Principles of Casting Technology

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Lecture - 29
Technology of Melting Types of Furnaces

Welcome to the lecture on Technology of Melting. So, in this lecture we are going to discuss about the melting facility equipments, mostly in the foundries you need the furnaces for melting. The furnaces are basically on the side of the casting units, a very large furnace cannot be suitable you will have to have the furnaces from where you can tap the metal and pour directly in the mold so by bringing in some of the reservoirs like ladle. So, we will discuss what are the common furnaces and what are the different types of furnaces, which are used in small or large scale foundries.

First of all why furnace is required, so we have discussed that, you need the unit from where you have to bring the liquid metal, so that it should have the adequate temperature, you also should have the adequate amount of liquid metal at proper temperature, so that you can pour the liquid metal into the mould.

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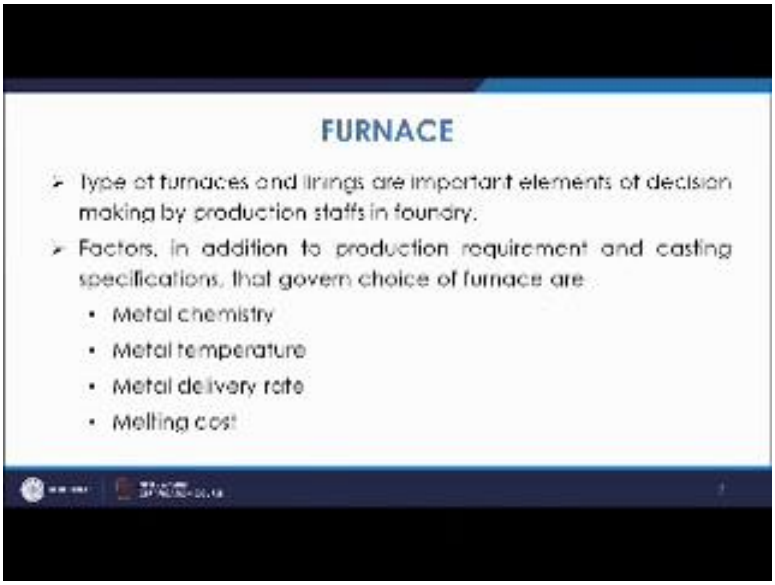

So, for the type of furnace and linings are important elements of decision making by production staffs in foundry. So, a furnace is basically it is a unit of melting, and as we know that normally the melting temperatures if you talk about non ferrous materials, you

can have the temperature range of melting maybe it starts from 3 to 400 and goes up to maybe 1100 for copper, and ferrous again it starts from about 1200 fore cast iron to even 17 to 1800 for steel. So, you need the equipment or you need a reservoir where you can melt these, and for that you need a shell and you need basically aligning of refractory material and both are very important element to decide what type of furnace should be there, what type of lining materials should be there, so that you can choose a particular furnace.

Lining materials are important because the erosion of lining takes place, there may be reaction of the slag to the lining material based on the nature of the slag. So, we have acidic or basic type of lining materials. So, these are decided and then you go for selecting the furnace and also the proper lining materials or refractory materials.

In addition to the production requirement and casting specifications, that governs choice of furnace. So, the factors which are important are metal chemistry. What is the metal composition? What are the amounts of? What are the types of gases which are going to be evolved? What kind of reactions may take place? All these things are important to be considered. So, what will be the slag composition? How it is going to react with the lining? So, these things are important parameters, when we go for a choice of a particular furnace.

Metal temperature you need a furnace, the temperature must be adequate. So, you must have a furnace which should provide you the metal at a particular temperature at which you can pour. If that temperature is lower than that in that case the problem of many kinds may emerge. So, you need to have the furnace, which can properly control the temperature of the molten metal, which can consistently deliver you the metal at a particular pouring temperature.

Metal delivery rate. So, at what rate you want the metal to be delivered from the furnace? What is the requirement of the metal in terms of tonnage and in terms of the amount of metal in particular time? So, that is metal delivery rate, so you need the furnace to deliver the material at a rate what you want at of particular temperature at consistent rate. So, you need also you have to decide what kind of furnace you require? What is the delivery rate of the metal you want; so based on that you have to decide the type of furnace.

Then melting cost, this is also important because to sustain in the future you have to see that what is the melting cost of the material. So, basically it depends that, how long you are going to use, what is the requirement, how many products are to be cast, how long you are going to use certain type of furnace. So, based on that, you have to go for because if you go for sophisticated furnaces with good metal delivery rate and you have to get the metal in quick time, you may have to go for other types of furnaces which are otherwise costly. So, if you go for costlier furnaces, it has to be justified because if you have to go in those cases you must have to the idea to produce large number of castings. So, this melting cost also is to be decided. So, these are the parameters which are essential while discussing about the kind of furnace you have to choose.

Let us go to the different types of furnaces, the different types of furnaces now basically they may depend upon what way the heating is going to take place? What is the heating mechanism inside the furnace or what is the mode of heating? So, like whether you are using the electricity, whether you are using the coke, whether you are using the oil or gas and based on that, we have the different types of furnaces which we will discuss one by one.

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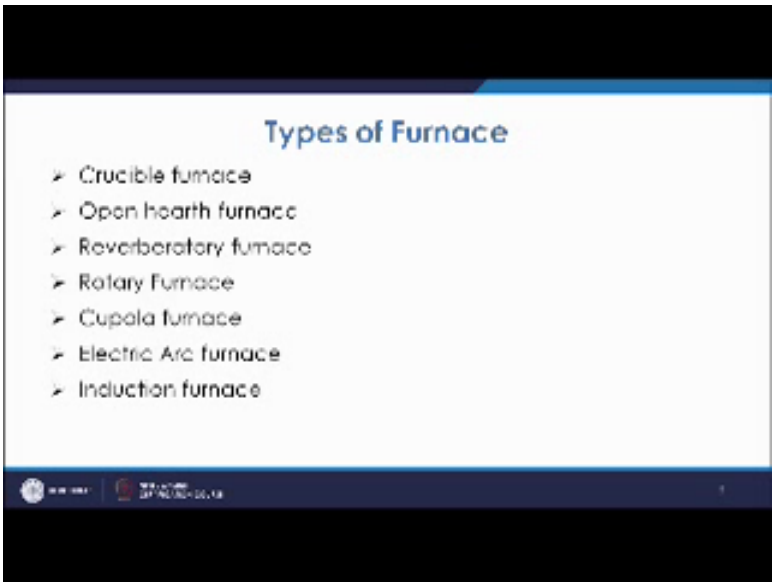

So, first is Crucible furnace. So, first of all let us see we have these different types of furnaces we will discuss today, crucible furnace, open hearth furnace, reverberatory furnace, rotary furnace, cupola furnace, electric arc furnace and induction furnace. So, let

us see what these furnaces look like and what are the features as we see we can have a discussion just in the rough way like crucible furnace here you have a crucible, and the crucible is heated all around or maybe from the top. So, by the different fuels like coke or oil and gas and then once it is heated then crucible has to be taken out and then pouring is done.

So, you similarly you have open hearth furnace, here you have the principle of regenerative heating. So, that is known as open hearth furnace and you have reverberatory furnace. So, you have a cylindrical type of furnace where the heating takes place by the flame and then because of the radiation, after heating the furnace lining you have the heating mechanism that is reverberatory furnace, the rotary furnace this shell is rotating. So, basically the linings which are heated because of the conduction and convection metal gets heated as well as the radiation heat from the flame, cupola furnace is a furnace which is normally used for iron melting. So, in that case you have a vertical shaft. So, in that shaft you have alternate layers of charge, coke and flux, is put in and then from the bottom you have coke bed, which is basically igniting the things and then slowly the metal after getting melted comes down.

So, from the bottom you can get the material tapped and these are the two furnaces which are based on electricity, so in this case you use the arc to melt the furnace, so you may have direct arc or you may have indirect arc. So, arc is directly in contact with the metal or arc is not in direct contact with the metals based on that because of the resistance which is offered by the charge metal that is based on this electric. So, that they are electric arc furnaces and this is induction furnace which is based on the induction effects, where because of the current flowing in the coils of copper which is water cooled, you have the induction current or ready current developed in the charge and then that produces large amount of heat and it is able to melt the material. So, we have these different types of furnaces let us discuss it one by one.

So, as we discuss the crucible furnace, it is basically used in small scale foundries where the metal requirement is small, you have to make small size of castings and you have a crucible, so this crucible or ladle that is normally known as a crucible. So, this is basically made of graphite or clay and then that is basically put in inside this and this is also of the type coke fired in or in a gas fired type of the crucible furnace.

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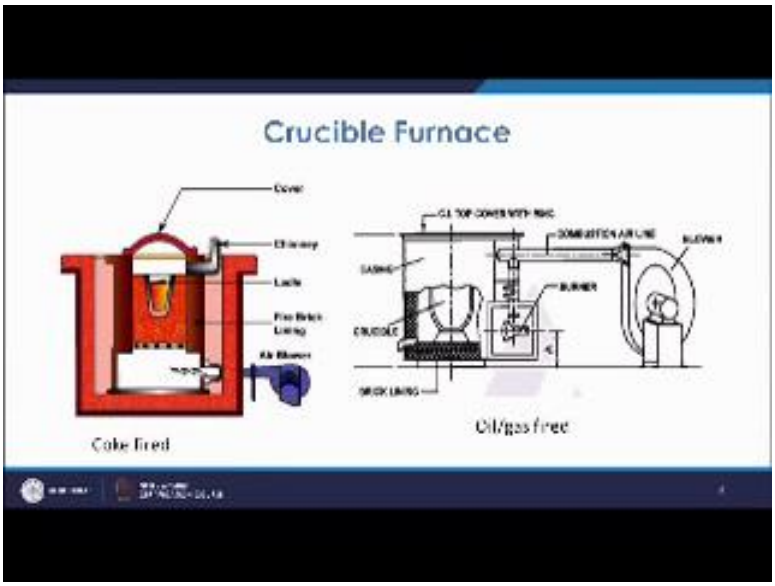

So, it is based on the type of fuel used, if the fuel used is coke it is coke fired type of crucible type of furnace and otherwise if you use oil or gas it is oil or gas fired crucible furnace. So, in this cases you have a crucible, which has the scraps or metal to be melted put in this and you have the coke which is kept here and somewhat removing the coke then you insert this crucible into it and then this coke is basically ignited and once this coke basically ignites, it gives a large amount of temperature, it gives the heat to this crucible and then from the top portion also and through the chimney you have the way to go out these flue gases and then these temperature is enough to melt the liquid metal.

So, in this case you have the oil or gas which is blown away from here and then it goes and its combustion products heat this crucible and then that is able to heat the liquid metal melt it, then later on in these cases you are removing the cover which is there at the top of these frames and then you can hold this crucible with the help of tongs suitable tongs, take it out and do the pouring. So, for small foundries normally these are used.

Open hearth furnace. So, this is based on the presence of a hearth and this is normally based on the regenerative principle. So, what happens once you have the air or gas or fuels which go from one side and the product of combustion basically when it is generated, so that basically is utilized. So, once it goes out the heat of that is used by the regenerator. So, further that basically goes heats this hearth or the brick walls, so that basically further. So, basically what you do is, you are utilizing the product of

combustion once primarily it heats the metal which is there, so it has a basically large and shallow depth of this metal charges, and then you have this is these are the two regenerators on both the sides.

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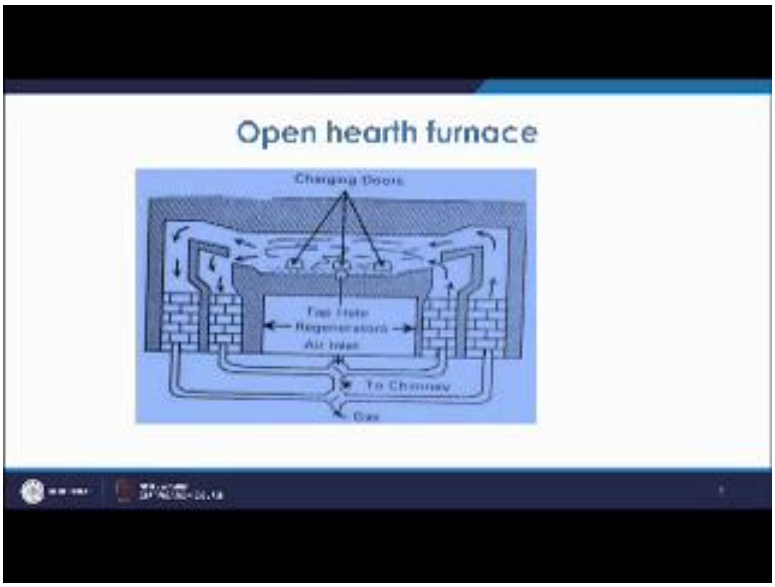

And then this product of combustion once they come out they are basically this cycle is rotated for sometime the inflow will be from this side and outflow from here, after sometime it is reversed and the inflow is from this side outflow is from this side. So, that cycle is basically reversed, the principle is that the product of combustion once it comes out it heats, the incoming the gas and the air or the fuel and the air which goes into this chamber. So, basically that is heated by the heat which is contained in the combustion products of this furnace. So, this way you are utilizing that heat, which otherwise would have wasted. So, that is known as open hearth type of furnace used for malleable iron castings or other castings also.

There is a furnace known as Reverberatory furnace. So, basically in that you have the charging, you have fired the furnace from one end and that basically goes and because of the heat which it supply the products of combustion, which is supplied to this charge there are normally getting large amount of heat and that heat is able to melt the material.

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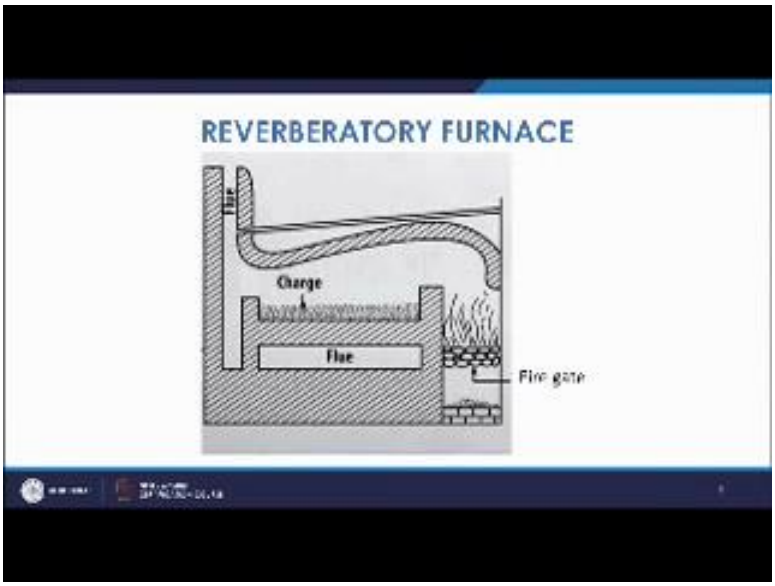

So, it has a large long shell and in that the blowing is from one side and then that because of that combustion products and because of the temperature of the flame, this heating takes place from the side of the walls which is refractory and then the heat and this is basically used for small scale foundries, where a small quantities of metal is required mostly for non ferrous materials.

In this variety let us first discuss, there is another name there is rotary furnace. So, in that rotary furnace what happens, it is a kind of Reverberatory furnace, where the shell is rotating. So, what happens initially the heating is by the radiation from these flames; however, once they rotate in that case the metal also gets the heat from the heated refractory linings on the sides. So, this way by conduction and convection and both as well from the radiation mechanism, you get the metal melted because it get adequate amount of heat firstly by radiation and then by conduction or convection. So, that is known as rotary type of furnace because it rotates on a horizontal axis it rotates.

Next is Cupola furnace. So, cupola furnace had been very popular for reproduction of basically iron castings like grey iron or malleable iron or (Refer Time: 17:07) iron castings; now this copula furnace was used because in those kinds of castings, the carbon requirement is quite high and as we know that once the carbon percentage is more than 4 at 4.3 percentage of carbon, the melting temperature is quite less close to 1135 or 40 degree centigrade.

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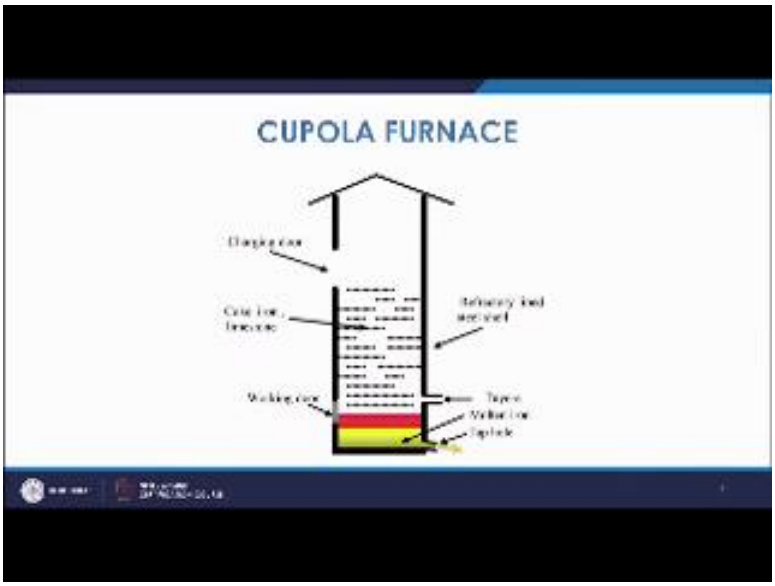

So, this furnaces are used for a purposes whereas, what happens you have the coke which is used initially you have a coke bed here, firstly you will have coke bed initially, this coke bed acts as the place, where the cokes are kept of certain height and then this the combustion takes place by allowing the air to pass through it and then igniting this coke bed so that the once they are ignited and then a large amount of heat is basically released and this heat and the product of combustion tries to go upwards.

Now, what happens in this case, you have the charging door, from the charging door you apply or you charge the metal, the charging is done of three things alternate layers. So, you will have iron ore, coke and limestone. So, alternate layers of iron ore, coke and limestone; again iron ore, coke and limestone. So, this way the alternate layers of iron ore, coke and limestone is used. Iron ore is the one which is the basic you know raw material because that will be part of the constituent, then coke basically has the purpose to supply the carbon. So, that and also it gets combusted easily and then the limestone is used as the flux. So, there may be variety of fluxes, but normally limestone is used then this flux is used because it will react with the impurities and it will form the slug.

So, this charge will be there up to certain height and then this basically vertical cell is of the steel cell and it is of refractory line from inside. So, it is a large vertical cell, it is basically supported on the pillars 4 pillars vertical pillars, and then this at the top you have a spark arrestor or chimney. So, basically it arrests the sparks, it lowers down cools

the sparks and allows the combustion gases the products of combustion to go into the atmosphere. So, the spark is basically reduced, that is why it is also known as spark arrestor.

So, in this case what you do is initially you have the tap hole here and another side you have the slug hole at the higher level. So, once you're liquid metal has melted. So, what happens once the product of combustion moves upward, it gives a large amount of heat that is generated inside the cell; so, that heat basically melts this iron coke and limestone. So, the iron is melted and that it will tickle through the coke bed which is there in the lower zone and then this iron which is tickling through the coke bed, it will basically take a l adequate amount of carbon. So, carbon will be picked up by that liquid metal and then it will be collected in this place that is the well and from here you can tap it. So, continuously basically charging is also done continuously and then you can tap the liquid metal from here. So, this is the cupola furnace.

Now, there are many varieties of cupola, one is cokeless cupola. So, what was seen that in this in the case of cupolas, where we used the coke and we used the coke for preparing the coke bed and the because of the coke which contains the elements like sulphur, there are a large amount of gases which are basically toxic or poisonous, they are liberated in the atmosphere.

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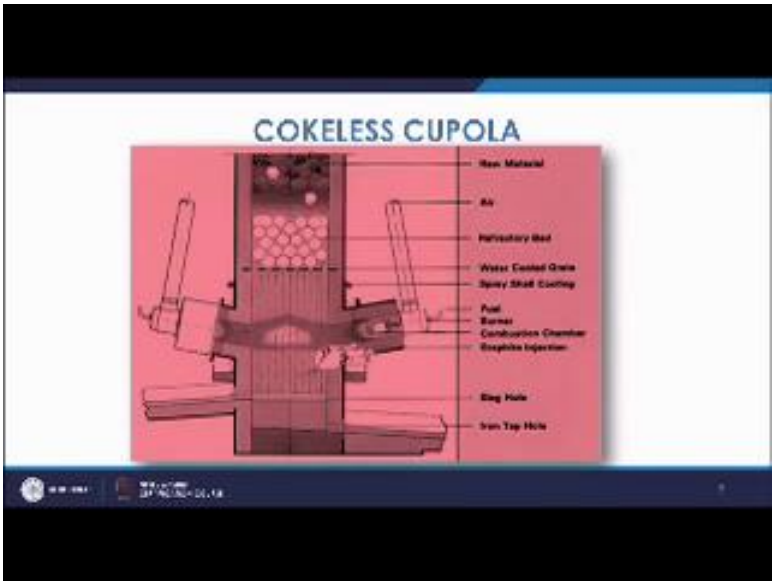

So, there has been a concept of having certain cupolas like cokeless cupolas; they were in practice in the foundries near the Tajmahal in Agra. So, there has been lot of damage in the environment because of the release of these toxic gases like SO2 or SO3 and that is why a number of cokeless cupolas were basically installed in those regions. So, what happens in this case is instead of these coke beds you have a ceramic bed.

So, you have the refractory bed, metal after getting melted it will pass through these refractory beds and then it will be basically going into this place where from you can have the tap of the liquid metal and as you see the slug hole is at the higher level in these cases. So, you have burners, basically you have fuel burners on both the sides the radial direction. So, on the periphery you have burners, these burners allow the gases. So, atomized in that case it goes it and the product of the combustion goes above it heats the ceramic particles then it goes up. So, raw material is heated it comes down and then you have the collection of liquid metal at this place, here you do not use the coke. So, basically it is more environments friendly and that is why it is known as cokeless cupolas.

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There is another variety of cupola one is known as divided blast cupola. So, divided blast cupola what is does that the tuyeres are at different levels. So, what you do is you have the tuyeres at 2 places. So, these are the tuyeres. So, what happens as we have seen in the earlier case you have one tuyere at this level, now in this case of divided blast cupola, the

tuyeres are at two places and then they come and they get heated the water or the air and they are basically supplied the at the two levels of height. So, that basically increases the efficiency that increases the metal temperature which is going. So, you have to have in optimum height at which the first you where and then at the second height that is to the second tuyere, so this way this kind of once it is divided, it is known as divided blast cupola.

Similarly, there is another kind of cupola hot blast cupola. So, it has also been seen that if you are increasing the blast temperature maybe up to the order of maybe 500 degree centigrade, in that case the efficiency of this cupola increases. The temperature of the liquid metal can be found little bit higher maybe 50 to 100 degree centigrade. So, that is known as hot blast cupola. So, you have different kind of cupolas these are basically the advancements in cupola, similarly use of oxygen in the cupola that is also one of the advancement in the design of cupolas. So, this cupolas are used for this iron making units, although they are used less because of the presence of furnaces like electric, furnace and induction furnace, but still they are there in the practice by many of the foundries.

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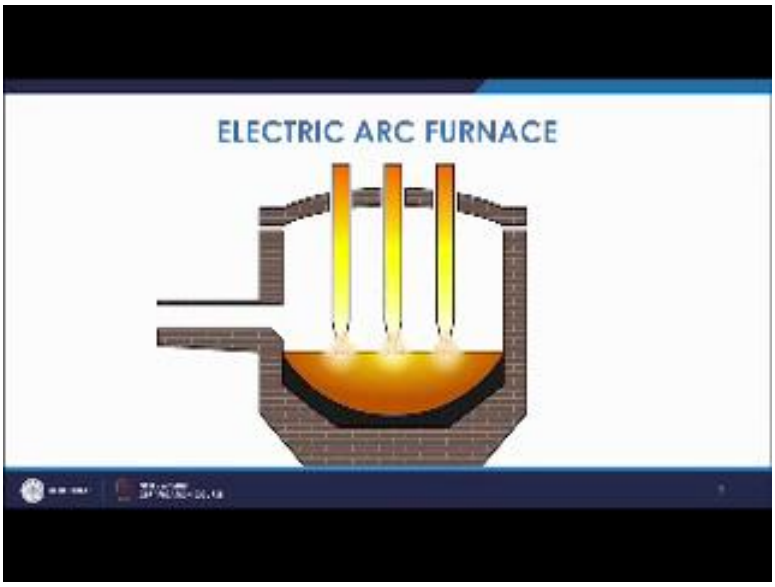

So, next comes; the electric arc furnace. So, electric arc furnace is working on the principle of the resistance which is offered by the melt which is there in this portion, and the arc is generated. So, these are the electrodes you may have the number of electrodes

depending upon how much heat you want to generate and what is that size of the furnace. So, these are the furnace linings, you have the shell, steel cell of large thickness and then you have lining materials and then these are the electrodes which may be cooled and these electrodes once they are coming lower down at one point of time the spark is generated. So, when they touch it the spark and then a distance is maintained, then in that case the spark is generated. This spark is indirect contact with the metal because of the resistance offered by this metal the spark is generated and then this spark results into the melting of the metal and soon this metal comes in liquid state.

So, in these cases you have two varieties, one is direct electric arc furnace and another is indirect electric arc furnace. So, this is the direct electric arc furnace type, where the arc is in direct contact with the metal.

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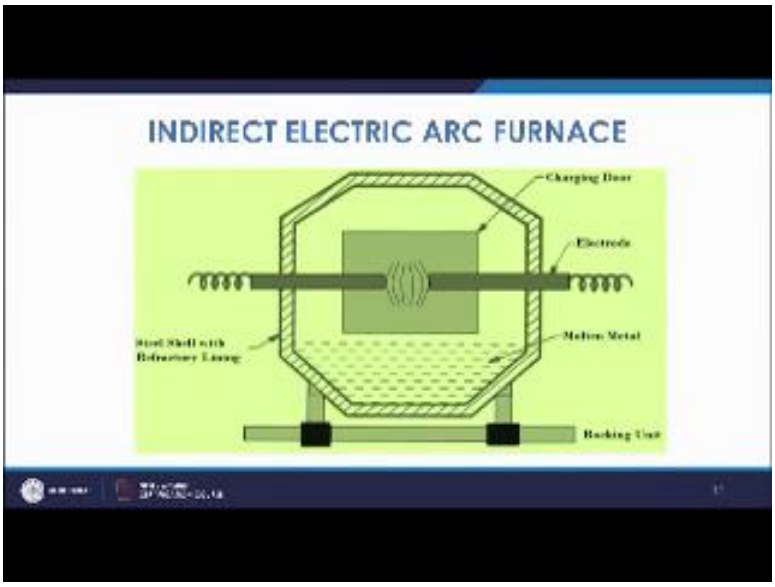

Then another variety is indirect electric arc furnace, where basically the electrodes are touched and in that case there if they are direct the arc is created and this arc is not in direct contact with the liquid metal and because of the mode of other heat transfers like radiation, you have the heat transferred to this metal and that basically gets melted. So, that is known as indirect electric arc furnace, maybe utilized for the lower temperature applications and also to assume that it does not contaminates the liquid metal.

So, these are the electric arc furnaces, in these cases you need to have the selection of proper lining materials of proper type that we will discuss maybe in the next lecture; you may have the lining material of a acidic nature or basic nature or neutral type.

So, that basically depends upon what kind of metal you are melting, what kind of slag is being generated. So, based on that you have the formation of these you know slags you have the selection of proper lining material.

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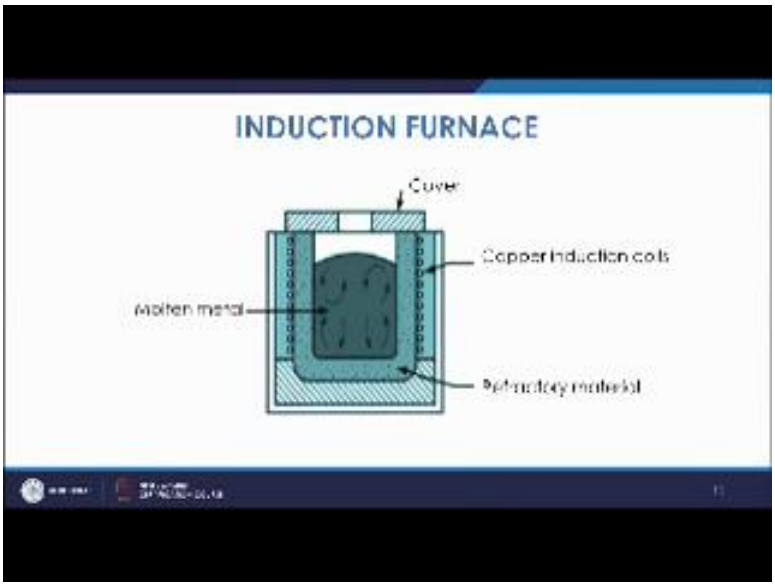

So, then comes the induction furnace. So, here what happens there is induction effect. So, what happens you have the primary coils these copper coils are there and when the oonj around this reservoir, and then once the electricity is passed so because of the induction effects, the eddy current is generated in the this charged material and because of this eddy current large amount of heat is generated.

Now, this heat is enough to melt the liquid metal in a very short time. So, the agitation is seen this currents are generated and the because of that induction current you have heating induction heating and then this way you have the melting of the liquid metal. So, these coils copper induction coils where normally they are water cooled and because the large amount of temperature is generated, you have the lining materials that is refractory lining, so that again may depend upon what kind of material we are melting. So, these furnaces are known as induction furnace, in the induction furnace you have two varieties: one is coke type and another is core less type. So, this is a coreless type of induction

furnace you may have the presence of a core that is known as a core type of induction furnace.

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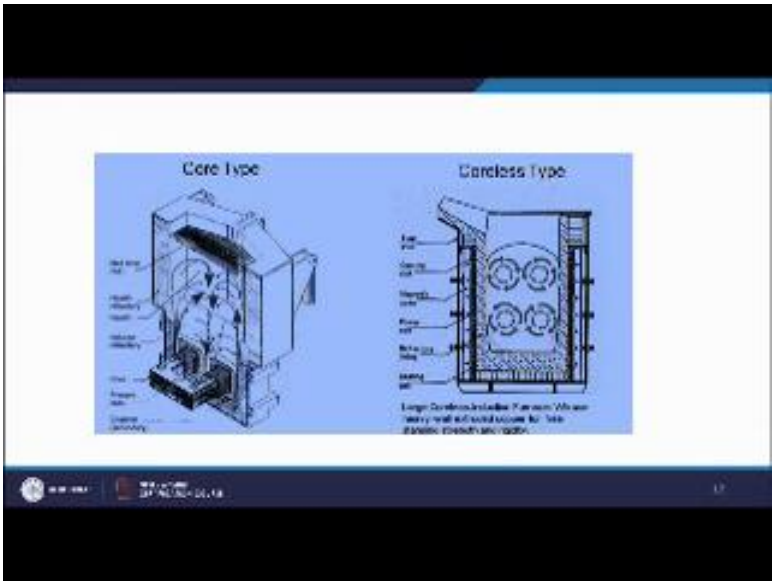

So, depending upon the presence of core or not core, you may have the core type or core less type of induction furnace you may see the kind of convection current which is established in the case of this induction currents, they are normally used because the melting is too fast, the melt talks too less time. So, that is why these are used they are preferred you may have the induction furnaces of different capacities different sizes.

So, these are basically the outlines of different kinds of furnaces what we normally see in the casting industries or foundry industries, so that is all about it.

Thank you.