Steel Quality Role of Secondary Refining and Continuous Casting

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Module - 04
Lecture - 18
Genesis of Entrapment

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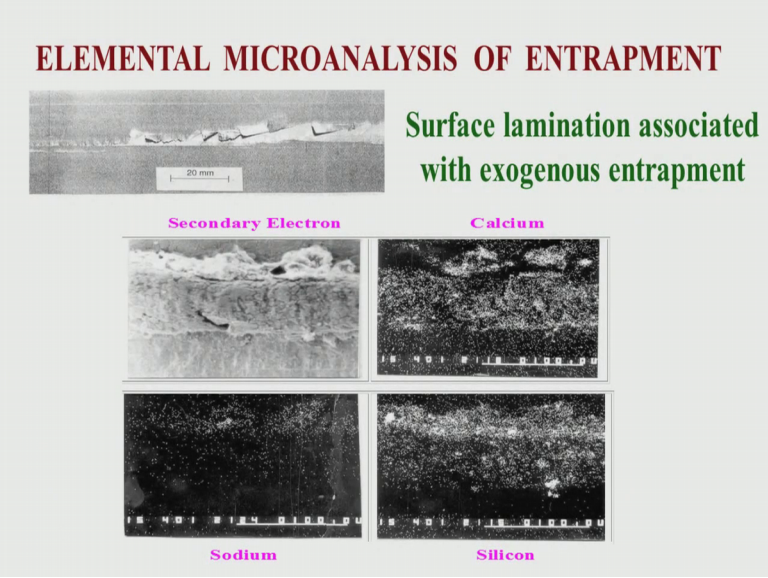

Let us try to see how does it look like and how we decide; what is the source of the lamination, what is the source of the problem. A surface lamination in the product will look like this; you know the surface is getting sort of torn, this is because of some entrapment large entrapment which causes the surface problem in the final product roll product, whether it is a hot role product or a cold role product. If we get a lamination, lamination basically means that is sort of additional surface is getting generated. So, the surface lamination it has been found that they are associated with exogenous entrapment

So, long I have been talking about we have to prevent exogenous entrapment. So, if some large exogenous entrapment gets inside the liquid steel. So, during casting it will get entrapped, then during rolling it will come near the surface and the surface will have some defects which is called surface lamination. Now if you got sample from your small sample put it under scanning electron microscope, where there is a possibility of knowing; what are the elements present in the entrapments. Entrapment is basically I

have told you basically these are oxides. Now what type of oxides here I am to understand we have to study then only we will know where from they have come what is their genesis.

So, in scanning electron microscope which has: a w d x or e d x attachment. That means, when the electrons are falling on the surface x rays are getting generated. So, from the x rays we can know from the wavelength we can know what are the elements present in the exogenous entrapment. So, the defect was looking like this. So, you see this is under the microscope optical microscope it looks like this, then if you put it under the scanning electron microscope this secondary electron will look like this the defect, and then from the elemental x ray analysis we can know what are the elements present; whether it just calcium, whether there is silicon, whether there is sodium this elements will give us certain clue will give a certain definite clues has to the genesis of the entrapments.

Like we know if calcium is present, if sodium is present, if silicon is present; that means, it is a complex oxide of calcium silicon and sodium.

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And we have mentioned you know like what are the possibilities like if it is a slag is a ladle slag we know it is basically very much rich in calcium oxide and some amount of aluminium oxide and small amount of silicon oxide will be there. Some very small amount of add on oxide also might be there. If it is tundish slag, this relatively it is more rich in silicon oxide where from silicon oxide is coming? It is coming from the you know

to a tundish slag; that means, tundish slag which we have we have I have told it is a basically two states tundish slag, the lower lower layer is basically rich in calcium oxide, but the top layer is basically rise ask which has very which is very rich in silicon oxide. So, some amount of silicon oxide also will come to the tundish slag. So, it is relatively rich in silicon oxide compared to ladle slag.

Then mould slag I have mentioned it is it has some amount of sodium, certain amount of calcium fluoride. So, depending on what are the elements present we can know what are the genesis. Like here we are getting calcium we are getting silicon we are getting sodium. So, sodium indicates. So, presence of sodium indicates that definitely it is coming from the mould slag. So, this is important how we decide what is the source.

So, the casting has already taken place, rolling has taken place we have found defects on the surface, we are trying to know where from this defects have come. So, it is a postmodern analysis, we cut small samples then we decide to do lot of analysis first we see under the optical microscope, then we these defects can be if these are relatively big this can be seen not with normal eye, even with normal naked eye it can be seen that means, it is a very large size of defect which is forming in the rolled product, and under this defects there are exogenous entrapments.

So, we want to know what are the source perform this exogenous entrapments have come. So, we can know these by putting this sample under scanning electron microscope, where there are e d x or w d x attachments. W d x means wave wavelength dispersive analysis of x ray, e d x means energy dispersive analysis of x rays. This we will take up later on subsequently in details, you know where how you know different defects are analysed and all I will take up, but just give you an idea of how the defect looks like, what is the source of defect we can know like putting it under scanning electron microscope, which has w d x or e d x attachments. So, from where the elemental x rays can be detected, detector can analyse what are the elements present in the sample from the wavelength or from an energy.

So, you know from this area we just see where calcium is present, some of the you know; that means, these are the areas this is the defect area which is which we have found that it is they have calcium, we have found they have lot of silicon, we have found there are some sodium. So, from this analysis we know what is the source of the defect. Since

sodium is present we can tell that the source is mould slag. So, we have to be careful why mould slag has been entrained; whether the you know the level of fluctuation was more, whether the proper mould slag characteristic was not used, mould powder characteristic was not the desirable viscosity interfacial tension. So, what was the reason we have to analyse? So, this is an important you know source of analysis, important way of understanding where from the defect has come.

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Then I had mentioned last time that you know the exogenous entrapment they are not uniform found in the cast or role product. As I have mentioned the start and end of casting there is a possibility of having reoxidation products. So, argon shrouding is the solution then there is a possibility of tundish slag, at the end of the casting if you do not allow to be if you do not allow some amount of liquid steel to remain in the tundish toward the end of casting. So, suitable dam and weir are necessary, they allow some amount of liquid steel to remain in the tundish and do not allow the slag to get you know inside the mould. So, this is very important.

Then during steady state casting as I was telling there is a possibility of mould slag entrapment, as we have found in the sample what we have analysed. So, what was the problem? May be the suitable characteristic, this is steady state casting I am talking about; that means, steady state casting means too much of fluctuation was not there normally too much of fluctuation you will find in unsteady state of casting; that means,

when there is a change in you know casting speed or similar reasons will be there, but in steady state casting there is a possibility of even getting mould slag entrainment, if the powder characteristics are not suitable.

That means the viscosity and interfacial tension of the powder was not suitable. So, there is a possibility of mould slag entrainment. Where are the time of ladle changeover, there is a possibility of ladle slag getting inside tundish and finally, getting inside subsequently getting entrained in the liquid steel and finally, getting in the mould and during casting it gets entrained.

So, what is the way out? Way out is you detect the slag you have a detector when slag is will coming towards the end of the ladle change over at the end at the time of ladle changeover; towards the end of ladle getting emptied. So, either there is there should be detector or there has to be some amount of liquid steel in the ladle. So, that slag does not come. So, these precautions are necessary.

Then I have mentioned that there is a sudden change in a meniscus level you know or sudden change of speed. So, there is a possibility of entrapment of mould slag or even powder. So, I had mentioned that the start or end of casting have mould defects. So, we may separately keep those cast products or the slag or blue mode (Refer Time: 09:53) so that we can separately process the material because it is expected that the start or end of casting will have more entrapments, the cleanliness level will be less there will mould inclusions in those portions.

And just after ladle changeover, again there is a possibility of some amount of entrapment as I have mentioned. So, we have to keep the cast product from these areas separately, we have to process separately because these are expected to have mould inclusions, more cleanliness problems, mould of root of oxide inclusions entrapments. Then if there is a sudden fluctuation; at the time of casting we know where there has been a sudden fluctuation because you know the mould level is continuously monitor in a mould and caster. So, wherever there is a fluctuation we know at what stage of casting this fluctuation has taken place.

So, we can separate out that particular cast product after casting is over, because there is a feedback. We know where at what stage of casting fluctuation has taken place. So, all these issues in a modern casting are helpful in not only understanding what is the

possibility of inclusion entrapment, what is the possibility of cleanliness problem, and also we should we know we come to we will come to know during the casting stage at what stage there will be a problem. Not only we know; what are the possibilities of a problem, but we know at what stage of casting there is a problem.

So, that particular area of casting of the cast product that area of that particular postmodern of the slag or blue mode be lead, we can separately keep we can separate out from the normal cast products because we have a doubt, we have a there is a possibility of inclusion entrapment there is a possibility of you know quality problem. So, we must take out those cast products from the normal products.

So, I have mentioned what are the possibilities of having inclusion or entrapment. Now there is one interesting aspect I will discuss like.

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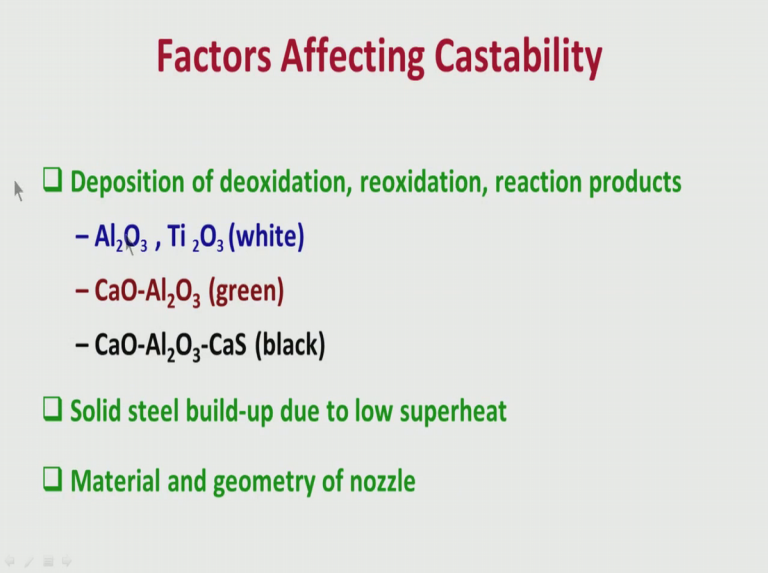

What are the factors which affect castability. That means, when you are casting continuous casting there is a possibility of you know I have mentioned that choking of s e n ports; that means, clogging of s e n ports, now what are the possibilities? I think mentioned the depositon of deoxidation products, reoxidation products or reaction products during casting; that means, whatever deoxidation products reoxidation products or reaction products are forming within liquid steel at different stages of casting, they might get clogged they might cause clogging.

So, what are the possibilities? If there are alumina and titania oxide they have mentioned these are solid at the temperature of the liquid steel. So, it looks like white. So, the clog product lot of clog product have been analysed and people have found if it looks white there is basically it is alumina or titania oxide, which is looking more or less white slightly greyish may be.

Then if you have a calcium oxide alumina combination, then I have mentioned earlier that you know CaO alumina combination. The relative portion of relative proportion of CaO and alumina will give us the liquid you know inclusions I have mentioned earlier. So, if it is a liquid inclusion no problem liquid will flowed up there is no possibility of getting clogging.

But certain you know ratio of CaO Al2O3 might also like only Al2O3 gives solid you know inclusions some portion of CaO Al2O3 can also give like CaO Al2O3 one mole of CaO one mole of Al2O3 is also solid at liquid steel temperature. So, that there might also create clogging. So, it looks green then as I have mentioned when we are using calcium fitting, calcium weir fitting what is the purpose of calcium weir fitting? The purpose is to make the inclusions alumina inclusions liquid by adding adequate amount of CaO and formation of CaO alumina of particular you know chemistry so that the solubility has rather the melting point is low and it is a liquid.

So, it helps the liquid inclusions to get flowed up and we do not get solid you know oxidation or reoxdation products, but if the calcium amount is not sufficient if there is adequate amount of sulphur in the steel then what happens? Calcium sulphide might also found and calcium sulphide these issues I have discussed earlier this calcium sulphide is solid at liquid steel temperature.

So, this combination of CaO Al2O3 CaS because both CaO and calcium sulphide will form simultaneously when we are adding calcium in liquid steel. So, if the sulphur proper desulphurization has not taken place; that means, the sulphur amount is slightly more if it is says 02503 or 04 the liquid window is very you know very narrow. So, there is a possibility of formation of solid particles during calcium injection. So, these are the solid particles and this looks black, this will cause nozzle clogging and interaction of you know continuous casting and the clog products will come inside the liquid steel in mould will generate additional inclusions entrapments.

So, these are the issues which might create problem during continuous casting. Then if the superheat you know always we are maintaining sudden superheat if the superheat is high I will come later on what is the problem. There will be more amount of you know core structure and the cast structure is coarse column nut zone will be there. So, that is not desirable, but if the superheat is very low almost near 0 or 5, there is a problem of solid steel build up that is the problem of solid that if steel getting solidified at the you know you know within the subentry nozzle. And at the port there might be solid steel build up slowly, which will again cause problem during casting interruption in casting. So, that is problem superheat should not be very low.

So, what is desirable is superheat of say 10 to 20. Too much of superheat is bad, the structure will be cast structure will not be desirable will have mould of column is a code structure which is not desirable, but very low superheat around 0 also may not be desirable from the point of view of this cleanliness as well as solid steel build up.

Then the I have mentioned the material and geometry of nozzle is very important, now subentry nozzle s e n what we call it s e n, geometry of s e n like how steel will come up come out from the port, what is the angle of port whether it is horizontal whether it is upwards angle is upwards, angle is downwards, what is the dia whether it is circular whether it is elliptical these are all important issues you know modelling can help in deciding a optimum design of s e n.

So, if the design is not much of problem will be there if the design is not good may be you know there is a possibility of castability, problem you know interruption during continuous cast.