Steel Quality Role of Secondary Refining and Continuous Casting
Dr. Santanu Kr Ray
Department of Mechanical Engineering
Indian Institute of Technology, Madras

Module - 03
Lecture - 14
Decarburisation

In the earlier lecture I was talking about the role of secondary refining in controlling the inclusions and entrapments.

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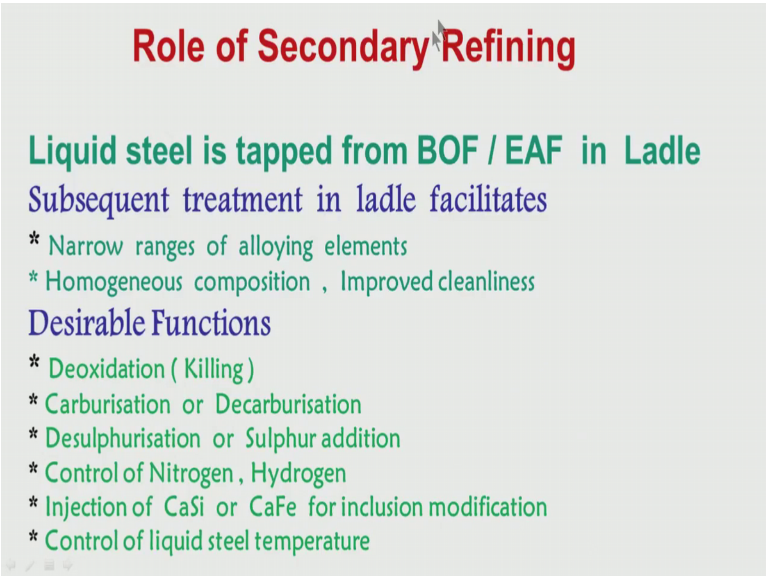

I talked about you know what are the desirable functions for the secondary refining stages like, deoxidation which I have covered, then desulphurization I have covered, control of gaseous elements like nitrogen and hydrogen I have covered, then injection of calcium in the form of Ca-Si, how does it help in inclusion modification? What are the limitations? You know, what are the precautions one has to take? And then what is the importance of controlling the liquid steel temperature for getting the desirable quality this I have talked about. I have not talked about I think decarburisation as one important requirement for secondary refining.

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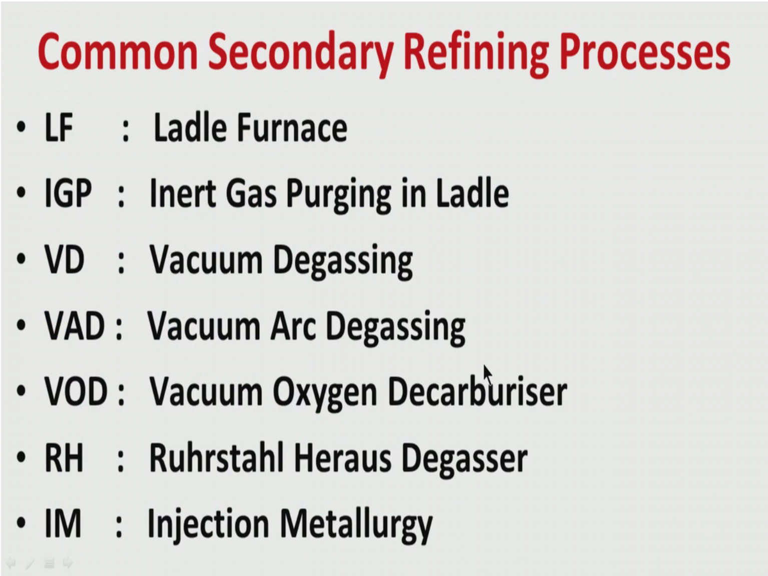

I had also talked about what are the different you know, processes like ladle furnace inert gas purging vacuum degassing, how it helps in achieving the different issues? Or different you know requirements for quality enhancement. Then I talked about VAD. Vacuum arc degassing how does it help in you know the arcing how does it help in increasing the temperature, controlling the temperature and how is it helpful. I had talked about RH process Ruhrstahl Heraeus Degasser.

How does it help in controlling the gaseous elements like nitrogen and hydrogen? I have talked about IM injection metallurgy basically how Ca-Si injection helps in modifying the inclusions controlling the melting point of the inclusions and related issues. What I have not talked about till is the vacuum oxygen decarburiser. How does it help in controlling a carbon? Which is very important, so today I will be talking about that.

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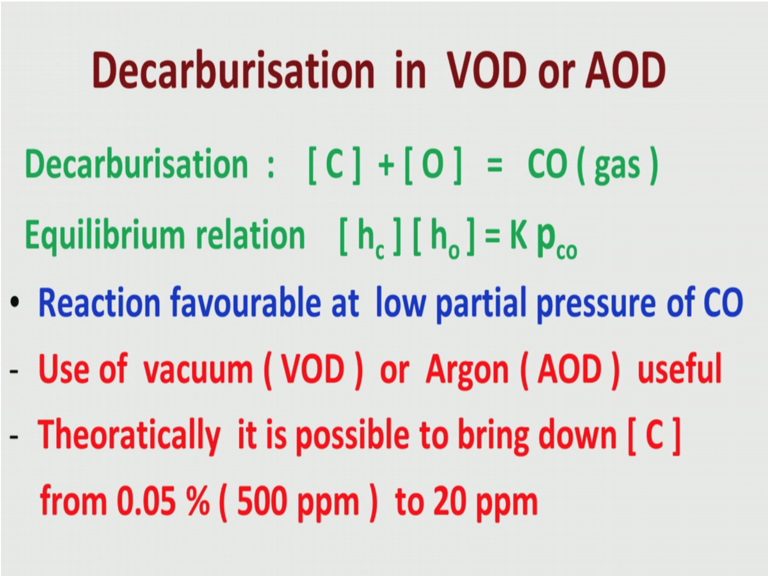

Decarburisation, it can be done both by vacuum as well as argon if you look in to the decarburisation reaction, then it will be clear how vacuum or argon helps in decarburisation. Basically the decarburisation reaction means, carbon which is present as elemental carbon in liquid steel will react with oxygen which, when you inject oxygen it will finally, go in to the liquid steel as elemental oxygen and this carbon and oxygen they will react will create carbon monoxide gas.

This is a gas and then the equilibrium relation indicates that the hendrian activity of carbon in liquid steel multiplied by the hendrian activity of oxygen in liquid steel is equal to the K the constant and the partial pressure of carbon monoxide, this is a gas. So, the activity of carbon monoxide is determined by the partial pressure of carbon monoxide. The activity of carbon is given by the hendrian activity of carbon.

Since carbon is present in very small amount oxygen is present in very small amount in liquid steel the hendrian activity which is equivalent to weight percentage of carbon since it is very low amount. So, the Henry's law is valid and. So, the hendrian activity in multiply of carbon multiplied by the henrdrian activity of oxygen is equal to the constant in to the partial pressure of carbon monoxide. Now this constant K I have discussed about this earlier for any reaction it depends on the particular temperature. Because this is the thermo dynamic you know, factor it depends on the temperature. So, at a particular temperature this is fixed. Therefore, if the partial pressure of carbon monoxide is come it can be controlled; that means, if it comes down then this is a particular constant; that means, is fixed at a particular temperature.

So, this 2 the multiplication of hendrian activity of carbon and hendrian activity of oxygen; that means, the weight percent of carbon in solution and the weight percent of oxygen in solution. Multiplication of this factor also will come down. Because this is constant at a particular temperature if this comes down this multiplication factor also will come down. So, in this process for a particular level of oxygen the carbon amount in solution will also come down. This is the technique this is a principle of controlling carbon; that means, it is it is the technique by which decarburisation can take place for a particular amount of oxygen when it is put in liquid steel.

So, how the carbon solubility can be brought down it can be brought down at a particular temperature when K is constant by reducing the partial pressure of carbon monoxide how is it possible? Let us now look in to the possibility it is possible by 2 ways, if you use vacuum; that means, if you use a vacuum oxygen decarburisation process. So, the partial pressure of all the gases will come down in the process carbon monoxide also partial pressure of carbon monoxide also will come down or if you use argon; that means, if you are putting argon in the process.

So, which is called AOD a argon oxygen decarburisation; that means, along with our oxygen you are putting lot of argon in the system in the process in the that helps in bringing down the partial pressure of carbon monoxide. So, either vacuum or argon these are the technique if you use vacuum then the process is called vacuum oxygen decarburization if you use argon then we call it argon oxygen decarburisation oxygen of course, is necessary, because this oxygen will react with carbon and carbon monoxide will be generated.

So, at a particular level of oxygen in the liquid steel, if the partial pressure of carbon monoxide is brought down the amount of carbon can be in liquid steel can be lowered. That is the technique of decarburisation. So, as I have mentioned it is possible either using vacuum that is in the process of VOD vacuum oxygen decarburisation, or using argon which is called argon oxygen decarburisation. So either you use vacuum or you use argon in the process, you can bring down carbon solubility carbon level in liquid steel. So, theoretically it can be calculated from this value of K and value of partial pressure of CO.

So, theoretically it is possible to bring down from 0.05 percent; that means, when you are starting the process solubility the carbon level is say 500 ppm; that means, 0.05 percent carbon. So, carbon contained in the liquid steel will if we start at 0.05 percent carbon which is the normal level after you know BOF, basic oxygen furnace. So, if you use that liquid steel and if you want to bring down the carbon either by using vacuum or by argon then it is possible to bring down to a level of 20 ppm either by using vacuum or by using argon.

So, decarburisation is very much possible which is a requirement may be a requirement in secondary refining, either by using vacuum or by using argon. In the process carbon monoxide is getting generated this is a gas. So, it will come out of the system. So, no entrapment, there is no possibility of any entrapment. You know, unlike you know deoxidation where alumina is generated unlike desulphurization where calcium sulphide is generated, or manganese sulphide is generated which has to be taken out From the liquid steel, to the slag it has to be taken to the slag phase.

Incidentally here carbon monoxide is a gas. So, the gas will bubble out will come out of the liquid steel when there is a vacuum or when you are using argon. So, in the process decarburisation will take place, carbon will come down from say about 500 ppm; that means, 0.05 percent which to it can come down to as low as 20 ppm. So, this is the beauty of this VOD or AOD it can bring down carbon level to a very low level depending on how much vacuum you are using, or how much argon you are pushing. What is the partial pressure of CO this will determine at a particular temperature how much of carbon finally, will be there in the liquid steel. So, there is a good process it is a useful process.

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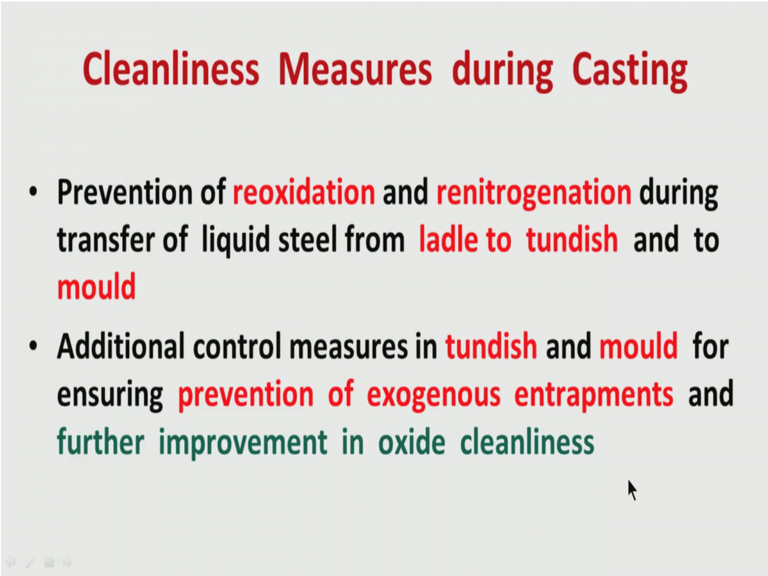

Now, we have come to the end of secondary refining; that means, we have tried to bring down the level of oxygen by deoxidation first. We had try to bring down the level of sulphur by desulphurization. Phosphorus we have taken care of in the primary steelmaking itself, as I have discussed earlier. So, we have taken a care of phosphorus in primary steelmaking; that means, BOF or EAF.

Then in the secondary refining first step is to control the dissolved oxygen content; that means, killing of steel deoxidation of steel. So, that also you we have I have told you how it is possible by using either silicon or silicon manganese or the better is aluminum which is a very good deoxidizer. And I have also mentioned to what extent deoxidation is possible for aluminum deoxidation is much better, it can be found out from thermo dynamics that why aluminum is a very good deoxidizer compared to say silicon or manganese.

So, after deoxidation we do desulphurization I have also mentioned why deoxidation is first required the dissolve oxygen has to be brought down then only desulphurization is effective. So, these I have discussed. So, after desulfurization, what you do? You do degassing you can take care of hydrogen and nitrogen which are the gaseous elements or even oxygen to some extent; it can be used like when you are using some carbon. So, it will react with oxygen if you increase some amount of carbon in liquid steel. So, some amount of dissolve oxygen also will come down. So, by degassing process we are controlling hydrogen.

We are controlling nitrogen I have also mentioned how vacuum helps in controlling this gaseous elements solubility of gaseous elements come down with the help of vacuum and it how it helps in reduction of nitrogen and hydrogen. I have also mentioned theoretically both hydrogen and nitrogen can be brought down to very low level, but in reality nitrogen reduction is a bit difficult because of kinetics. Because, nitrogen is a has to be removed nitrogen is relatively slowly removed because of the kinetic factor compared to hydrogen. Hydrogen diffusivity is very fast. So, it can be removed relatively faster.

So, the theoretical limit is of hydrogen can be achieved the thermo dynamic limit is of hydrogen can be achieved through degassing, but it is difficult to remove nitrogen to the theoretical level. So, what is necessary is removal of oxygen, removal of sulphur, because oxygen sulphur particularly is a surface active element. If it is not removed before denitrogenation then it competes with nitrogen for the acting as the surface active elements and it causes problem.

So, desulphurization is a necessity it is a prerequisite for removing nitrogen from liquid steel. So, I have talked about all these secondary refining processes. How this processes help in cleaning the steel. How these processes help in removing the undesirable elements to a control level, to a very desirable level. It cannot be totally removed, but you can control them bring them down to the desirable levels which is dictated as I have told earlier by the application requirements.

So, depending on the application requirements you can bring down dissolve oxygen you can bring down dissolve sulphur, you can bring down dissolved hydrogen, dissolved nitrogen, you can bring down carbon, if there is a necessity all these are possible through secondary refining.