Principles of Casting Technology

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Lecture - 27
Special Casting Process
Low pressure die casting, vacuum casting etcetera

Welcome to the lecture on Special Casting Processes. In this lecture we will discuss about different casting processes like low pressure die casting, vacuum casting, cosworth process, Squeeze casting or Thixocasting, rheo casting etc.

So, what for this low pressure die casting is required? Now what we have seen that in the case of die casting where the metal is subjected to the die cavity under a large amount of pressure and that pressure is basically held for certain duration, to ensure that solidification takes place under pressure and then the pressure is released, the dies are separated and the cast product is taken out.

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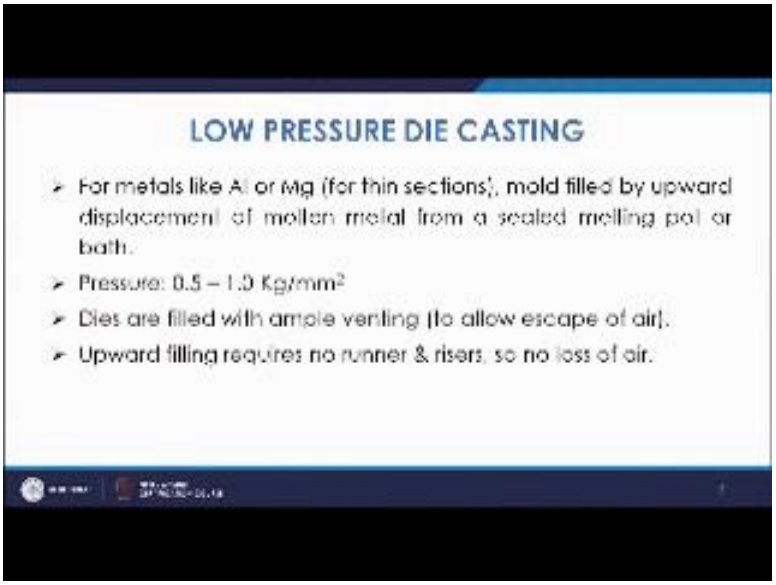

Now in this case the pressure requirement is less that is why it is known as low pressure Die casting. So, here the process is adopted in such a manner that the pressure requirement is less, now what happens for metals like aluminum or magnesium, the requirement is felt only because when you apply large pressure, then there is possibility

of formation of vertexes or turbulent pockets. Now for metals like aluminum or magnesium, which are highly oxidizable; if under the pressure, the metal is subjected to turbulent behavior or turbulent conditions, then that may lead to formation of oxides and that will spoil the quality of the cast product.

So, a process is thought in such a manner that this turbulent entry of the metal into the cavity should be minimized. So for that what happens because in the earlier cases, when you have to go for thin sections casting, you will have to apply lager amount of pressure and that may lead to formation of vertexes and turbulent conditions.

So, in this case the pressure is applied, but then the metal entry is from the downward to the upward direction, by the upward displacement of molten metal from a sealed melting pot or bath. So, what happens? You apply the pressure on the side walls and in such a manner that when it pressures thus middle portion which is having a tube, from there from the inside due to this pressure the metal goes and at the top you have the die cavity where the metal enters and you get the cast product. So, in this case the pressure level is 0.5 to 1 kg per mm square. So, it will be something close to 52 to 100 kg per centimeter square. So, dies are filled with ample of venting, so, that there is escaping of air allowed, you see that air should be escaped if any air comes into it or if the die has already certain air it should be able to go out.

Upward filling requires no runner and riser so, no loss of the yield. So what happens because there is the upward movement of the liquid in the mold what happens? There is no requirement simply it goes into the cavity, no need of the sprue or the riser or the runner. So in fact that improves the casting yield. So, no loss of yield basically it is yield there is no loss of yield as there is upward movement of the molten metal directly goes into the cavity, because in the earlier case you had the formation of sprues and all that, in this case there is nothing as such, so that yield is improved.

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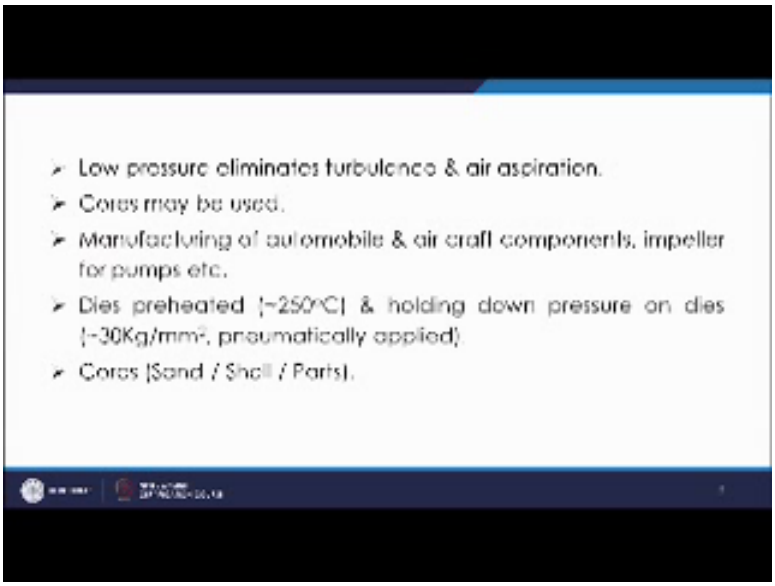

As we discussed the presence of low pressure eliminates the turbulence and air aspiration. So, as the pressure will be more if the at higher velocity you are at the corners, there are chances of formation of turbulent pockets and then the presence of these turbulence and the formation of the adverse pressure gradient situations, that may lead to the aspiration of air. So, basically that will contaminate the melt pool especially for those metals which are highly prone to getting oxidized; you can use the cores if there is requirement of core to be fitted.

So, this method is used for manufacturing of automobile and air craft components, impeller of for pumps etc. So, for these materials you use these process, dies are preheated when we close to 250 centigrade and holding them pressure on dies is there because you have to maintain the pressure and that pressure is about 30 kg per mm square. So, that is pneumatically generally applied because till that time it gets solidified you have to hold it because you apprising from the bottom, you have to clamp from the top, you have to hold it from the top and the cores can be of sand or shell mold or of the plaster of (Refer Time: 06:37) so that is shell.

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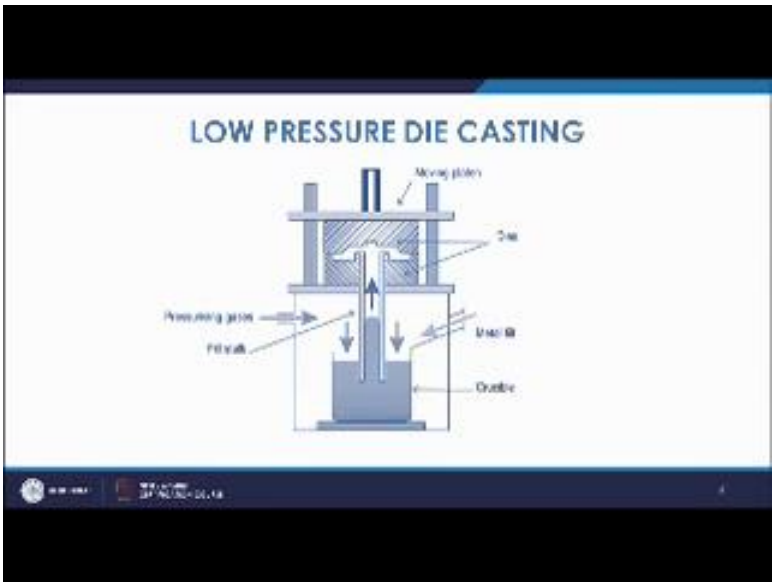

So, this is the example of low pressure die casting. In this case what we see is that you have the cavity here this cavity will be filled by the pressure, pressure you are applying from this side, this pressure goes and this pressures at this surface. So, once it pressures on this the liquid metal comes down and that will try to provide a shift in the upward directions, metal goes due to this pressure, it goes directly here. So, under that small pressure it will go there and it will go into the cavity directly and these are the dies which are clamped, which are basically having certain pressure from the top. So, they are holded at it is position and you get the product which goes into it gets solidified and then you can take the dies the 2 halves of the dies out and you can get the material out. So, this way you use this low pressure to get the cast component.

Another variety of the casting process is vacuum casting, as the name indicates here the feeding of the metal is because of the formation of the vacuum. So, once there will be movement of certain part that movement will induce the vacuum or you create the vacuum using certain pump then because of the vacuum, the molten metal goes into that portion where the vacuum is created because metal will show from the higher pressure resume to the lower pressure resume. So, the metal goes and under that metal goes into the right cavity.

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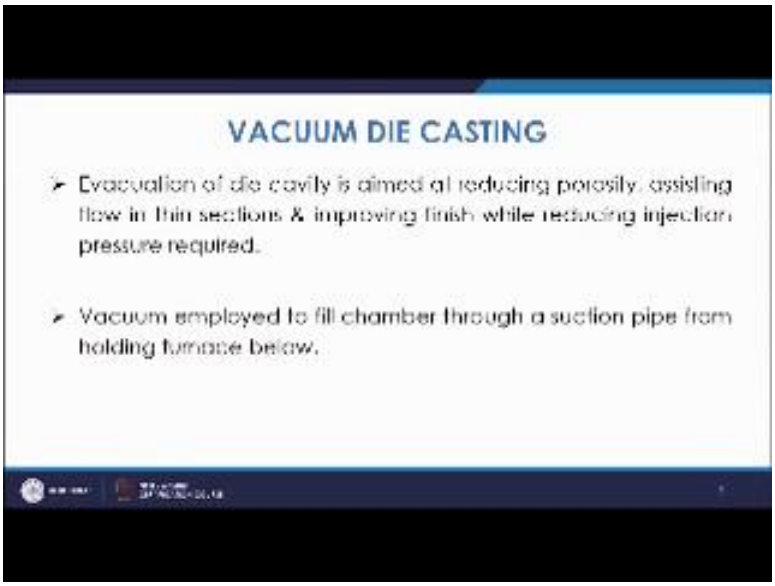

So, evacuation of die cavity is aimed at reducing porosity, assisting flow in thin section and improving finish while reducing injection pressure required. So, basically as it goes under vacuum, there is no chance of going any air into it or gasses into it that reduces the chance of any porosity which maybe formed, it can go into thin sections because it is all going everywhere because of the vacuum created. So, that ensures the presence of vacuum at any point ensures that, that portion will be filled by the molten metal and that basically helps in getting the very fine details on the cast product.

So, injection pressure is also less, vacuum implied to fill chamber section pipe from holding furnace below. So, you have on the bottom side you have a holding furnace and that from there the vacuum is implied through a pipe.

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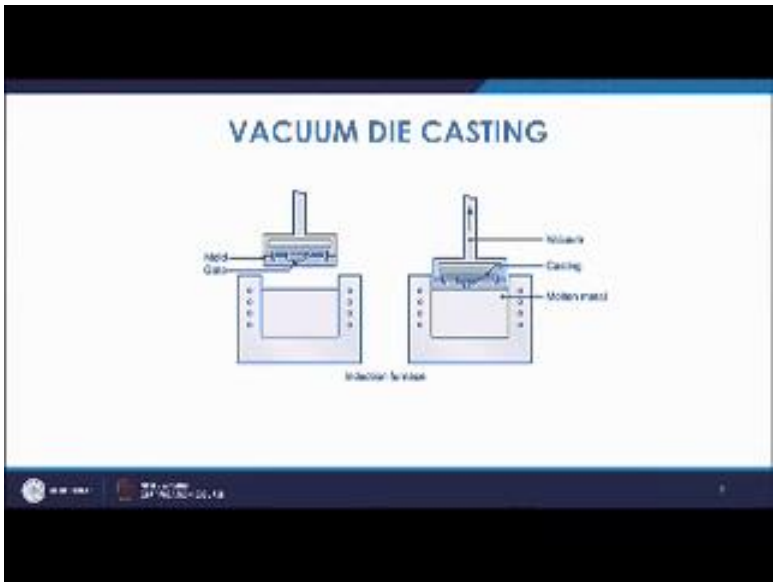

So, this is how it goes you have this mold and in that once you create the vacuum, so they have certain mechanism by which you can create the vacuum. So, once the vacuum is created you have the pump attached, from there you can create the vacuum; once the vacuum is created the molten metal will enter into it. So, that will molten metal will go inside and it will go into all the cavities. So, it is there is no contact of molten metal with air. So, it is directly going from there into the cavity and that is why the chances of having impurities or porosities they are quite less in such cases.

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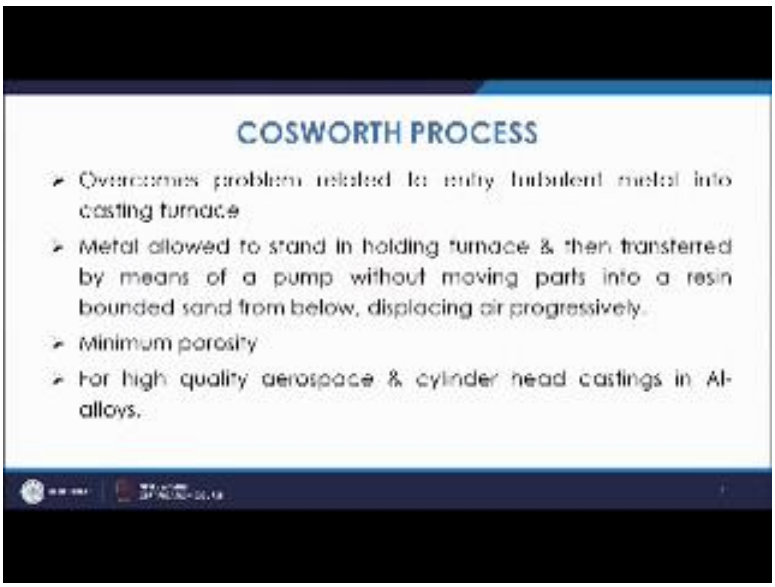

Cross worth process; now cosworth process is based on a pump known as cosworth pump. So, it over comes the problem related to entry of turbulent metal into the casting furnace. So, what happens when you give the molten metal into a casting furnace in a turbulent manner, then there is chance of the dissolution of atmospheric gasses or dissolution of air into the melt, and that basically will spoil the quality of the melt; here metal is allowed to stand in holding furnace and then transferred by means of a pump without moving parts into a resin bounded sand from below, displacing air progressively.

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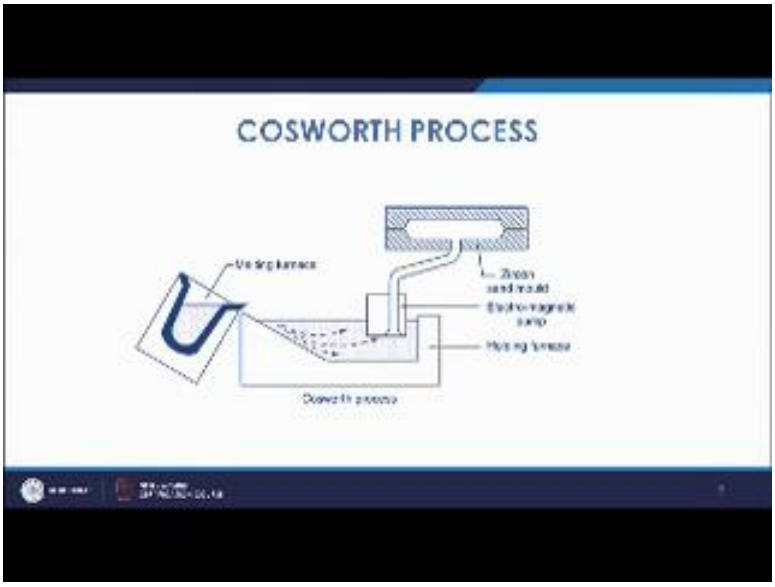

So, what happens? You have a holding furnace that is here and then this is a holding furnace, melting furnace is here it will come here and then there is a cosworth pump. So, that is a pump because of this pump this metal goes into this molt. So, without moving parts and it will go into resin bounded sand from below. So, this is the resin bounded sand and the melt will travel from here to this resin bounded sand. So, what you see is since the mate melt is not at all exposed to the atmospheric air or in any way it is not exposed.

So, from here it goes through that cosworth pump, which is non-moving which as non movable parts. So, it will take this liquid metal through this channel and it will go into this resin bounded sand and here when it comes into contact with this molding material that is resin bounded sand, this is (Refer Time: 12:55) sand mold which has quite a good conductivity as compared to the silica sand or other sands, then in that case it gets

solidified and you get a clean kind of product. So, based on this the use of this cosworth pump it is this process is known as because it also is a very low pressure and the metal entries from bottom to top. So, this gives a clean kind of cast product. So, that is known as cosworth process.

Next type of casting is squeeze casting, as the name indicates he has some squeezing action is implied.

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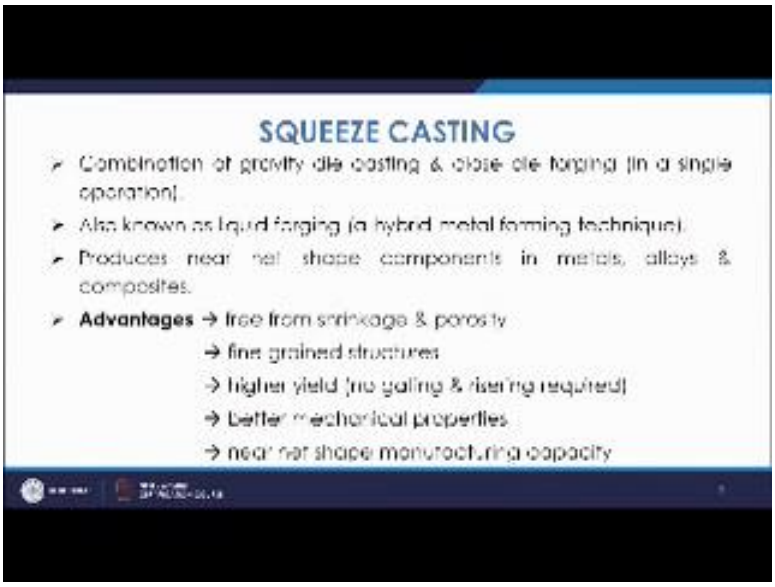

So, this process is a combination of gravity die casting and close die forging in a single operation. So, what happens in this process, what we see is in the gravity die casting? What we had seen is the dies are closed and then you are pouring the liquid metal, liquid metal enters into cavity under the action of gravity. So, that is why that is a case of gravity die casting. Close die forging; so close die forging is a forging process, forging process is nothing, but applying with the compressive forces on any product under the closed dies. So, dies will be meting each other and then they will apply a pressure on the product so that the metal which has been putting, it will ultimately follow the contour of the cavity. So, that is close die forging.

So, die forging basically is of two types: one is open and one is closed die, in the open die forging you have the flat surface that is not the case here it is a closed die forging means there is cavity and graved in that dies, just like you have the die for these die castings. So, there also you have different dies you have bottom die and top die, bottom

die is fixed and top die moves or you may have even both die moving in I mean depending upon the situation, but in this case. So, basically this method is the mixture of or the combination of these two processes.

So where what happens; so this is also known as liquid forging a hybrid metal forming technique. Liquid forging means the forging process is carried out when the metal has certain liquid fractions. So, what happens in case of forging what we do is, you are heating the material to certain temperature it has not gone to the liquid state, but here not completely liquid state, but you are basically first of all putting the material in the liquid state and then you are pressing, so that is why in the liquid state itself you are applying the pressure, that is why it is known as liquid forging.

So, it is producing a near net shape component in metals, alloys and composites. So, if you look at the process you do see here, you have a hydraulic press and you pour the liquid metal into the mold and then from the top this punch portion, this is the die and this other half of the die.

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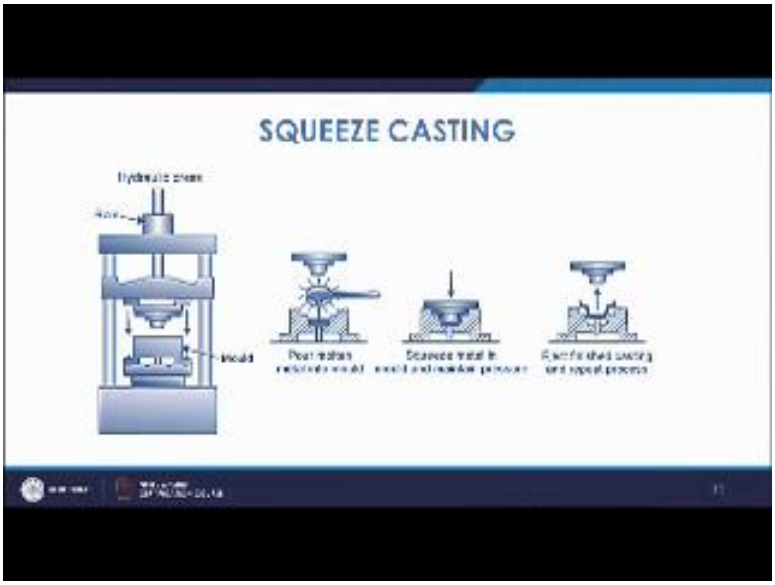

So, you have made such kind of cavity. So, from the top once you have poured the liquid metal into it, you put this upper die portion and then you apply the pressure over here. So, this liquid which is there in this mold under the action of this pressure it gets solidified and it solidifies in a very small amount of time and it this type of technique because you are forging in the liquid state normally the forging is done for the solid

product for the solid pieces, but they are heated may be hot forging or cold forging maybe carried out at different temperatures at higher or lower temperatures.

But in this case this is liquid and then you are applying this pressure from the top. So, that is squeezing the metal in mold and maintaining the pressure, that is why it is known as squeeze casting then you are taking this die out or the sponge out and then you are ejecting using the ejecting pins this finished casting that is taken out and this way the process is carried out.

So, what are the advantages because you have the liquid state itself, there you are applying all the pressure and get the solidified product so the chances of formation of any gaseous pocket is minimized. So, because these gaseous pockets are likely to form when there is gradual transformation from liquid to solid state and there is no scope of the air to go out, but here all of the sudden on the liquid itself you apply the pressure, there is no time in between transformation process, all this process occur simultaneously and the shrinkages and porosities are they are all negligible; you have fine grain structure because the top die that is punch which moves from top to bottom, it is at low temperatures, so the under cooling experience is quite high and that is why you get a quite a fine grained structure.

You do not have any requirement of getting or risering. So, because of the absence of getting or risering requirements, the yield is quite high. So, in the case of other castings like gravity die casting or so you are giving the extra metal which is basically a part of the cast product in the form of sprues runners and risers. Now here you do not have that you have the punch or the upper die it has the shape, according to the products shape or the shape of I mean material which you are likely to get you are directly getting that. So, once you remove the pressure then you are getting the product. So, that is why because of not having any getting and risering your casting yield is quite high.

Better mechanical properties as the material will have fined grained structure and also it will be free from shrinkage and porosities. So, once you have fine grained structure, the properties will be better, the fine grained structures produce good tensile strength or strength based on certain formulas which tell that because of the fine grains your strength of the material is higher one of the formula is (Refer Time: 20:54). So, because of that you get better mechanical properties near net shape manufacturing capacity.

So, basically what you see is in one way itself you are getting completely near to the net shape. So, then you do not need to go for further machining of the object, you are getting the final product shape in one go itself. Now what are the process parameters?

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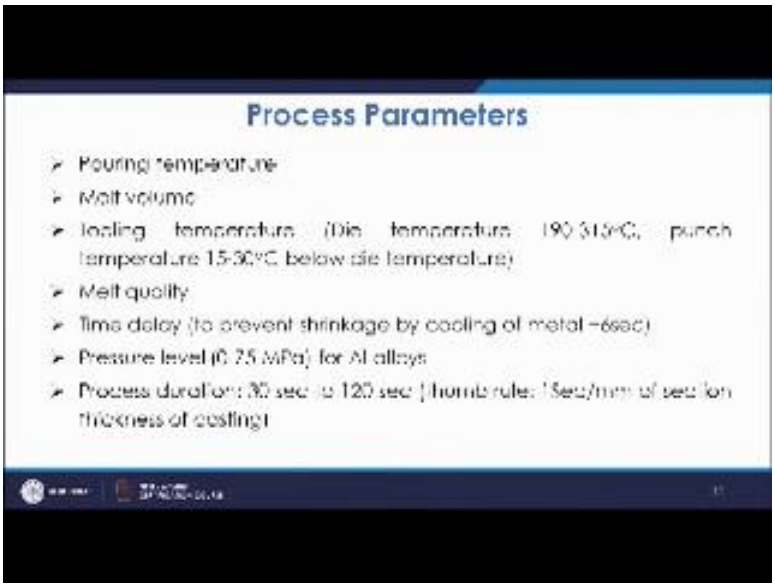

So, process parameters are like pouring temperature melt volume, cooling temperature melt quality, time delay, pressure level and process duration. So, basically you will have to maintain a balance to see that there is proper amount of these controlling parameters or there is proper level of all these controlling process parameters, like pouring temperature or melt volume has to be adequate. So, that it does not when you are basically putting in the cavity. So, in during that process you should not loss the supper heat, the temperature should not come down basically the temperature comes too much of down in that case you may require large pressure to be applied. So, once this temperature comes down, the requirement of the pressure to be applied from the top die or the punch it will be quite high. So, your pouring temperature has to be adequate.

Similarly, melt volume; melt volume also has to be properly controlled, if the melt volume is less then there will be under face, the cavity will not be completely filled and if it will be more then there will be losses, it will go as splash or if not then it will create a large amount of pressure, melt volume has to be controlled. Cooling temperature; means you are basically keeping the temperature, die temperature is something close to 190 to 315 degree centigrade and then this punch temperature will be kept 15 to 30

degree C below this die temperature. So, this way you have to maintain the temperature of the melt.

Melt quality like melt should be free from any kind of impurities dirt or so because if it goes inside the cavity it will try to good trapped into it and that will spoil the complete casting. Pressure level has to be maintained maybe from 0 to 75 mega pascal and you will have also that duration that is now a 30 second to 120 second, the thumb rule is 1 second per mm of section thickness of casting, that is the duration of the process. So, this is how we have seen that this is squeeze casting.

There is another kind of (Refer Time: 24:30) working process or casting process it is known as semi solid metal working process because here what happens you see that it is a kind of because you also do some working on it, some firming process goes on some pressure we apply that is why we also call it as semisolid metal working process, now it is varieties are many.

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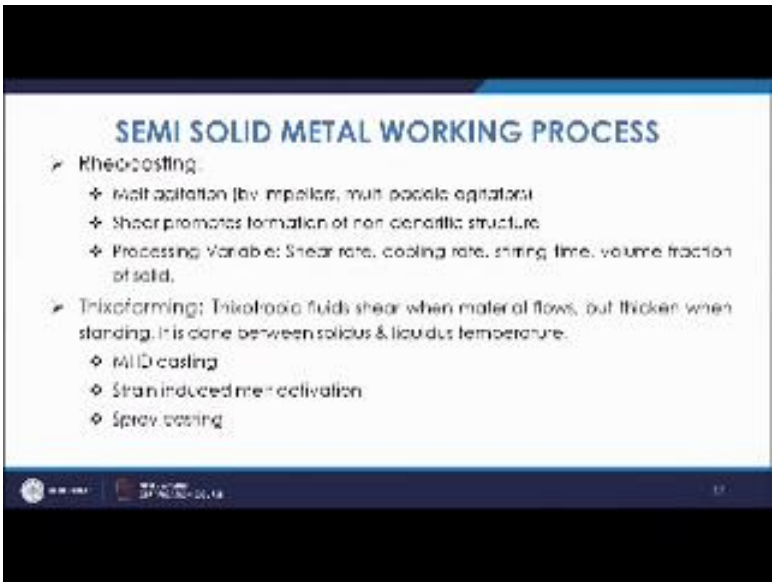

One of them is rheo casting. So, what is rheo casting basically? So, in that case what happens now in this case in this semi solid metal working process, the aim is to avoid the dendritic type of a structure and you try to see that you get favorably equiaxed global of the structures.

Now, what is that process which induces all that? So, the rheo casting is there, in the rheo casting basically what happens is the melt is there which is agitated by the impellers or the multi paddle agitators. So, there is melt in that you have impeller or agitator, which is evolving inside the melt, now and also it is getting cooled. So, what happens then in formation of the spherical or if the particles and being in an alloy, it will try to have dendritic arms, but because of the continuous a stirring and agitation, these dendrites are broken. So, ultimately what you get is because of this serial the dendritic structures are gone and the non dendritic type of structure is formed.

So, the processing variables are shear rate cooling rate, stirring time and volume fraction of solid. So, these are the processing parameters which basically control what way you can get, what kind of a structures? So, basically in this as the time moves and as these variables change the shift from the dendritic structure to the equiaxed structure will be observed and because of the breaking of these dendrites.

Another kind of this process is Thixoforming. So, thixoforming is based on the thixotropic word which is nothing, but it means that you know that because of the shear material flows, but it thickens when standing. So, when it is standing it is thick, but once you apply the sheer force it will flow. So, it is done between solidus and liquids temperature and basically for that these are the processed which are used for further thixoforming or thixocasting of the product and that is MSD casting where the DC continuous caster is there and you apply the magnetic field and because of that these dendritic structures are (Refer Time: 27:41) because of the continuous rotating magnetic field in the continuous caster, there is avoidance of the formation the dendritic type of a structure.

Similarly, strain induced melt activation where it is hot ward and cold ward and then kept into a range of solidus plus liquids. So, because of the high angle grain boundary formation, on that concept this is strain induced melt activation is there then you cast, so you get a fine structure and then there is a spray casting where the metal is melted and sprayed through a nozzle and then it once it goes on a surface of straight then there it takes in certain shape that is spray casting; then these products are go going for getting thixocast or thixoformed.

So, these are the semi solid metal working processes, which are there in the practice which are the basically future generation metal working processes or casting processes which are used, although they are little bit costly because of the presence of the equipments which are costly, but they give you very good quality products.

Thank you.