Steel Quality Role of Secondary Refining and Continuous Casting
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Module - 03
Lecture - 15
Cleanliness Measures in Ladle and Tundish

I will come to the next stage after secondary refining what do you do with the liquid steel you have to do the casting. So, whatever processes you have used for making a clean steel; that means, you have controlled all these elements undesirable elements we have controlled dissolve oxygen, you have controlled sulphur, you have controlled nitrogen, you have controlled hydrogen, you have controlled carbon if it is a necessity, you have control phosphorus of course, in primary steelmaking stage.

Now you do not want this good steel which is relatively clean steel after secondary refining to get contaminated again during the next casting stage. So, all the steps which you have taken for secondary refining for cleaning should not go to waste how do you do that because in casting; that means, what we have to do we have to prevent reoxidation and renitrogenation during transfer of liquid steel from ladle to tundish and to mold.

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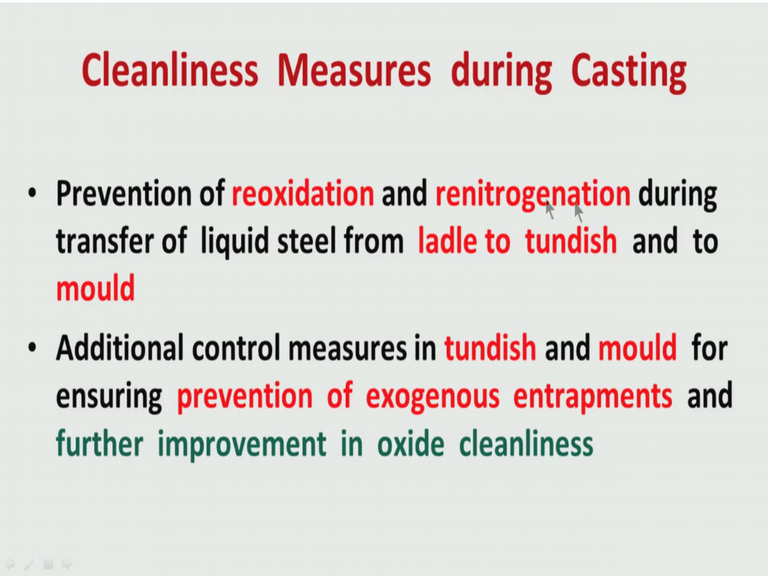

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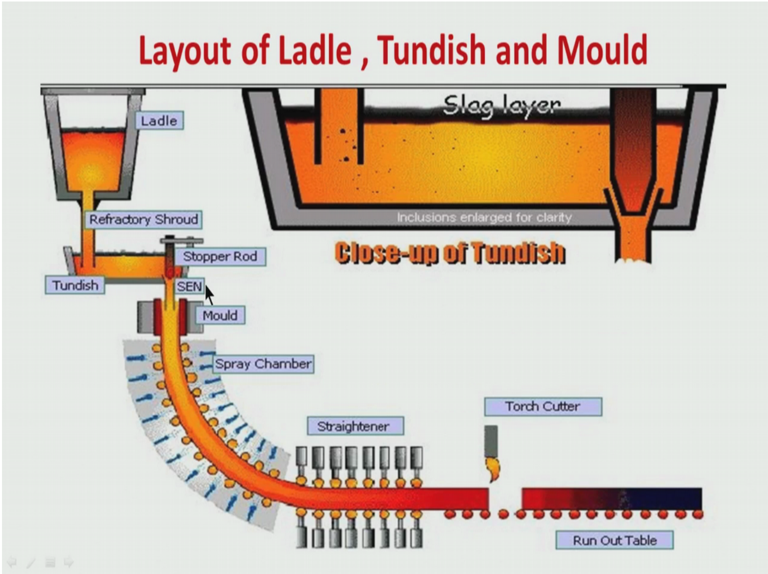

I will just first discuss with you what is how the continuous casting takes place. You have done all the refinings in ladle. So, the liquid steel which is relatively clean is in ladle. So, this from ladle liquid steel now has to be poured to tundish which is intermediate is a buffer sort of container which maintains liquid steel during casting and from this tundish it will be poured in to the mold of the caster.

So, first the ladle has to be fixed then from ladle liquid steel comes down to the tundish, and from tundish it come comes down to the mold for continuous feeding in to the caster. So, this is the stages. Here this tundish there is a close up of the tundish it is shown in a you know larger size what happens in tundish. I will now one by one discuss how this ladle tundish and mold we have to be careful about everything all the steps so that whatever state steps we have taken for cleaning the steel do not go to waste.

The steps which we have taken to clean the steel should not be going to waste; that means, we have to be careful that whatever cleanliness level we have achieved it should not increase cleanliness level is again should increase, only it should not decrease; that means, all the elements particularly oxygen nitrogen which are there in here which there is a possibility of you know pickup of oxygen; that means, reoxidation pickup of nitrogen from air that means, renitrorgetnaion during transfer of liquid steel from ladle to the tundish from tundish to the mold. So, we have to be very careful. How do we do that that is what we are telling where to prevent reoxidation and renitrogenation during transfer of liquid steel from ladle to tundish and again from tundish to the mold this is the first requirement.

Then additionally some more control measures have to be taken in tundish and mold for ensuring that the exogenous entrapments a new exogenous entrapments are do not get in to the steel they are prevented; that means, from the ladle from the tundish lining I mean or from the mold slag there is a possibility of exogenous entrapment getting entrapped or entrained in liquid steel which should not happen which should be controlled because we have taken all the you know important measures to clean the steel we do not want the steel should be again get dirty from the exogenous entrapments. The first our step is to prevent reoxidation and renitrogenation from air during transfer of liquid steel from ladle to tundish and then from tundish to mold first step.

Then the second step is to undertake some additional control measures which are we take telling you one by one in ladle, in tundish and mold to ensure that exogenous new exogenous entrapments from the ladle lining tandel tundish lining or tundish slag or the mold slag they should not get entrapped or entrained in liquid steel and if there is a possibility we have to go for further improvement in oxide cleanliness like the dissolved oxygen content if it is possible, we should take measures to reduce it further and we should get sufficient time for the oxide inclusions to float up.

We should get sufficient time for the oxide inclusions alumina to get transformed to calcium aluminate of proper you know melting point lower melting point so that, they become liquid at a liquid steel temperature and it allows them for faster you know coming up to the liquid slag and get absorbed by the slag. So, in the process the oxide cleanliness increases.

So, if you now look in to this continuous casting steps from ladle liquid steel is coming to the tundish which is a buffer, because continuously liquid steel has to be fed from tundish to the mold. So, this is called buffer the tundish is called buffer because one after the ladle is emptied another ladle will come. So, the tundish will maintain the liquid steel level so that from here continuous feeding to the mold is possible that is the beauty of continuous casting unlike you know ingot casting ingot casting one ladle emptied means the tinning is over.

So, one heat we call it one heat one heat is in one heat means one ladle one ladle is emptied means the heat is tinned one heat has been tinned in ingot molds. So, the tinning is over, but here ladle after level ladle can continue one ladle will be emptied another ladle will come tundish acts as a buffer.

Continuous flow to the mold is possible we can go to 10, 15, 20 even 100s 100 of heats. So, one after another ladle will come tundish will be there. So, the it is important to maintain cleanliness level in tundish; tundish refractory is important there should not be erosion there should be sufficient amount of residence time in the for the liquid steel for the inclusions to float up these are the issues which I will be taking up one after another.

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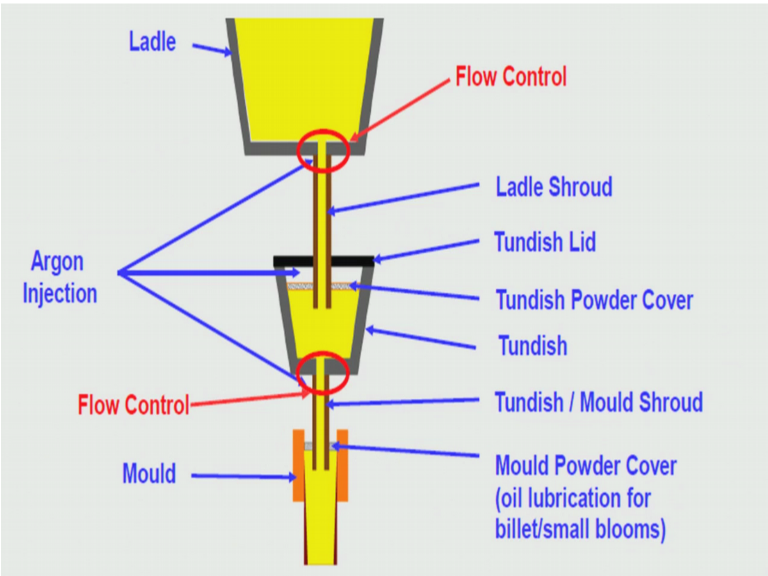

So, first as I was telling from ladle liquid steel is coming down to the tundish. So, there has there is a flow control because liquid steel cannot drop on its own the flow has to be controlled how much flow how much of liquid steel flow velocity you want from ladle to tundish that is important. So, there is a flow control here at this stage at the bottom of the. So, there may be a slide gate. So, there is a flow control device like slide gate, there may be different device also for flow control. So, what is important here is whenever liquid steel is coming down from ladle to tundish, it is coming down through a refractory shroud; on top of that we are pushing argon we are doing argon shrouding.

So, there is a refractory shroud there is a argon flow on top of that. So, this helps the refractory shroud as well as the argon shrouding these helps in controlling reoxidation and renitrogenation nitrogen pick up. So, it will controlling oxygen picker it will control nitrogen pick up from the air. So, first the refractory shroud as well as argon flows. How much argon will be flown these issues I will be discussing this will show to what extent argon has to be flown to what extent you know oxygen reoxidation can be controlled renitrogenation can be controlled.

So, this is one another one is again from tundish to mold there again has to be a flow control either by slide gate or by other means. So, here again it is flowing liquid steel is flowing from here to the mold through a refractory you know nozzle, which is called sub entry nozzle because it is submerged in the liquid steel during casting. So, it is called sub entry nozzle. So, again there has to be argon flow in the sub entry nozzle. So, to control nitrogen pickup and oxygen pick up.

So, these 2 are very important argon injection here at the flow control level from ladle to tundish and again from tundish to mold this is first requirement; there is a ladle shroud as well as argon injection. Here there is called sub entry nozzles and shroud the refractory shroud and as well as there is an argon injection. Now let me first then come to the how much of this argon how much of inert gas has to be flown how do we decide.

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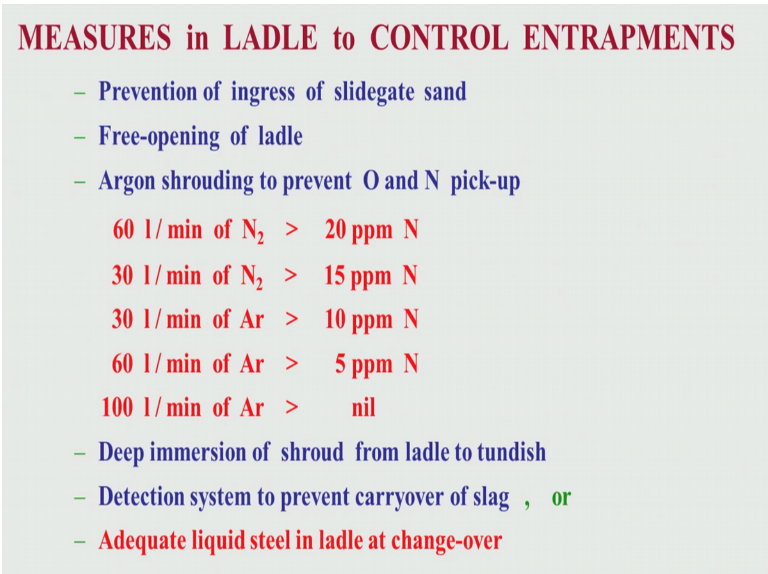

So, what are the measures in ladle to control entrapments, first when the liquid steel is there in the ladle you know initially we have to put there is a you have to put some sand in the slide gate, before we are pouring liquid steel from BOF in the data priming stage when you are pouring liquid steel from BOF for electrical furnace, first the ladle has to be closed; that means, we are putting the slide gate we are putting some you know sand to close the output of ladle the exit of the ladle.

So, when we start tinning that means, when the ladle has to be open first the slide get when it is opened, the sand whatever sand was there in the slide gate at the nozzle that will try to come down and fall in the tundish we do not allow it, because it is what is that just sand is basically means is some exogenous entrapment it will cause exogenous entrapments, it will deteriorate the cleanliness level. So, first that has to be checked it should not fall in the tundish, we should try to just take it out when it is just following we should not allow it to fall in the tundish.

Next is free opening of ladle; when you are controlling the slide gate we are allowing the liquid steel to come out from ladle to tundish, we call it free opening is possible when just by just when you are pulling out the slide gate it should fall, that we liquid steel should come out because we do not want it to be poked with oxygen because you know when oxygen in lansing is if it is required that means, it will create reoxidation. When you are trying to open the ladle it is not free opening then we are trying to open the ladle with oxygen lansing because you know steel has got stuck, still has got solidified at the exit.

So, we are using oxygen lansing which is not desirable. What is desirable is free opening of ladle the slide gate when you open the slide gate liquid steel should flow out come out. So, it is called free opening of ladle. So, prevention of in grace of slide gates sand control of that is first requirement when you are opening the slide gate, next the ladle should open free; that means, the slide gate when you are trying to open the slide gate liquid steel should come out without oxygen lansing, without the necessity of oxygen lansing. If you do oxygen lansing if does not open free. That means, we are creating reoxidation which is undesirable as I have told many times which is undesirable.

Now we have suppose we have controlled the sand we have opened the ladle free. So, the liquid steel is coming out from the ladle as I have shown you liquid steel is coming out from the ladle to the tundish through this shroud, now we have to make some iron injection we have to push some push some inert gas; that means, iron. So, now, how is it done we can be there has been some experimentation for this, the argon shrouding is definitely useful compared to nitrogen shrouding. If you use nitrogen what is going to happen say we are using 60 liter per minute of nitrogen.

So, it has been found that there will be an increase of nitrogen pick up to the extent of about more than 20 ppm. If you reduce the nitrogen flow to 30 liters per minute even with this there will be a 15 1 5 ppm of nitrogen increase nitrogen increase in liquid steel. Now if you use instead of nitrogen if you use 30 liter per minute of argon, still some amount of small amount of nitrogen is pick up is there, because 30 liter per minute of argon may not be adequate to control air ingress and if air ingress is there like oxygen there will be some nitrogen pick up also. If you use 60 liter per minute of argon there is a flow of argon how much argon do we pass it has been found out there is experimentation.

So, all these are important to note. So, if you pass 60 liter per minute of argon through the shroud even with this there is a small amount of nitrogen ingress 5 ppm of nitrogen, where from nitrogen is coming from the air; that means, some amount of air is still entering the system. So, if you use 100 liter per minute of argon then there is no nitrogen pick up, and if there is no nitrogen pick up there will be no oxygen pick up as well because no air ingress is there its taking place. So, 100 liter per minute of argon it has been found experimentally is required is desired to control oxygen and nitrogen pick up. So, this is very important we should we must remember that when we are pushing argon for shrouding purpose to prevent oxygen and nitrogen pick up how much argon do we push.

Because argon is you know is expensive compared to nitrogen. So, how much do you push if you. So, if you push 30 liter per minute it is not adequate 10 ppm nitrogen still pick up we be there. If you put 60 liter per minute of argon still 5 ppm; if we push 100 liter per minute of argon if you are allowing harden 100 liter per minute of argon to flow. So, there be no pick up at all. So, you have to remember 100 liter per minute of argon is useful. So, we do not go to beyond this level because argon is after all expensive. So, this is adequate.

Now, when you are using the shroud as I was just showing to you that this this is a refractive shroud this shroud has to be masked in the tundish. If it is just above the tundish then again there be an open flow which will call re oxidation and re nitrogenation. So, this has to be masked in liquid steel to what extent you know again some experimentation can be done, but important is it has to be masked in the liquid steel in tundish.

Similarly, from tundish when it is coming to the mold it has to be masked, how much will be mass I mean lot of thermo dynamics lot of kinetics is there lot of experimentation has been there, but what is important is that it should be masked. Liquid steel should not be allowed to flow through air directly flow through here to prevent oxygen and nitrogen pick up. So, as I was telling that this is the level of oxygen flow which is necessary to control oxygen and nitrogen pick up when liquid steel is coming down from ladle to tundish.

Again deep immersion of shroud from ladle to tundish deep immersion is necessary then another important thing is. So, when liquid steel is coming down from in the ladle, it is coming down to the tundish as I was discussing a silly question it is getting emptied it is coming down to at tundish from tundish again it will come down to the mold.

So, tundish the ladle is getting emptied. So, on top of the liquid steel what is there is a slag; because the slag was generated during the secondary refining processes, during the different secondary refining processes we need slag you know. So, slag was there at the top of the liquid steel. So, what does slag contain? It contains oxides it contains calcium oxide, some amount of m g o, it contains some amount of small amount of maybe Al2O3.

So, these are the oxides small amounts small amount of maybe iron oxide which is not desirable very small amount many manganese oxide this is not desirable, some amount of Sio 2 though it is not desirable. So, the slag contains only oxides. So, when the liquid steel is coming down the slag is also coming down finally, when the liquid steel is when the ladle is empty; that means, liquid steel has totally come down.

So, we should not allow the slag to come down after liquid steel and get in to the tundish because slag is at exogenous constituent is basically oxide. So, liquid steel is liquid steel which is steel. So, we do not want slag to get in to the tundish in to this entrained in to liquid steel. So, we have to stop the slag from getting in to the tundish. So, what do you do that, how do you know when slag will come. So, there is a technique, there has to be a detection system to prevent carryover of slag.

That means, at the bottom at the exit at the flow control you know here there has to be a device which will give an indication that yes slag is starting now. So, immediately the slide gate will be closed. If you close the slide gate earlier then what happens; that means, the total steel has not come out; that means, the yield is coming down you are wasting some liquid steel it is a good liquid steel, it is a clean liquid steel we have taken all the measures to clean the steel. So, we do not want too much of liquid steel to remain under ladle after all it is going to be going to rest.

So, we want that as mean as much amount of liquid steel whatever goods steel we have produced should come in to the tundish, but we do not want the slag to come in to the tundish. So, we have to make a compromise; when do we stop the ladle, when we control the flow of the liquid steel. So, this is what I have been telling that you know there has to be a detection system to prevent carryover of slag. As I had mentioned you earlier you know the primary steel which was produced in BOF or electric arc furnace, we had mentioned that you know the primary slag carryover is very undesirable, we have to control the slag it should not come from BOF or EAF to the ladle during pouring. So, what do we do there we use slag cut off, we use some measure to control the slag from coming in to the ladle. So, here also we use some other technique.

So, we are it is a detection system they are also there is a direction system, here also there is a detection system to prevent carryover of slag. Now when this is not there you cannot prevent the carryover of slag, you do not know when the slag will come when the liquid steel has been completely drained out and slag will get in. So, what do you do? You put some amount of liquid steel in ladle at change over because to be sure the slag does not come in to the tundish some amount of liquid steel here wasting; because there is no if there is no detection system you have to waste some liquid steel at the time of emptying the ladle; so some of the liquid steel acute on top of that is slag.

So, the slag cannot come inside the tundish. So, this way the yield of the liquid steel will slightly go down, but the quality will be ensured no deterioration of quality no exogenous entrapment of slag will be there. If the slag comes in then the slag is an exogenous entrapment it acts as an exogenous entrapment we do not want ladle; ladle slag to come in to the tundish like here also we do not want tundish slag to come in to the mold tundish slag this I will discuss later on, but right now I am discussing ladle. So, ladle at the end of the emptying of the ladle at the stay of that we do not want slag to come to the tundish this is very important.

Now I have discussed that that the ingress of slide gate sand when we are opening the ladle during teeming this is important this has to be prevented. The ladle should be free open; that means, no oxygen lancing will be necessary we have to be very careful about that that is why the proper quantity of sand it proper you know characteristic of sand is very important slide gate sand these helps in free opening of ladle.

So, free opening is an requirement because if there is no free opening then you have to use you know walking you have to use oxygen lancing in the process some amount of liquid steel get reoxidized, and this amount of this will contaminate some amount of liquid steel which is again going to the tundish. So, reoxidation renitrogenation will take place. So, next is some argon shrouding is necessary now I have shown and discuss how much of ladle flow is necessary about 100 liter one minute I have mentioned is necessary to control or to prevent oxygen and nitrogen pick up. Any amount of argon will not help 30 liter per minute of argon steel there is some nitrogen and oxygen pick up because some amount of air in gas will be there.

So, if it is 100 liter per minute of argon, then air in gas is controlled and there will be no nil pick up of oxygen and nitrogen. Then what is important is deep immersion of shroud this is very important it helps in preventing you know liquid steel to be exposed to air because it is coming through a tundish the shroud and there is a argon cover also. So, if the shroud is immersed in this thing tundish liquid steel then tundish then there is no scope for reoxidation and renitrogenation no scope for contact with air. And then I have told you if there is a detection system to prevent carry over slag that is ideal we do not want the slag at the end of the emptying of ladle to come in to the tundish slag is an exogenous entrapment we do not want that it will affect the cleanliness level, it will increase the oxygen cleanliness level oxide cleanliness level do not want that.

And if that is detection system for slag carry over is not there then there has to be adequate liquid steel in ladle at the end of the emptying the ladle. So, that slag does not come in to the tundish. So, this is very important.

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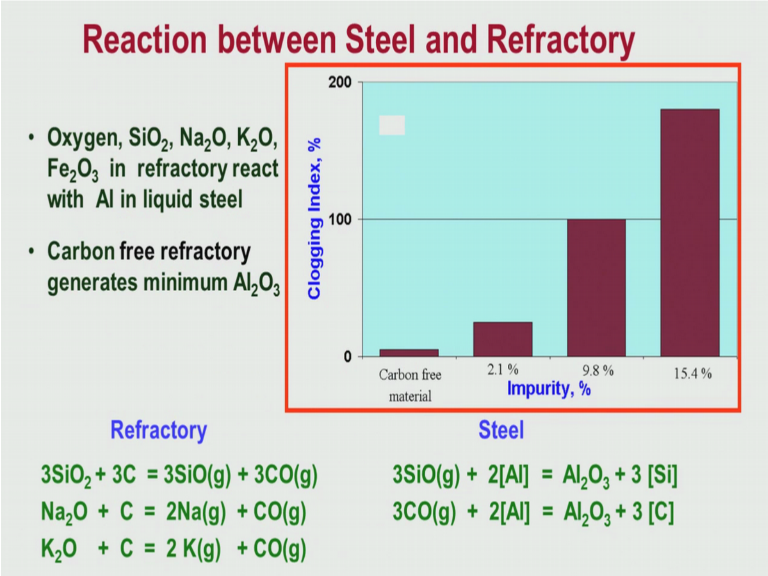

Now, I will discuss about another important issue, I have talked about the refractories there is a refractory lining in ladle you know what type of refracted you use that is very important where I have told you that it has to be a basic refractory because during secondary refining if it is a basic refractory then it will react with you know Sio 2 and can take care of and if it is a acidic refractory. That means, some amount of Sio 2 is present then retune they will react with aluminum and called an cause aluminum ox aluminum in liquid steel and cause alumina formation which is getting entrapped in liquid steel which is undesirable.

So, the type of refract is very important it has to be basic that we know. Now suppose it contains some Sio 2 it contains some sodium oxide, it contains some potassium oxide, if it contains iron oxide in refractory, then what happens I have told you it will react with aluminum in liquid steel how does it react will see that.

Now again the carbon in refractory is also very important refractory should not have any carbon if the carbon level of refractory is almost nil it is very good, otherwise it will react I will come to that how carbon is deleterious from the point of carbon in refractory deleterious from the point of view of cleanliness of steel. This refractory suppose I we have some amount of carbon we have some Sio 2 with the refractory, this Sio 2 will react with carbon and Sio gas carbon monoxide gas is generated. If you have sodium oxide in the refractory this will react with carbon in refractory will cause sodium as gas and carbon monoxide as gas if we have potassium oxide it will react with carbon and will generate potassium as gas and carbon monoxide as gas.

Now, what happens to this Sio as gas and carbon monoxide at gas? This Sio will now react with aluminum in liquid steel I have mentioned many times that we have deoxidized the steel good amount of deoxidation is very good amount of deoxidation is possible, only when they are we do deoxidation or killing with aluminum some amount of aluminum will all be there as elemental aluminum in liquid steel.

So, this elemental aluminum in liquid steel will react with Sio which is forming in the refractory between Sio 2 reaction from Sio 2 and carbon, and this will generate alumina and silicon in liquid steel. Similarly carbon monoxide will react with how carbon monoxide is forming? It is forming from the carbon, carbon reacting with carbon in refractory reacting with Sio 2 carbon reacting with sodium oxide carbon reacting with potassium oxide.

So, if this constituents are present in refractory Sio 2 sodium oxide K2O similarly Fe2O3 again if it is present some examples I am giving the carbon in refractory will react with Sio 2 refractory with sodium oxide with refractory, with potassium oxide with refractory and generate Sio and carbon monoxide. So, carbon monoxide generation is bad Sio generation is bad, because they will react with aluminum in steel and form alumina. So, the alumina will get formed which again has to be removed from liquid steel we do not want alumina in liquid steel. So, this has to be removed from liquid steel and our problem, then silicon carbon also increases in liquid steel which is again we do not want. So, reaction between steel and refractory we have to keep in mind that the impurity content in refractory in the form of Sio 2, sodium oxide, potassium oxide, iron oxide carbon should be less.

So, this is an indication; now I have shown here if the impurity increases then there will be more of clogging what is clogging clogging? Basically means jamming from alumina this alumina all of I have discussed several times all of you by this time know that they are solid at liquid steel temperature. So, if there are alumina particles in steel even if there is some small amount of aluminum which is always present in liquid steel when you are killing with aluminum, if it the steel comes in contact with air alumina forms here the reaction between steel and refractory lining again alumina is forming.

This alumina which is solid at liquid steel temperature will clog the orifices which will clog the outlet of the ladle which will clog the outlet of the outlet of the ladle; that means, outlet in the of the refractory nozzle say if it is from the ladle root tundish or from tundish to mold it can clog everywhere normally if you go to the steel plant if you are doing teeming with you know aluminum kill steel you will find that the during teeming the nozzle is getting sort of choked there is a formation of re information of alumina when it comes in to contact with air.

So, this is because of alumina which is solid. So, we do not want alumina to be present in liquid steel. So, alumina can be present if there is an oxy reaction with oxygen as I have told several times, also it can present if there are impurities like oxygen Sio 2 sodium oxide, potassium oxide, iron oxide and carbon in refractory which is reacting with liquid steel. So, refractory has to be quite clean refractory imputed level in refractory should be good then only we can control the cleanliness of steel. So, this is very important we want clean steel. So, you also want clean refractory, we want good quality steel we also want good quality refractory to get clean steel this issue is very important.

Because after all metallurgical vessels has refractory ladle there is a refractory lining. So, this refractory should not have too much of impurity, here you see if the carbon free material you are wheezing the clogging level is almost negligible and if you are wheezing using high level of impurity in the refractory clogging level is increasing. If the clogging level increases means we have to interrupt the process sometimes if this is very high. The exit of the you know the nozzle exit gets choked if there is too much of clogging; that means, basically is choking off the exit chocking of the nozzle refractory nozzle.

So, this is creating this will create problem during teaming. So, this is very important we must try to remember this.

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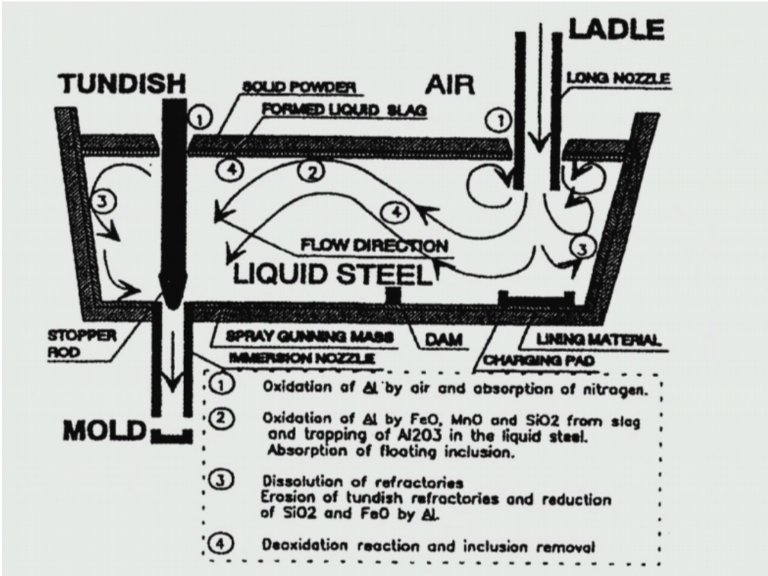

Now, let me talk about like as I have shown you earlier that from ladle we are allowing the liquid steel to form in the tundish, this is a bigger view larger view of the tundish and from tundish liquid steel is getting in to the mold. So, one ladle depends on what is the heat size it may be 150 ton it may be 200 ton 250 ton 300 ton. So, after this amount of liquid steel is poured in tundish the ladle is removed and another ladle will come. So, liquid steel is still there in the tundish.

So, tundish life is very important. Tundish is there for quite some time tundish is you know there for several heats ladle may be one after one it you are removing it and we can inspect it if you that you know ladle if the refractory lotion is there or some problem is that is refractory maybe we have to change you have to do some patching, but the tundish there is several heats several thousands of tons of liquid steel will get in the tundish continuously so, the tundish refractory is very important.

Now how does it happen or what are the possibilities how what do you do in tundish. First let us see how this tundish look like the ladle from ladle liquid steel is this is a nozzle refractory nozzle, from ladle liquid steel is coming down in the tundish through this nozzle. We I have mentioned nozzle must be masked in liquid steel it should not be at the top of the tundish. So, that there is no air ingress it must be immersed in liquid steel then liquid steel flows and then within the tundish there is some residence time this is very important, we should allow liquid steel to remain in tundish for some time so that whatever inclusions are there they should float up and get absorbed in the you know slag here.

And then finally, liquid steel comes down to the mold again there is a refractory nozzle there is a stopper rod or may be some slide gate mechanism this is important. Here stopper that is shown there may be a slide gate as well and then at the exit of tundish to control the flow of liquid steel. Now what is happening here look at what is mentioned here one. One is oxidation of aluminum by air and absorption of nitrogen I have whatever I was telling that at the in the top of the tundish there is a possibility of reoxidation and renitrogenation by if the liquid steel comes in to contact with air.

So, it must be covered the liquid steel in tundish must be covered with some slag this is very very important. There has to be a slag cover both from insulation point of view so that the temperature of the liquid steel does not come down very fast also to prevent reoxidation, to prevent renitrogenation there has to be slag cover then what is happening just see when liquid steel is you know flowing after it comes down is flowing that 2, 2 is basically at the interface of the slag.

So, oxidation of aluminum by Feo, MnO, Sio 2 from slag the slag; again is very important as I have told you for ladle slide here also slag should not have constituents like iron oxide, manganese oxide, Sio 2 otherwise the aluminum in liquid steel will get oxidized and alumina will form. So, this is important the slag constituent what will be the slag that is very important.

Next what is happening here liquid steel is there contains continuous flow. So, at this point; that means, the refractories should not get eroded here should not react with the liquid steel. So, at this point here also refractory there is a possibility of refractory erosion, there is a possibility of reaction of liquid steel with refractory do those should be prevented otherwise again the cleanliness level will go down exogenous entrapment will come up steel will become dirty.

Then there is a possibility of deoxidation reaction and inclusion removal in steel; that means, if there is a some soluble oxygen in the liquid steel there is a aluminum in liquid steel. So, there is a possibility of some deoxidation aluminum reacting with oxygen forming alumina. So, there is a possibility of deoxidation reaction and whatever deoxidant that means, alumina they are forming we should allow them sufficient time to float up and get absorbed in the slag. So, slag is very important here what type of slag you use is very important normally 2 level of slag is used.

The top level of slag is basically insulating type you should not allow you know the temperature to come down temperature liquid steel it should be insulating type. So, normally you know it is rice husk which has been use is a good insulator, but the carbon in rice husk it is very important it should not be the carbon in rice husk should be low otherwise there will be carbon pick up, but that is a top level of the slag below that there has to be a basic slag.

Why basic slag because you know again I am repeating this basic slag should not contain iron oxide manganese MnO and Sio 2 otherwise this slag will react with dissolve aluminum in liquid steel and generate alumina which is a possibility of getting or contaminating the steel. So, there is a 2 stage slag we call it, the top one is insulating type rice husk type and below that there is a basic slag which will be useful for absorbing the alumina inclusions which will float up this is very important.

So, how do you increase the residence time of you know liquid steel in tundish you see the flow you are not allowing direct flow, you are allowing the liquid steel to flow this way; that means, you are increasing the residence time of liquid steel in tundish. So, that you know floatation of the inclusions is facilitated inclusions get sufficient time to float up and get absorbed by the basic slag. So, how do you do it? You can use some dam is called dam you can use some other constituents flow control devices which will allow the steel to flow in a circuitous way, which will not allow direct flow from here to the exit of the tundish. So, it is a circuitous flow; that means, you are increasing the residence time of liquid steel in tundish here look at what is there.

It is a you know that sort of thing which tries to protect the bottom of the tundish because liquid steel will come down and I have told you that it is immersed slightly lower below the top level which is the slag level to protect the liquid steel. So, whatever liquid steel is coming out it might impact the bottom of the refractive bottom refractory lining the bottom refractory lining of the tundish to protect it there is a pad there is a special refractory lining, special refractory component device, which is called a charging pad at the top of the lining material.

So, it prevents selective erosion of the lining at this point because the liquid steel will impinge here, the incoming liquid steel will impinge here. So, it has to be protected this area is protected. So, it is called a charging pad. So, what I have told you is the design of tundish is very important, it will allow it should allow liquid steel to flow not directly, but in a circuitous way. So, that the residence time is more the inclusions can float up this is very important, for that dams wares think like that flow control devices are used at particular locations.

So, that is design of I know tundish to enhance the flow control to increase the residence time there should not be too much of you know dead volume the liquid steel whatever is coming should not stay at a particular location, you know if there should be a continuous flow or the residence site should be more. So, this is very important the dead volume should not be high this is very important. So, this charging pad has to be there to protect this particular location where there is a possibility of impingement of liquid steel coming liquid steel with the bottom at this location. So, these are important issues.

Thank you very much.