Glass Processing Technology

Prof. NS Venkatamurugan
Department of Civil Engineering
Indian Institute of Technology, Madras

Lecture – 04
Float Glass Manufacturing

Hello, everyone. Welcome to the module on Float Glass Manufacturing. In this module we will talk a little bit about how the base glass is being manufactured through the process of float glass manufacturing.

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Before we go into that, a bit a little bit of brief about the glass history; glass as everyone knows is not new is been there for ages for nearly 6 millenniums. Glass was being manufactured for making jewelleries 4000 BC long time ago and over the years it has undergone various transformation and people have gone into blowing glasses, making hollow glasses about 300 years ago they were making glasses flat for the first time by pouring it on a table. And, the first continuous process in this process came into being in 1913 in the Fourcoult and Colburn process.

And, from there the flat glass is transformed into a float glass manufacturing process in 1957 when this particular process was invented and as we speak till date this is a process which is seen as the best quality base glass producer for both architectural as well as for the automotive purposes.

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The float glass manufacturing process follows this sequence. First we need to have the raw materials we prepare mix them and convert them into a batch and we take this batch with various raw material mixed up. It goes into the furnace where it is melted up to a temperature of 1600 degree centigrade and when the glass is molten it is cooled to a workable range where we can give the thickness and the width to the glass and then, it takes it is taken into the float bath and where the thickness and worth has been given and then we take it into the annealing where the stresses are balanced and then we take it to the cutting to cut it into the shape and the sizes that the customer demands.

Glasses the way the glass is being manufactured couple of decades ago to how it is being manufactured you can see a little bit of data at the bottom. The quantum of glass that is manufactured worldwide and even in India's we speak the quantity of glass is being produced is really in going up astronomically. This is one good thing that more and more of glass that we use the more natural materials that we are using for our architectural as well as various other applications.

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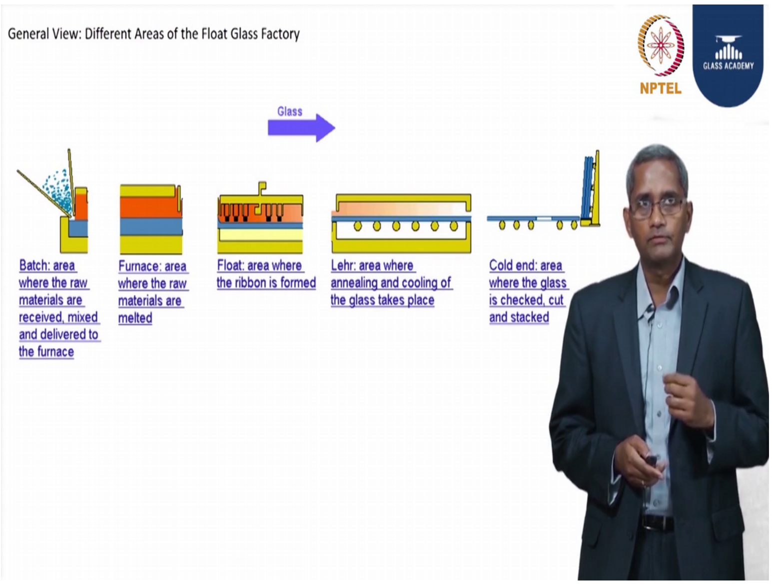

So, the batch area is where the raw materials are received, it is mixed in the right proportion and delivered into the furnace. The furnace area is where the raw materials are melted as I said at a temperature of 1600 degree centigrade, which mind you it is one third of the surface temperature of the sun and from there it is taken into the float bath where there is a molten tin bath on top of which the glass is made a and float on top of the molten tin. At that time we a cube few equipments like the top roll machines to give it thickness and the width which we want to meet the customer demands.

Once the thickness and the width is given then we need to cool the glass to room temperature. While doing so, we need to be very very cautious and careful because the glass can undergo stress. So, the annealing, the slow rate of cooling is done in the layer where the cooling is done in different stages before it reaches the cutting line at a say temperature of 60 degree centigrade, when the glass is cut to different dimensions and then it is stacked and packed and dispatched to the customers place.

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Little bit about the raw materials and I think most of you would know that to make glass we need silica sand. If you melt silica you will get glass. So, the glasses silica is called as the glass former. There are also few other raw materials that we are adding to the silica sand. We will see that need and they purpose began adding these raw materials in the next couple of slides.

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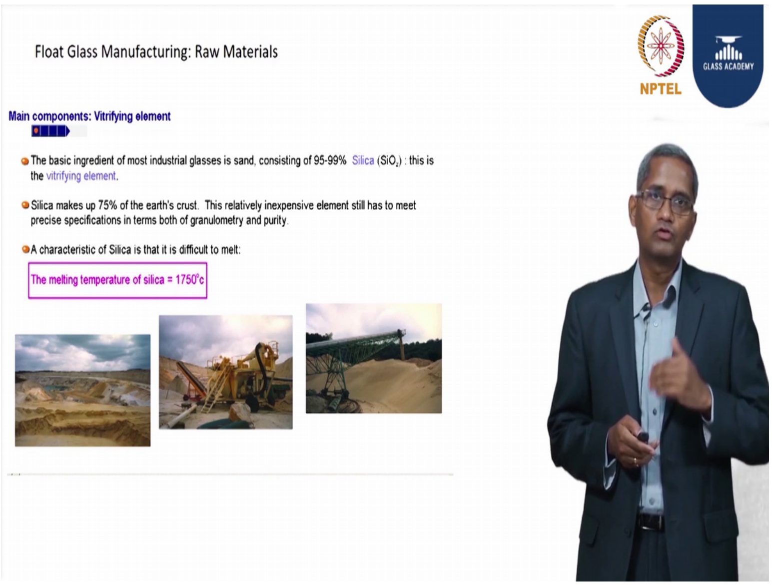

Now, as I said silica sand is the main raw material that is used to make glass. If you melt silica you get glass, but the problem is the silica melting point is very high at 1350 degree centigrade. To melt at such high temperatures we will be requiring lot of energy and on top of that we need the furnace which can withstand such high temperatures and to give you know give an another information nearly 75 percent of the earth's crust is made up of silica and so, most of the refractory's that we manufacture that we use in the furnaces are also made up of silica.

How do we melt silica? In a silica furnaces, so, we need to have a very high temperature withstanding refractory's which is going to make the furnace cost were very very expensive. So, for this simple reason we need to bring down the temperature at which we can melt this silica sand.

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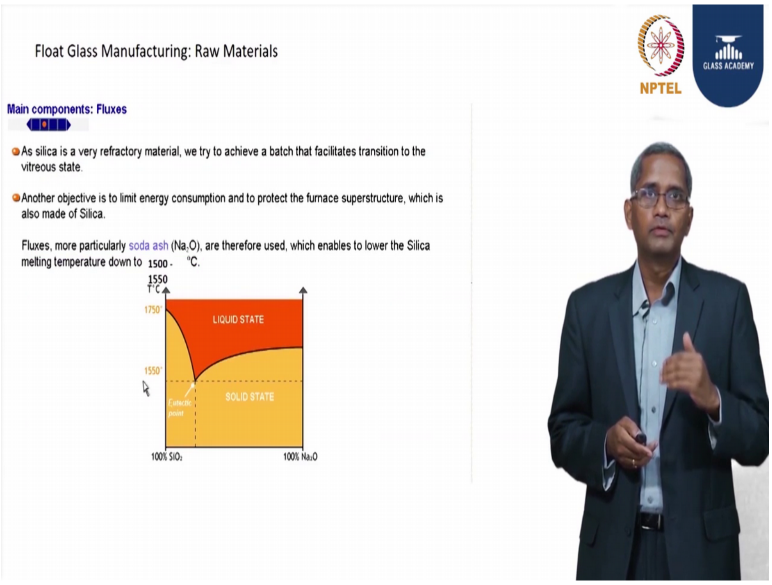

And, for this purpose we add the flux. Flux in the form of soda ash sodium carbonate is added at about 13.5 percent of the total composition of glass into the sand which will reduce the melting point. What was 1750 is down below 1600 degree centigrade. So, we wanted to make glass. So, we melt we wanted to melt silica, we have a temp problem of high melting points. So, we added the flux in the form of soda ash now we were able to melt the silica into glass.

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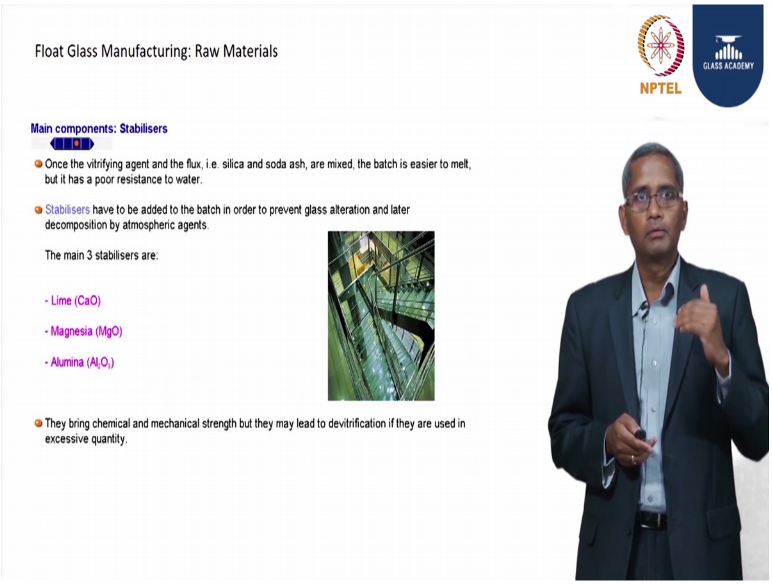

But, the problem is the product that we get out of the mix of silica as well as the soda is not stable which means that it does not have the enough strength like our bones need calcium magnesium etcetera. The glass also need a lot of strength and to give the strength we input calcium oxide magnesium oxide and alumina and this will stabilize the glass and give it the required strength the calcium oxide comes from both dolomite and limestone and the magnesium oxide comes from dolomite and alumina if it is not adequately represented in the raw material main raw materials we can supplement with feldspar which has the high alumina content.

So, silica the glass former to reduce the melting point of silica the flux we add soda and to stabilize the glass we add calcium oxide, magnesium oxide and aluminum. Now, what we want to make glasses in the in the SiO 2 is available in the form of SiO 2 itself the flux we need it in the form of Na 2 O, but what we add is in the form of Na 2 CO 3. Na 2 O goes into the glass the CO 2 escapes into the atmosphere.

As a stabilizer what we need is CaO into the glass, but what we add is limestone and dolomite which is available as CaCO 3 the CaO goes into the glass and CO 2 escapes into the chimney. And, similarly MgO is required Mg we supplement in the form of this MgCO 3 through dolomite. So, MgO goes into the glass and CO 2 escapes into the atmosphere.

So in fact, for every 100 kg of raw material that we add only 82.3 percentage of the material gets converted into the glass. The remaining 17.7 percentage goes off as a CO 2 into the chimney. This process of removal of the CO 2 from the raw material is called as the process of refining. Once the raw materials are melted next the CO 2 has to go out and this refining has to may ensure that if there is no CO 2 in the form of bubbles that is present in the glass is not there anymore.

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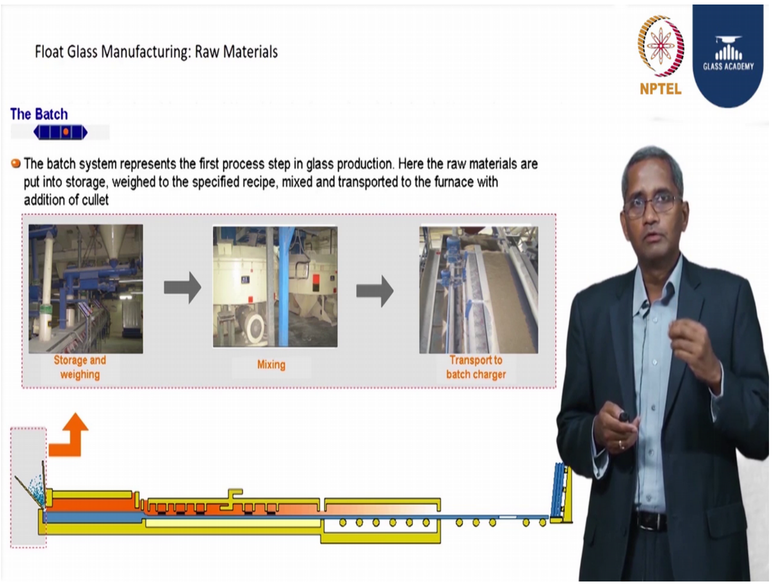

In order to make this refining process much more efficient we add a refining agent that is in the form of sodium sulfate. So, these are the basic raw materials that we use. To make different tinted glasses for example, in the form of green we need to add iron oxide and we had to make a blue glass we need to add iron oxide plus cobalt oxide, we in order to make a glass which is bronze in tint we need to add selenium, in addition to iron oxide and then to make a gray glass we need to add a nickel oxide.

So, we add this small coloring components to the main components which once again I repeat the glass former silica and the flux to reduce the melting point soda in the form of soda ash and to give the stability the strength required to the glass CaCO 3, MgCO 3 and the alumina we add it in the form of limestone dolomite and feldspar and then to get this refining process done efficiently, we add the refining agent which is sodium sulfate.

All this raw materials in the right proportion are mixed in what is known as a batch plant there are big silos which stores this material and from there it is taken weighed down and then from there it is taken to a mixer. A bit of water is added to ensure that the batch is that a good 3.5 to 4 percent aged moisture content which will keep the different raw materials homogeneous. The homogeneity of the raw metals is very very important to make sure that the glass is optically good and quality the chemical homogeneity is the most important things.

So, the quality of the glass is largely determined by how good draw material that we put into the furnace and how well we homogeneously mix it. So, batch plant is very very crucial to make sure that the final glass quality is the best level that we can aim for. So, from the mixer it goes into the furnace through what we call as the doghouse.

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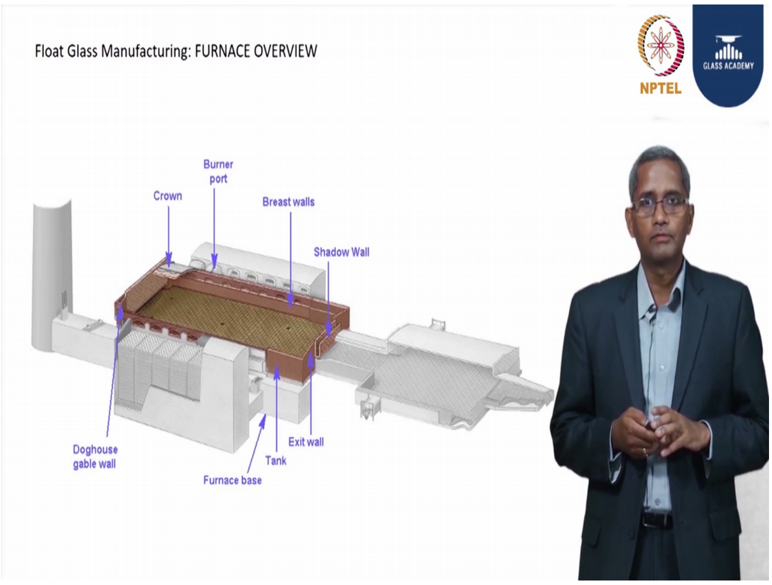

So, these are all the this is a schematic which shows the different parts of the furnace and where the raw material enters into the furnace is called as the doghouse. Typically the doghouse is something which is there at the entrance of a house and so this is a place where you feed the raw material. So, it is called as a doghouse and the furnace in itself has got three components to it the first is the melt up which is a melting and refining taking place after that is what we call as the neck and the third segment is called as the working end.

And, each of the segments has got three parts vertically if you have to take it, one is a tank which holds the molten glass and of course, we need a roof around which is called as a crown and this a space between the tank and the crown is called as a superstructure.

And, we have on both sides as you can see on the sides what is called as a regenerator. There is a lot of heat that we need to provide into the furnace to ensure that the glass is melted and so, in order to retain the furnace at such high temperatures we need to necessarily let the flue gas go out at a high temperature.

In order to regenerate this waste gas at a high temperature going out of the furnace we have regenerators which put back the heat back into the system. So, the first is the melter where the melting happens and the refining happens and then it goes into the neck. As you can see then the neck has got a very narrow channel in which having melted and refined the glass now we need to thermally homogeneous you know bring the glass together and also provide few equipments in the neck mixing equipment, so that we mix the glass together thereby the temperature of the glass is more or less homogeneous which also is essential for the optical quality of glass.

So, having melted refined and homogeneously bringing the glass together now we need to bring the temperature of the glass to the workable range. So, the end in which we bring the glass to workable range is called as a working end and then we take the glass into the forming region which is a float bath at 1100 degree centigrade.

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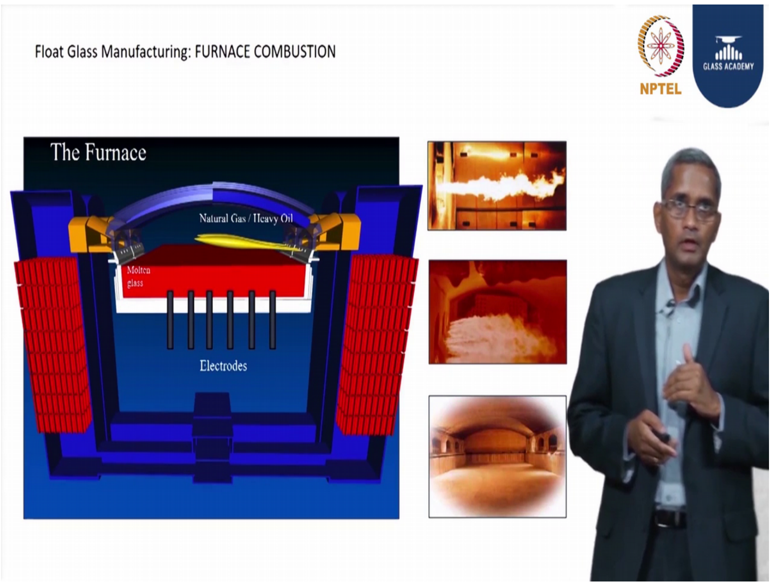

So, some more details of the furnace again you can see this is how the cross section of the furnace would look like. There are obviously, in order to provide 1600 degrees temperature that we maintain the furnace with we need a lot of fuel and a most of the furnaces would use natural gas and for the plants which do not have the facility for natural gas also uses heavy oil.

So, there is a burners setup on both the sides as you can see in this diagram. In addition to the heavy oil or the gas we can also supplement energy in the through electrodes from the bottom. So, this is quite efficient the electrodes if we make tinted glass for example, because the bottom temperature tends to go too low because of the heat transfer being restricted due to the non availability of radiation as a source of heat transfer, the electrodes from the bottom can really help in quickly providing the heat into the molten glass from the bottom. We will come to that later.

For now, this particular pictures shows us how the fuel is being injected in this case we call it as a right side as in the picture we can see and the flame is coming out from the right side. The oxygen that is required for this combustion comes through the regenerator. The red color the blocks that you see on both sides the oxygen in the form of combustion air comes through the regenerator on the right side and comes over where the oil is being injected into the furnace the combustion takes place.

The ignition temperature is already available because the furnace is always maintained at 1600 degree centigrade. So, from the right hand side firing with the heat going into the glass the waste gas goes out of the furnace through the left hand side regenerators, when it goes out the temperature of the flue gas is around 1450 degree centigrade.

In order to essentially maintain this temperature at 1600 inside the furnace there is no other way, but to let the flue gas go out at 1450 degree centigrade. This flue gas when it goes out through the regenerators on the left hand side. The regenerator is stacked up with there is a special refractories which can quickly absorb the heat quick heat transfer capacity and also got a very high area surface area to volume ratio. So, that it has a lot of surface area for it to take the heat of the flue gas that is going out.

So, when the flue gas comes out this refractories absorbs the heat and what comes in the waste gas at 1450 degree centigrade when it goes out into the chimney we let it at 450 degree centigrade. These regenerators continue to absorb the heat, but it has been designed in such a way that it can observe the heat for about 20 minutes time not more.

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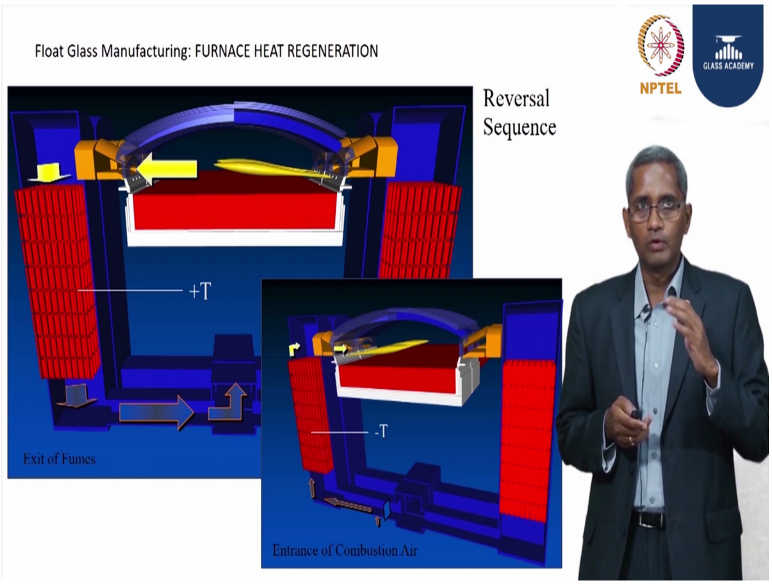

So, what we do is to do a process called as the reversal. In this process what we do is for 20 minutes of firing continuous in the first picture which you see on the background the firing has been happening from the right hand side towards the left hand side. The flue gas at a high temperature has been going down through the regenerators at 1450 whatever flue gas has come in the heat has been absorbed, stored in the regenerators and the flue gas is wasted through the chimney at 450 degree centigrade and this regenerator after 20 minutes is now more or less full with lot of heat.

At this particular point of time we stop the fuel and the combustion air on the right hand side and make the change in the equipment such that the combustion starts from the left hand from the left hand side which means a fuel oil and the combustion air are coming in the left hand side the combustion air passes through the regenerator which is already now soaked with heat. So, this regenerator what is absorbed the heat with the flue gas coming at 1450 takes the atmospheric temperature combustion air passes it through the regenerator and the combustion air enters inside at 1300 to 1350 degree centigrades. So, what we lost at 1450 we have majority regained it back in the form of combustion for air for the next 20 minutes time.

So, this combustion air it reacts with the fresh fuel coming in to keep the temperature of the furnace at 1600 degree centigrade during this 20 minute period when the firing from the left hand side, the flue gas goes on to the right hand side regenerator and the right hand side region it starts to get the heat and. So, every 20 minutes we swap around which is called as a reversal and the heat is recuperated back into the furnace. So, this type of furnace is called as regenerative furnaces which is quite normal among all glass manufacturers.

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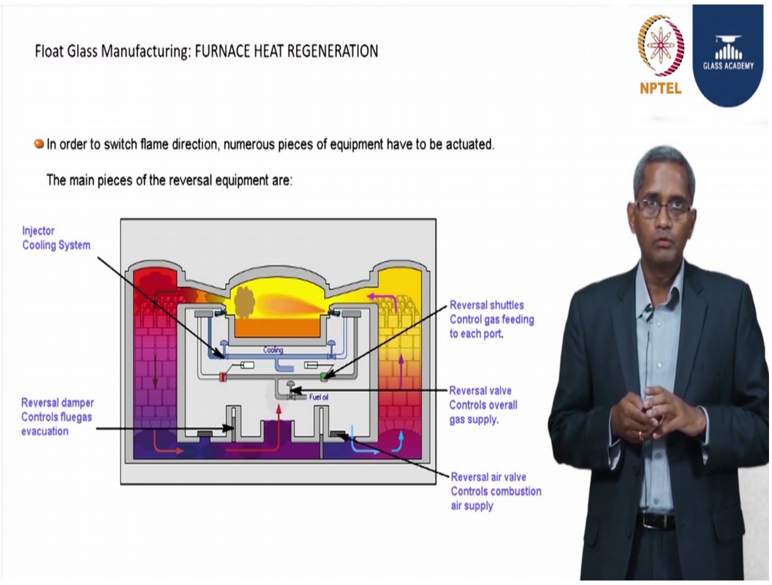

This is another picture to just tell another way to clearly understand how the combustion happens. The furnace is the one which is there in the middle the right to towers the right and left the two towers that you see are the regenerators. In this case the picture as it shows the firing is happening from the right hand side, the flue gas is going to the through the regenerators on the right hand side and the waste gas is going out.

The reddish color on the left hand side regenerator top when it goes out into the chimney it turns slowly the color into blue which means the temperatures have gone down to about 400 – 450 degree centigrade.

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