Principles of Casting Technology
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Lecture – 30
Technology of Melting
Melting practices, Refractories in Furnaces

Welcome to the lecture on Technology of Melting. In this lecture we will discuss about the practices which are followed in melting; normally we will confine our studies to cupola melting and in the arc furnace or induction furnace. Then also we will discuss about the refractories which are used in the furnace, so in a terms of lining. So, about them also we will discuss in brief. So, let us come to the cupola operation.

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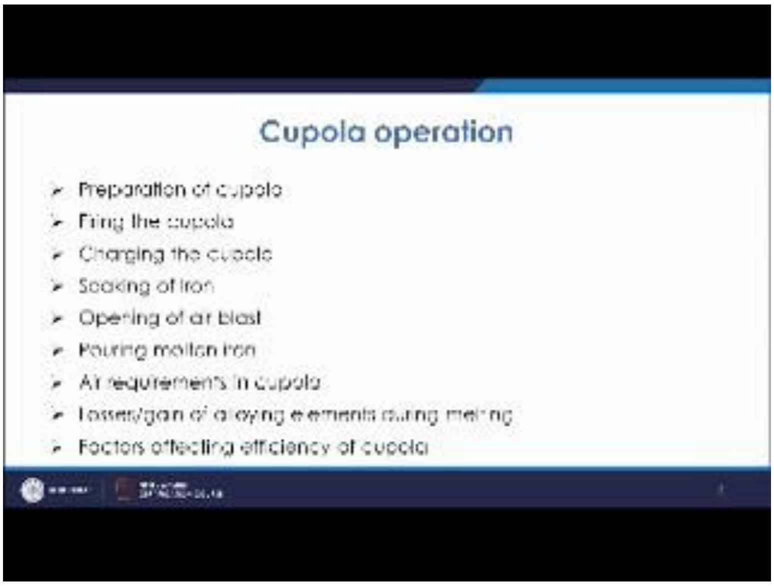

So, we had earlier studied in the previous class that cupola is normally used for melting iron, mostly cast iron and it is normally know it is replaced with the arc induction furnaces, but still they are used for medium or small scale foundries because it is a cheap operation based process. So, as we know that in the cupola operation you have these activities which are to be followed. So, first is preparation of cupola. In that basically you are keeping the cupola prepared by cleaning by putting the things in place. So, once you have the coke bed prepared at the bottom then you have the alternate layers of metal or ore then coke and then flux. So, that alternate layers are kept in you have the two years ready so that you can start putting the air into it blasting it.

Then the next operation is firing the cupola. So, firing the cupola means certainly when we talk about initially we preparing preparation of cupola means you are keeping the cupola clean and neat so that you can start the operation, keep the coke bets ready. Then you are igniting this by firing it, so you can use the kindles of wood to fire from the bottom and then you fire the coke bed with air passing through that. So, once it is ignited then you are charging the cupola with that charge metal; that is metal coke and lime stone alternate layers. And then the soaking of iron takes place, so that iron will be melted and then it will be start coming out it temperature will go on increasing and it will be melting, coming down here blast is opened.

So, then once this air blast is opened in the later stages it increases the temperature of the molten metal which is coming through the coke bed and tickling down into the bottom portion of the cupola and the your pouring the molten metal. So, this is how the process goes in cupola. You have to adjust the composition of the charge; you have to adjust the composition of various elements so that if suppose there is the efficiency of certain alloying element you will have to add them, and you have to make it as per your requirement.

Now coming to the point of air requirement in cupola; so basically you need to have the air which is to be blasted for the combustion of the coke, so this air requirement is there and that is normally some value. So, on the basis of that you can find. So, if you have a certain amount of metal in that case you need to provide some amount of air at certain pressure. So, you have basically for a charge, you know the charge is the that molten metal which you get it is by melting the iron ore the scrap which you put in that then it is combining with the coke and the limestone that is basically that works as the flux; so that will form the slag.

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So, air requirement is normally 8.4 cubic meter of air per kg of coke. So, if you know the amount of coke which is required to burn then you can find the amount of air which is required. Now the amount of coke basically depends upon what is the amount of molten metal to be melted or there is a metal to coke ratio. So, there is metal to coke ratio that is also known as coke rate and that basically varies from 6 is to 1 to 12 is to 1. So, if you have 6 kg of metal then you need 1 kg of coke. So, that it can be melted and then you can get the liquid metal.

Now, the thing is there is one more understanding and one more calculation which is given that the plan area that is 14 centimeter square of plan area of the cupola is required for delivering 1 kg of metal per hour. So, if you want the metal delivery rate at 1 kg per hour normally you need 14 centimeter square of the plan area that is of cupola. So, these are the formulas which are normally used for calculating the dimension of the cupola, the amount of coke, and once you know the amount of coke you can find the amount of air requirement.

So suppose for example, if you have the plan to have a 5 ton per hour of metal requirement. And in that case if you take the metal to coke ratio; if the ratio metal to coke is taken as 8 is to 1. So, in that case for 5 ton of per hour of the metal to be delivered you need amount of coke per hour that will be 625 kg. So is 5000 kg upon 8, so that is 625 kg. Now this was basically for 1 kg per hour of the coke requirement; so for 1 kg it this is the plan area required for the cupola, so for this part two 625 kg coke plan area required of cupola that will be able to deliver you this amount of 5 ton of metal per hour this will be 625 into 14. So, this is 8750 that is centimeter square.

And once you know this 8750 centimeter square is basically the area of the cupola that is its cross sectional area so you can find the diameter the cupola and diameter of cupola can be found out; so that is pi by four d square will be 8750, so d will be under root 8750 in to 4 divided by pi. So, once you get that you can calculate what will be that. So, 8750 upon 3.14 into 4 and under root. So, it is something close to 106 centimeter.

So, you can have a cupola of diameter basically, so this cupola diameter has to be something 106 centimeter. So, the cupola diameter; you have the cupola here so this diameter has to be 106 centimeter which will provide the metal delivery rate at a value of 5 ton per hour. So, this is how you try to find out the dimension of the cupola, amount of coke required, based on the amount on the amount of coke required you can have the requirement of the air.

Loss and gain of alloying elements during melting; now during the operation of cupola melting there is loss or gain of many alloying elements, now among these alloying elements normally we have carbon, silicon, manganese, sulfur, and phosphorus, and then rest is that is iron. Now, we will discuss about the basically loss or gain of alloying elements during the melting process. And we will discuss mostly about the elements that is carbon, silicon, manganese, phosphorus, sulfur, and iron.

So, basically what happens the carbon; carbon basically once the molten metal comes down then this picks up the carbon from the coke, so it has basically reaction with the. So, it has you know contact with the coke because you are putting the alternate layers of coke. So, it is in contact with that coke, so it picks up the carbon from there. Then further it comes through the coke bed, so there will be pickup of carbon.

So, some amount of carbon is picked up may be 0.1 to 0.23 percent of 0.3 percent maximum that much pick up is there of carbon. So, you have to adjust the carbon composition by putting proper amount of carbon in the charge itself and then there will be some pick up during the melting process. Now that pick up will depend upon the quality of coke, the size of the coke, I mean also the amount of coke, the coke bed height all these things will basically decide about the carbon pick up.

Then coming to silicon; so silicon is basically lost during the process, so there will be loss of 10 to 15 percent of silicon when the melt comes down and when there is combustion process during that process the silicon is lost and this silicon has to be basically balanced, you have to provide extra silicon to have the composition with the limit. So, that can basically either be compensated by providing the charge in such a way that you have silicon in the charge or so high silicon content charge may be gained or you may to do at least the addition of ferrosilicon which has the silicon content to a quite larger extent. So, that will compensate for the loss of the silicon.

Similarly manganese; so manganese also is lost, there will be loss of manganese and this manganese has to be basically compensated again by the addition of ferromanganese. So, these are the elements which are lost

Now is sulfur; now sulfur is basically there is a pickup of sulfur, so because the coke which we use it has sulfur so the melt picks up this sulfur. And, that is why you will have to see that what kind of charge you have to provide so that they should not be much of the sulfur. So, it will depend upon the type of coke you provide. If the coke has larger amount of sulfur there will be larger pick of the sulfur, and large amount of sulfur is not basically good for they castings specially for the production of hazier and casting sort the teller and castings this presents of sulfur is deleterious for the (Refer Time: 15:29) process. So, you will have to see that this sulfur content is not picked up. So, basically even you can go for proper basic lining so that this sulfur, I mean pick up is inhabited

Then phosphorous; phosphorous basically is not much of the change in the amount of first four us during this cupola melting. And then there is rest of iron. So, iron is also lost in the process and something closed to 0.3 to 0.4 percent of iron is lost during that. So, you have to balance it by putting the charge which is reach in iron. So, this way you are basically balancing or you are maintaining the proper composition of the charge metal.

Then comes factor affecting the efficiency of cupola. The factors which are basically affecting the efficiency of cupola are; basically coke rate, blast rate, coke size. So, these are basically affecting the quality or the efficiency of cupola. So, as we know this coke rate has to be basically proper so that the cupola melting is proper.

Similarly, you have the blast rate. So, blast rate is something that how mach of air is required to be putting into the cupola and that is normally 70 to 125 centimeter cube of air that is required to be sent and that is for per square meter of cupola area. So, this is the blast rate which has to be maintained.

Now, next is coke size. So coke size also you know there are two coke sizes; one is for the coke which is in the charge which is given, another is the size of the coke in the coke bed. And basically, so coke has to be used in the coke used along with charge and in the coke bed; and coke used in coke bed. So, basically it will vary from 50 to 75, and this will vary from 125 to 150.

So, normally this size is varying from 50 to 75 basically this is mm and this 125 to 150 mm of the size of that coke; there is diameter of the coke normally is used. So, depending upon what is the diameter of this cupola that is the plan area based on that you are normally going for this sizes of the coke. So, these are the factors which affect the efficiency of the cupola.

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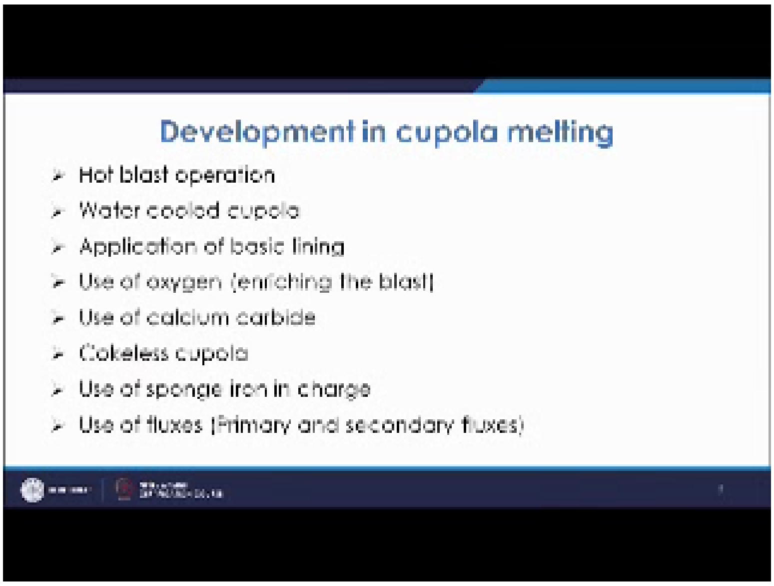

Now, there are many developments in cupola melting, and we had discussed about few that is hot blast operation where we increase the temperature of the air, and that increases the metal delivery rate. You have water cooled cupolas where the what happens basically in many cases there is large amount of corrosion or there is erosion of the refractories and because of higher temperature and may be because of the reactivity of this slag, so in those cases where or when the temperature is quite high what you do is you may provide the water jackets on the side of the cupola or even we can spray the water so that is continuously done so that this in that case basically you have to increase the temperature so that the drop in temperature is compensated. So, this is also practice. So, wherever you do that water cooling you do not provide the refractory lining. So, this way you are increasing the efficiency of the cupola.

Application of basic lining many a times you need to have the basic refractory lining to be provided, because for the efficient removal of the sulfur and phosphorous this basic lining is to be provided acid line, acid slags are not effective in that case. So, you provide the basic lining. Oxygen enrichment of the blast is done and oxygen enrichment of the blast basically increases the metal temperature, so that increases the efficiency of the cupola. Calcium carbide in also used as a flux, but its main purpose also is to go for the reaction and that reaction is exothermic reaction. So, large amount of heat is generated and that increases the temperature of the melt. So, your good quality of melt you are getting at higher temperature.

Then varieties are coke race cupola which we discussed. That is basically where the coke is not use you use the ceramic refractory bits. Use of his sponge iron is also reported in the charge. So, that basically it this is helpful in the sense that. So, in this case your slag which is formed that is less viscous so that way it is becoming easier to take this slag out. Then you also use the flux is primary and secondary fluxes; primary in larger quantities and this in smaller quantities you have different kinds if fluxes which are used in the cupola. So, that you have different kinds of flux is which are used in the cupola.

Primary fluxes you have dolomite, magnesite; in the secondary fluxes you have fluorspars. All this fluxes are used and you have about 5 to 7 percent of fluxes are you normally used and that is of the weight of the metal charge. So, this way you use the different kinds of fluxes. Then we will come to the requirement of or in the practice of melting incase of electric arc furnace.

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So, in the electric arc furnace as we know there is a typical (Refer Time: 25:55) furnace known as Harold furnace.

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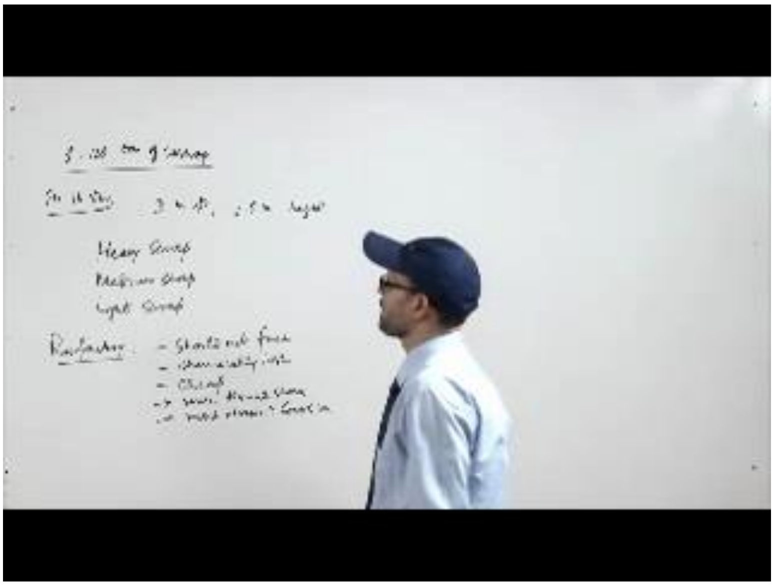

Now in the electric arc furnace normally you can go for up to may be 5 to 125 tons of casting. So, you can have on you can smaller value even from 1 ton onwards to 125 tons of metal can be melted in go in this electric arc furnaces.

Now, in these cases you have the diameter ranging from 2 to suppose 5 meters that. And for a typical 10 ton of metal for 10 ton metal you have diameter of 3 meter 2.5 meter of height. And then you have basically a 25 mm thickness of solid cell which is around that and you know the refractory thickness is quite big. So, this way you have some outer dia and inner dia of the furnace and in between you have the refractory cell, so that is may be of the order of 30 to 40 mm or 50 mm.

Now what happens in this case the charging practices; so as we know in the case of electric arc furnaces you have electrodes from the top which are lowered and once they come in contact with the charge metal then the arc is developed, and this arch is basically able to melt the metal. Now, the practices that doing the melting practice it is to be kept in mind that the arc should not be in a position to basically do the damage to the lining. So, your charge material should be properly kept and so charge is basically normally heavy scrap. So, that comes about the runners or raisers heads. Then you have medium is scrap and light scrap; medium scrap and light scrap.

So what happens, it is properly distributed in the furnace so that the requirements is that it should properly be melted and it should not be in a position to damage the lining because the arc; if it goes and if hits the furnace refractory that refractory may get damaged and that may be erode it. So, that is seen that how you are putting. So, normally it is seen that just below the arc where the arc is initiated, closer to that the heavies scrap should be there. Towards the end you must have the lighter scraps. And then once it is melted the arch is basically prevented to completely directly strike the bottom and damage the lining.

Now, in this case what we do is you have acid line or basic line basic lining. So, that is done depending upon the type of slags which are in practice. As we have discussed that in certain cases for the composition controls like suppose if you want to control the amount of sulfur and phosphorous you will have to go for basic lining process. So basics that is basics slag has to be there; basically it is nothing but these basic linings they do not react with this basic slags. So, linings are done to ensure that they do not react. So, if the lining is basic and if the slag is basic they would not react, but if the slag is acidic and lining is basic they may react and they may result into other chemical compound and will basically spoil the life of this refractory lining. So, that is basically kept in mind.

Then comes the induction furnace. So, as we know in the induction furnace the refining cannot takes place. So, it is basically for melting purpose then churning purpose the mixing takes place because of the eddy current motions and the normal mixing phenomena is quite good in case of induction furnace. So, it is also from 1 kg to several tons of casting so that that melt can be melted, that melt can be prepared using this induction furnace. In the induction furnace basically the frequency is there, you have high frequency medium and low frequency type of induction furnaces are used to depending upon the frequency of the current you which we use. And it has also a monolithic thick type of lining structure. And this is basically very quite operation is there normally the cupolas are replaced with this kind of furnaces in most of the foundries.

There are many advantages of these induction furnaces. However, the disadvantage is that the cost factor and also that you cannot do the refining in this furnace. So, that is the disadvantage of these induction furnaces. Normally in we go for the ferrous melting in these cases. In the case of induction furnace you have the loss of alloying elements up to quite low extent and as we have discussed you have core, type and core relates type of induction furnace. So, both types of correlates are normally used for non ferrous materials and core type, so core less is used for ferrous materials; sorry and core type is used for normally non ferrous materials which are where the core is inserted in the metal in the metal bath. So, that is all to this is the currents eddy current. So, that is how these you have the varieties of core less and core type of induction furnaces.

Coming to the refractories for melting unit; so why if refractory is required as we know that the main purpose of the refractory is to which stand high temperature. So, refractory basically has the quality of resistance against the temperature up to a higher value. So, they do not fuse below 1500 degree centigrade normally that is the minimum requirement of the refractory that is should not fuse below 1500, because most of melting takes place. It has to be below 15 in non ferrous and even for iron castings, but once we go for a steel it is even higher.

So, you need to have metal which should not fuse at elevated temperature; elevated temperature where the melting takes place. Then it has to be chemically inert, it has to be cheap, it has to resist thermal shock, it has to resist abrasion and corrosion. So, there are many qualities which basically a refractory should have. Now it should not react. Basically, bases on that you have the type of refractories you may have the acidic refractories, basic refractories, and neutral refractories. So, the lining may be known as acidic, basic and neutral.

So, in acidic basically they do not react with the acids slags. So, normally they are silica based, so that is acidic. Then you have basic which are normally the based on dolomite or bauxite these magnesite, these are used as the basic refractories and it has better qualities like magnesite or dolomite they have better qualities it they have basically. There are the properties one has the superior values, but may be at the expense of the cost one may be cheaper another may be costlier, but it may have a better properties.

So, depending upon what kind of requirement you have, you can use these different kinds of properties, different kinds of refractories.

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And neutral normally is your conium is used as the oxide is their which is used as the neutral refractories. Apart from that we have other refractories also which are neutral. So, this way you have different kinds of refractories which are used in the furnaces depending upon the requirements, depending upon the type of slags which you are likely to get you use the different kinds of refractories.

Thank you.