Steel Quality Role of Secondary Refining and Continuous Casting
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Module - 03
Lecture - 13
Different Routes and Temperature Control

Whatever I have discussed under secondary refining the different stages, I think now let me talk about how starting from you know primary steelmaking to the continuous casting, what are the in a schematic way, what is actually happening. Say primary steelmaking is again and again mention is basically either BOF or EAF or can be induction furnace as well, but normally BOF and EAF.

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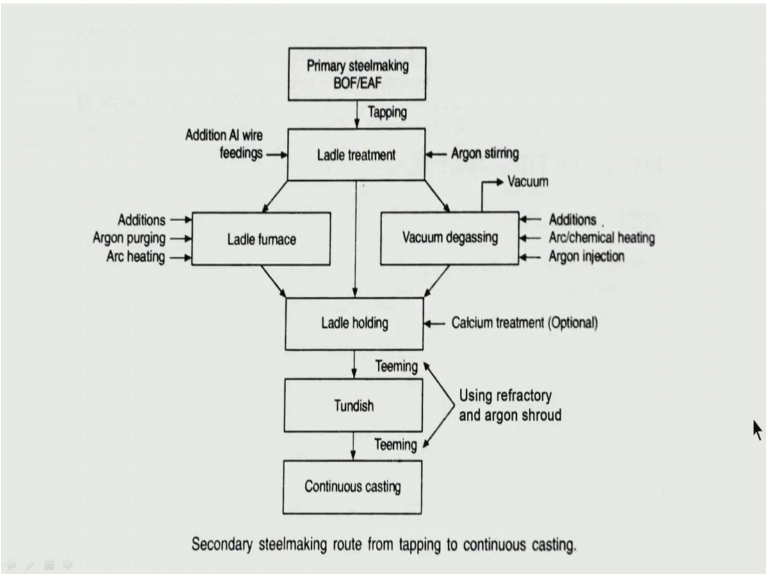

Secondary steelmaking route from tapping to continuous casting.

Let us we have most of the large steel plant they are using either BOF or EAF some smaller plants they are also using induction furnaces now what is happening? From here we are tapping liquid steel to the ladle. So, this is the ladle which will be used for secondary refining. So, in from primary steelmaking furnace BOF or EAF or induction furnace we are tapping liquid steel in the ladle. I have mentioned we have to be careful about the slag carried over slag from primary furnaces should not be allowed to come during tapping there is a possibility of slag coming at the towards the end of the tapping because of funnel formation you know I have mentioned. So, we must have a slag topper a slag stopper not to allow the slag from getting carried over to the ladle, otherwise this would create problem I have mentioned because this slag has high amount of iron oxide some amount of manganese oxide, some amount of phosphorus oxide this will create difficulties in subsequent secondary refining processes.

So, now what is going to happen? Now we are going to do after we tap in ladle we are going to ladle treatment. So, how what we can do first I have to deoxidation. So, I can use aluminum ware feeding which can do deoxidation, some argon rinsing is necessary I have told you why because argon can be send in the ladle from the bottom because this will try to enhance the flotation of the alumina type of inclusions as silica type of inclusions which are forming by deoxidation reaction, this will enhance the inclusions to float up and get absorbed by the slag.

So, this is important argon stirring is important then in ladle treatment. Now this ladle treatment at this stage basically means even if I do not take it to the ladle furnace or you know other vacuum degassing just in the ladle itself we can do certain amount of secondary refining like deoxidation is possible like argon stirring is possible. So, inert gas purging is possible. So, deoxidation and inert gases purging this are possible in normal ladle itself without taking it in to the ladle furnace or in the degasser. Now if you want steel better quality of steel we want good desulphur desulphurization we want degassing. So, what is the way out? We have to take the ladle to the ladle furnace. So, what are possible here additions are possible, addition means we want to form a good quality slag here of high basicity because Cao has to be more then only desulphurization will be possible.

So, additions for slag formation as well as additions for you know getting alloying elements proper of proper quantity; that means, for alloy ferroalloy addition can be done here, we can do argon purging also here. So, we can do arc heating if it is a ladle furnace means, we can do arc heating here so; that means, the temperature adjustment in whatever processes we are doing whatever additions we are doing there is a temperature drop. So, we have to increase the temperature. So, ladle furnace provides us that facility we can increase the temperature here and if you are processing the liquid steel only in the ladle we cannot heat it. So, too much of addition is also not possible.

So, there is some limitations in normal ladle treatments without using ladle furnace or vacuum degassing. First desulphurization is not possible to the desirable extent degassing of obviously, not possible too much of addition will bring down the temperature. So, what we can do? We can do deoxidation we can do argon rinsing this is possible. So, cleanliness oxide cleanliness we can control, but sulphur is difficult to control only at this stage. So, sulphur control; that means, desulphurization is definitely possible in ladle furnace, temperature management is much better here because we can heat. Now we instead of ladle furnace we go to the vacuum degassing units it may be Rh circulation you know degassing is possible it may be v d it may be VAD. So, what we do again additions are possible.

Again you know arcing is possible like if you do VAD on Rh heating is not Rh, if you go to VAD then arcing is possible argon injection is always definitely possible. So, and if we say vacuum process means we can use vacuum whether it is VAD, v d or r h. So, instead of normal just simple ladle treatment we if you are in ladle furnace or vacuum furnace some more secondary refining possibilities are there. So, quality level can be enhanced further. Now next after you know inclusion levels have been controlled quality we expect that the quality is enhanced what do we do? We can hold the ladle because I have as I have told you this holding the label ladle will help us in two ways first, it is possible here to do calcium treatment; that means, whatever calcium injection I have just talked about few minutes back.

So, that calcium ware can be fed at this stage in the ladle, this ware which is present in the spoon with the form of spoon with the help of a feeder this ware has been pushed deep inside the ladle. So, ware injection is possible at this stage, and then if you are holding the ladle we are allowing the inclusions to float up whatever aluminum inclusions are forming, whatever calcium oxide aluminum are forming this holding will help us in allowing the inclusions to float up, and if you have a argon facility which is normally all the ladles have argon purging facility this is helping the inclusions to float up.

So, after this we have to go to the tundish if you are going for continuous casting. That means, from the ladle we have to go to the tundish. Now we have to again do teeming; that means, the steel liquid steel whatever is there in the ladle now should go in to the tundish. Now at this stage some refractory nozzle is necessary, because whatever care we have taken in enhancing the quality of steel in controlling the inclusions in steel particularly oxide inclusions, what is going to happen if we do an open teeming; that means, the liquid stream even it is coming out from the bottom of ladle to the tundish if it is opened; that means, it is reacting with oxygen and nitrogen in open air.

So, they will be reoxidation they will be renitrogenation; that means, oxygen and nitrogen liquid steel will go up, oxide inclusions will form and we know that due to reoxidation this oxide which are going to form this are basically exogenous inclusions sort of. So, they are in large in size very harmful to the liquid quality. So, we have to be careful about this teeming, we must do this teeming with the help of some refractory shroud, together with argon you know rinsing. So, argon passing through refractory nozzle will help the stream to be protected; will not allow the stream to react to get reacted with oxygen and nitrogen.

So, dioxide reoxidation and renitrogenation possibility of this are control. So, the extend will be much less if you team in presence of refractory nozzle as well as oxygen rinsing. Oxygen shrouding we call it we call it shroud refractory shroud as well as argon shroud. Now from tundish finally, the liquid stole steel is allowed to move to this continuous casting mold. So, again the liquid steel will be coming out. So, again at this stage of teeming there has to be refractory shroud which we call as sub entry nozzle, the liquid steel is not allowed to fall just like that there has to be sub entry nozzle and there has to be some argon shrouding to protect the liquid steel liquid stream the stream of liquid steel from getting oxidized then nitro renitro renitrogest.

So, this is the sort of sequence of activities which are essential for getting a good amount of rather a good quality of steel; you know the desired quality of steel to control reoxidation of steel. The total oxygen control total oxygen contain in liquid steel at the final stage should not be more than 25 ppm if you do all these if you take all these cares, it can be further controlled to even less than 15 ppm, if you do all these if take this all this measures and do all the controls.

So, for getting a good quality of steel we have to be very careful at every stage starting from you know slag cutting out the primary slag using slag stopper; and then taking precautions or taking steps whatever necessary at every stage of secondary refining. Proper deoxidation, proper argon stirring you know proper heating if necessary because in the process you see so many steps we have to pass through the temperature might come down.

We need a particular range of temperature here during casting or ingot casting whatever is continuous casting or ingot casting. So, this particular temperature manage to get this temperature particular temperature, managing the temperature during the whole course of its you know whole course of steelmaking stages is very important. And when it is when the liquid steel is coming out of primary steelmaking it is relatively high, but during the process of secondary steelmaking the temperature might come down. So, what is necessary sometimes it to use the arcing facility of ladle furnace or even in the vacuum arc degassing we have some arcing facility. So, some heating is possible. So, temperature management is relatively better.

So, the temperature of liquid steel which is coming on the primary steel need not be very high here, because in between if the necessity is there we can do some arcing and temperature increase. Because unnecessary leave we should not go to very high level of temperature in BOF or EAF because that makes the steel dirty some of the refining processes are affected here, dephosphorization is not very good if the liquid steel temperature is high. So, all this controls you know the erosion of in refractories are high. So, if the steel becomes more dirty. So, temperature at the end of BOF should not be very high, it is very easy to control temperature here because more oxygen in put here.

The oxygen combining with silicon oxygen and all on carbon and all the temperature is will go up because you are autogenous reaction here the lot of heat is generated. But unnecessarily we will not should not go to very item range you should not go to more than 60, 50, 60, 70 temperature, because then what is going to happen is disphosphorization is not good in at the BOF stage or EAF stage. We may have lot of you know oxide inclusion in the steel so the iron yield is relatively less because some iron is lost as iron oxide and related issues we have to face. So, if you are taking the steel during secondary refining to ladle furnace or VAD, there is a possibility of temperature control by using the reheating by heating reheating here.

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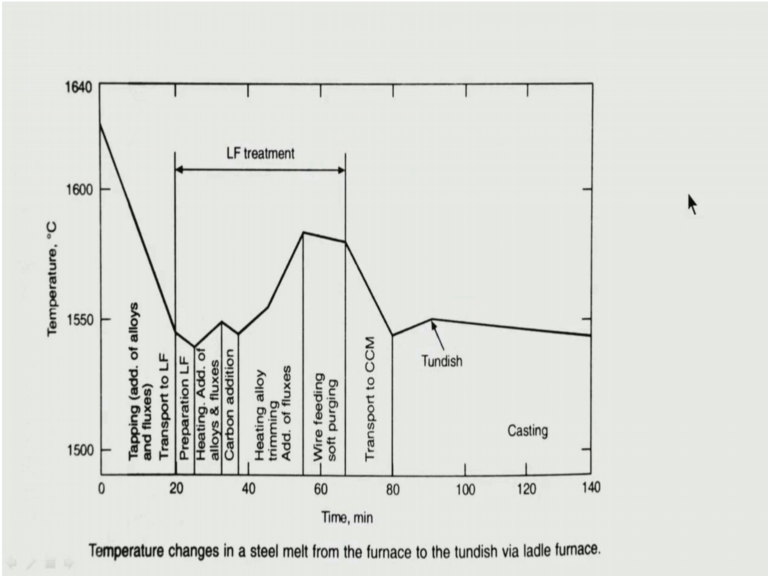

Temperature changes in a steel melt from the furnace to the tundish via ladle furnace.

Now, whatever I was telling you this is a temperature management how we do it in reality. Say here liquid steel temperature after BOF or EAF say it is up to this; that means, may be is about 1630 also it should not be very high as I was mentioning if you are using you know LF, it should not be very high because there is the possibility of increasing the temperature of liquid steel during subsequent LF treatment. If you are not using LF then possibility the temperature has to be slightly more here, because we have no scope for heating in the liquid steel except what do we it chemical heating that is by use of aluminum.

That means, aluminum oxygen reaction will generate some heat. So, there is some possibility of chemical heating, but otherwise directly they no it there is no possibility unless you really form a VAD; that means, wherever there is no possibility of reheating temperature after BOF EAF has to be slightly more may be 40 50 degree centigrade more here.

If the process you know the extent of dephosphorization is relatively less, if you have more temperature here. Now, what is going to happen? We are tapping it and we are you know adding the alloying elements all this will cause the temperature to come down by say about to be 70, 80 degree centigrade here it is coming down to be slightly more and then we are starting the ladle furnace treatment, there we can increase the temperature. So, what we do is we can fast you make all the additions because then temperature loss will be there, then we may add some carbon for adjusting the carbon if it is necessary or the as the first step of deoxidation we can add some carbon.

So, in the process we can get some temperature increase and then using arcing we can increase the temperature. So, here you have mentioned some during the heating we can add some teeming additions for adjusting the alloy chemistry, we can add some fluxes because calcium oxide has to be added because you know the slag has to be behind c a o for good desulphurization then we can do ware feeding also for deoxidation ware feeding of aluminum is possible here. So, some purging is also possible.

So, at this stage at even ware feeding of calcium is done at this stage last stage of you know LF adjust outside the LF then we are transporting the liquid steel which is in ladle to the continuous casting way. So, again this some temperature drop and then we are pouring the liquid steel in some tundish, tundish is already preheated before it is before the liquid steel is poured through there is a slight increase in, temperature and then of course, the casting start there may be slight decrease during the process of casting.

So, at the stage of casting the desirable temperature is somewhere here depending on of course, you can gives me alloys its along 15 50 or so. So, therefore, what should be the pouring temperature from BOF or EAF? It depends on what is our desirable casting temperature if we take the ladle through ladle furnace or VAD, then there is a possibility of heating a accordingly we adjust the pouring temperature if the we do not take the ladle through LF or VAD; SO that means, there is no possibility of heating then the temperature here pouring temperature has to be slightly more may be around 40 50 degree centigrade more because there is no scope of heating.

So, what is important here for temperature management is? Depending on the final requirement of temperature, this is dependent on what this is dependent on what is the liquidus of the particular alloy and some super heat has to be there so; that means, what should be the casting temperature. So, liquidus plus super heat say about liquidus plus 30 degree centigrade or 40 degree centigrade that is a super heat. So, that temperature we have to; that means, when we are starting the casting we must have that temperature in the tundish, because during the process of casting there may be a drop of may be 10 degree centigrade or so.

So, we must ensure when you are starting the casting the desirable temperature is there in the tundish the liquid steel which is there in the tundish. So, tundish proper heating is important here, if there is no heating of liquid steel through LF at LF or VAD, then temperature has to be slightly more pouring temperature from BOF or EAF though that is not desirable, but it when there is an order provision for temperature control; that means, we are not using either LF or VAD, then temperature has to be slightly more here to get the desirable temperature during casting.

So, this is the way we maintain a desirable temperature, and then I have mentioned how by the difference secondary refining processes we get the desire desirable quality, how we are using at every teeming stages you know refractory shroud and argon you know rinsing or whatever is called argon shrouding argon protection so that there is no reoxidation this is very important, because whatever care we are taking from making a good quality of steel in secondary refining that should not get jeopardize at the time of teeming by reaction with oxygen and nitrogen.

So, reoxidation renitrogenation are not x are not desirable, they have to be stopped. How do we stop it by using proper refractory shroud by using proper argon shrouding during teeming from ladle to tundish and again from tundish to mold. So, this is very important.

Thank you very much.