**Glass Processing Technology**
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**Lecture - 24**
**Tempering Part I**

Hi, welcome to Glass academy. Today we are going to learn about Tempering, a process all about how it is taking place at the process of glass.

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Let us look at the agenda first, upon completing this model, you will able to answer; what are the difference between the annealed glass and tempered glass and purpose of thermal treatment, basically heat treatment, a tempering process, list of various types of tempering process, Do's and Don'ts, common defects and test as per the EN standard. So, this is today what we are going to discuss about. So, let us begin.

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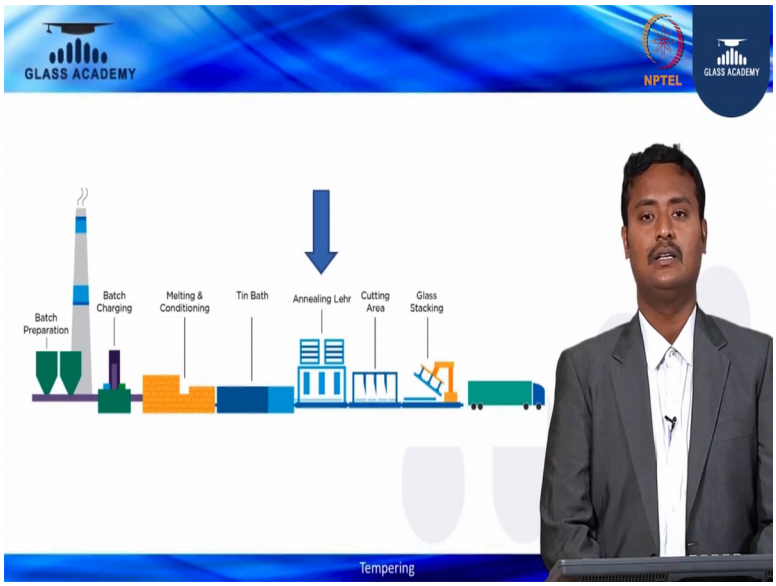


So, as you all know about it that how the float glass manufacturing process. So, this is the osmotic diagram for float glass process, where this is the annealing layer is starts. So, why people are calling is annealed glass? Because the annealing process take place at the time of manufacturing of the raw glass.

So, annealing process is nothing but the when the hot temperature goes into the cold media which is very much slower phase, thereby you are getting the induced internal stress thereby getting into the attain into the glass. So, annealing process is the very slow cooling process certain controlled subject to controlled an pressure and temperature.

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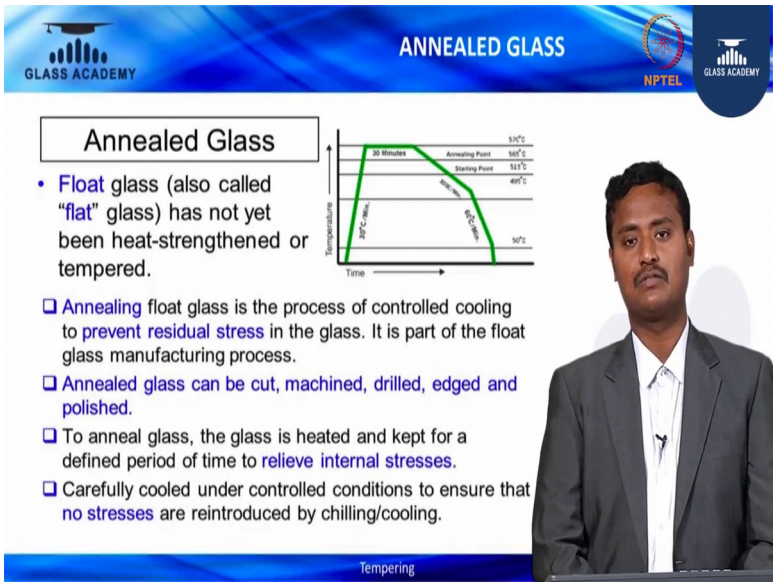


What has been the float glass people would ask you because float glass is nothing but flat glass or you can say its annealed glass in the raw glass during manufacturing process which is called because the molten stage of the glass has been placed on the tin bath, the tin is medium where the glass play which is transmitting to one place to another place which is floating across. So, that is why it is called the float glass.

Annealing float glass is the process is controlled and cooling to prevent residual stress in the glass, it is the part of the float glass manufacturing process annealed glass can be cut machined or drilled edge process polished or heat treatment can be done or lamination as all other process can be done.

So, annealed glass; the glass is heated and kept for a different period of time to relieve the internal stresses carefully the cooled under the controlled conditions to ensure that no stress are reintroduced by chilling and cooling. So, this is the annealing glass.

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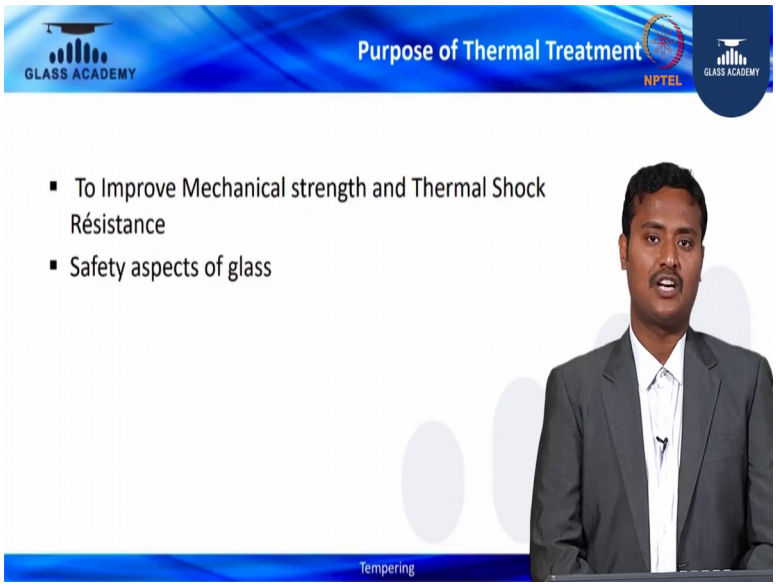


So, let us move on. What is why we need to use as a thermal tempered glass what is the purpose of using the tempered glass; so, to improve mechanical strength and thermal shock resistance.

So, mechanical strength which is nothing, but tensile strength and compressive strength and plenty strength thermal shock resistance which is there will be a temperature differences causes will have a glass breakages in order to prevent this thermal shock, we have to temper the glass and most important widely normally people would called tempered glass is a safety glass, yes. So, the tempering process its help to attain the specific characteristics is one of the best characteristics is to safeguard our people who are working there. So, it will not harm anybody. So, safety aspect is it will improve the safety aspect of the glass.

So, there are two purpose basically why we have to tempering one is improve the mechanical strength and the thermal shock resistance and most important to increase the safety aspect of the glass.

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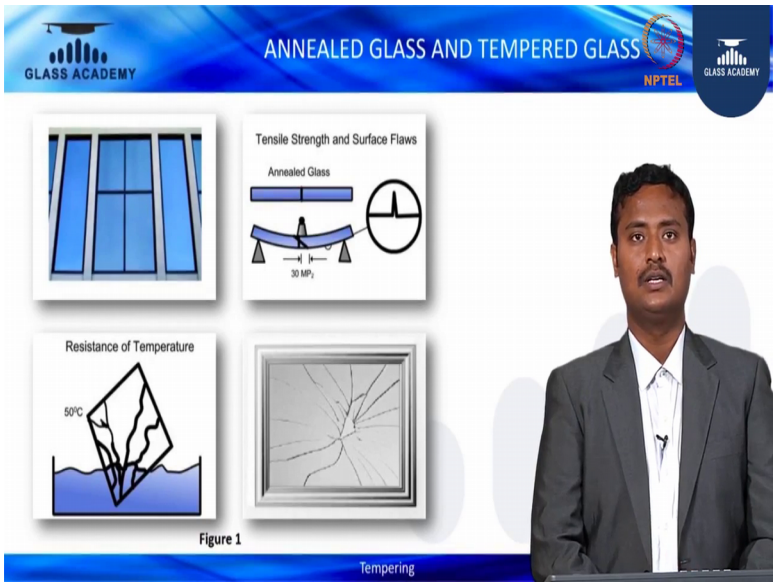


Yeah, let us move you see that the there are glasses glazed on the windows see that tensile and surface flaws also mentioned over there and below pictures have mentioned 50 degree centigrade the glass annealed glass, if it is uses it resist up to 50 degree centigrade beyond which it will breaks. So, annealed glass and the bottom most right hand side which we will able to see which is the breakage fragmentation if the annealed glass broke; how it look like this. So, these are the pictures are elimination.

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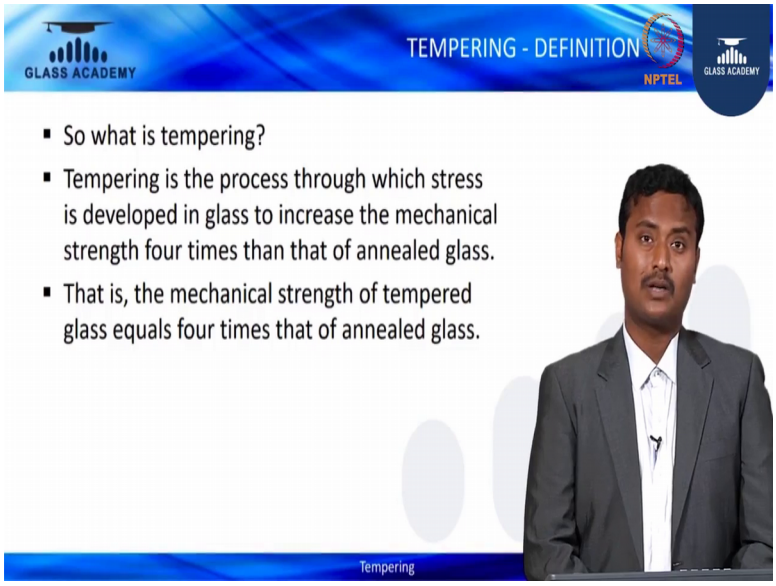


So, let us move on what is tempering. So, tempering is the process which a stress is

developed in the glass to increase mechanical strength [vocalised-noise] 4 to 5 times than the annealed glass that is mechanical strength tempered glass equal 4 times that of annealed glass basically to increase the tensile and compressive strength of the glass.

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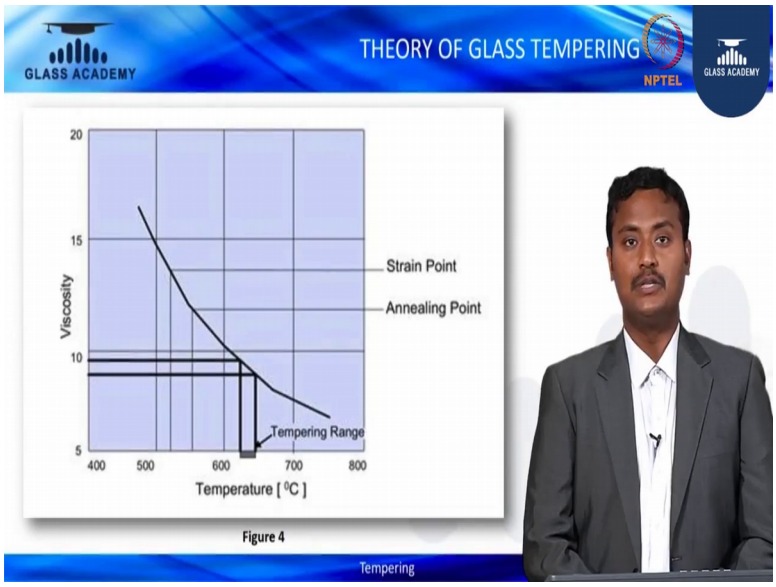


You see the range of the tempering range high. So, this is the place where tempering ranges starts here, you can see the strain point annealing point here. So, which means glass subject to heated up to 670 degree centigrade where the curve which started.

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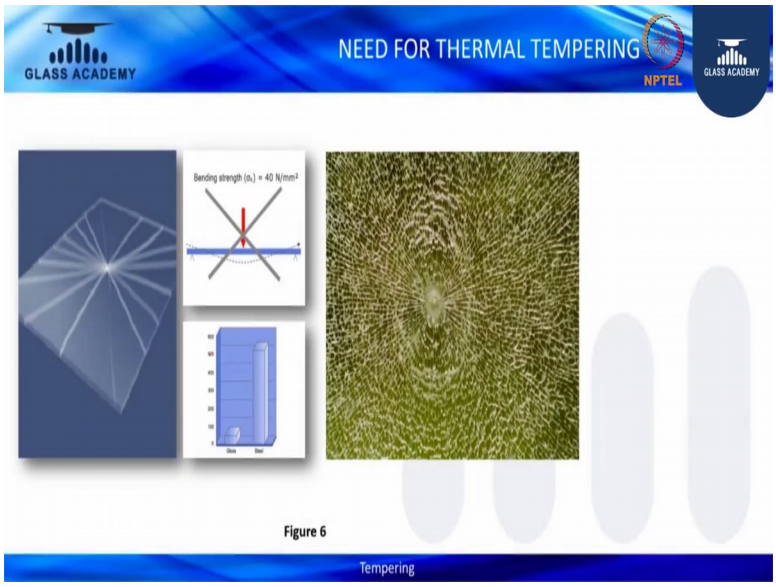


This is the fragmentation pattern of the tempered glass why need of the thermal glass the

left hand side, you see the annealed glass fragmentation which is harm the people because the very basically it is sharp in nature; it will hurt the people to not avoid that breakage event. So, we have to increase this strength of the glass, you see that the fragmentation patterns completely different from left hand side to right hand side, the right hand side pictures; what you see that is fragmented which is has dull edges, if it glass broken, it will not hurt anybody. So, that is pictures says for us.

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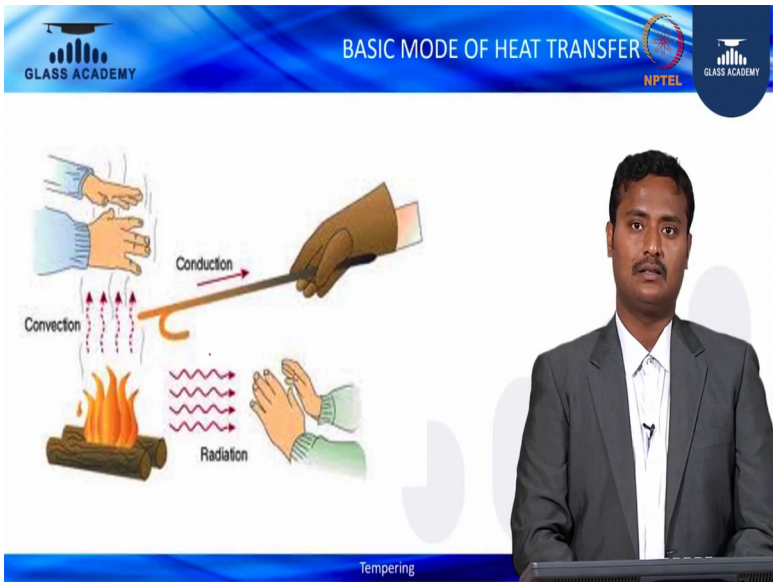


And basic mode of heat transfer as you all know it is convection and conduction convection radiations.

So, let us discuss the basic concept of heat transfer which is takes place at the tempering plant. So, so before get into the tempering process this is the basic step which we have to understand which is the conduction convection radiations. So, conduction which is nothing, but the heat which is been felt or the transmitted the medium is any form of medium.

So, imagine the any iron rod which is tipped or the edges are heated up the slowly you will get the feel of the heat at the tile end of the rod which means you will be that heat is been moved from one place to another through any medium with this iron rod. So, if you say that hundred percent of heating process I mean 100 degree centigrade when at the tip of the iron rod when you feel the tile, it will not be 100 degree centigrade may be it is a 50 degree centigrade, 40 degree centigrade because of the heat loss. So, so considerably

we are getting the heat loss at the conduction process.

Let us see the radiation process the flame is there people or the finger where you are getting that the heat is been felt because of the electromagnetic waves the glass mean the heat is transferred from one place to another through electromagnetic waves which is called radiation process.

Whereas, convection process you see that and this if the flame risk completely transmitted to the other the heat is completely transmitted through air molecules and air is present. So, the heat is capture the air and it will claims further that gives more efficient energy transform from one place to other through air medium. So, which is convection is best medium as far as the mode of heat transfer. So, that is why in tempering process convection is most widely used in all of the tempering latest tempering machines, I hope you all understood what the basic of mode of heat transfer.

So, I am emphasising here. So, if you understand this you can understand better in the process of tempering.

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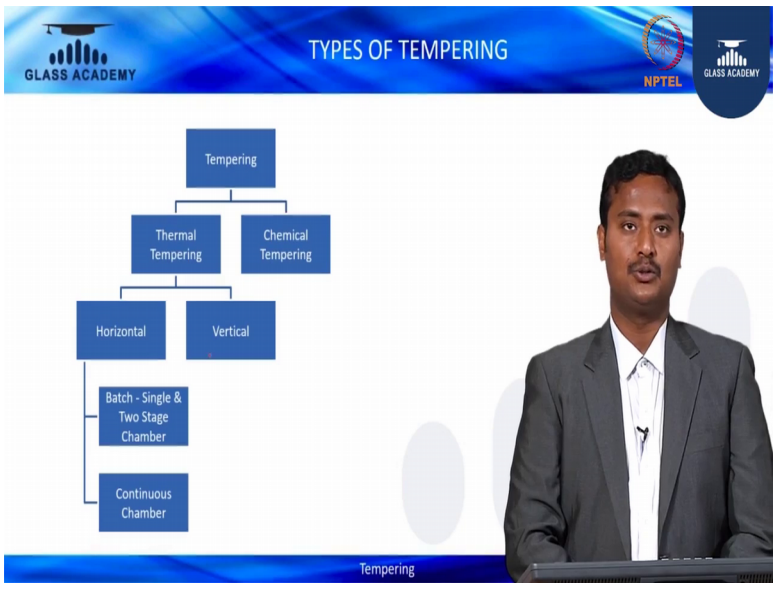


So, let us move on types of tempering divided into two types; one is thermal tempering and chemical tempering and further thermal tempering divided into two types, one is horizontal and vertical tempering and again horizontal tempering divided into two types; one is batch single two stage chamber or continuous chamber.

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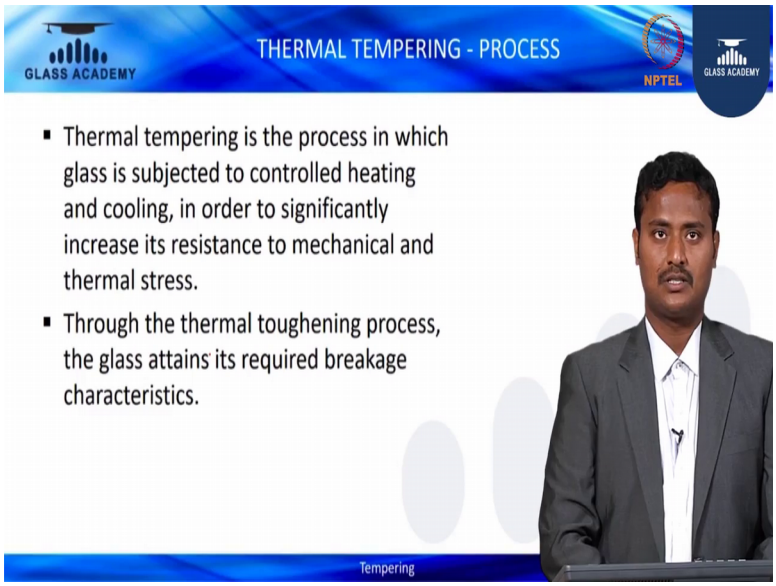


Thermal tempering process having said that here earlier thermal tempering is the process in which glass is subject to controlled heating and cooling in order to significant increase in the resistance of to the mechanical and thermal stresses, thereby you are getting the required breakage characteristics through this process. So, basically the heat and pressure which widely used for tempering process the heat is powerful medium and air is powerful medium in this air which is involved the how fast you are cooling the glass, you will be getting this tempered glass which means to the surface compression is rendered on the glass is faster which is take place on the tempering process. So, we will see the further.

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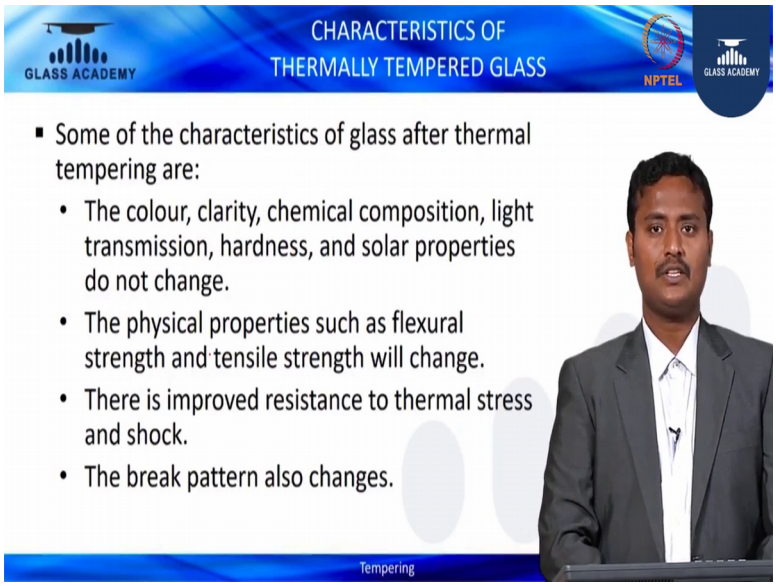


Characteristics of thermally tempered glass; some of the characteristic of glass after thermal tempering are the colour, clarity, chemical composition, light transmission, hardness, solar properties which will not changes at all, if you do it tempering, it will be remain same forever there is no changes at all on.

The physical properties such as flexural strength tensile strength compressive strength definitely it will change that is the need for tempering of why we are doing there is improved resistance to the thermal stress and shock through resistance thermal stress this is most important; for example, if it use the annealed glass on this wizard or windows the thermal differential between this edges on the mid plate it causes the breakages which is called thermal breakages; obviously, taken place with help of 50 degree centigrade within that it will breaks in order to avoid that. So, we have to do it tempering process. So, this is the one of the characteristic of thermally tempered glasses breakage pattern also changes yes; obviously, this would changes breakage pattern all as well.

Annealed glass has a sharp edges; it will hurt and the human beings who was in near the working area; whereas, tempered glass break this, it will not hurt anybody because it has a dull edges kind of roughly it is a kind of dull cubical particles rate where it will not hurt so which we have seen here.

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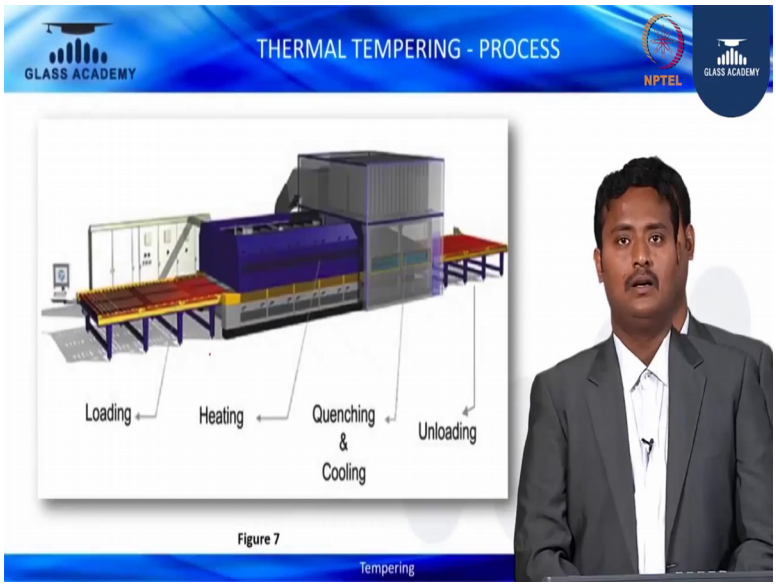


So, so, let us look at what is tempering how it is taking place. So, what is the mode of heating transfer? So far, we have learned about it let us look at it this is the osmotic diagram of tempering plant, it is widely used this is called horizontal tempering machine where you can see the first portion is loading where you have to load the glass with respective sizes of the orders or with respective size of the how much it can be handle. So, loading can be which means before tempering as annealed glass after washing all that the grinding polishing cleaning and the things over the first step is we have to keep it on the loading phase where annealed glass float glass flat glass that kept on the loading table.

And next it is set of phase called the heating chamber this is vital playing role in terms of tempering process heating is most important process in terms of tempering and the next phases quenching cooling where this special characteristics of tempering like surface compressions and mechanical strength which will attain at the phase it in quenching and cooling phase.

The next is a unloading phase. So, which means there are 4 stages of tempering process loading heating quenching and cooling and unloading process. So, upcoming slides we are going to discuss about in detail and this is sections of tempering machine.

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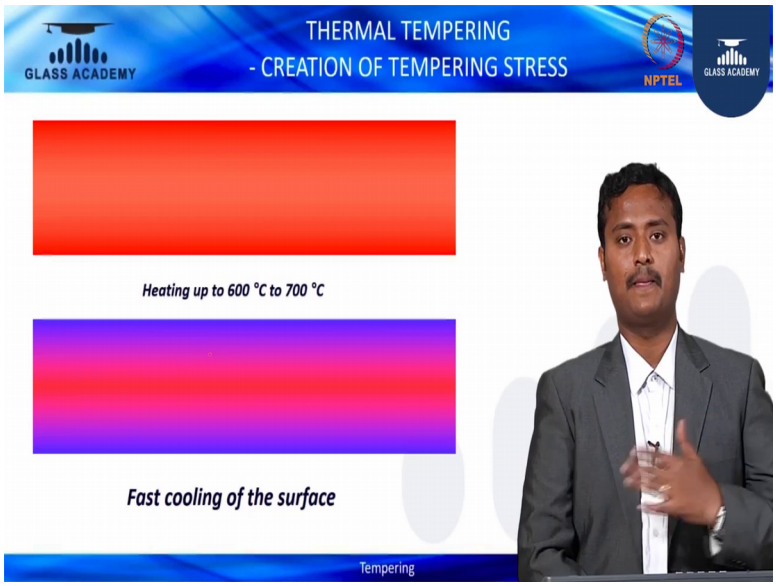


Let us see how heating taking place at the heating chamber you see that you are heating the glass up to 600 to 700 degree centigrade, it depends upon the manufacture manufacturer the temperature, it will be depressed because what is the distance between the glass kept on the rollers and the heating coils and heaters are produced the so depends upon the manufacturer may vary. So, that is why it is heating up to 600 to 700 degree centigrade, you are heating the glass on it.

So, if you want to do it tempered glass, thereby you have to do a rapid cooling which means a fast cooling on the surfaces you see the difference between the two images the first images is a completely heated up to 700 degree centigrade which is; obviously, it is red colour where you can see this below second picture after rapid cooling the surface compressions is rendered on the surfaces where the top and bottom which mean the glass surface two phases; one is phase 1 and phase 2 which means as say an tensile or you can say at the centre still the heat is there. So, that is the cause in the tensile strength which is playing across here.

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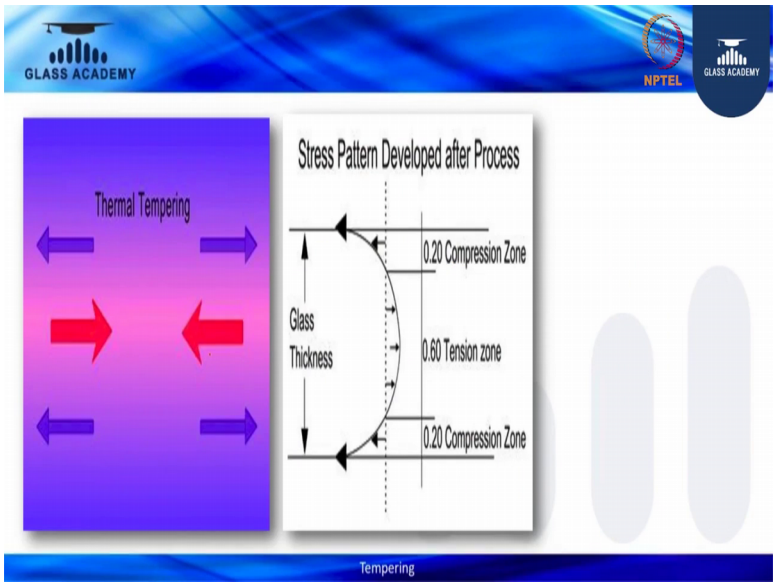


You see that the graph which here which I showed you with respect to before see that the same temperature playing a major role here. So, after surface compression rendered you see that the red colour glass would become a blue colour I mean I am just explaining the process how to change its not like blue colour when you tempering it in order to clarify you I made it as a blue colour. So, that is why.

So, in the blue region where you see that 0.2 region that is compression zones because the surface compression to rendered on the top because the faster when rapid cooling the surface is getting the heated up first; so, those areas like phase 1, phase 2 is easily get cooled up because of the rapid cooling. And this where 0.6 that is zone called tensile zone and again it is 0.20 compression zone, the stress pattern is developed after process.

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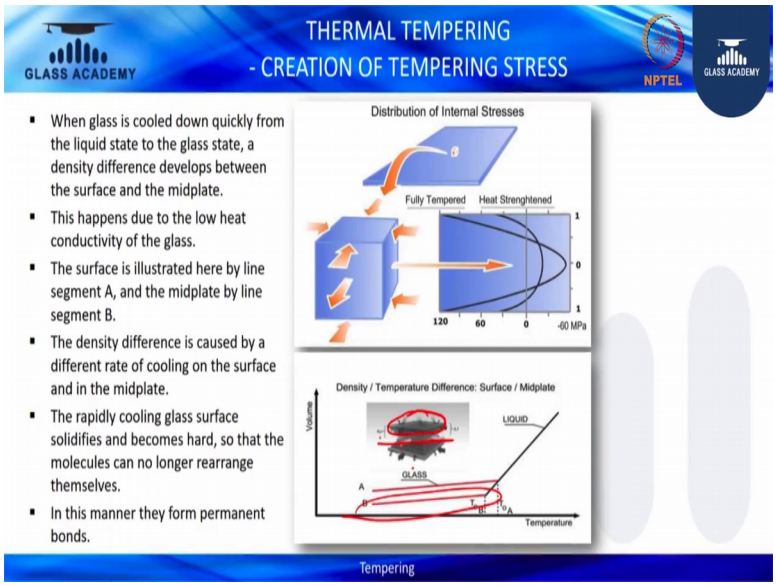


I will explain you in a bit manner the when the glass is cooled a quickly from liquid stage to glass stage the density difference develops between the surface of the midplate. So, midplates it takes longer time to cure whereas, surface is faster to cure this happens due to the low heat conductivity of the glass the surface is eliminated here by the line A and midplate line by B; segment B, you can see through over here. So, so this is the line which I am saying about it and see that this is the top most portion, where the surface compression strengthened and this is the this is the midplate where your tensile zone is taken place.

The density difference is caused by a different rate of cooling surfaces midplate the rapid cooling the glass surface is solidified became the hard. So, that the molecules cannot no longer changes rearrange themselves in this manner they form permanent bonds.

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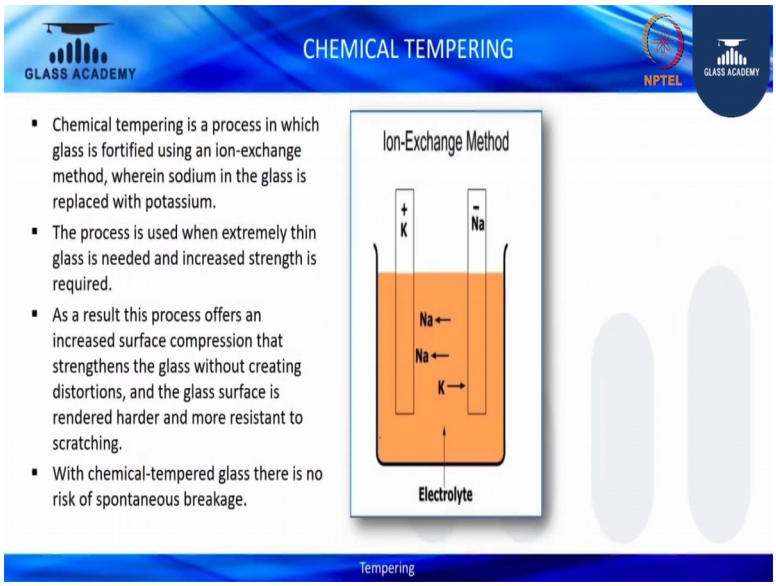


So, let us move on chemical tempering basically this chemical tempering is widely used for thinner glasses not for the thicker glasses as of now and this is for small batches it cannot be used mass production because limited space of this apparatus or machines to be used for this mostly, this is widely used for mobile phones watches where which you cannot fact that there is a furnace into furnace because roller distance is 150 mm where the small size glass or lesser thickness where you not able to fed to the furnace those glasses can be tempered with help of temper chemical process mobile mobile for tempered glass for mobile applications for the in order to avoid the scratch or if it is falls from one place to other it will not you know shatter proof. So, those applications widely used chemical tempering process.

So, let us look at it what is happening inside of this chemical tempering. So, chemical tempering is a process in which glass is fortified using an iron exchange method wherein sodium in the glass is replaced with potassium basically sodium and potassium exchange their molecules the process is used when extremely thin glass is needed to increase strength is required having said earlier this process widely used for the thinner glasses where which you are not able to do it on the arrays on the tempering which means heat treatment thermal tempering process.

As a result of this process offers an increased surface compression that strengthens the glass without creating the distortion and the glass surface is rendered harder and more

resistance to the scratching, this is the most important for thinner glass application where the scratch proof like watches very small tiny watches will have see the scratch for resistance watches how it is possible because it is basically this a glass in order to avoid the scratch.

So, you have to do a chemical tempering. So, those words whenever you come across the scratch proof. So, basically those watches glasses are used to chemical tempering with chemical tempered glass, there is no risk of spontaneous breakages this is one of the wider ideal solution for tempering process, whereas, tempering process iron exchange method is the best process for the thicker for that is thinner glasses to that.

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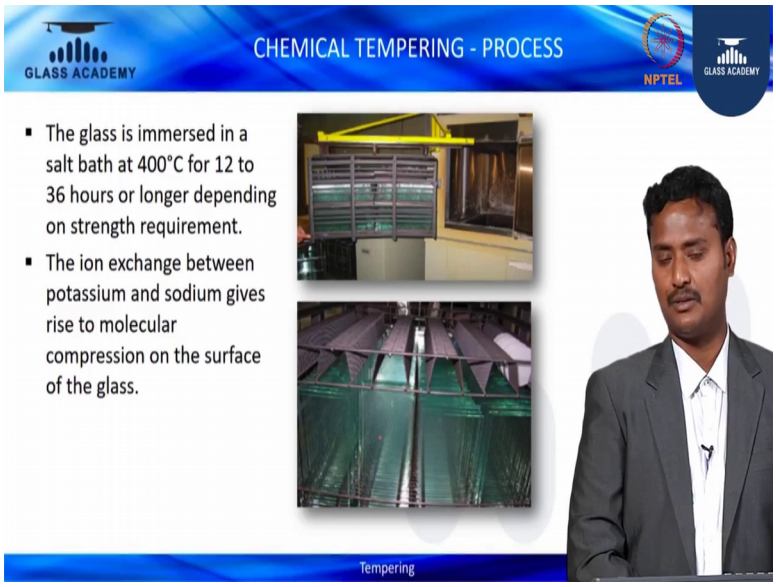


So, let us look at the process, the glass is immersed in a salt bath at a [vocalised-noise] 400 degree centigrade to for a 12 to 36 hours, it depends upon the load how much keeping the load that duration will not be varied the iron exchange between the potassium sodium gives rises to the molecular each other and thereby the compression on the surface of the glass is being rendered. So, this is the process of chemical tempering.

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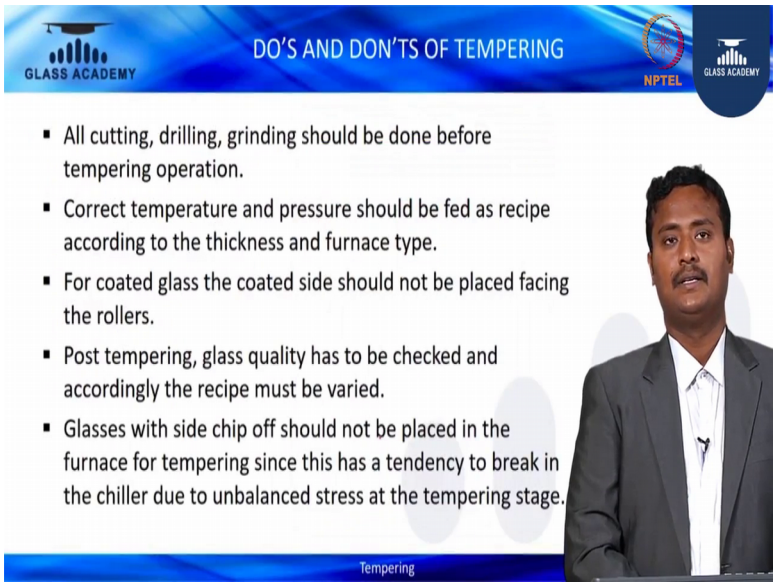


Let us move on to Do's and Don'ts tempering all the cutting drilling grinding should be done before tempering operations correct temperature and pressure should be fed as recipe according to the thickness of the furnace; for example, if the one for one process who has recipe of the 6 mm clear glass cannot be put as same recipe as for other furnaces or even low e glass, if using it the same set up parameters cannot be used for the other machines because if the furnace to furnace have to be ready, but we have to keep in mind at the time of during validation or when you do this testing trial.

We have to understand what the best recipe out of which you can get out from your questions for coated glasses coated side should not be placed on the roller phase because the coating would damages and roller get damages thereby nothing when coating it throw away you will have a more scratches and performance would not be get from this the coated surface.

So, all the times whatever you are since from the great opening which means cutting pre processing like grinding washing drilling and tempering all the coated product should be always fed as the top side of the coat spacing on the air side basically, we should not be contact with the rollers.

Post tempering glass quality has to be checked according to the recipe must be varied and we can check with that you can check the quality in terms of tempering parameters anything is obvious which is not acceptable for you and your naked eyes.

So, we can access through we can eliminate those help of tempering parameters or else there is EN standard European standard EN 12150 which will help us just you know set of quality; what we are expecting for particular projects. Glass with side chip should not be placed in the furnace if you keep this chip of this one; it will break into the Chiller during that chilling operation which is quenching operation the glass would break. So, that is the one.

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