Principles of Casting Technology

Dr. Pradeep K. Jha
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture - 39
Defects in Castings
Casting Defects: Types, Causes and Remedies

Welcome to the lecture on Casting Defects. We will discuss about defects in castings and we will discuss about types of casting defects, causes and it is remedies. As we know that when we cast any material, we are basically liquefying the metal by heating it to a very high temperature above it is melting temperature then we are holding at that temperature we are basically heating to a temperature higher than it is melting temperature that is the degree of super heat then we are pouring it in the mold.

So, basically after pouring in the mold the metal gets solidified then after solidification we are taking the material out of the mold. When we use the sand mold, the mold is broken because mold is only once used and when we use the multiple use molds like metal or graphite, then we need not to bake the mold every time. We have during this process a number of transformation is taking place the metal converted from solid to liquid state then further converting from liquid to solid state and in that process at many places and also when it is poured during the pouring process, then further while it is entering to the mold and then further during the solidification inside the mold. So, all these phases there is likely, but there may be a certain kind of defects because we are not able to maintain the parameters in the idealized manner. So, there may be certain defects and these defects can normally be categorized under the heading gas defects.

Gas defects means, the defect is in the form of gaseous pockets or because of the gaseous which are formed they lead to such kind of defects. That is known as gas based defects and under that you have blow holes, open blows, air inclusions or pinhole porosities. Similarly, you may have shrinkage cavities because during the solidification process you may have the shrinkage, because of that if there is no adequate care taken up then that may lead to the formation of shrinkage cavities. There may be defects because of the molding materials and that is cuts and washes, metal penetration, fusion, run out, rat tails and buckles, swell and drop.

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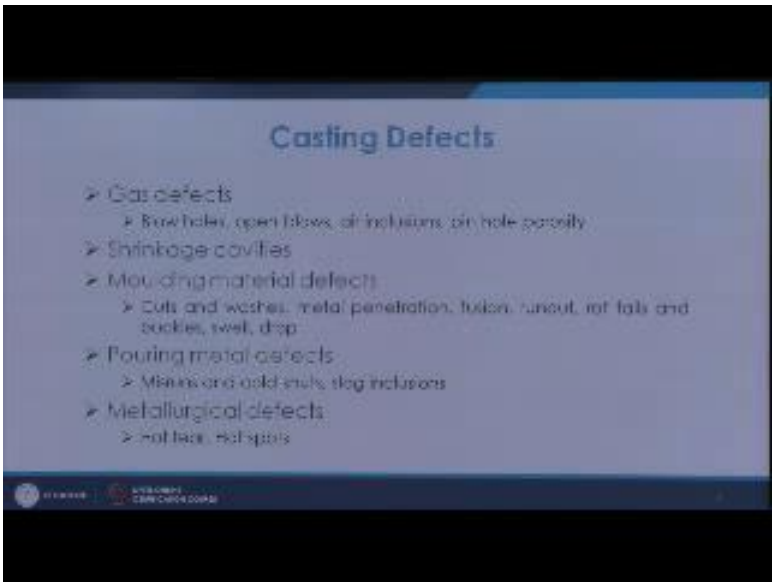

Then you may have the defects in the category of pouring metals, that is when we are pouring and that is misrun and cold shut and also the slag inclusions and then metallurgical defects like hot tears, hot spots etc. Let us discuss one by one about each kind of defect, once we see the gas defects. Gas defects in that blow holes or open blows they are basically because of the entrapment of the gases inside the metal. What happens, when we are basically heating the material the material at higher temperature normally has a larger solubility of the gases. Many gases tend to get dissolved at higher amount at higher temperature. When we are cooling as the temperature comes down the solubility of these gases go on decreasing drastically.

Now, these gases required to go out of the mold. They must go out of the mold that their entry through the mold and may ensure a defect free casting as far these gaseous defects are concerned. Now, if these gases are not able to go out, then and if they are inside the casting then they are known as blow holes. This blow holes are those gaseous cavities where which are found inside the casting, casting surface. And if they are on the surface of the casting and they are open to the atmosphere having if they are open at the surface then they are known as open blows.

Similarly, air inclusions this is also again, a variety of the gaseous defects because of the air entrapment or because of the sucking of air and that is air inclusion and then pinhole porosities. Pinhole porosity is typically, because of the gaseous like hydrogen. We know

just like our gases the hydrogen when it is basically, into the melt and if it is not able to go out of the melt. In that case, hydrogen comes out in the later stages and it goes in the form of very fine holes. So, that gives a free very fine pinhole type of a structure on the surface that is known as pinhole porosities. All these gaseous defects, are basically the causes of these gaseous defects is because the gaseous which are there inside the melt they are not able to go out and there is no having the flushing of the gases out of the melt or out of the mold could not take place and they are basically entrapped.

The reasons may be, because of the improper permeability of the mold because if there is not proper permeability then this gases are not able to go out and that is how it is stuck in, also you if you do not do the proper degassing. So, many a times we need to go for degassing techniques and if you do not do the proper degassing then these gases are entrapped. So, you have to go for proper degassing, that much of the gases which are dissolved into it if they are basically removed during this degassing process, that also is one of the reasons. Once we know the reason the remedies basically known to us. If it is because of the proper degassing, then proper use of degasses should be it is remedy. So, you must go for proper degassing techniques you must have the mold quite permeable. So, that you this allow the gases to escape though it that is one thing.

Another thing is if you have a very high pouring temperature. As the temperature increases the chances of gases being observed into the melt is higher. So, you must also maintain the proper pouring temperature you must not increase the temperature to a larger extent, because at larger temperature of pouring you have more chances of gases being observed. You also should have proper gating practice; there is a chance of air being suede if there is proper, if there is lack of proper gating system. In that case, you may have the entry of these gases from the outside and they go inside they may form if they go inside then there will be air inclusions. All these are the remedies once we know the causes the remedies are known and based on that proper gating practice, proper permeability level, proper use of degasses, all these can be adopted to take care of such defects.

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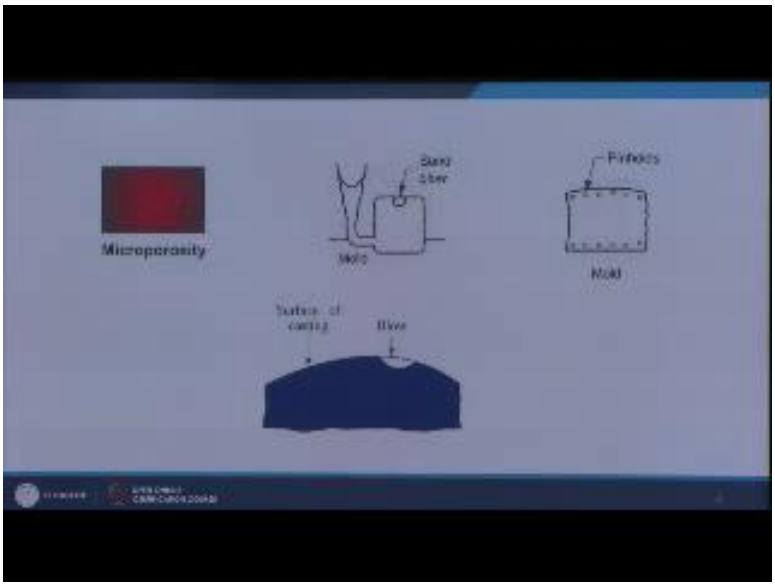

If we look at the defects if you see these are the cases of micro porosities what we see here is white structures they are the cases of micro porosities you see the pinholes where pin, pins because the gases try to come out of it, pinholes show like that. These are the blow holes or open blows if it is on the surface that is why you have blow holes and open blows showing here then coming to the shrinkage cavities. Now, shrinkage cavities are basically the cavities which are formed because of the shrinkage during the solidification process.

As we know when there is solidification taking place when there is formation from liquid to solid and solid part basically, because of that the shrinkage takes place we have already discussed about the shrinkages and the shrinkage amount is basically compensated by properly supply the adequate amount of metal from the riser.

If the riser is able to feed the amount that is required in the case in those areas where shrinkage is taking place then it is fine, but if not then in that case the shrinkage cavities are likely to occur. We know that the reason is because shrinkage is bound to happen because once we have the formation of liquid to solid state in those cases, since the density there is density change from liquid to solid state. So, there will be volume changes because of that you will have shrinkages and that is because of the improper kind of material which is there. If you have a large solidification ranges you will have shrinkages more likely to occur, also shrinkage defects is likely to occur if you have the

improper mold making. If you have certain portion of the casting which is isolated and it remains isolated during the solidification process and if it is not basically attached to the active feed channels then in those portions the shrinkage may occur.

Shrinkage cannot be avoided, but rather shrinkage has to be compensated. If any portion is basically cut off or if is isolated then in that case shrinkage may occur. So, you have to see that proper directional solidification is maintained, proper directional progressive solidification is there. There is no much control on the progressive solidification however, but on the directional solidification you can have proper control you have the proper placement of riser, proper size of riser and proper use of chills that may avoid the shrinkage cavities.

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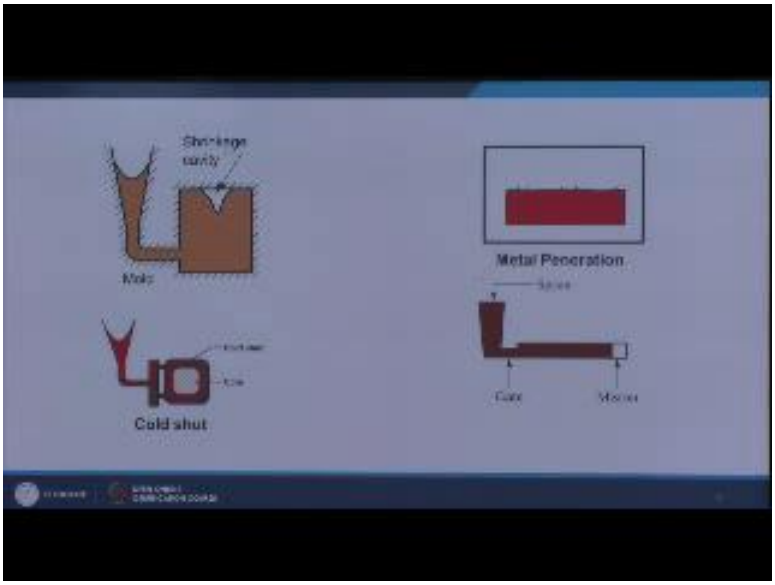

Shrinkage cavities will be like this, if you see this is a normal cavity where the shrinkage cavity will look like this. That has to be basically supplied with extra metal so that there is no shrinkage defect.

The defects like cuts and washes, metal penetration, fusion, run out, rat tails and buckles swell or drop they are under the category of molding material defects. These defects occur because of the improper molding materials, like cuts and washes. That is basically, because of the poor molding material at many a points this there will be the washes or this sand is getting washed away, is if it is not properly rammed up if it is not have it does not have a adequate strength in that case there will be washing of the sand. If there

is no adequate strength, green strength or dry strength of the molding material in those cases such defects are likely to occur. These defects are because of the improper strength of the material and also because of very high velocity of the molten material. In that case, it is not able to sustain that high velocity or high impact and then they get washed away and basically it is because of the improper strength of the molding material, they get washed away and you have such defects.

Then you have different kind of molding material defects like cuts and washes, metal penetration, fusion, run out, rat tails and buckles swell and drop. They are basically because of the improper molding materials, coming to the cuts and washes. Under the molding material defects you have defect that is cuts and washes. Cuts and washes I mean under this variety of defect there will be rough surfaces appearing on the casting surface. They are basically because of the cuts or there is washing away of the molding material typically sand, when the metal is entered into the mold. That is because of the improper strength of the molding material or improper binding of the molding material or sand grains adequate inadequate strength of the molding material. So, for that you will have to have proper strength of the molding material, proper use of binders, properly baked mold in those cases these cuts and washes can be avoided.

Metal penetration, many a times the metal penetrates in between the sand grains and there will be rough surface on the casting surface that is known as metal penetration. So, basically metal as penetrated in between the sand grains, this happens normally because of the very cores sand used and that basically is the interface between the molding material and the molten metal. In those cases, you have very cores sand which is in contact with the molten metal, the molten metal will go in between the cores sand grains and that will appear as every rough surface that is known as metal penetration.

To remove such defects you need to have a use of mold wash or finer sand particles fine sand or fine facing sand must be used. That the molten metal at the surface in is in contact with fine sand particles and you get the fine surface finish. Fusion, so fusion is basically the fusion of the sand and the metal, at the surface of the molten metal the temperature is highest. The sand if it is not have proper refractoriness value, then it may try to fuse and gives you a glassy surface. So, basically it is because of the fusion of the sand on the surface that happens because if the sand used is a very fine quality, very fine size which has or if the clay percentage is more. In those cases, the sand has low

refractoriness values as we know that refractoriness value also will be varying with the sand grain size as well as it is purity.

If there is not much of purity or if there is very small size of sand grains which is near the molten metal surface or if the clay percentage is more because of which there will be loss of the refractoriness value, in those cases this fusion may occur on the surface and the surface you will have to remove, surface finish will be basically poor. For that you have to check it the molten metal of adequate refractoriness and proper size of the sand that you have adequate, refractoriness and the fusion is avoided you have also to see that there is not much of the clay involved which reduces it is refractoriness. Run out, run out is that kind of defect in which the molten metal basically comes out of the mold, because of the faulty mold making this run out takes place? For that you have to see the properly the mold making procedure that there is at no point the mold metal so, molten metal should come out that is run out.

Rat tails and buckles, rat tails is basically you have the appearance of very lines small lines like rat tail on the rat tail there are certain impressions. So, similar kind of impressions is observed on the casting surface that is why it is known as rat tail. This is basically, occurring because of the compression failure are the surface of the casting from inside. So, what happens at the high temperature if there is not proper expansion properties in the sand, at that high temperature the sand will expired and further it must while the metal cools it must adjust according to the metal or properly that the sand and metal interface is smooth.

Now, if the expansion property of this molding sand is not adequate, if there is not much of carbonaceous material we have understood that there are uses of additives in the case of molding sand, that proper expansion properties are ensured. If there is not of the adequate of this carbonaceous materials are these materials which give proper expansion properties, in those cases the sand gives away the surface gives away and then there is cracks to accommodate that stress which is generated at that point the sand surface gives away and that basically generates small cracks on the surface and that is known as rat tails and when it is have a severe it is known as buckles. This is because for removing this, the remaining is that you must use proper additives, carbonaceous materials the extreme molasses that you proper expansion properties in the molding material.

Swell, swell is the increase in the dimension of the mold. So, because of that the size of the casting becomes larger and this happens because of the casting I mean mold not able to withstand metal static pressure of the molten metal. If your mold is not having adequate strength, it does not have proper strength proper ramming is not done then in that case, when you pour the molten metal it becomes over sized that is known as swell. For that you have to do the proper ramming the mold must have adequate strength. So, that this defect is not taking place, to ensure that you must do proper ramming proper strength must be there in the mold.

Drop, drop is basically when you have the cope portion and if there is some particle from the cope that is sand particle falls on the surface of the casting that is known as drop. There is improper, ramming of the sand in the cope portion in that case we have chances that the sand from the cope portion falls into the casting and it floats on the surface it goes into the surface that is known as the drop. So, you the remedy is that, improper ramming in the cope portion is the cause and you should do more proper ramming that is it is remedy you must do proper ramming of the cope portion.

Next, is the defect because of the pouring metal? Under that you have defect like misrun and cold shuts, misrun and cold shuts are because of the pouring metal which is going inside the mold. Now, misrun is that because of certain reasons the molten metal is not able to go till the last point in the cavity that is known as misrun. So, basically the cavity is sort of molten metal that is misrun. Misrun may be because of improper purity of the metal that molten metal goes inside the cavity because of the fluidity property. If the purity is not high, in those cases the metal may not reach to the extreme end.

One reason is purity and fluidity is basically affected by the temperature. The other factors remaining constant you have the temperature which is in your control, if the proper temperature is there then fluidity will be better, the temperature is lower the fluidity becomes less. So, you must maintain proper pouring temperature to maintain proper fluidity that metal goes inside the cavity with proper fluidity and goes to the fore based point with ease. Another reason may be because of very cores grains, if the cores grain of sand is used and if it is there on the surface where metal is flowing. Then there will be large resistance offered by these surfaces to the molten metal flowing. So, that may also limit the distance up to which the molten metal goes with is. So, you must have

a proper surface, proper finish to the surface, proper use of sand grains that the fluidity is adequate and the cavity is filled properly.

The next is cold shut, cold shut misrun and cold shut are both same other, but in the case of cold shut it is for such castings, where the molten metal goes in two different directions and they have to meet at some point. So, basically in ideal case or in most of the cases you must they must meet at the proper temperature that they fuse properly. If that temperature is not proper, if that temperature is not adequate in that case this fusion is not proper and there may be a line a defect line that shows that they are not properly fused or that is a defect known as cold shut. It is because again of the more time taken or more temperature lost during the flow of this liquid metal from the two sides, two directions and they are not able to fuse properly.

Again the reason is may be because of the improper fluidity and improper design of the mould because of if it goes in one direction and in the metal comes from other direction and if in some cases if it is losing more of it is super heat in that case it is not able to fuse properly, those defect which is occurred is known as cold shut. They can again further be prevented by having the adequate fluidity to the metal having adequate temperature to the melt.

Slag inclusions, slag inclusion are again the formation of slag's. That is because of the improper fluxing of the material slag's are there, these slags are basically not able to be once we are not able to trap these slags properly then these slag's go into the melt. We must have adequate methods first of all to remove these slags. If you do improper fluxing in that case slag's are more there and slag's may go inside the melt and then that makes the slag inclusions. These slag inclusions are can be removed by proper fluxing of the material and proper filtering of the slag's when they go inside the melt that way you can remove them.

If you look at such kind of defects, like misrun or cold shut if you look at thus liquid metal has not been able to go up to this level that is misrun. Similarly, the metal is coming from both their streams and if they are not able to proper fuse properly fused then it is a defect known as cold shut. Then the next defect is metallurgical defect because of the metallurgical parameters and one of them is hot tear. So, as the name

indicates there is a tearing action because of that there will be cracks observed that is known as hot tear.

Now, hot tear is basically of observed near the solidest temperature line when we have basically cooling in alloy or the material which has a solidus I mean solidification range, then what happens that during the cooling initially it is completely liquid and as the temperature goes down the matrix will be consisting of liquid as well as solid particles.

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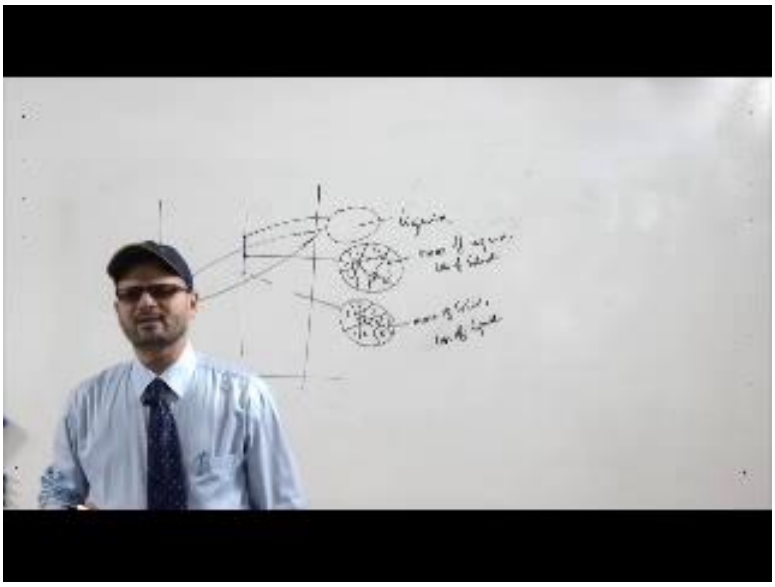

So, you can see in the case of binary alloys. What happens, now in those cases as the temperature comes down here you have completely liquid and as the temperature comes here you will have more of liquid and less of solid, more of liquid less of solid. So, just below that as we move the solid goes on increasing more of solid less of liquid.

Now, what happens that when we come near this region, then in that case you have a network where mostly you have liquid and then you have mostly you have solid and then you have some portions of liquid. Now, in those in these situations or we will come closer to this even closer to the solidus line most of the network is solidified and if they will have some pockets of liquid lines. Now, under these cases what happens that the structure is weaker and in those cases if you experience certain kind of tearing then in that time the metal or the material has very low yield strength at that temperature. Also if you have certain eutectic low temperature eutectic like iron phosphor in case of iron, but in those cases the solidified their melting temperature is basically even a smaller.

You will have low temperature eutectic presence that also makes because that makes that situation I mean that region even weaker. In those situations even a small tearing or even a small because of the change in the design of the casting or the shape of the casting if there is any experience of tearing observed, in that case the casting fails. So, there will be tearing observed and then that is known as hot tear. So, as we see in the case of this, what happens as we discussed you have more liquid here, here you will have mostly solid and some part, some part solid and mostly liquid.

So, you will have all liquid and some solid some part are solid and then mostly liquid. However, when it comes at this point you will have mostly solid and a very small part as liquid. So, you will have all this as solid and some part may have liquid and at this moving during this temperature range if there is any tearing observed because of that your strength is very small and if it is not able to sustain in those cases, because this liquid pool is completely isolated and as during the solidification during that process of solidification the because of it is geometry or structure when this tearing observed and then there is crack formation that is known as hot tear. This is normally more aggravated when you have larger solidification range. So, you will have to see that there is not much of the solidification range of the materials; you should take the proper material of lower solidification range. In that case you will have lower possibility of these hot tear a kind of formation.

Similarly hot spots, hot spot is something which is because of the formation of hot I mean chilling. In many cases when we are cooling and because of the presence of chills or because of the improper cooling at certain places where the cooling is very high you have formation of hot spots. This is basically; typically the problem is found when we are making the gray irons. If you have the chilling at certain point the gray iron is not converted basically you do not find gray iron you find the white iron because of the chilling that point it is known as that is hot spot. These are the different kinds of casting defects which have the causes and properly remedies are to be taken and that is how you can get a defect free casting.

Thank you.