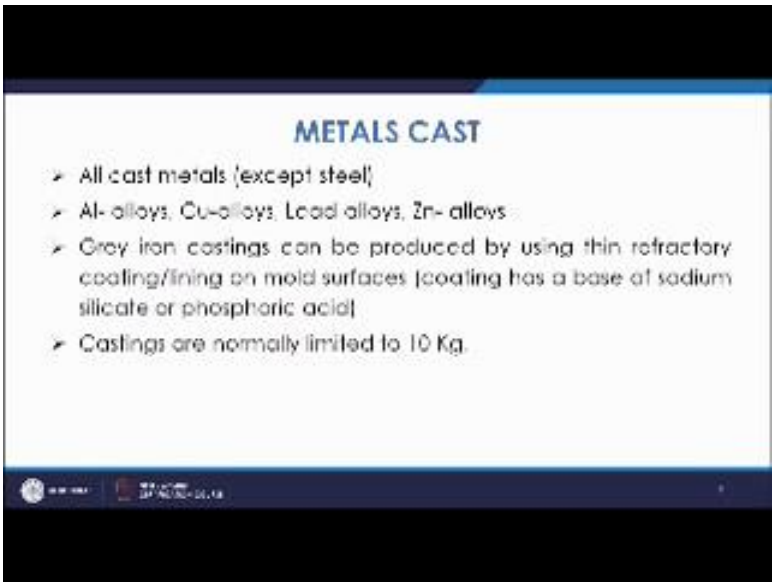

So, mostly cast metals except steel, aluminum, copper, led or zinc alloys, even grey cast iron. So, also sometimes produced and in that case what we do is, inside the die we provide the refractory coating before pouring. So, every time before pouring we provide a refractory coating so that it does not damage the surface and that is nothing, but a coating based of sodium silicate or phosphoric acid; castings are normally limited to 10 kg of size. So, when we are discussing about the size limitation, in that process it is very much important to mention that normally it is size is limited to 10 kgs.

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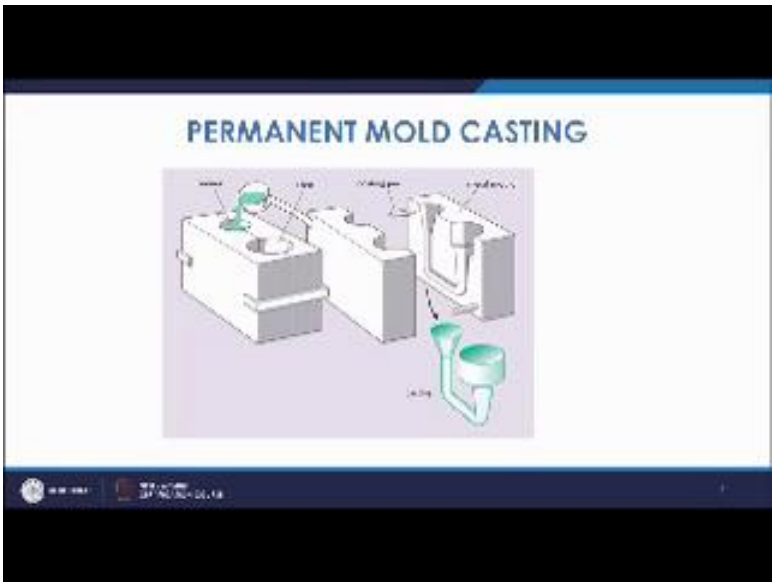

So, this is the figure which shows that how a permanent mold casting looks like you have these two dies and you see that you have cavity cut in to these, so you have the pouring cup here and this is the riser and through the pouring cup you will pour the liquid metal here from, the metal will come and ultimately come in to the riser and after sometime it will solidify and once you take these two, so these are these are ting pins, you as we locating pins, so they are basically they are to fix them together and once you move them apart your casting is taken out. So, this way you are getting a cast component made of metal in a metallic die that is a gravity die casting because here your simply pouring the liquid metal from here and it goes by the action of gravity towards the bottom side.

Next is pressure die casting. So, we have seen the castings where there is flow of the metal towards the bottom because of the gravity, but then we can also push the liquid metal inside the cavity under pressure. So, in that case basically advantageous is that the metal can go into the shallow cavities fine details can be achieved. So, it is good for mass production because under pressure the solidification is completed and the production rate is higher.

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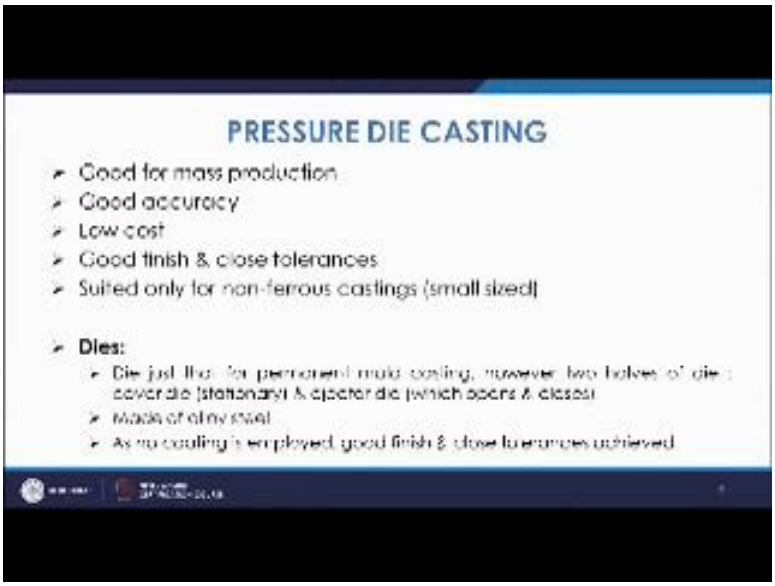

Good accuracy is there, cost is lower because the productivity will be higher, good finish and close tolerances and suitable for non ferrous castings as it applies for the permanent mold castings most of the properties are same as that one.

Now in this, case dies just that for mind mold casting. So, you have in this case the difference is that is you have two halves of die, one is fixed to a place from where it has the support and another part is movable. So, it can move and then this process is carried out. So, the die which is fixed is known as cover die or a stationary die and the die which can be moved forward or which can be taken out and then further closed that is known as ejector die because which opens and closes; die is made of alloy steel normally in this case and since no coating is employed, you have good finish and closed allowances.

So, in this case you do not apply coatings because under pressure and it is not possible to apply the coating every time because mechanized process that comes up and goes. So, in this case you do not apply the coating and you have good finish and tolerances achieved. Now in this case die casting basically functions in the same manner, you have the two die halves which is closed, you secure them together then the molten metal is forced into this die under pressure and then once we ensure that the metal has solidified we open the ejector die back words or you open it and the in that case the casting is also taken out.

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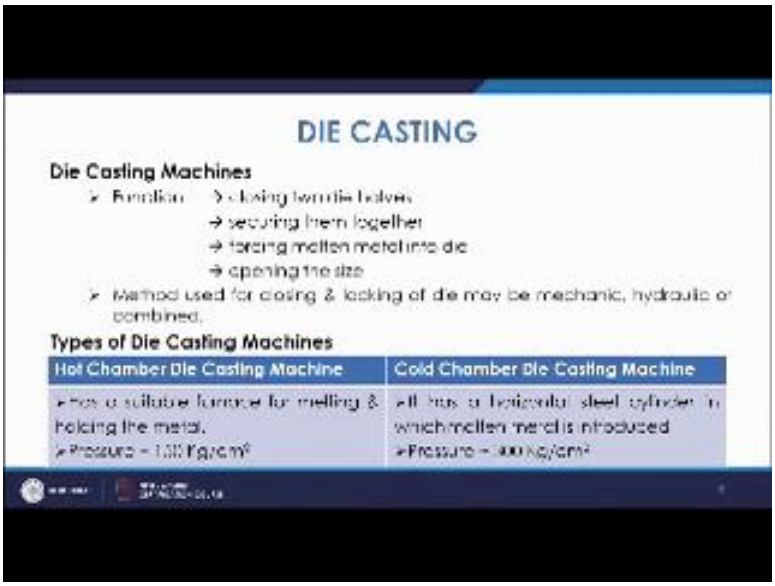

So, the method used for closing and locking of die may be mechanical, hydraulic or both mechanical as well as hydraulic based. So, this way you have the methods to operate this ejector dies, how to take it out and again further close it and apply the pressure I mean pressure for inducing the liquid into it so all these things are may be either mechanical or hydraulic based. So, we will discuss about the types of die casting machines. So, basically there are two types of die casting machines, this is hot chamber die casting machine and cold chamber die casting machine.

So, as the name indicates the hold chamber, makes in this case you have a chamber which is hot or an higher temperature as is nothing, but it is a part of the furnace itself and the molten metal with some mechanism from the furnace, goes into the space between the dies and then it is solidified under pressure. So, you have the high temperature liquid metal available with the machine itself and from there you are pumping the liquid into the unit. Now this is basically done for the metals, where there is fear that if you are having a mechanism not of this kind then the metal may lose the heat and there may be problem of solidification or they in that may solidify prior.

So, in this case the pressure applied is normally 150 kg per centimeter square. Now there is cold chamber die casting machine which has horizontal steel cylinder in which molten metal is introduced and the pressure is 300 kg per centimeter square, now let us see how these two are different.

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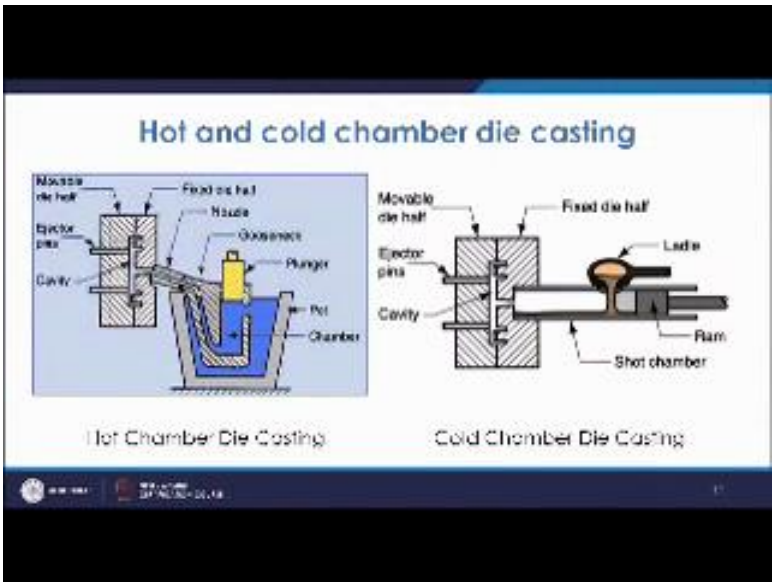

So, in this case in the hot chamber casting, this is a furnace, so you have heating you know arrangements, and the metal will be supplied from here. So, then once you apply this plunger, the metal will go from here and through this goose neck and it will be forced into this cavity and then it is this pressure is maintained.

So, once it goes inside after certain predetermined time, this pressure is released this ejector die is taken out and the metal is which is cast is taken out. So, what happens is this metal is always ready with because it is always heated from all the sides it is like a furnace. So, your uninterruptedly your process goes on; whereas in the case of cold chamber die casting, you do not have a furnace attached to it you have to bring the liquid metal from the ladle. So, furnace is somewhere else you are bringing the liquid metal and from there you are pouring into this pipe and further you are pressing it, it goes here and then under pressure it is solidifies there, once you ensure that the solidification is complete the ejector pins from with the use of this ejecting facilities this die halve is moved in this direction and then this metal which is solidified is taken out with the help of ejecting facilities.

Now, what we see is, in this case you have the molten metal having adequate heat always in hot state and the in these you are bringing the liquid metal from certain distance. So, certainly you need to provide the adequate amount of super heat, adequate degree of super heat so that it can come satisfactorily and does not lose a super heat before it goes

into the cavity and stars solidifying, and in this case that is there is no fear of such kind. Now in this case this is normally suited for the metals with low melting temperatures alloys because in that case there is fear of decreasing the temperature even lesser and if that it decreases somewhat even if it loses it is super heat, in that case there is chance of basically having defects like colds sorts or So, or the metal may pre solidify before going into the cavity and this is normally for somewhat higher ranges like aluminum or copper we prefer to go for these methods.

In this case as it is a cold chamber process we see that here you have the pressure, which is put in is the larger values that is 300 kg per centimeter square. Now what are the metals which are basically die cast? So, we have already discussed the metals which are typically die cast are zinc, aluminum, magnesium, copper base alloys, tin base alloys, lead and others. So, these are the low melting point alloys or materials which are suitable to be cast using these die casting machines. Now design of die casting dies. So, they are certain design considerations which should be kept in mind, what are these arrangements of die cavity and parting lines.

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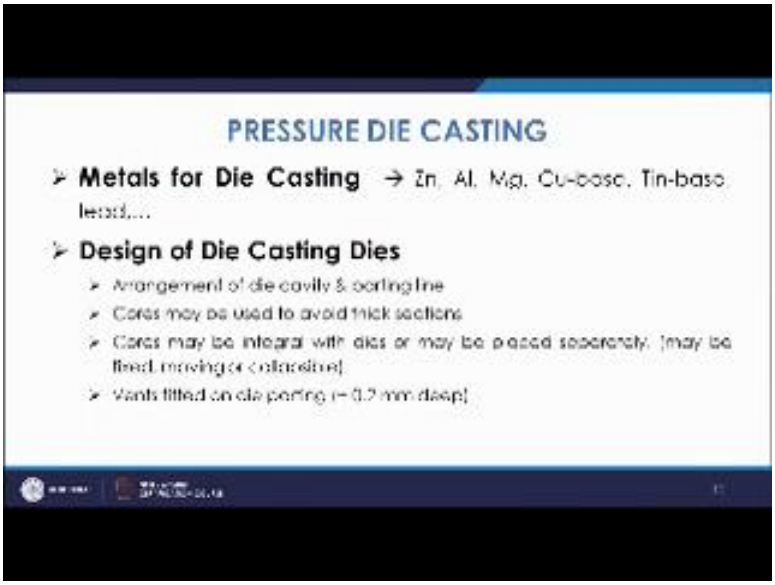

So, die cavities should be at appropriate places and there must be a parting line. So, that parting line should be at the center so that way that should be properly defined, Course may be used to avoid the thick sections wherever you have thick section, in many cases you may think of having the recess or the holes by drilling it, so in that case you are to

make thick section. So, you try to avoid having the formation of any thick section and provide the course. Core may be integral with dies or may be placed separately; so you can have the course is die itself or you can provide separately from and you can fix them and do the work every time.

The core may be fixed, it may be moving or it may be collapsible or it may be of different parts in difference pieces. So, that way you may have the course of different types. So, it either may be fixed or it may be moving or it may be of collapsible nature; you must have the vents on the die parting plane. So, these vents are normally of the order of point two mm deep, to allow the gasses which are entrapped and they have to escape, so even the vents are there, so at the die parting plane die parting lines, so that the gasses which are there they have the time to escape out.

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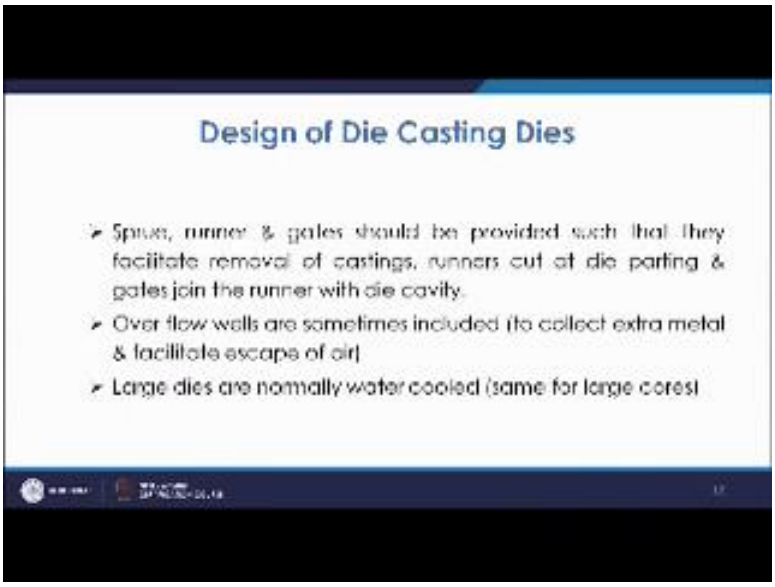

The other aspects are you have the sprue runner and gates are provided. So, that they facilitate removal of casting, runner cut at die parting and gates join the runner with die cavity. So, you have all these sprue runner and gates are provided and you have the exact locations or appropriate locations where you should provide them; over flow wells are sometimes included. So, you to see that there is facilitation of the removal of air or the extra metal should go to ensure that your die cavity has completely filled; you have over flow wells provided.

Then larger dies are normally water cooled. So, similarly larger cores they are also water cooled because we do not want to have that will be very costly and that will be very chunky, so larger dies are made water cooled. Now the inherent advantages we have already discussed about this hot chamber and cold chamber die casting, our die cast is in general, but half for hot and cold chamber die castings these are the inherent advantages and disadvantages. The advantage is that it has a very high production rate. So, you have to simply push the metal it under pressure it solidifies take the metal quickly and a further again go on.

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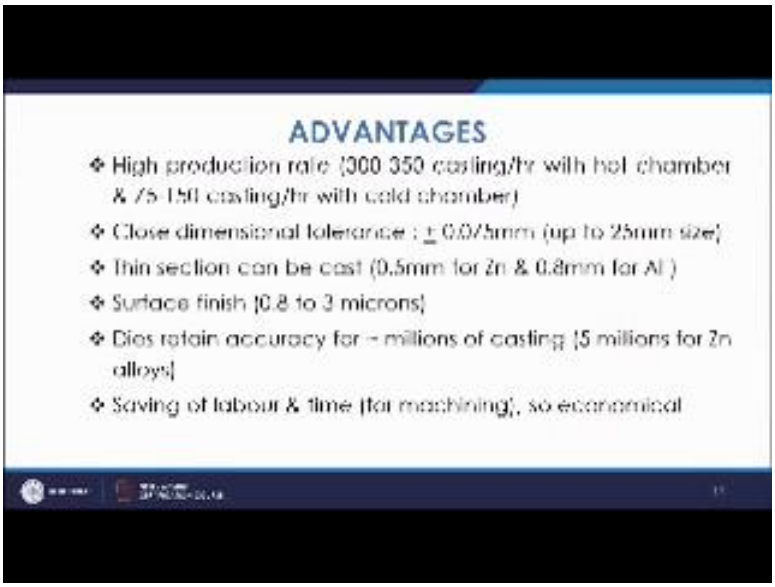

So, basically quite a high production rate is there in case of hot chamber you can see 300 and 350 per hour can even be produced and for cold chamber you can have re castings of 75 to 150 castings per hour so this way this is large productivity level with these. Closed tolerance may be of the plus minus of the order of 0.75 mm for a 25 mm size, this much of tolerance can be achieved in case of these hot and cold chamber die castings; thin sections can be cast because you are pressing the metal under pressure, so you can thin sections can be very easily cast.

Surface finish is 0.8 to 0.3 macrons that is r a value can be achieved, dies retain accuracy for large number of times may be of the order of millions may be for Jaden it has been reported that may be 5 millions of castings can be produced with one die. So, you can see that how many units is of products can be made by one die. Saving of labor and time

because you need to give small machining allowance, so this is there is saving of labor and time and that is why it becomes economical. Disadvantage is now there is certain limitation also to this process, one is that only certain allowance can be cast and mostly for low melting point alloys you cannot cast high melting point alloys, weight limitation is there as we have hard we have studied that up to 10 kg or so you can cast.

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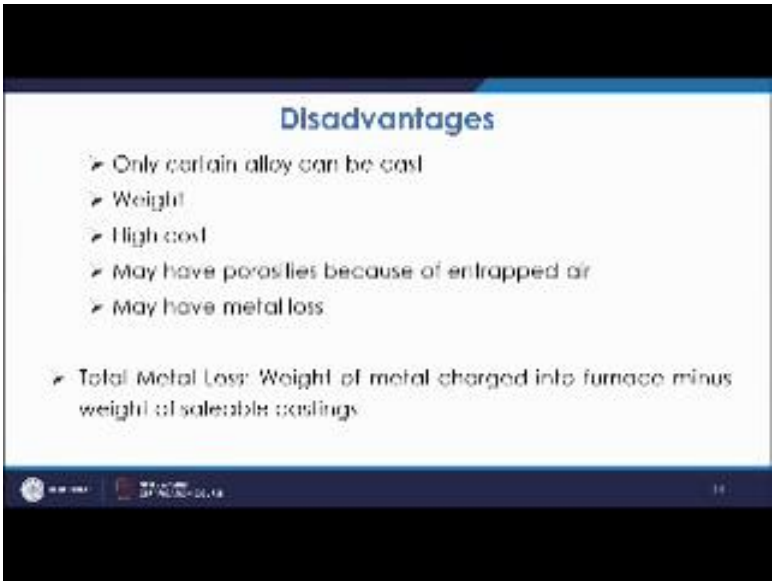

So, larger sized cast cannot be made by this method, cost is initially certainly high because you have to have the dies made of metal, you have to have some mechanism mechanization is required. So, this way the cost is more you may have porosities because of entrapped air and also metal loss during the process because of certain other type of phenomena like formation of oxides, formation of slugs, so all these may lead to some metal loss and that metal loss is nothing, but weight of metal charged into furnace minus weight of saleable castings that is metal loss.

So, these are the disadvantages of this process or limitations of the process we can say in more correct manner and about these hot and cold chambers die casting machines. We will discuss about other type of casting machines in the next lecture to come.

Thank you.