Fundamentals of Manufacturing Processes

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Lecture – 22
Casting: Casting defects & their preventions

Hello, I welcome you all in this presentation this presentation is related to the subject fundamentals of the manufacturing processes and we are talking about the casting process and today now we will see that the casting defects and their causes and the preventions or the remedies.

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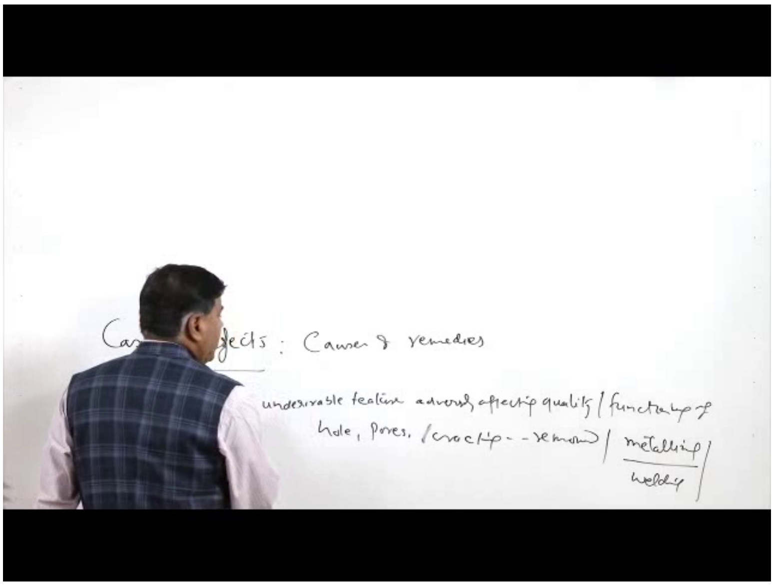

So, the topic is the casting defects basically causes and remedies or prevention. So, to define the casting defect you see any undesirable feature; undesirable feature which is adversely; affecting the functioning of the casting or functionability of the casting feature adversely affecting the quality and the functioning of the casting can be considered as a casting defect.

So, some of the undesirable features like there is a hole or pores or cracks or many of this kind can be removed and so that the casting which has been produced can be used again and for this purpose basically the metalizing that is the deposition of the metal and the welding are commonly used. So, that the defects in the casting can be removed and the casting can be used for the purpose for which it has been made.

So, if we try to put the casting entire type means there is there are very wide range of the casting defects which occur in the casting.

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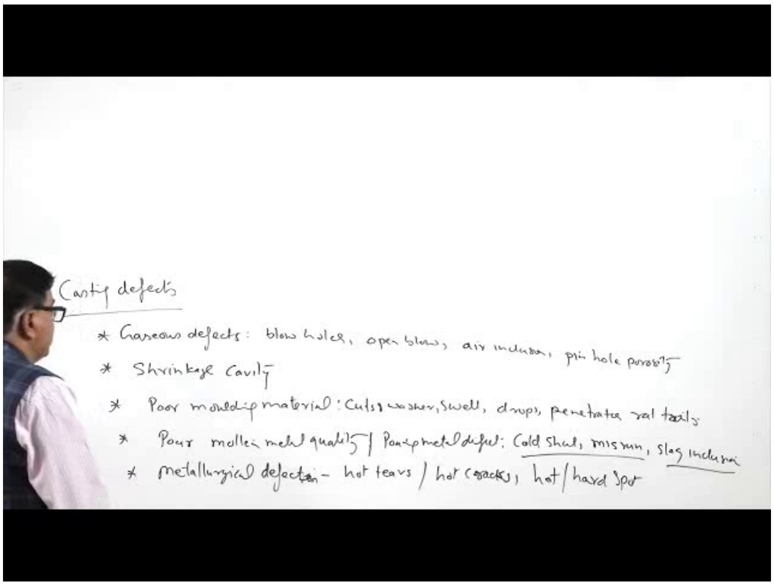

So, we need to put them in the different categories for the systematic and clear understanding about the causes of the casting defects. So, the casting defects can be put in 5 categories; one is like the gaseous defects those which are related with the presence of the gases in the casting under this we have a like blow holes open blows air inclusions and pin hole porosity, all these are the gas based defects and primarily caused by the reduced permeability or the limited venting which is available in the mould cavity for escaping of the gases.

Another is like the shrinkage cavities which happen due to the high volumetric contraction of the molten metal in cores of the solidification. So, shrinkage cavity occurring due to the shrink contraction of the metal in cores of the transformation from the liquid to the solid state third is those which are occurring due to the poor molding material used for preparing the sand mould and under this; there are many defects like cuts and washes swells then drops penetration rat tails etcetera and the others defects also.

Then they are a fourth category of the defects which are related with the poor molten metal quality and because of this or we can say the pouring metal defects. So, these are may be inform of like some impurities are present in the molten metal which is poured into the casting or the molten metal being poured is not of the correct temperature because of which some defects develop in the casting like cold shut and mis-run and slag inclusions.

So, the first 2 types are caused by the improper control over the pouring temperature and third one is caused by the improper filtration of the molten metal and because of which impurities are getting into the mould cavity and the fifth one these are the metallurgical defects due to the unfavorable metallurgical transformation taking place in the casting and these are like hot tears or these are also termed as hot cracks and then hard spots also termed as hot spots. So, hard spots on the hard spot. So, we will these are the 5 categories of the casting defects and these are the specific defects falling in the different categories there may be few more which I will be elaborating subsequently along with the regions and the remedies.

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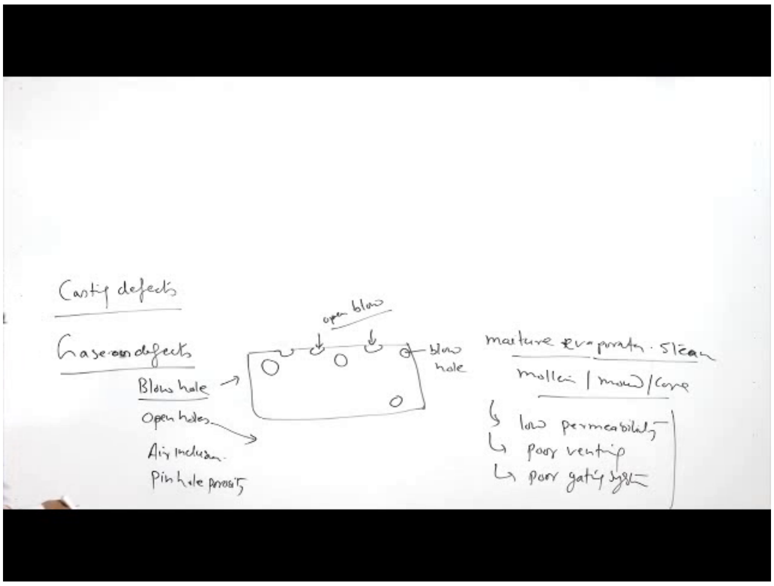

So, first of all I will be taking of the gaseous defects gaseous defects and we have blow holes open holes air inclusions and pin hole porosity. So, first of all we need to see that how to recognize these kind of the defects. So, say this is the casting if there are blow holes then these are the large pockets of the gasses in the casting, but these are present inside the casting.

So, and these are primarily caused by. So, blow holes are primarily caused by these are blow holes and primarily caused by the evaporation of the moisture evaporation a generating a steam and a steam whatever is generated due to the molten metal mould oblique core interaction. So, that is steam remains with the casting itself or within the mould self due to the low permeability means the steam generated does not get enough a space or time for getting of the mould cavity poor venting and the poor getting system getting system not permeating the gaseous or the moisture which was generated to come out of the mould cavity leads to the blow hole defects.

So, basically the primary reason is the moisture steam generated and whatever the steam is there that is not able to come out of the mould cavity. So, remains in the casting if it is inside then it is termed as the blow hole and in case of the open holes these are similar to the these are similar to the blow holes,, but these are open to the casting surface like this.

So, open holes are blow holes which are open to the surface of the casting. So, like this these are the open blows these are the open blows and open blows are also caused by the same reason excessive moisture generating the steam due to the heat of the molten metal and then due to the lack of permeability poor venting and the poor getting system these generate the presents of the air pockets even at the surface.

So, these are the open holes. So, we need to work on proper venting improving the permeability and improving the getting system. So, that the steam excessive amount of the steam being generated can be taken care of at the same time moisture also need to be controlled properly. So, that unnecessary extra steam is not generated.

Now, air inclusions these air inclusions basically generated due to the presence of air in the molten metal.

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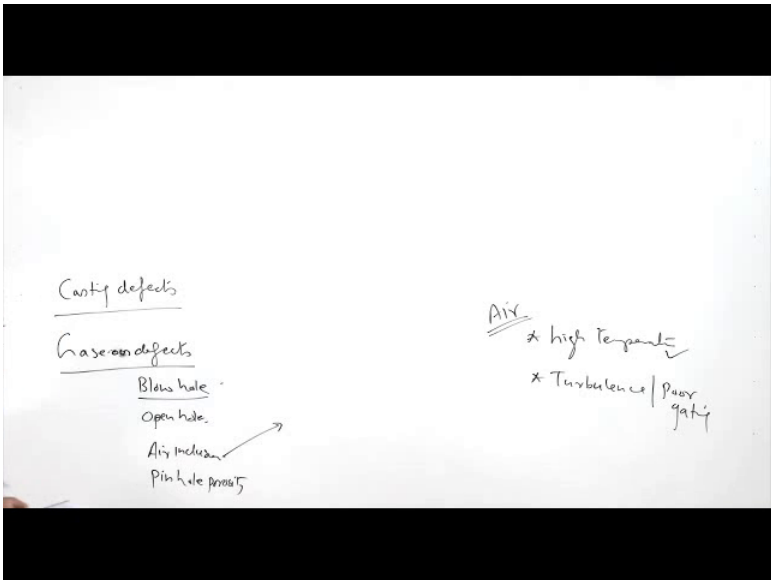

So, where from this air actually is coming in this air comes in through the following channels like the molten metal is of the very high temperature. So, the atmospheric air or the gases are dissolved in the molten metal the 2 excessive turbulence in the flow of the molten metal through the gating system is taking place.

So, the gaseous or the atmospheric air is going with the molten metal due to the turbulence this happens primarily due to the poor gating system. So, high temperature and the high turbulence leads to the presence of the lot of a atmospheric air with the molten metal and if this air does not get; this air remains with the molten metal after reaching into the mould cavity and it does not get time to come out. So, the air in the molten metal if does not escape then also leads to the presence of inclusions these are finer than the blow holes and these are air inclusions

So, these are basically caused by the presence of the air or the atmospheric gases due to the; they are dissolution at the high temperature or the mixing of the atmospheric air in the molten metal due to the high turbulence during the flow of the molten metal in the gating system. So, we need to control the proper pouring temperature for this purpose as well as the gating system needs to be improved. So, that the turbulence can be reduced in order to avoid unnecessary aspiration of the gases and air into the molten metal pin hole porosity.

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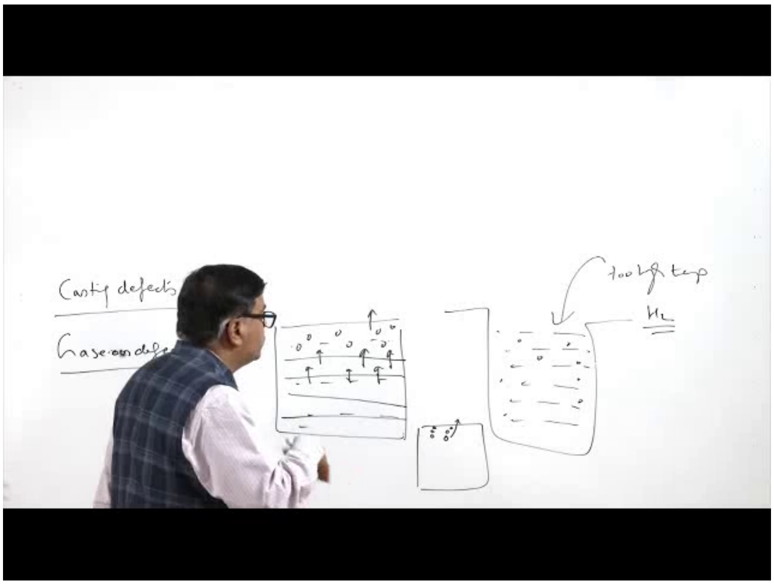

Basically this is caused by the hydrogen when the molten metal being poured in the mould is a too high temperature, it is too high temperature. So, the hydrogen either it hydrogen has got mixed in process of the melting or hydrogen was produced due to the decomposition of the moisture into the hydrogen and oxygen; so the hydrogen if it gets dissolved in the liquid metal.

So, especially in those cases where the solubility difference in the liquid and solid state is too high say this is the liquid state and this is the solid state if these difference in the and this is the temperature of the solidification or you can say melting point. So, at when the liquid metal is at sorry; this is the solid state and this is the liquid state. So, high difference in the this is the liquid state high higher melting point this is the melting point temperature and this is the solubility of the hydrogen this kind of trend is shown in both aluminum as well as in case of the iron.

So, when the temperature is below the melting point the solubility of the hydrogen in the solid state or in the aluminum as well as an iron is very low,, but as the temperature crosses the melting point this there is a large difference in the solubility increase a significantly. So, when the molten metal is at high temperature hydrogen gets dissolved in the molten metal, but as the solidification come is solidification is over or the temperature as the solidification completes the hydrogen is rejected due to the reduction in solubility and therefore, what we find initially if the hydrogen was uniformly present in the molten metal. So, as a solidification progresses the hydrogen is rejected into the molten metal in cores of the solidification. So, the excess hydrogen rejected into the molten metal.

So, this hydrogen actually tends to come out of the molten metal and if it is not able to come out completely from the molten metal then it gets rapped. So, basically in the castings if we see the path of the hydrogen porosity will be like this wherein the path or the holes pin holes these are a very fine size they will be showing the direction in which the hydrogen gas was trying to through which the hydrogen was trying to come out of the molten metal in coarse of the escaping from the casting.

So, basically this direction indicates the direction in which hydrogen was trying to escape and. So, this kind of porosity is of the very fine in size that is why it is are also called the pin hole porosity or micro porosity it is basically caused by the hydrogen. So, we need to control the temperature of the molten metal and even property gassing is used in order to take care of such kind of the issues related with the hydrogen porosity. So, what we need to do that property gassing and the control over the pouring temperature is needed in order to reduce the issues related to the hydrogen porosity.

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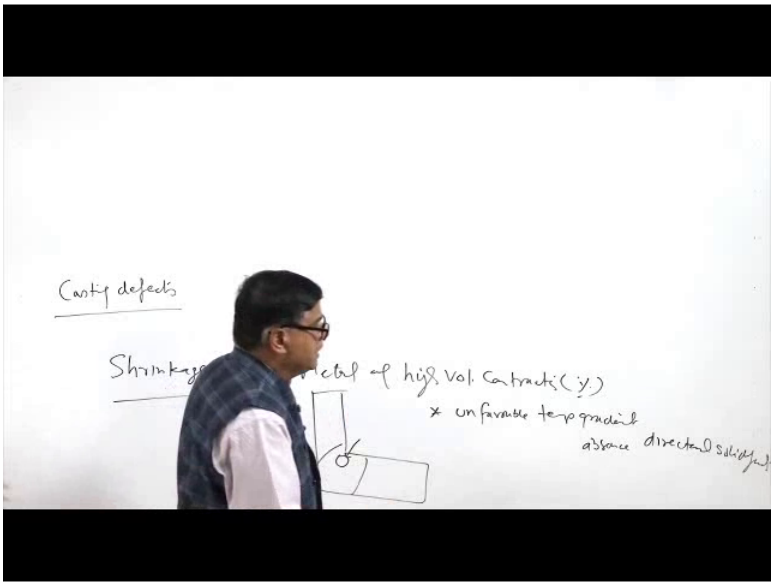

Then the shrinkage cavity shrinkage cavity this kind of problem is caused in case of the metals of the high volumetric contraction for which volumetric contraction percentage is too high. So, in this case, basically the region which is solidifying at the end leaves behind the unfilled cavity like this. So, this is the section this is the large mass which will be solidifying at the end even this case due to the unfavorable temperature gradient. So, this large mass which will be left unfilled at the end and will be leading to the defect in the casting.

So, this basically happens due to the unfavorable temperature gradient which is not leading to the directional solidification. So, we can say absence of the directional solidification or even if it is there, then even if the chills are being used to ensure the direction solidification if the chills are not placed suitable then the unfavorable temperature gradient is developed and which will be leading to the and presence of the shrinkage cavity it basically happens due to the lack of filling capability of the molten metal or poor the fluidity.

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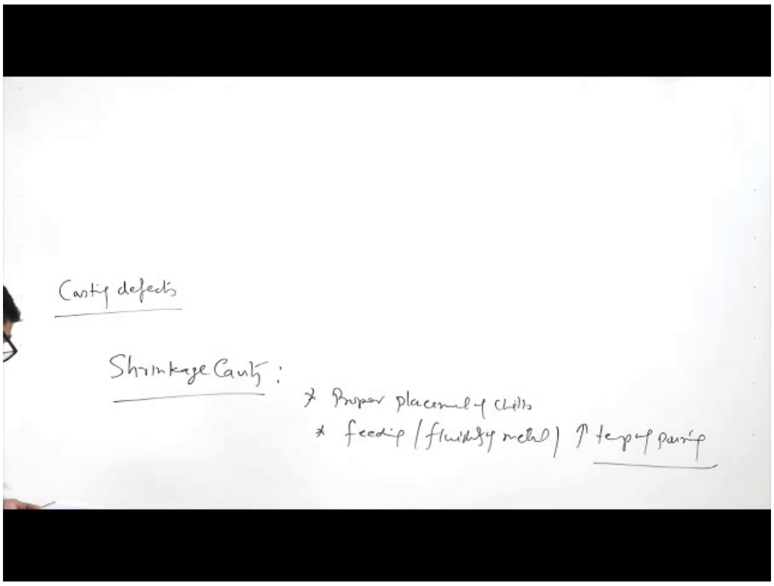

So, there 2 things which can be done proper placement of chills primarily to develop the suitable temperature gradient in the casting; so that the directional solidification can be achieved in order to avoid the shrinkage cavity and another is feeding can be improved feeding or the fluidity of the metal can be improved for this purpose what we can do we can increase the temperature of pouring metal the metal temperature at which molten metal is poured into the casting can be improved as well as the risering also can be designed and placed suitably.

So, that the shrinkage can be taken care of by the riser effectively even if the riser is not placed properly then the riser will not be able to feed the liquid metal to take care of the shrinkage on account of the liquid to the solid state a contraction and that can lead to the shrinkage cavity. So, proper placement of the riser's proper pouring temperature and proper use of the chills will help to avoid the shrinkage cavities

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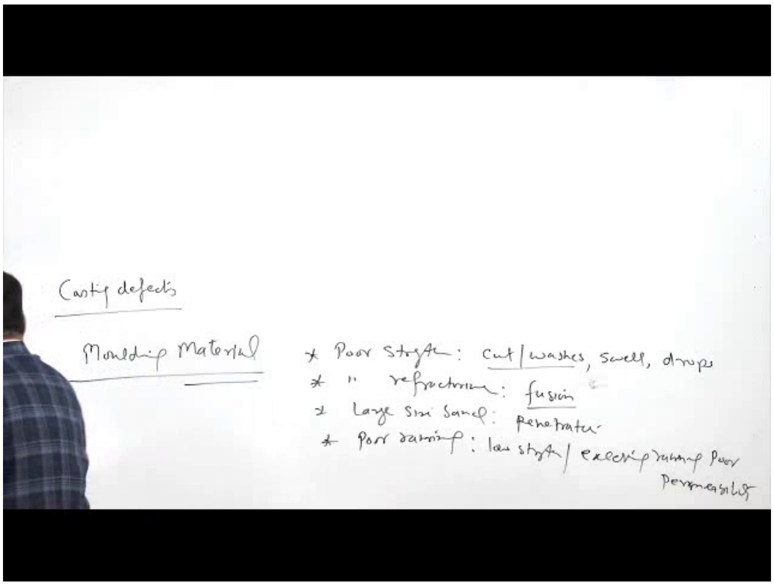

Then the third category is the poor molding material properties. So, the molding material properties sand molding material properties which lead to the presence of the defects in the casting is mainly about the poor strength of the molding sand the sand is a poor refractoriness or very large size sand and poor ramming either it is excessive or the limited. So, these are the some of the things which will be leading to the presence of the defects in the casting.

So, the defects which are caused by the poor strength are like cuts and washes it is just like erosion of the sand wall due to the turbulent flow of the molten metal then swell is the another where metallostatic pressure mould wall is not able to take the metallostatic pressure of the molten metal, then the walls shift and the swelling takes place and then here it is drop is also one of them and the rat tails or the; so, drops is the another defect which is caused by the poor molding strength.

So, fusion of the sand is due to the poor refractoriness of the molding sands. So, in this case the molten metal the molding sand wall fusions with the molten metal and forms the part of the casting large cores sand causes the defect of the penetration where thin metal will be entering between a spaces of the coarse grains and the poor ramming leads to the either low a strength or it. So, the drops and the cuts and washes are excessive ramming or excessive ramming leads to the poor permeability.

So, of the mould to escape the gasses is reducing due to the excessive ramming. So, these are some of the ways by which poor molding can lead to the defects in the casting now one buy one will be taking of these defects first is like cuts and washes.

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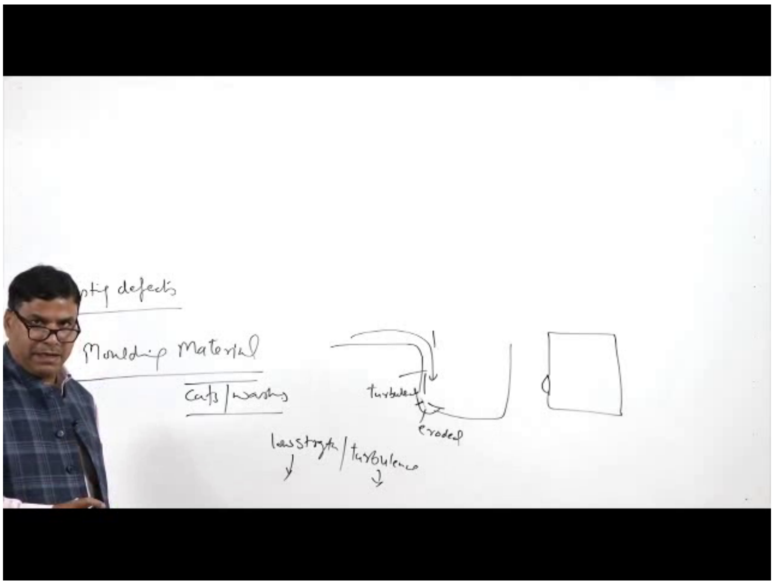

So, basically when the through the runner and in gets when the molten metal is drawing into the mould cavity; so, the flow of the molten metal in the mould cavity if it is very turbulent then the mould walls get eroded and because of these some of the spaces are created like say this.

So, basically the additional metal is deposited instead of getting casting of this say we get wherever the metal is eroded we get the casting of this shape. So, this is the eroded zone. So, wherever from the material is eroded or sand material is washed out or it is subjected to the cut due to the turbulence, then it will be leading to the changing shape of the casting and will be leading to the increased metal deposition in those areas.

So, if the casting is desired in this,, but due to the cuts and washes if the material is eroded then we get the additional piece of the metal in those areas. So, these needs to be removed this will be modifying the shape of the casting acts. So, this happens probably primarily due to the low a strength of the sand mould as well as turbulence. So, we need to we need to work on the proper gating system. So, the turbulence can be reduce and we need to do the proper molding use of the proper clay proper ramming for achieving the desired strength. So, the cuts and washes can be avoided.

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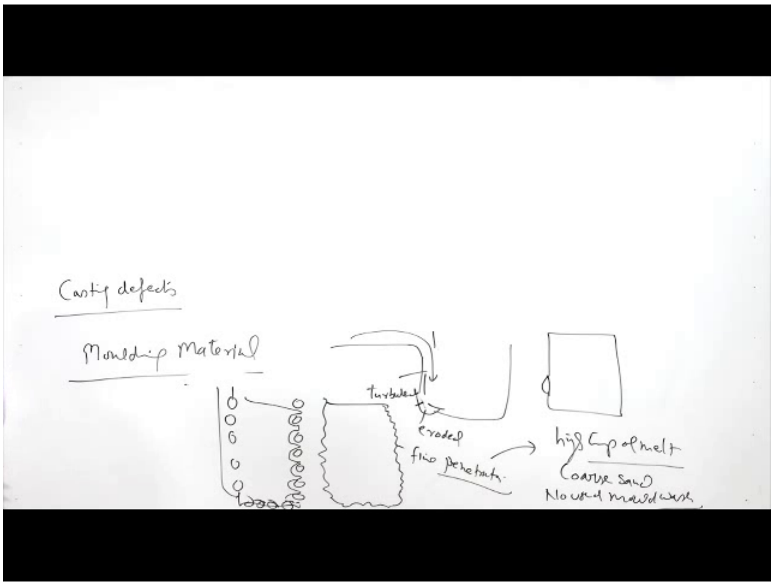

Another defect is the penetration like say if the mould is made of the cores and particles like this and like say this is the mould wall and similarly is mould is made of the cores and particles like this. So, when the molten metal is poured, it will filling in the fine spaces like this and this especially happens when. So, we get the casting with the all these impurities all these irregularities. So, these are basically fine penetrations due to the entry of the molten metal between the spaces in the spaces between the cores and particles.

So, these will be leading to the increase roughness of the casting surface. So, there are 2 main causes for this one is very high temperature of the molten metal or of the melt. So, high temperature means increased fluidity molten metal will be entering into the spaces easily and will be leading to the penetration as well as very use of the cores; sand cores sand particles providing the enough space between the particles and third is no use of the mould wash basically mould wash helps to fill all these fine spaces between the sand particles. So, if is used then all these spaces are filled in and the penetration defect is reduced.

So, the to take care of the penetration defect we need to use the mould wash we need to use the proper pouring temperature as well as the we need to avoid very cores sand in the molding process penetration is the another.

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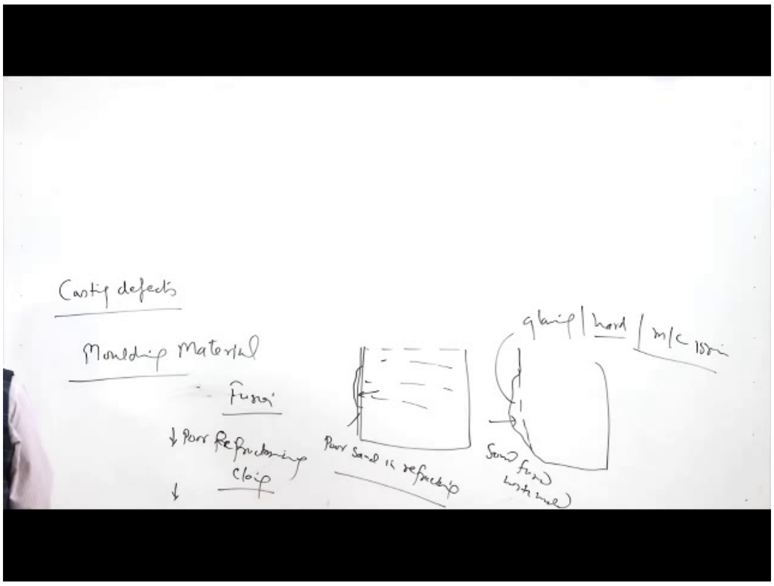

Sorry, fusion is the another issue which is in countered in the castings say this is the mould wall and if these area has been made of the poor sand in terms of the refractoriness, then this will be fusing with the molten metal. So, when we pour the molten metal the mould wall will be coming in contact with the molten metal and if it fuses then the casting forms of this kind where the shape has been modified basically and the sand has been fused sand fused with metal.

So, basically this is glossy surface which is very hard and may be difficult to machine. So, machining issues are related to the glossy surface this needs to be removed and this happens primarily due to the poor refractoriness poor refractoriness of the of the clay which is used. So, the proper type of the clay needs to be selected for this purpose. So, that it does not burn out during this another thing which can be done instead of using the too high temperature of the molten metal; molten metal pouring temperature can be controlled suitably. So, that such kind of fusion can be avoided of the mould walls. So, the pouring temperature should be according to the kind of the molding materials which are there and can sustain the temperature of the molten metal otherwise it will fuse

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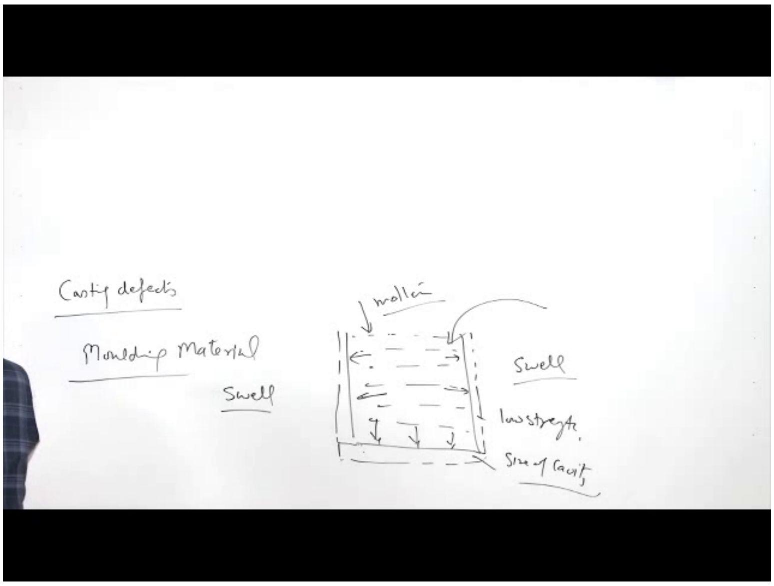

Swell is the another issue which is in countered like say this is the mould wall and if these are made of the low strength these are made of the low strength. So, when the molten metal is filled in the mould cavity it will applying the metallostatic presser on to the mould walls if the mould walls are made of the lowest strength then the mould walls will be shifted back side. So, the shifting of the mould wall the back side or in the lower side it will be changing the size of cavity.

So, basically the mould size is enlarged when the swelling takes place. So, this is basically swelling inform of the shifting of the mould walls. So, this will increase the requirement of the molten metal to be fed into the mould cavity as well as it will increase the molten metal which is to be fed from the riser as well. So, the risering is to be done properly when the swelling defects takes place. So, that it actually whatever a spaces additionally spaces have been created due to the swelling they can be taken care of by feeding the molten metal from the ladle as well as feeding the molten metal from the riser to take care of the contractions related with drops in the same way like if there is a cop and drag portion like this; this is the drag portion of the cavity

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So, if the in the cop side if the mould material is strength is poor then a small portion this is the hanging portion a small piece of the molten metal a small piece of the molding sand can fall after breaking from the upper surface of the of the mould in the cop and this will be creating the additionally space. So, basically it will be modifying the casting shape, this is the region where from the small sand lump or the piece of the sand wall has been broken, this is called drop; it happens basically due to the poor strength of the molding sand and it can be taking care of easily by proper ramming. So, that the drops are avoided; so, ramming helps to increase the strength in order to avoid the drops.

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Now, will be coming to the poor pouring metal as I have said poor pouring metal can be there in 2 forms one is poor quality of the molten metal which is being fed into the mould say it has lot of the gaseous if property gassing has not been done or if it has a; it is having the inclusions if the proper filtration of the slag has not been done then all these things will be going in the mould cavity. So, we may have the slag inclusions or we may have the gasses dissolved with the molten metal.

So, both these will be leading to the slag inclusions slag inclusions and the gaseous defects another point is another point is the another point is related with the improper pouring temperature of the molten metal. So, the they are 2 types of the issues which are caused by one is like slag inclusions if the molten metal is fed with the inclusions due to the poor filtration then inclusions will weakening the casting and another is like cold shut and the mis-run.

So, these 2 are the defects related with the pouring temperature or the low fluidity of the molten because fluidity is influenced by the temperature of the molten metal as well as the composition of the metal of the casting. So, fluidity will be leading to the longer time for filling the cavity. So, it will be adversely affecting the casting quality in these 2 aspects one is mis-run and another is mould cold shut.

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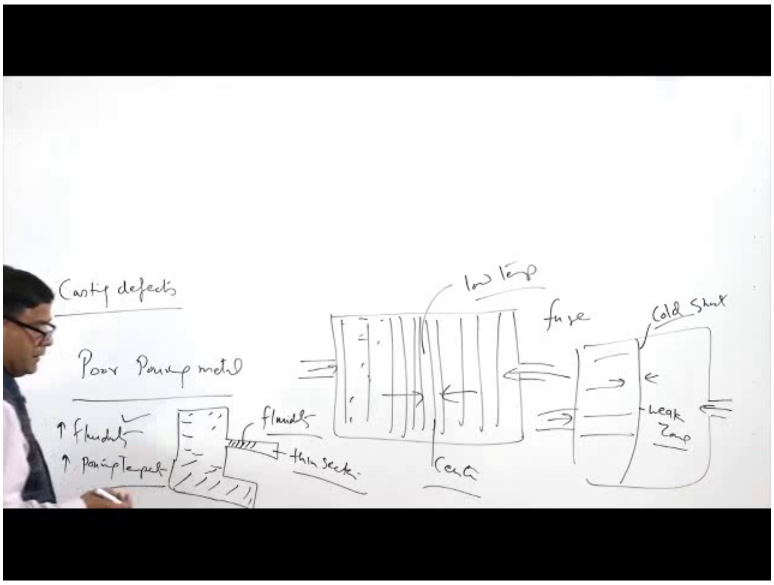

So, what these 2 defects are basically in case of the large size castings like this is the mould cavity and we are having the 2 gates like this. So, that it can be filled in the cavity can be filled in the earliest possible time.

So, the filling of the mould cavity when the molten metal is fed molten metal will be fed from the 2 sides. So, in this case in the mean time when the cavity is filled in 2 sides will be means the molten metal is streams coming from the 2 sides, they will be meeting at somewhere at the center. So, if by the time when they meet each other if the temperature is reduced significantly if the at the time at the time when the 2 streams coming from the 2 sides meet each other the temperature is reduced, they do not fuse effectively and in that case even after the solidification if they have met at this line. So, this is the zone which is filled by the filling of the molten material from one side this is the zone which has been filled in by filling of the molten material from other side,, but this is the region where proper fusion has not been taking place in the molten metal proper mixing has not taken place then they it will be leading leaving the weak zone at the interface where the 2 streams have met with the each other and this is due to the limited temperature or poor temperature.

So, this kind of defect is called cold shut and. So, primarily increase in temperature of the molten metal will help to reduce the cold shut problem as well as the time being taken to fill up the mould cavity also needs to be removed by designing the proper getting system. So, that the temperature of the molten metal does not reduce significantly before the; at the time when the fusion when the 2 sides meet with each other in order to avoid the cold shut kind of defect.

Another one is like the fine; the mould cavities having the fine details like this. So, if the cross section to be filled n is of the large means the section thickness is more it can be filled in effectively, but if the section thickness is fine then we may fine that molten metal may not be able to reach till the end. So, this is this happens primarily due to the limited fluidity of the molten metal when the all the spaces of the mould cavity are not filled in by the molten metal due to the limited fluidity especially the thin sections.

So, to deal with this issue we need to improve the fluidity and we need to increase the pouring temperature. So, basically the gating system needs to be designed. So, that it can be filled in effectively fluidity can be improved by adding some by adjustment in the composition as well as increasing the temperature of the molten metal. So, that the molten metal is able to reach all those fine spaces which are to be filled in by the molten metal for producing the sound casting as desired.

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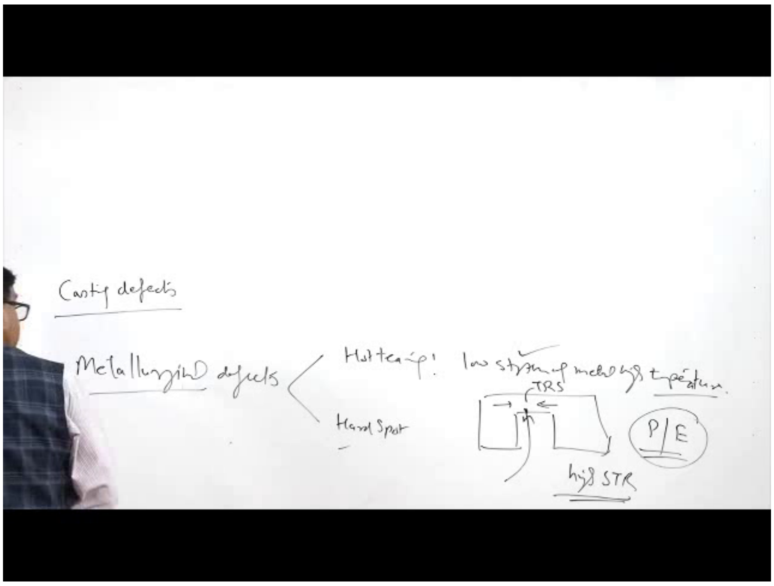

Now, the last category of the defect is the metallurgical defects under this category we have the 2 types; one is the hot tears and another is the hard spots both are very simple here this happens due to the low strength of the metal at high temperature. So, when the casting cools down tensile residual stresses are developed. So, certain casting designs like this certain casting designs like this.

So, when this portion is actually subjected to the tensile residual a stresses. So, when the casting after the solidification; when the casting cools down from the high temperature to the room temperature tensile residual stresses develop; so, if at the high temperature if the metal is of the lowest strength, then it leads to the development of the cracks or. So, this are called hot tears this kind of tendencies found mostly for the metals having the high solidification temperature range.

So, basically the pure metals and eutectic systems eutectic alloys; they do not suffer this kind of problem, but all those metals having the wider solidification temperature range they come across the hot tearing problem; another one is if the gate the design of the casting is poor which is promoting the tensile residual stresses, then that will also be leading to the hot tears. So, proper control of the composition sometimes helps to reduce the solidification temperature range or to take care of the low strength of the molten metal at the high temperature; so, that the hot tearing can be reduced.

Another like say in case of the steels it is the Magnus to sulfur ratio is maintained above certain limits.

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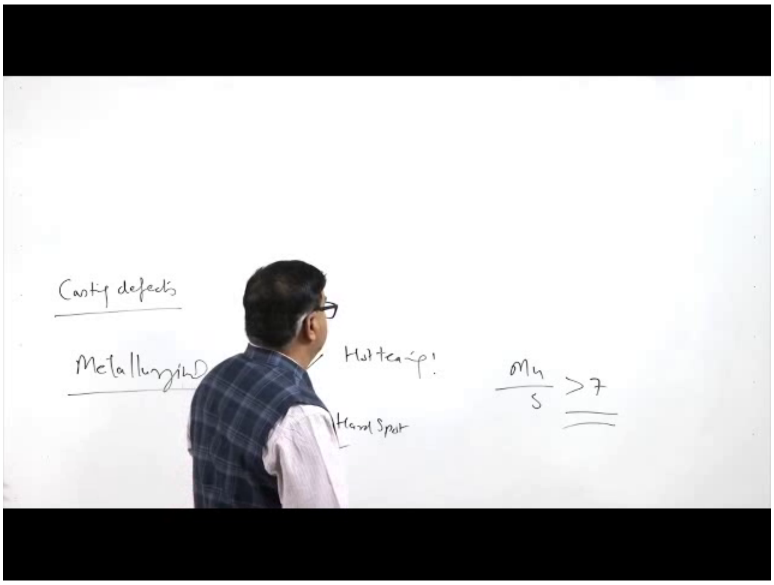

For example typically Magnus to sulfur adjust ratio is maintained more than seven depending upon the carbon content in the a steel for hard spots; we know that in case of the say cast iron if the silicon content is low.

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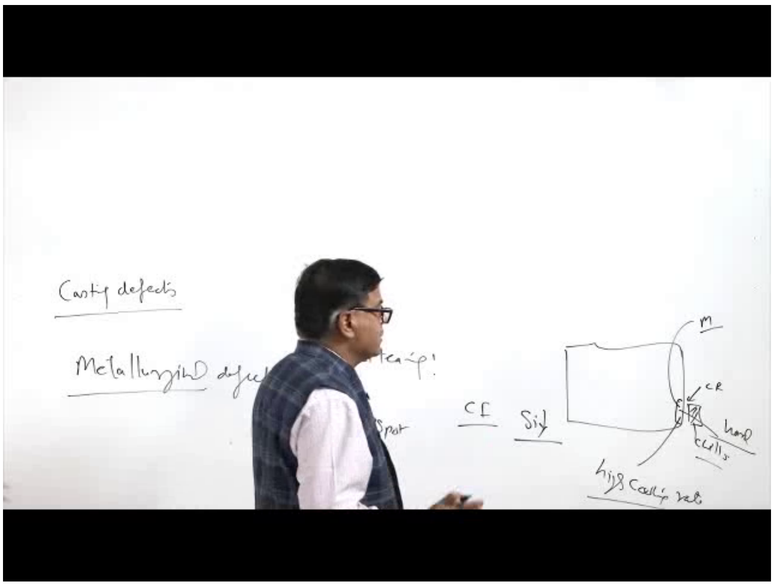

Then the cast castings where to in order to achieve the directional solidification if some of the chills have been used like say this is chill. So, chills basically they will be in increasing the cooling rates in very localized manner. So, if the chill has been placed here in the mould; so, this region will be cooled very fast.

So, in the cast iron castings having a low silicon content if the cooling rate high cooling rate is experienced by the surface then this leads to the instead of the graphitization this causes the martensitic transformation. So, very hard region is formed in the areas where the chills are applied for achieving the desire achieving the directional solidification, but these increased cooling rates sometime leads to the formation of the martensite near the surface and which leads to the very formation of the hard spots. So, these hard spots are found difficult to machine and these chills are used at the location where the shrinkage cavities will have the tendency to get formed.

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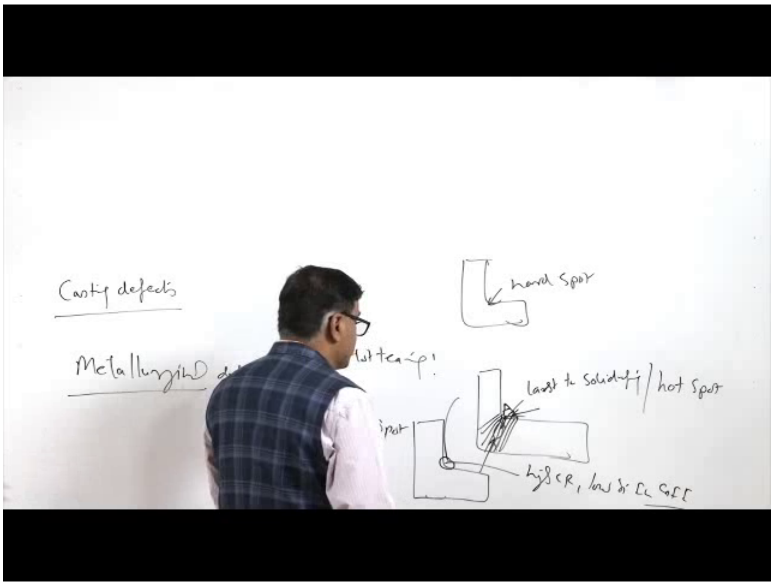

So, especially in the castings where like this; this is the area where that there is a tendency for the shrinkage cavity formation means this is the region last to solidify means this is the basically hot spot. So, in order to avoid the formation of the shrinkage cavity here will be using chills. So, this chill basically ensuring that the solidification in this region is taking place at much faster rate. So, this not the region of the last to solidify, but this increase cooling rate may lead to the formation of the hard martensitic structure near the surface; so, due to the high cooling rates.

So, high cooling rate low silicon in gray cast iron can lead to the formation of the white cast iron. So, basically this is leading to the formation of the hard spot in this area. So, basic to avoid; to avoid the hot spots or the shrinkage cavities we use chills. So, wherever chills are used high cooling rate in case of the hardnable steels and in case of the cast irons with low silicon can lead to the formation of the hard spots.

So, that is how we complete our the entire categories of the casting defects now will conclude this presentation in this presentation, I have talked about the various defects in the castings and the ways by which those casting defects can be taken care off.

Thank you for your attention.