Theory of Production Processes
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Lecture – 20
Casting defects: Types, causes and remedies

Welcome to the lecture on casting defect. So, in this lecture we will discuss about the different types of casting defects the causes and the remedies of the casting defects. So, casting defects are caused because of many factors in the casting process as we know that when we start making the casting product, you start from pattern making, then we start we make the course then we make the mould we have to fit the pattern I mean core into the cavity once we take the pattern out and then we pour the liquid metal.

So, liquid metal once getting poured it will start solidifying inside depending upon the conditions of cooling and then after the solidification we try to take the metal out in case of sandman casting or sand mould we have to remove the sand we have to use the you know casting after doing the finishing and all that. So, during this process you have certain kind of defects which may come if the parameters process parameters are not controlled properly and the defects basically are a various types.

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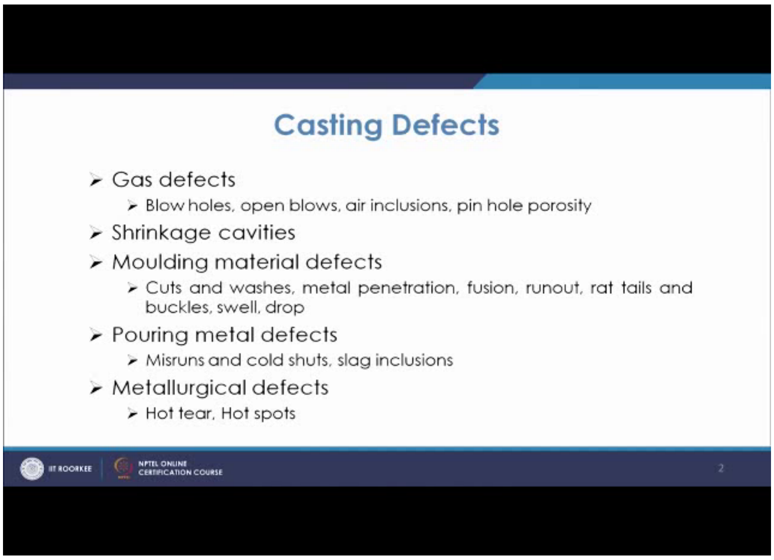

And in general they are categorised in certain you know in they are classified in certain way. So, we will discuss one by one those defects causes and remedies, but we will have the special emphasis on the metallurgical defects specially the hot tear because most of the other kind of defects people might be aware they might have studied during their earlier courses, but still we will have a review of such you know defects their causes and remedies and also we will try to have more knowledge about these defects specially the remedies which we can think of.

So, let us go to gas defects. So, what are these gas defects, these are basically because of the gases which are generated or which are entrapped, as you know that when you pour the liquid metal into the cavity. So, in that case the solubility of gases are basically more with temperature. So, in most of the cases as the temperature of the molten release quite high, the gases are you know they are into the liquid melt specially when if you are not doing the making the precautions for that or you are not doing that treatment for taking the gases out as most of the foundries normal foundries you do not have that specially in mind. So, you have the source of these gases may be in the molten metal because of the high temperature at high temperature the solubility of most of the gases are higher.

Then you know the mould is permeable. So, the mould being permeable if your sectioning of the gating system is not proper suppose the sprue which is the vertical sprue which required to be tapered and it is not taper in those cases or the runner is not full and there are the conditions such that it is taking the air from outside. In those cases the gases may come many a times you have the gases which are there inside the cavity it itself and it is assumed that when the liquid metal will go into the cavity then these gases will be driven off. So, that is assumed, but that may not happen. So, these are trapped. So, when the liquid metal goes into the cavity it is supposed that because of the as the liquid metal will take the spaces in the cavity the gases which are there they will go out and that depends upon the permeability of the mould.

So, if that not being so, in that case the chances of those air or the gases getting interacted with metal cavity I mean the mould I mean the metal in the mould cavity is there so that may result into such defects. Now the gases defects which are of the following types like blow holes you have open blows you have air intrusions and you have pin holes porosities. So, blow holes and open blows they are basically the gases pockets and normally we tell that if it is inside the surface below the surface level then it is known as blow holes you will have a small holes appearing in the casting.

So, that is blow holes we look at the micro structure you can see that similarly sometimes it has the appearance on the surface, that mean it is open. So, that is known as open blows you have the air pockets also because of the inclusion of the air. So, that is known as air inclusions and pinhole porosity is also a gases defect basically it is because mainly because of the hydrogen gas this gas normally is has a tendency to go out towards the end. So, they leave a pinhole kind of you know appearance. So, that is because of the presence of the hydrogen gas in the melt. So, you have to remove the hydrogen gas otherwise this pinhole porosities may come.

So, these are the typical gases defects which are coming up if you talk about the reasons the reasons will be one is that you have a proper you know you must have the way to remove the gases from the melt. So, you when you are melting and you are pouring at that time you should see that gases are not there very high pouring temperature means there are more chances of gases being dissolved into it and you do the sufficient way to remove the gases.

So, go for vacuum melting or so, that also you can see that there are no gases you know absorbed into it second is that if you have the you know less permeability of the mould. So, if the permeability is less in that case the mould is not able to drive off the gases which are there inside the mould or they are generated. So, they are not able to be driven off properly and that gases might get the tendency to you will be trapped inside the cavity and they may go inside the casting and that may lead to such defects. So, accordingly and then if you look at these air inclusions now that another result I mean reason may be because of the poor gating design.

So, if you have the poor gating design and if there is a ros pressure gradient you know developed somewhere if you have a taper sprue is not there you have this straight sprue you required to have the tapper sprue in those cases there may be the cases in which the aspiration of air. So, that air inclusions may come, so that is also one of the reason. Now pinhole porosity as we discussed the presence of hydrogen and that may be also one of the reason may be because of the moisture present in the green science. So, many a times you know that hydrogen that may be formed inside the casting solubility is more at higher temperature and then the hydrogen will try to come out. So, that may lead to pinhole porosity. So, accordingly you will have to have the better permeability of this sand mould you must have the proper gating design to avoid aspiration of air you should see that there is no moisture in the not much of the moisture in the green sand mould. So, these are the, you know remedies for these gases defects.

Coming to the shrinkage cavities, shrinkage cavities as we discussed that the metal undergoes shrinkage as it solidifies so, this is because in most of the cases when the liquid metal converse to solid state then there is change of density, density increases and the volume changes. So, you have the shrinkage now this shrinkage is because of the contraction during the first and second stage of solidification that is liquid shrinkage as well as the solidification shrinkage and this needs to be taken care of by supplying the adequate amount of risers also placing the riser at appropriate location that is also important it is not that you provide the riser I mean of enough volume then it is necessarily going to give you a strong casting in terms of I mean not having shrinkage it is not that I mean you will have to see that where the riser is located riser has to be located.

So, that proper direction of solidification is achieved. So, you will have to see I mean if the there is a very thin casting portion they need to provide the riser in those cases. So, you will have to provide the riser to those places where there is heavier mass. So, actually the flow should be from there towards the regions which is away from the riser which is basically which has the lower cross sections which are having thinner cross section or so.

So, basically the shrinkage cavity one will be. So, reason is basically you know one is that if you are melting a liquid metal of larger freezing range then you will have the chances of shrinkage cavities. So, you cannot do much with that that depends upon what kind of material you have. So, may be by adjusting certain cooling range you can somewhat you know decrease that, but not much, but then placing the risers appropriately taking the risers of actually appropriate volume.

So, placement should be appropriate volume should be appropriate and also you have to see that what will be the feeding distances. So, we have already calculated those feeding distances for plate or bars. So, you can see that where to be placed how many of risers to be placed. So, this way you can try to remove or to minimise the presence of shrinkage cavities.

The next type of defect which comes is the moulding material defects. So, once we are you know finalising the pattern and then also course and all that then we are making the mould and then putting the course into it. So, because of the moulding materials what are the different kinds of defects which come, just like cuts and washes, so they are basically because of the washing or cut because of the, you know you have the sand which is ramped not properly.

So, then it gets washed away or there have been cuts on that surfaces of the mould. So, for that you will have the appearance on the material surface also. So, that is because of the improper moulding material property. So, if it is not properly ramped or you have not provided adequate you know sometimes you have not done enough to see that when the metal is falling.

So, because of the impact it will have a chance to erode the surface of the mould. So, many a times we provide the core I mean where it falls on the bottom. So, that is it does not you know do the damage at the bottom where it hits especially the heavy materials heavy metals with high specific gravity when they fall then that time you must have that surface where it should impact that must be of the material we should sustain that impact. So, we have the special course sometimes made of you know course which are able to sustain that. So, one will be that then the moulding is not proper. So, if the moulding is not proper bonding is not proper in those cases also this may come. So, accordingly you will have to do these ways for avoiding this type of defects.

Metal penetration, metal penetration is that the metal basically penetrates into the sand grains. So, this is because you are using very course sand which are basically in touch with the liquid metal. So, because of the pressure the liquid metal goes into the voids in between the voids of these course and grains. So, this way these metals will go and it will have a rough structure on the surface. So, once the mould is removed once that cast part is removed and mould is dismantled that time you see that there is a zigzag over the surface because metal has gone into pores of the sand.

So, you must use the mould washes you must see that there is fine surface finish where the metal is touching the sand grains basically when you pour the liquid metal into the cavity, fusion is basically the fusion of the metal with the sand basically sand has the binders you have additives and all that and specially if you have used the sand of very fine you know size in those cases it is refractions is basically is reduced also if it is impure if it has oxides then it is refractiveness if poor.

So, when you are pouring the liquid metal especially the metals of higher melting temperature in those cases they try to have a reaction at the surface and they try to fuse and that gives a rough the kind of appearance, drastic kind of appearance because of the reaction products and that is known as fusion products. So, when they are trying to be removed they give the appearance of a rough surface. So, that is because of the fusion product between sand and the metal. So, this has to be removed by having proper you know material which can withstand at that temperature you have to have the washing by proper refractive grains. So, that it can withstand at that temperature and it is not fused. So, that is the remedy for that.

Run out means many a times because of the faulty moulding process the liquid metal comes out of the mould. So, that is also because of the you know improper positioning or improper also that way the liquid metal goes out of the mould. So, it is because of that improper also match of the flask. In fact, even sometimes we have the shift type of defects also which occur because of improper you know positioning of the course. So, course shift may also be there. So, these are there because of the proper you know positioning.

So, then later on you have the rat tails and buckles. So, these are because of the compression failure of the sand. So, what happens that when the sand comes in contact with the hot liquid metal, then at that temperature high, temperature it tries to expand. So, because of the absence of enough carbonisation material you must have the carbonisation material which should be you know volatile at that temperature and then it should give it the expansion properties.

So, basically if you do not have the proper expansion properties you have additives also added you must know that your there are additives which enhance the expansion properties. So, if the expansion properties are not enough in that case basically what they do is they try the surface try to give up. So, what happens, then you have a zigzag kind of surfaces and if you have that in both the on all the directions. So, you will have a structure like rat tail which is zigzag cross that appears on the surface of the casting and that is known as rat tail.

So, this is because of the poor expansion properties and you can basically improve these properties by adding proper additives and having proper carbonisation material in the sand mould especially towards the facing side and buckles are basically the rat tails which are more severe so that is buckle, then you have swell. So, swell is basically enlarging of the dimension of the moulding mould cavity.

So, that becomes the situation when you pour the liquid metal because of the metal static pressure the cavity itself becomes large so that is known as swell, this is because of the poor strength not adequate strength of the liquid metal which is not properly ramped. So, this sand which not quite having good strength. So, that is to be removed by having that sand of proper strength you must have this proper strength in the basically mould you must have a proper moulding procedure proper ramming. So, that you do not get such defects of swell.

Now drop, drop is a kind of defect in which the metal I mean surface top surface of the casting will have the sand casting sand particles falling from the cope portion. So, if the cope portion if there is no proper ramming then that will drop inside the cavity and you will have these sand particles or inclusions which is on the surface or, so that if it falls on that. So, you must have proper ramming basically. So, for that this is also because of improper ramming, these are the, I mean different defects which are because of the moulding material.

Now coming to the pouring metal defects, now pouring metal defects are related to the pouring methods now in that basically we have one is misrun and cold shut. So, misrun and cold shut are the you know defects which occur because of you know that once you misrun means a kind of defect where the you are not able to completely fill the cavity, cavity is not fully filled. So, although there are more reasons, one of the reason is that the pouring metal has not adequate temperature.

So, misrun and cold shut is related to the property that is fluidity. So, you have studied fluidity, fluidity is dependent upon temperature. So, if the fluidity is not more in that case many a times what happens that the cavity I mean when we are approaching in the cavity and the metal will advance towards the further end of the cavity and by the time it goes towards the last end it loses it is all heat and then it stops. So, it is not able to fill the whole cavity. So, that is known as misrun, it is sort of the liquid metal. Whereas, the cold shut in cold shut basically in certain type of cavities you have the metal flowing from different areas then they have to basically mix. So, this it is assumed that when the metals from different areas are coming and ultimately you have to see that they mix at that time when the temperature is adequate enough that they are fusing properly, but if that not being.

So, if during the process the metal looses heat. So, that they are losing the super heat they are coming at a stage where they are not able to properly fuse from the 2 sides I mean among these 2 streams which are coming from different directions. In that case the point where they fuse if it is not proper fusion or at proper temperature then there will be a defect at that point, that interface. So, that is known as cold shuts that is again because of the lower fluidity and again will may depend upon different factors like you have metal temperature, you have surface of the casting,

I mean not casting you can say mould cavity inside because if you have the very course grained sand, sand grains which are there is no mould was in that case they will find in more resistance while flowing and then certainly temperature is the one. So, this is the reason and for that you need to have proper temperature you must have proper gating design. So, that they should not go and loose the super heat in between. So, that when the 2 streams meet they have already lost it is super heat or temperature. So, that situation should not come.

Slag incluses, this is what the misrun and cold shut let us go to slag inclusion. So, slag inclusion is another defect in which you have the presence of slag. So, that may be as we know that many a times we are purifying the material we put the flux. So, that flux will react with impurity and then slag is formed. So, basically slag is formed that slag needs to be skinned off. So, we are providing at many stages the filtering mechanism you have filters strain filters are there strainer course are there.

So, they take these inclusions out now, but by some means they come inside the cavity or if the I mean that may be the situation if your filter mechanism is no defective or many a times if you are pouring the very drossy material then there may be formation of dross inside also because of the you know conditions which are present inside the cavity or in the gating network where because of the aspiration or because of the inclusion of air or.

So, them or because of the high turbulence there will be formulation of drosses or inclusions also. So, that if goes to into the casting then that is known as slag inclusion.

So, for that you need to see ensure that the proper filtering of these slags are there at spaces at the places and you have also see that the network is right. So, that there is no formation of drosses or impurities inside and then you can avoid them metallurgical defect is we are going to discuss about the 2 kinds of metallurgical defects that is hot tear and hot spot.

Hot tear means it is basically a tear that experience these experienced by the metal at a stage when the metal is weak basically during the stage of cooling stage comes when you have a network of solid grains and also you have liquid pockets at some places though you have coring structures in that case, but then if in that situation if there is a tearing because of metal mould interaction or because of the geometrical features if there is a tear at that time when you have the liquid in that time the tear can be compensated because you have the liquid metal which can sustain that, but when you have more of these structures ore of the network made of solid and then some of the liquid as liquid in that case when we are tearing now the when you have the pull then that results into formation of cracks. So, that is known as hot tear.

So, basically it is seen at many places may be because of the presence of course, or may be because of certain sections which are cooling at differential rates many a times you have the casting where they are you have the larger I mean external portion which is a ring suppose which is found cooling at a fast rate, but the central portion is cooling at the very slow rate. So, you have the change in there you know contraction rates because of that there is a cooling and when the temperature comes in though that coherent region in that case this hot tear occurs. So, hot spots are also because in certain cases you know when we are dealing with the gray iron or so many a times you have regions where because of large cooling you have these formations of these spots.

So, coming to the different kinds of defects we can see the picture.

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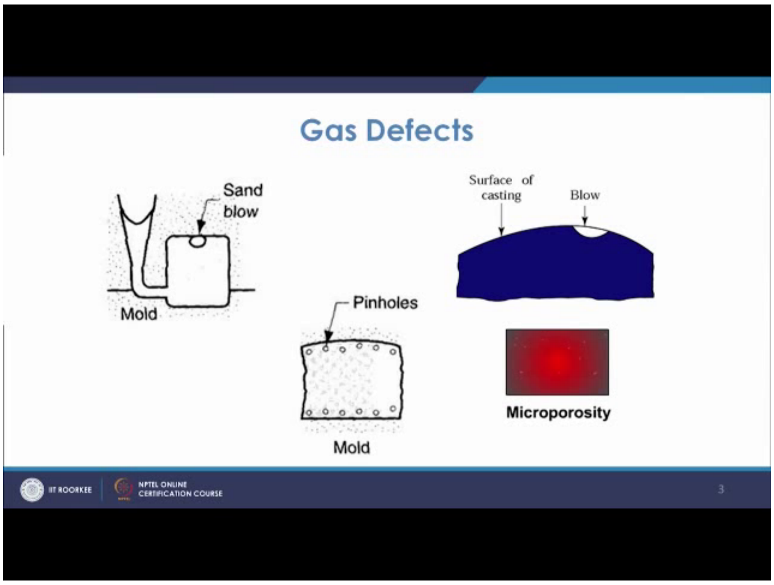

What we see is that this is known open blows or sand blow you have the pinholes you have micro porosity you have the blow upon blows which are at the surface.

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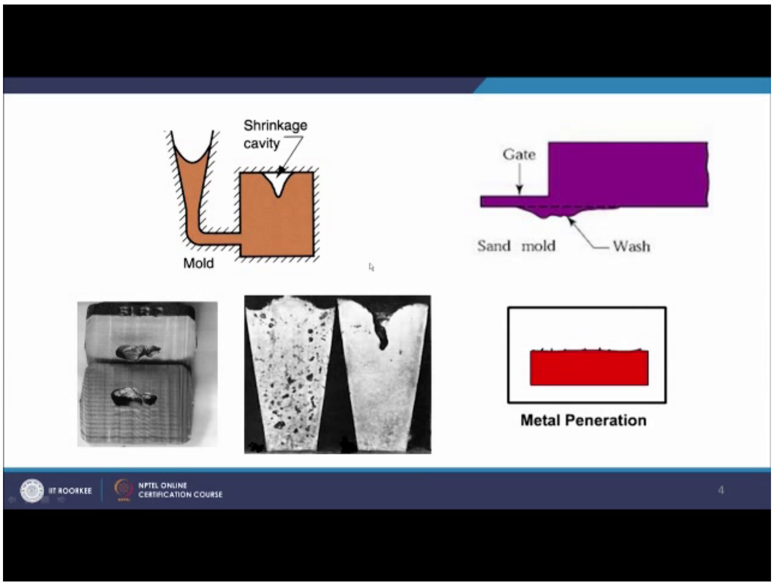

You go to the cavity you have shrinkage cavity as you see this is a casting where you have got in the last portion which is the solidified you have the cavity appearing in this fashion which looks into the structure like this, also you that see that the shrinkages at different places in that here and you see that this kind of piping is there available in the this is because of the shrinkage. So, these are the shrinkage examples wash in this figure you see that metal penetrates on because metal has binded into the mould I mean sand in between, that is metal penetration.

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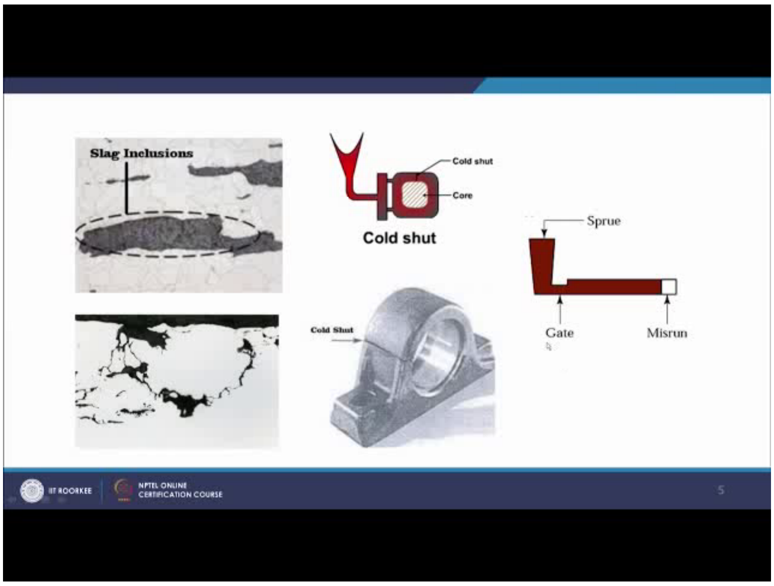

You have the slag inclusions which you see slags are they are inside this structure. So, this is the example certain slag inclusion you see the cold shut here and misruns.

So, misrun in that you the liquid metal has not been able to go may be till the last point of the cavity. So, that is known as is run cold shut is that you have metal from these sides and it is they are coming, but while they this stream which is reaching from this side this is stream which is in this from side they have lost the heat and they are not able fuse. So, this kind of situation may come where one liquid metal is coming from this side another is coming may be from this side and by the time they reach here you will have improper fusions so, that is an example of you know cold shut.

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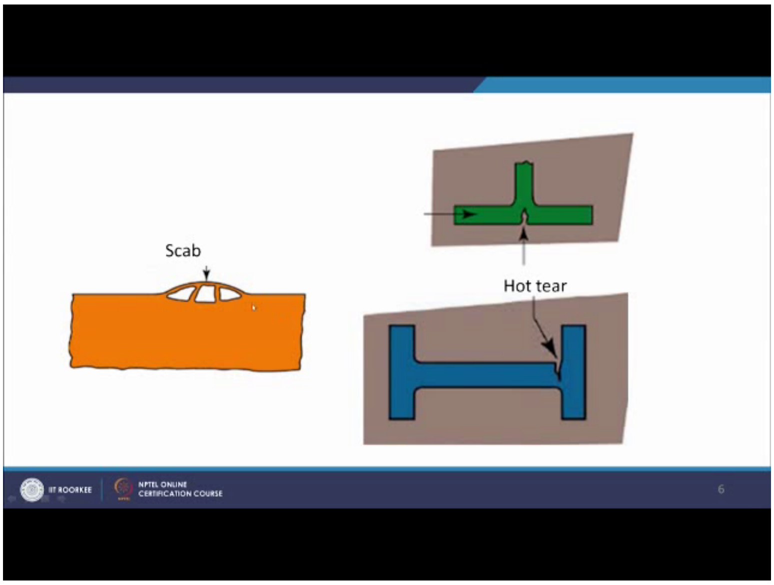

Then you have this scabs example. Then you have the hot tear. So, with respect to you know hot tears what is can be understood here is that if you look at, I do not I mean phase diagram.

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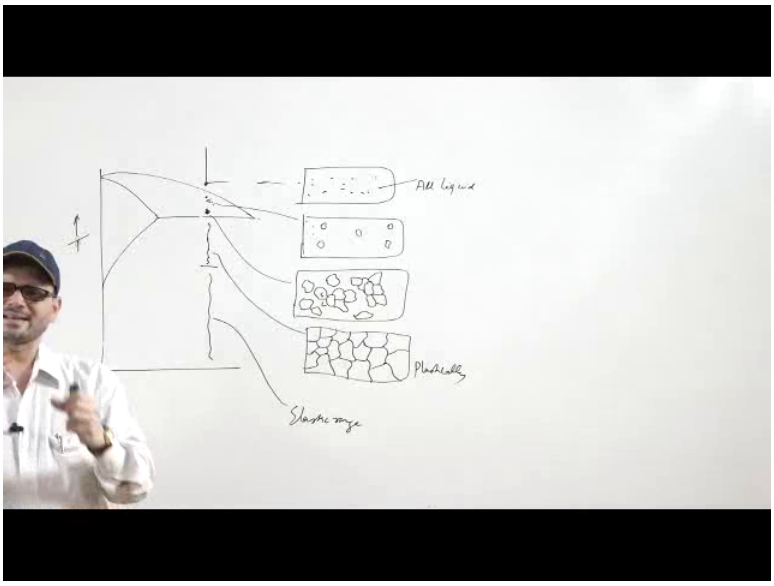

What you see that. So, what happens, that in case of the alloys as the temperature will come down. So, this is temperature, as the temperature will come down at this point you have completely liquid, this structure is completely liquid all liquid. Now once it comes here in this one then in this zone basically you have a small amount of solid crystallised and more of the liquid. So, in this zone to this zone basically in this you will have the network of having at I mean solidified grains at some places and then you will have all the liquid mostly.

So, this is in this zone and then once you come closer to this then you will have more of the solid and the less of the liquid. So, you will have more of the solid like this you may have the structure like this. So, in between you have sometimes liquid and these are all the solids. So, you may have more of more of these structure is to go going towards the solidus towards the solidus you will have that structure.

So, coherent kind of structure you are going to get near this solidus now what happens in this stage and once you come to this range then after that in this range you have the grains completely solidified, but this is a plastic deformation range where if you have the you know if you have applied the stresses then the deformation occurs. So, you will have the plastic grains and then if you come even further lower down this will be elastic range. So, here the grains will be deformed elastically, but now what happens in these regions or close to this region you have a coherent network and you will have more of the solid portion and less of the reserved by the liquid.

Now, in this region if you have the tear then more is the liquid and less is the solid. So, they are taken care of, but then once it comes to this stage in that case because it is near to the solidus temperature may be sometimes it is below that also happens. So, in that case the metal being very weak in case of it experiences the crack there may be cracks observed wherever you have that kind of tearing observed. So, that leads to this kind of defect known as hot tear.

So, many a times it is observed also below this solidus temperature especially in the metals when you have certain impurities especially like in iron you have the phosphorus. So, suppose you have iron phosphor eutectic is there. So, even if you come down to lower temperature in those cases those eutectics they are of lower melting point they will be in liquid state. So, you will have more solid network and at some points in the pockets you have liquid network also now because of that you have the chances of these hot tearing.

So, normally the pure metals they do not have that high chances of hot tearing, but in case of alloys it is more and that too when you have the eutectic of such impurities with the metals then in that chances you end becomes more. So, that is the reason of, this is kind of metallurgical defect which is very important defect that needs to be seen, also you must know have the control of the collapsibility properties also because the theory which is observed may be if your collapsibility property of the core or the mould is better, then this can be avoided. So, that also is one of the reason and that can be avoided.

So, basically that is the main reason that because of the tearing which it gives because once the temperature goes it will expand and then it will try to contract. So, that time if the collapsible property is not enough in that case it will try to tear. So, once it tries to tear at this junction as you look at this point in that case the tear because that collapsible property is being not enough. So, that leads to this kind of defects. So, that is how you can understand this hot tear type of defects.

Thank you very much.