Glass Processing Technology

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Lecture – 05
Float Glass Manufacturing

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So, now having melted the glass to some extent efficiently, because we are re-generating the heat and we have now homogeneously brought the class together in the neck and we have reduced the temperature in the working end to 1100 degree centigrade, and this is a very critical temperature 1100. This is the temperature at which we can form the glass; the forming operation, like in most of the industries to work on the glass and form the glass to the shape that we want.

In this case of the glass manufacturing we are talking about the dimensions and the thickness ok; the width and the thickness, so that is formed in the float bath. In the initial introduction I talked about the float bath having molten tin, why molten tin and Pilkington Brothers invented this particular process in 1957. Till then the glass was being made vertically taken up and the glass was trying to follow the gravity and sag, even though you have good set of rollers on the sides which were taking the glass vertically up the (Refer Time: 01:32) carbon process since 1913.

The optical properties were not as good, because the glass was tending to sag and becoming wavy and so Pilkington Brothers thought: what is the best way to make the glass flat. So, all of us know the flattest of flat surface that we can aim on earth is nothing, but a liquid surface. So, they thought how about having two immiscible liquids like oil on top of water. If the glass can float on top of something which is molten condition, then we could make the thickness and the width in the glass is floating then that could give a very very flat surface. This idea is what propelled to what we now, know as the float glass manufacturing process.

So, they found that it is possible and for which we need very importantly three properties for the medium or rather the substrate, on top of which the molten glass can float. One the glass is at a density of 2.51 kg per litre and so necessarily, the substrate needs to be at a higher density, much higher density than the glass itself. So, that whatever happens the glass will always remain on top of the substrate, rather than the other way. Tin as I say already said, tin is a medium that we use at 7.3 density is very very high in comparison to the glass, so that glass will always float on top of that tin. So, it fulfills the property number 1 in terms of density, the glass to stay on top of the substrate floating. The second, the good temperature in which the glass can be formed, as I said is 1100 degree centigrade.

So, at this temperature the glass has to remain a liquid and when we can take the glass out of this bath, it can be taken at around 600 610 degree centigrade. This is the temperature in which we can say that the glass is now rigid enough to travel on rollers. So, at the temperature of 610, also the tin the substrate needs to be in liquid form. So, even at 1100 or 600 we need the substrate to be in liquid form. So, the melting point needs to be much much lower and the evaporation temperature need to be much much higher than 1100. So, the evaporation temperature of 10 or 2300 is much higher than our highest operating temperature 1100, and the melting point of tin at 231 degree centigrade is much much lower than the lowest operating temperature of 610 that we met in a end of the float bath.

So, the tin in addition to three other metals which fulfill is chosen because of its availability and the price. And so the tin about 200 to 250 tons of tin depending upon the size of the float is poured into the float bath before it started off and then the glass, when it arrives in to the float bath on a continuous basis. It comes at as a very steady pull rate as we call that turns per day as the way it is accounted for. It comes and pours the flow of which is control like how we control the water flow in a dam through a sluice gate. The same way at the end of the furnace, there is a twin which is regulated to open more or less to keep a control of the exact quantity of a glass; that is designed to flow into the bath. The glass flows in into the bath at 1100 degree centigrade and then it pours in and then we need to do some work. Let us given, let us little bit digress and talk little bit in general.

Let us take cooking oil. I pore a small quintile let us say 5 ml in one place, a 50 ml in another place, it spreads. It spreads differently, but because this oil is a same it has got the same viscosity, it spreads and forms the thickness on its own and thickness remain same. Similarly when we pore the glass on to this molten tin, it forms a equilibrium thickness of 5.7 millimeter at 1100 degree centigrade with the viscosity of the glass. If 5.7 is the only size we need we do not have to do any work just pore and take it out and we give it to the customers.

But we need to make anywhere between 1.4 millimeter 1.6 is 1.82 millimeter 2.3 4 5 6 8 10 12 15 and 19 millimeter, glass which is produced on this float bath. So for different thicknesses we need to make the glass a thinner, then we need to make the glass stretched and make it thinner, the equilibrium thickness to repeat again is 5.7 millimeter. So, if you want make a glass thinner than 5.7 we need to stretch the glass and make it thinner.

If you want to make a glass which is thicker than the equilibrium thickness of 5.7, we need to compress the glass and make it thicker, and this is done on the bottom right picture as you can see. There are three pairs of what we call as the top row that is shown in the picture, some of the float lines could use as highest 10 top rules depending upon the thickness we use. This top roll machine has got a cylindrical head, which goes inside the bath and gets nipped in into the top of the glass on both edges.

This top roll machine can have 4 operating properties; one it is rotating and when it is rotating, it is rotating at an anticlockwise direction in such a way that it is pushing the glass forward. The speed at which it can push the glass forward we have a control, so this top roll machine has got a controller speed.

Second, I can push the glass forward, at the same time I can make the glass, I can make, I can, sorry I can make the top roll little bit open up or close which means in addition to moving the glass forward I can also open the angle of the top roll machines; such that it is stretching the glass outwards. If I close the angle to a negative angle then I push the head of the top roll, inner side towards the top roll thereby I am making the glass thicker.

So, second property the parameter we can operate the top roll is the angle on. In addition to that we need to take the top roll in and out and also depending upon the width we need to operate at certain penetrations, so there is an possibility to make the top roll go in or come out and then how much nip you need to give, how much strength you need to give for the glass from the top roll machines, so we need to have an nipping mechanism. So, that top up and down is operated as well as the top roll. So, using this four set of a properties or the parameters of the top rolls we provide the thickness of a glass.

Now, let us understand little bit more, I talked about the angle, how the speed helps in determining the thickness. Let us assume for example, the first top roll machine, the speed at which it is pushing the glass, I can set it at let us say at 2 meters per minute. So, whatever is the glass coming the glass is coming at a constant flow rate and its moving 2 meters in 1 minute duration. The next top roll, I increase the speed to 3 meters per minute, same quantity of glass which is being travel traveling at a speed of 2 meters per minute.

Now, the second machine is forcing it to travel faster at a speed of 3 meters per minute, so it covers a larger area and naturally the thickness reduces. And then third top roll for example, I further increase the speed to 5 meters per minute, so what has come in 2 and then meters becomes 3 meters now its 5 meters, so it is going to reduce in thickness much more.

So, when I have to make thicknesses which is too small; for example, 2 or 1.8 or 1.6 millimeter, we need to employee more number of top rolls to keep on incrementally increasing the speed and stretching the glass more and as well give an a big incremental difference between the one top roll to the next top roll so, that we get the thickness to the lower side.

On the other side if I have to make the glass thicker, I have to compress the glass and make it thicker; the first top roll same quantity of glass is coming, I keep the top roll speed at 10 meters per minute and then the glass is traveling at 10 meters, then second top roll I reduce the speed to let us say about 8 meters per minute so glasses being travelling fast, suddenly you put a break and allow it to go slowly at 8 meters, there is thickness build up that you can see.

The next top roll I reduce it to 5 meters per minute for that the thickness builds up and progressively if I want to make extreme thicknesses like 15 millimeter 19 millimeter, then we keep on employing more number of top roll machines and have a big difference between the speed in the from the one top roll to the next top roll by way of which we could provide the different thicknesses that we want.

So just to summarize, the float bath is a place where the float glass manufacturing the name comes from. Glass is floating on a molten tin bath. the flattest of flat surface that anyone can aim on the earth is a liquid surface, so glass floating on a molten tin, provides a very flat medium when we make form the glass, and since the glass is formed when we have the flattest as a substrate, the glass that we produce in this method provides the best optical quality that so for the manufacturing processes I have given us

And how the thicknesses are given, we spoke about the top roll machines which predominantly decide how the thickness are formed. Out of the four parameters the penetration, then nipping, the angle and the speed. The speed and the angle contribute significantly to the thicknesses that we want to manufacture, and when you have to make a glass thinner than the equilibrium thickness; that is from 2 to 5 millimeter for example.

We need to increase the speed and open the angles, and if you have to make the glass thicker we need to detrimentally reduce the speed, starting with the high value in the first top roll all the way down to the lower value on the speed and close the top roll angles which will give us the thicker glass, so this is a float bath process. And further once the thicknesses are given the glasses allowed to cool down, there are a few aerial coolers which have put in the in the downstream of the top rolls. In order to help the glass to reduces temperature to about 610 degree centigrade, at this temperature the glasses taken on the rollers; when the glass exits the float bath.

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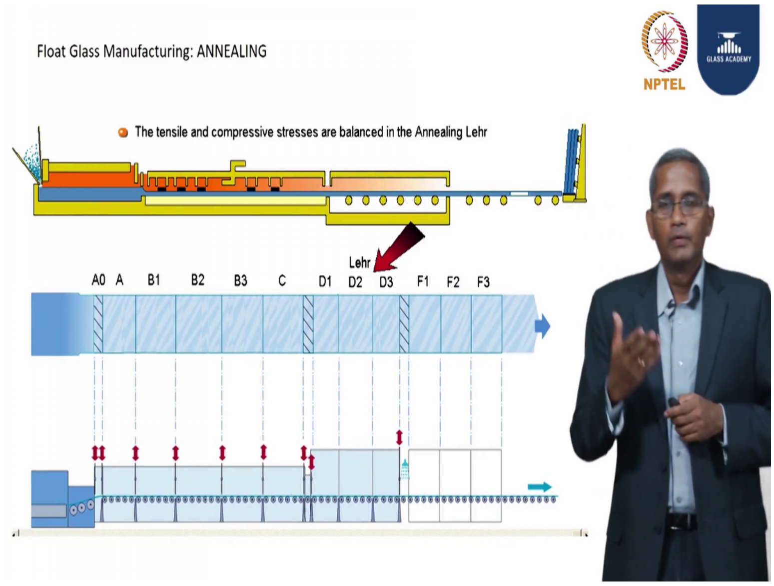

Now we it passes into the annealing layer, the annealing layer as you can see there is various segments that are given and in each of the segments the method in which we cool is different. In some of the segments; for example in the A zone, the way the air is provided is a cold air, it is in the cold current form, you can cool the glass very fast.

The B segment is divided into B 1 B 2 B 3, a very long range we have a reason for that I am going to explain that in a few seconds, and after that it is a C zone, in which again a cold air mass quantity of glass air is being passed to have a very little bit of faster rate of cooling and in the D zone it is a preheated air, but direct you know cooling with passing off the air in contact with a glass, not through the ducts as it is done in A B and C zones, and in F zones it is done with a mass air cold air directly into the glass to cool at a faster rate

Now let us little bit talk about what is this annealing range of the glass. The glass that we make, as you saw in the raw materials is using silica, soda, as well as the calcium ignition etcetera. So, the type of glasses we make, it comes under the category called as the soda lime silica glass. The soda lime silica glass annealing range is the temperature range of 480 to 540 degree centigrade, which means above the glass above the temperature of 540 degree centigrade the glass is set to be plastic and strain, which means whatever you try to do to the glass now jet pocket whatever it does not take any stress, because the glass is plastic it gets back to its original shape.

Below the temperature of 480 the glass is set to be elastic in its state which means you cannot induce any stress on to the glass permanently, but you can break it, but this temperature range of 480 to 540 for a soda lime silica glass, is the annealing range in which whatever stress happens remains permanently in the glass. And this 540 to 480 temperature is actually cooled in the B zones; that is why you have a very very longest B zone divided into. In some cases it could even go a bigger furnaces these days with 1010 capacity for example, have B 1 B 2 B 3 and B 4.

So, we have a very very slow rate of cooling in the B zones. Why we need to have slow rate of cooling? For example, the rate of cooling if it is uniform you will not have any stress, the stress will be remain neutral, but the glass is travelling on a roller, you can cool that top, you can cool the bottom, only after the top and the bottom is cooled the center gets cooled. At any point of time the temperature on the surface on the top bottom and the center will always remain different and the rate of cooling will also be very difference. For the simple reason we will have stress on the glass. All that we can do is to reduce the stress closer to neutral ok.

To give you an simple example what gives us the best stress profile. For example, let us take a example of a balloon, you blow a balloon and you pic it with a pen it does not form a hole, it blast open why, because when the glass there a balloon is blown, the forces are acting away from the body tensile stress. So, the moment you initiate a puncture into the balloon the tensile stress takes this whole and makes it into a rupture.

Let us take another example of a car tier and you will finds a difficult to penetrate into the car tier, but if it penetrates unlike a balloon it does not burst, because the rubber of the car tier is made with compressive stress, the forces are acting towards the body. So, similarly when we are having high tensile stress, when I tried to cut the glass it has a small impute, the glass can shatter and break like how a balloon is blasting. When you make a high compressive stress on to the glass, you may find it very difficult to cut like an a car tier. The nail might find to difficult to penetrate inside.

Similarly we might find it difficult to cut the glass that is why when you do a toughening process, we need to pre cut the glass and then you toughen the glass, because you cannot cut the toughen glasses. Like an arrays are for example, which is got a mild compressive stress you will be able to slice it with a very clean edge.

So, what we are aiming at in the annealing process is to have a good cutting quality and the glass has to come out without any breakage, we is better to have a mild compressive stresses on the edges, and this is a done with a very slow rate of cooling using a various blowers and different control mechanisms which are inbuilt into the annealing layer.

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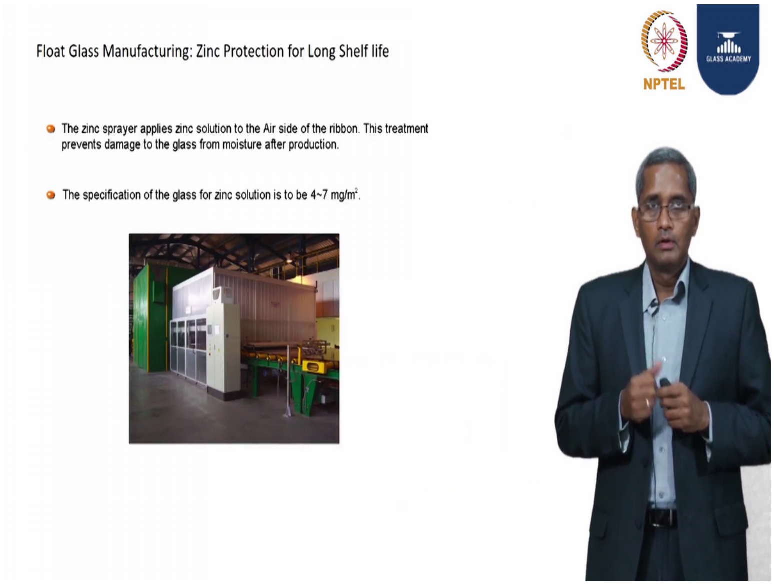

And now the glasses cooled to a temperature of a 60 degree centigrade. Now, it is time to meet the customers requirement in terms of meeting the dimensions as well as the other quality, for the glass to remain longer in a humid conditions even, to avoid the problem of weathering attack, the glass is sprayed with zinc citrate online.

So, all the glasses that you buy will have zinc citrate coating protection against weathering which can happen, because of a humid atmosphere in the glasses store in the various floors in the longer time. So, this is a process that you see on the picture.

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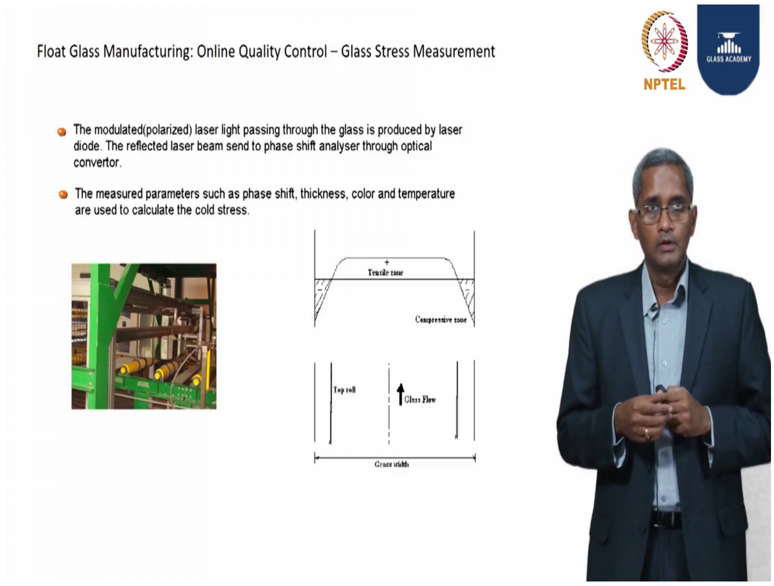

And next is we talked about the stress profile on the annealing layer, and there are online equipments which measure and tell us continuously how much is the stress on the glass, so that we can regulate and avoid bad stress glass being sent to the customer online

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We also have all the float lines are equipped with Hi-tech deduction devices which can spot defects, un melted raw materials or bubbles which come, because of a poor refining which we talked about the seo to the test escape out of a glass if not done efficiently, it can pass into the glass. Even the defects that we cannot see by naked eye, even with good lighting there are scanners which can tell us where this defects are and these are scraped online.

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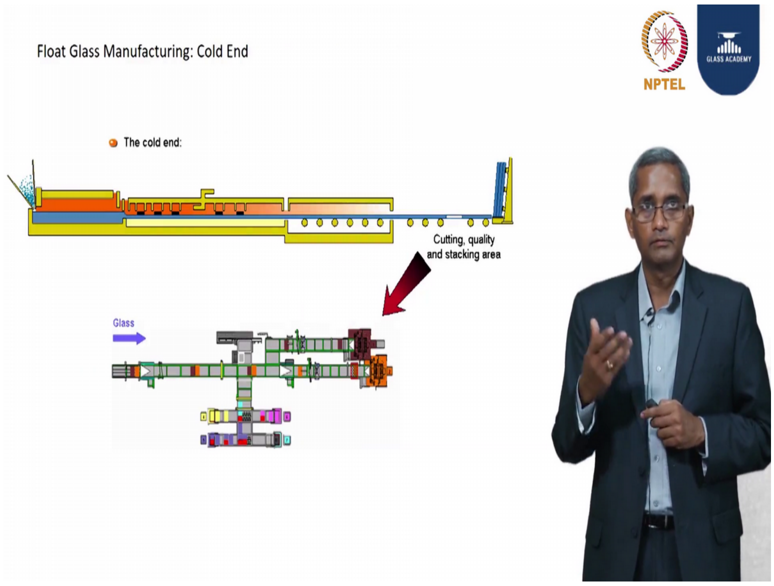

This is a deduction system, having directed and scraped all the bad glasses, another good glass alone travels into the cutting line. Cutting line depending upon the customers requirement as different possibilities to cut.

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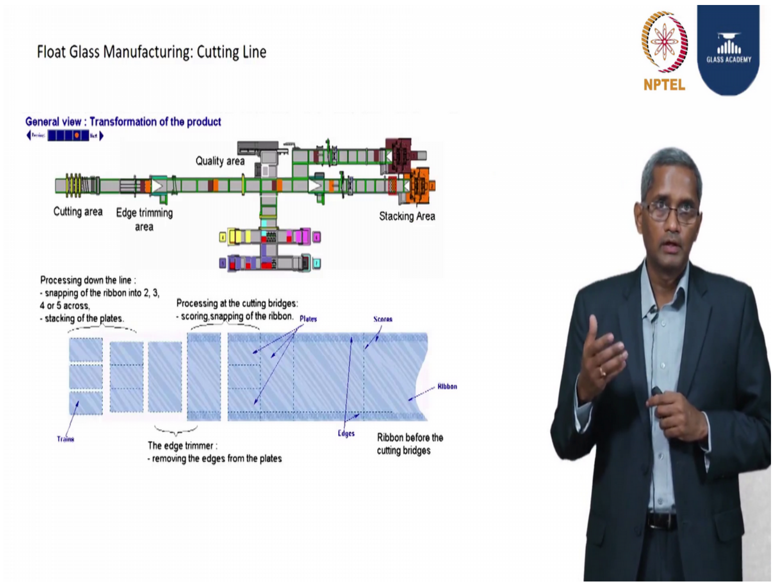

And as you can see you can cut it into a big size glass a called a jumbo glass or you can cut into medium size glasses, which is called as a DLF or small standard size is called is a triple S. You take it into the stalkers and robots and, just to tell you when we think of a glass manufacturing typically in a conventional way, we always think that it is a very very high temperature, people are walking very toiling and very dusty atmosphere.

But the technology has facilitated these days at, all the hot and the cold end cutting controls as well as furnace operations are float bath operations are done through distributed control systems. There is very minimal people interactions, they need to do or minimized exposure to heat and dust is absolutely not there and, even when you come down into the cutting line to pick the needs of a glasses, it is quite like when you high technology industry that you would see.

There lot of robots and stalkers which pick up the glass without any need for aim humans to do this activity. So, this is the float glass manufacturing process and I hope you got some information related to what you are looking for.

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Thanks for watching.