**Glass in Buildings: Design and Application**
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**Lecture - 04**
**Coatings on Glass - Need and Types**

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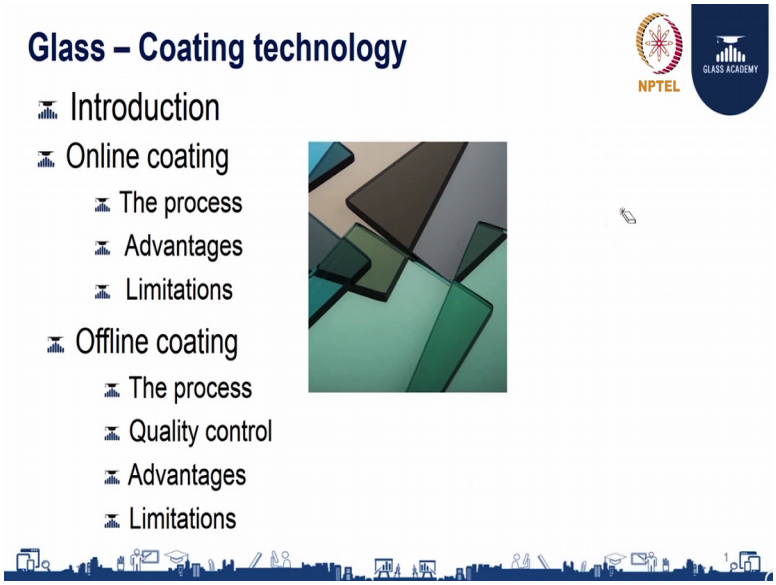


Hello. In today's session we are going to see about the Coating Technology on Glass. I am Swaminathan, I am Associated with (Refer Time: 00:29) for the last 13 years, I am in charge for the Coating Operations in the Chennai Plant.

The topic for today will be basically the introduction on the need for coatings, on glass and how do we add value on glass by coatings, and the different processes of coating. First the online coating, we will study about the process, its advantages and its limitations. Then the offline coating process, we will detail about the process, the quality control methodology, the advantages and the limitations of the process.

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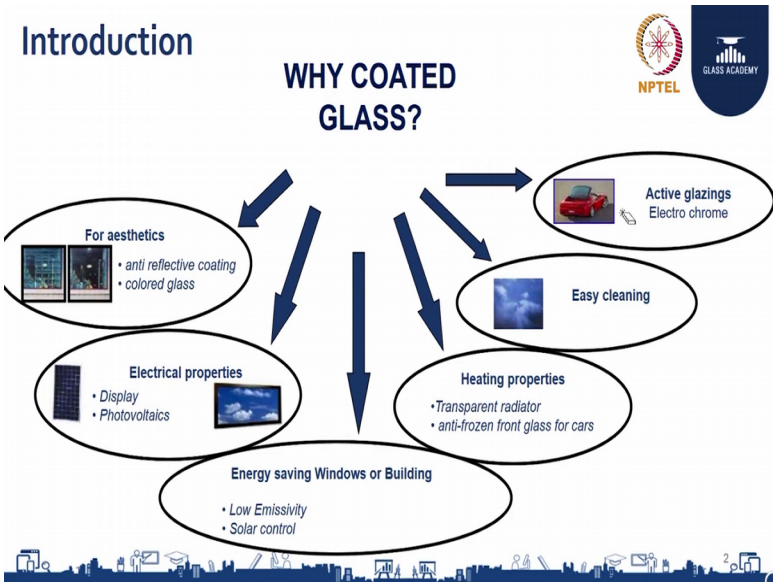


Why coated glass? What are the value additions on the glass that is achieved by coatings? Let us basically have a overview.

First functionality can be in terms of energy savings in terms of hard buildings and exterior glazing applications. Second could be on for better aesthetics for anti reflective and also for coloured glass. And we can achieve good electrical properties in terms of display and photovoltaic applications. And glasses are also easy to clean. So, that is that will be an adder functionality by coatings.

And there can be heating properties where we will have no anti froze and anti fog applications on that. And last could be active glazings where we will have the glazing which will respond to the atmospheric conditions. So, these are the functionalities achieved by coatings on glass.

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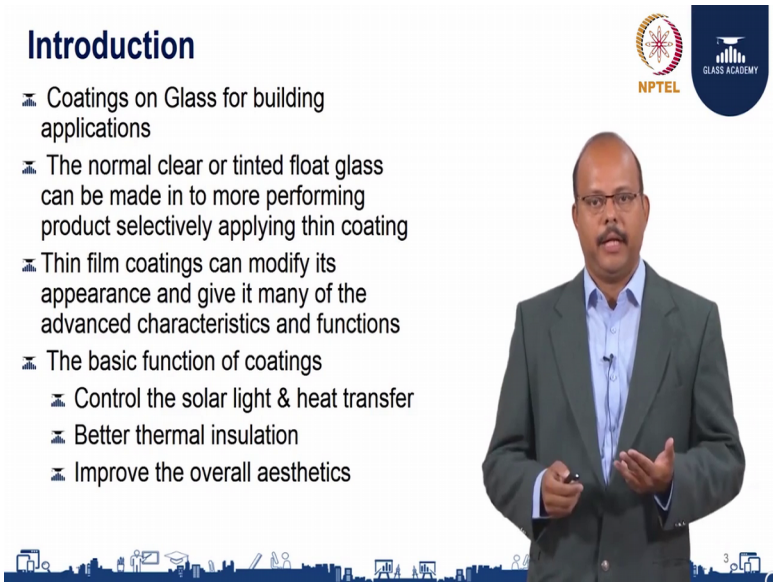


Now, going forward let us understand specifically the coatings for exceeded glazing applications for buildings. A normal clear tinted glass can be made to be more performing by adding selective thin film coating on the glass. The thin film coatings can modify the appearance and gives it a advanced characteristics and functions.

The basic functions that can be added on the glass could be the below: one could be in terms of solar control, and control of light and heat transfer, and better thermal insulation, and improve the overall aesthetics of the building.

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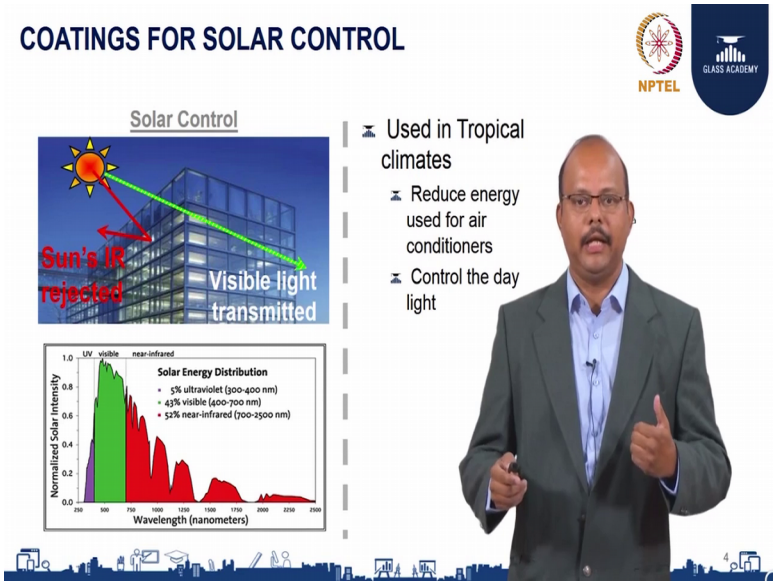

So, the main functions of the coatings in terms of basic thermal insulation and solar control we will see in detail here. So, in terms of solar control what we have here is the solar spectrum, where we will have the complete solar spectrum with the solar wavelength. Here in terms of the overall energy distribution the idea here is to let the maximum sunlight inside the building and cut the solar heat outside.

So, the coatings achieve this functionality and the application this mainly in terms of traffic climates where we will have the added advantage in terms of reduced energy for the air conditioners and controlling the daylight entry into the buildings.

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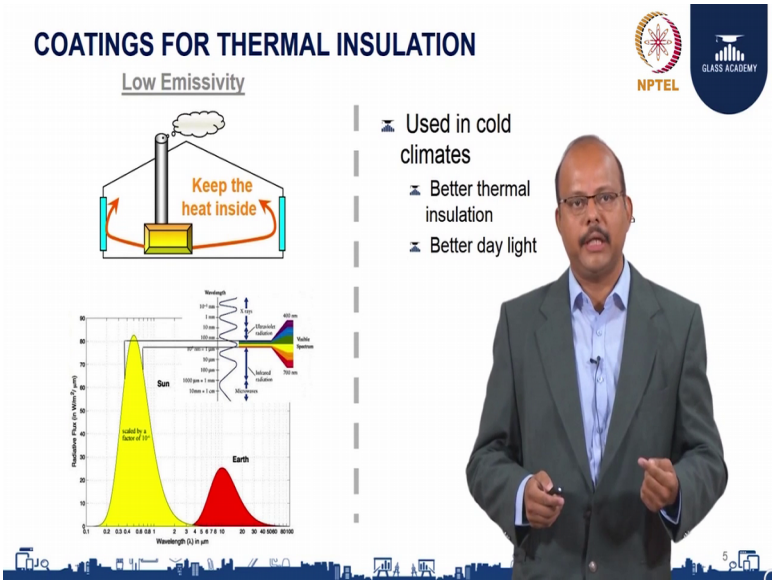


The second application is in terms of low emissivity, where the interest is to keep the heat inside the building. Here the major; now the major focus is on the controlling the emissions from the blackbody emission that is within the building. So, here the glass acts as a insulation complete insulation material.

So, the application here is in terms of mainly in coated coat limits where we will have for better thermal insulations and having daylight entry into the glass, into the buildings.

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So, basically functionality achieved by the major processes which can be categorized into two major functionalities: one is online coatings and second is offline coating. We will see each of this in detail in the coming slides.

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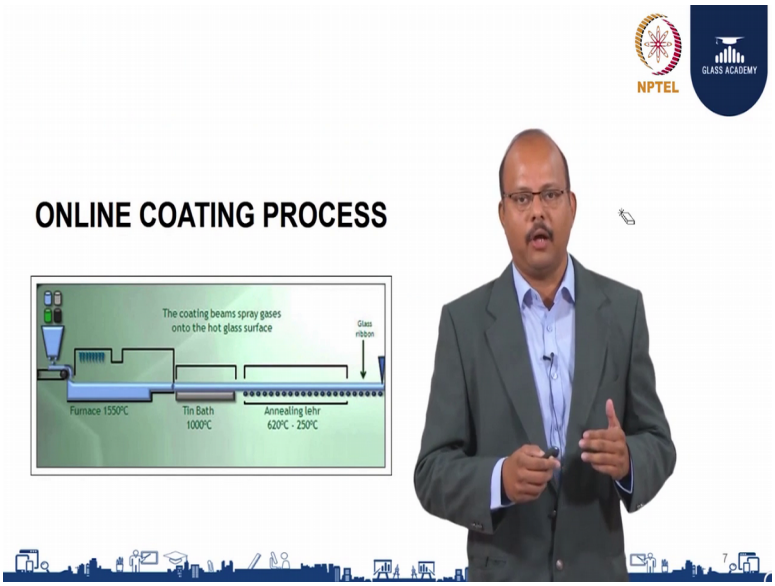


First we will cover the online coating process.

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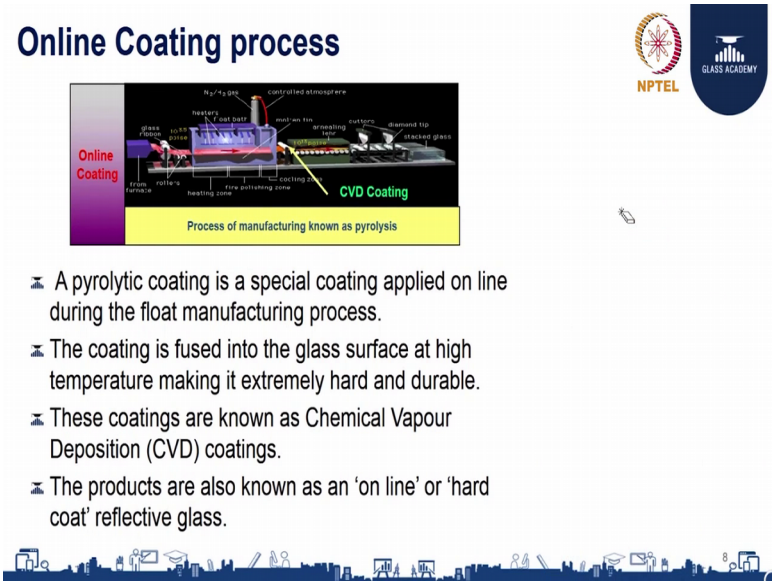


The online coating process it is traditionally a pyrolytic coating process which is applied in the float glass manufacturing process itself. Here the coating is fused onto the glass at high temperatures makes making the actual coating extremely hard and durable. These coatings are generally called as CVD or chemical vapour deposition coatings. These are also known as online coatings are hard coating reflective glass.

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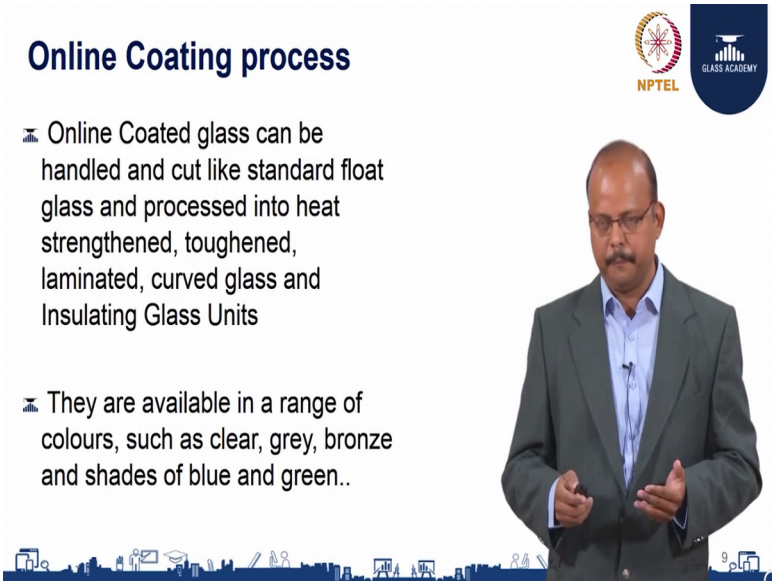


This online coated glass can be processed in terms of standard float glass process. They can be heat strengthened toughened laminated curved and can be used in IGU's. These

know online coated glasses are available in clear and also in all the available tins that is produced by the major float glass manufacturers.

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Now, let us move on to see the advantages of this online coating process. This online coating process by virtue of its scale of process, it is a large production runs are possible and this is by the by its by its scale its highly economical. And also the process is quite simple in its not very complex and it is easy to install maintain and manufacture. So, these are the major advantages of online coating process.

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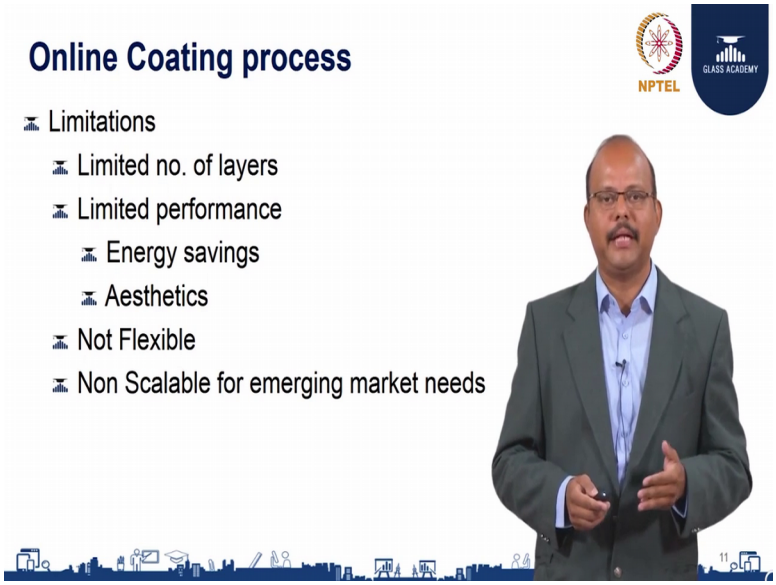

Let us now understand the limitations of this online coating process. So, first we have only yes, limited number of layers that is possible in terms of this online coating process. So, by virtue of limiting the number of layers we also have the limits on the performance that is achieved by these online coatings. So, either in the forms of the limitation in terms of the energy savings that could be achieved or in terms of aesthetics that can be us that is the limitations here.

And by since last year process we have limitations that it is not flexible, so it cannot meet the customers demand in terms of varied sizes and small production requirements or small volume requirements. And it is not scalable to meet the emerging market needs any new functionality that is near by the market we do not have the technology which can be which can respond to these needs. So, these are the major limitations in terms of online coating process.

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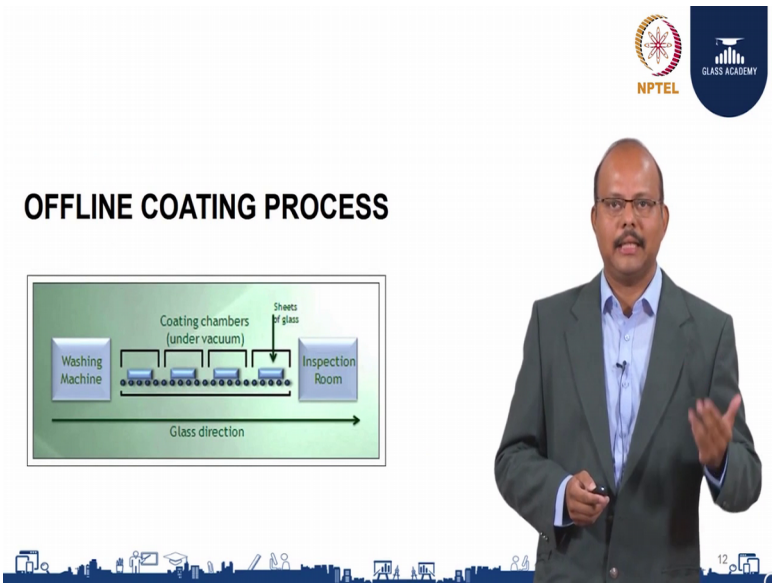


Now, let us understand the offline coating process in detail.

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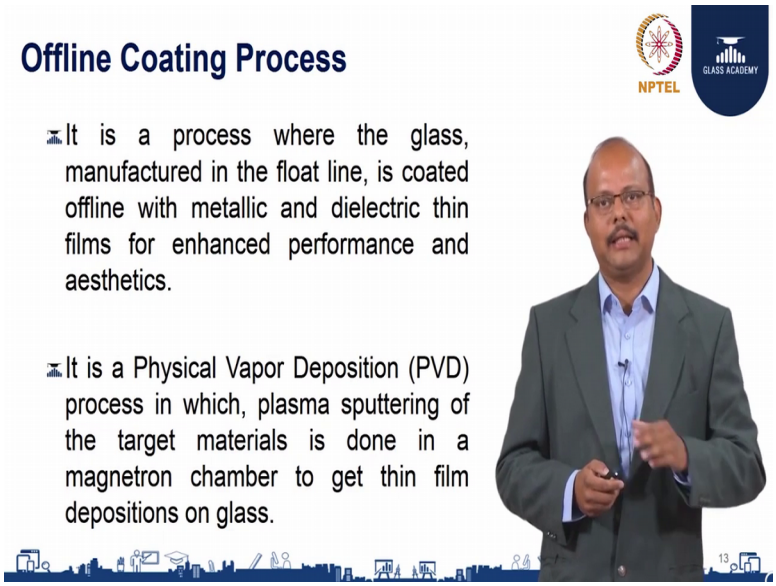


The offline coating process is its actually a process which is happens outside the float glass line where the glass from the float line is quoted with thin films; that is metallic and dielectric thin films wherein we achieve enhanced performance and aesthetics.

It is generally a PVD process in which plasma sputtering of target materials is done in a magnetron chamber to get the thin film depositions on glass. So, there are several thin film layers that is deposited on the glass to achieve this enhanced performance and aesthetics on the glass.

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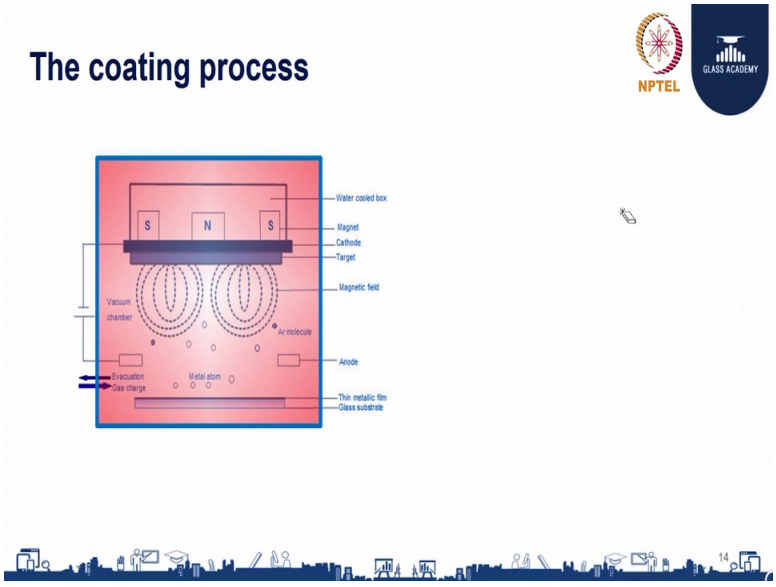

How is the coating process done? We will see it in more detail in the coming slides.

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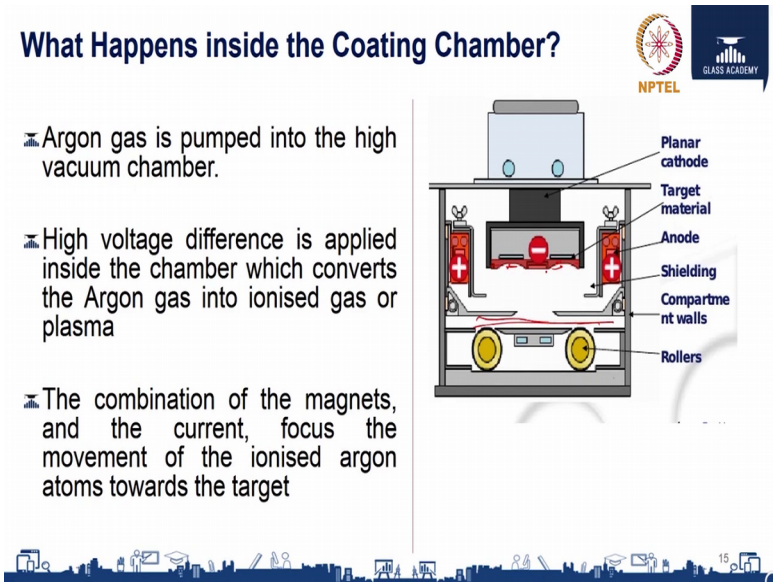


This is the typical cross section of a sputtering chamber. We can see here we have this chamber this entire chamber is kept under very high vacuum; the vacuum level could be the range of 10 power minus 6 millibar range. Here we have in this sputtering environment in on these are the rollers in which the glass the glass will be moving on the surface at a fixed line speed. The material that is need to be deposited on the glass is fixed here as a target material. This is the target material and the glass will be moving on the top of the rollers at a fixed line speed. This entire chamber is kept under ultrahigh vacuum.

Now, so in this vacuum environment we now have the process gas which is normally an argon gas is pumped into this high vacuum chamber. What happens here is the and on top of these we also have a high voltage potential to which is applied between the chamber and the body of the chamber and the cathode. In this high voltage environment the argon gets ionized and knows it gets converted into argon ions and it forms the plasma around the material; that is the target material that needs to be deposited on the glass.

So moving on; so, this is also the therefore entire plasma is concentrated on the surface of the target by combination of magnets and current. So, this is and we have also have the kinetic energy transfer taking phase from the know argon ions which is hitting on the

surface of the targets here.

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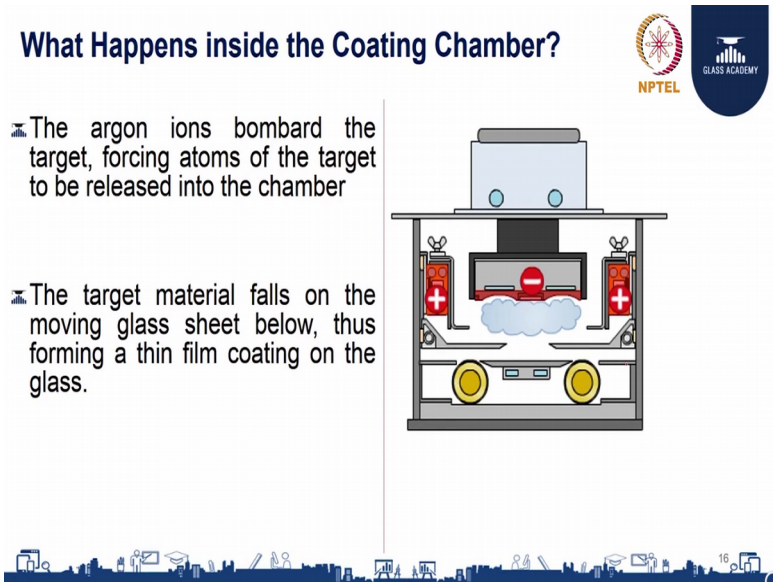


So, the argon ions bombard on the target surface forcing the atoms of the target to be released in the chamber. And these target materials as know from the surface of the target it falls on the glass sheet below and forming a thin film coating on the glass. This is how a thin film layer is coated on the glass, like in a coating typical coating chamber we have know series of chambers wherein we have one layer on top of the other coated as per the needs of the product.

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So, let us know and understand the advantages of this coating process. So, the main advantages are in terms of better density of coating. And we by this thin film coating we also achieve superior optical quality. And we love very high uniformity, in terms of very good uniformity across the width of the know glass layer. And huge range of products is possible as per the needs of the customer.

We can manufacture both the as we saw earlier, the both anti solar and low e range of products in this offline coating process. And this causes flexible, and you can also adopt to the different needs of the coatings that is can be emerging needs of the market can be addressed by new technologies that is you know possible from this offline coating process.

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The limitations of this coating process are it needs capital investment. And since the process is quite complex it needs expertise in terms of both process management and also in terms of product development. So, we need deep process expertise here to manage this.

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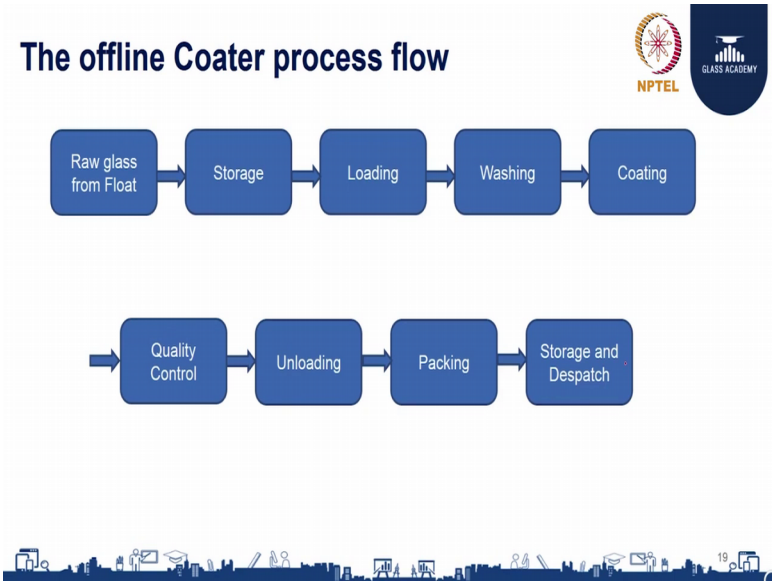


Now, let us understand in a overall coater plant; how the coater offline coating process happens at a broader level. The process is as we said the raw glass is received for the float line, and then it is taken for storage, and it is it is taken into the line and it is loaded. And the first process is washing wherein we clean the glass surface. That is needed that is going for coating. And next the coating process happens. Post the coating we have quality control. We unload the glass and then it is send for packing and then it is stored and despatch the customer. This is the broad overview of the process flow of coating.

Now let us understand each of these steps in detail.

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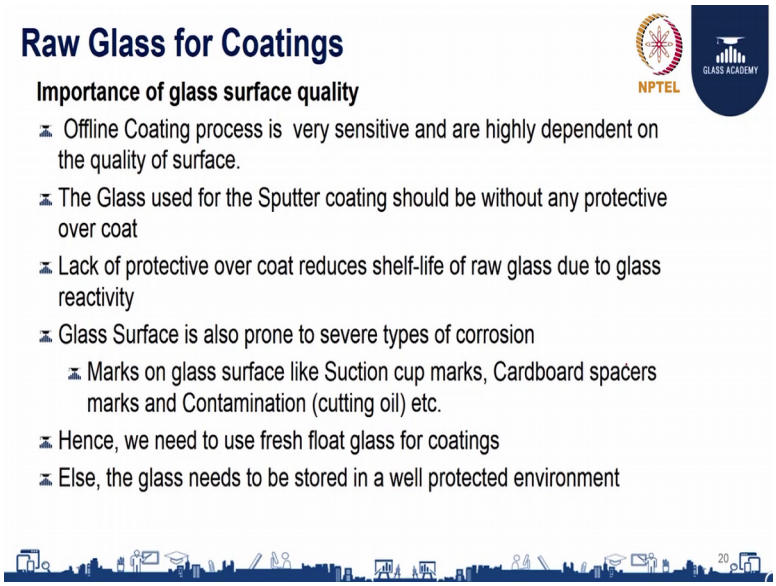


The raw glass: the raw glass from the raw glass for coating. The surface of the raw glass is quite critical for this coating process. See as such the coating process is very sensitive and is highly dependent on the quality of the surface of the glass parent glass.

So, the parent for sputter coating should be without any protective over coat, it should not have any over coat. So since, by virtue of not having only over coat these raw glass can be you know susceptible for reaction to the atmosphere. So, the shelf life of raw glass is critical here. So, on top of this raw glass is also prone for corrosions, like suction cup marks and know phase of marks and oil traces.

So, it is advisable to use fresh glass from the float line for this coating process. If it is not possible, then the glass has to be stored in a productive environment so that know the glass surface is protected and can be no use for coatings. This is highly critical.

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Next process is washing. For the washing process the water quality is extremely critical. So, the water should be free from sediments minerals and ions, for not we get the superior surface quality after cleaning.

So, the normal conductivity of the water should be in the range of 0.1 microsiemens for centimeter cube. And the typical water treatment process what is recommended is you know once we have the raw water it has to be initial filtration, it has to be go for UV treatment, dual media filter and yeah reverse osmosis process, and electrodeionization process. And the final quality water has to know be separate for the directly to the washing machine for the complete cleaning.

The washing process has a pre cleaning process. You are polishing section by which we prepare the surface of the glass for coating. And then initial rinsing final rinsing and curing. The EDI water is generally given directly to the final rinsing zone.

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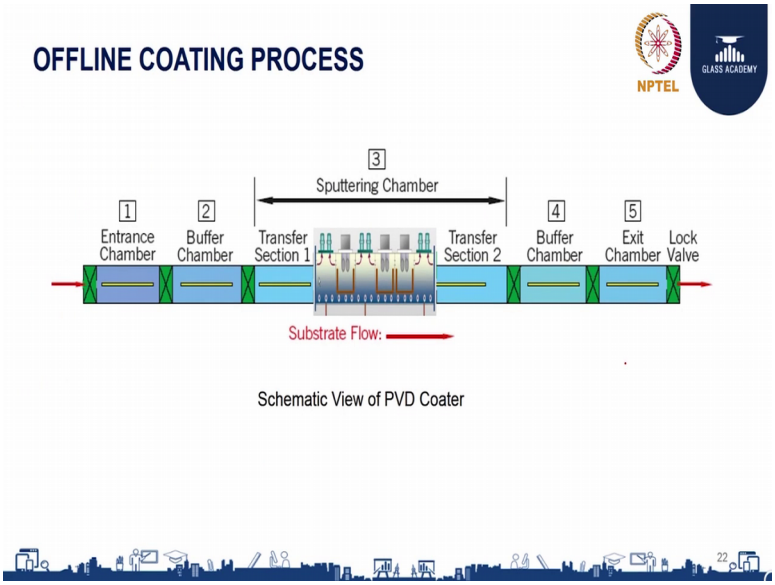


Now, moving on this is the schematic view of the PVD coater setup here we have the blocks which is set in terms of empty chambers, buffer chamber, and then the sputter chamber, the exit buffer, and exit chambers. So, this is the series of blocks.

As I said the entire sputter chamber is kept under ultrahigh vacuum, in the range of 10 power minus 6 millibar. So, this vacuum range is achieved in terms of steps, so the entry chamber and the buffer chamber this support in terms of achieving this know process vacuum. So, the glass is moved in term in steps to achieve this high vacuum environment.

So, entrance chamber can be know it is from the atmospheric pressure you can go down to 10 power minus 2 millibar, the buffer chamber generally is maintained at 10 power minus 4 millibar from there the transverse section operates at the process vacuum.

So, the glass is moved in steps in under vacuum is built in steps downwards here. And the exactly the reverse process happens in the exit section here. From the transverse section we come to the atmosphere in steps. So, from 10 power minus 6 millibar range we come to buffer chamber varies 10 power minus 4 and then the exit chamber at 10 power minus 2, from there it breaks down to the know atmosphere where the venting is done and then it the glass is transferred to the know atmosphere for the unloading section.

So, this is the basic you know schematic view of the entire coater plant as such. Let us see this sputter chamber in more detail here.

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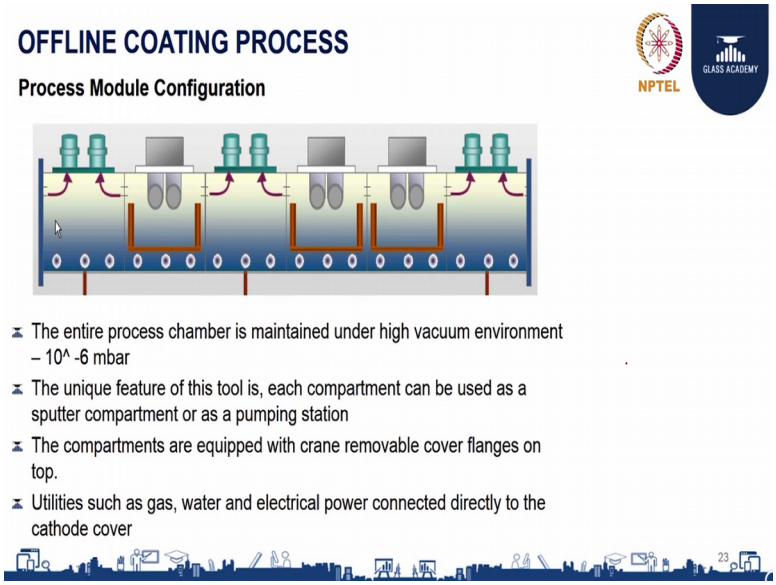


First we will see the entire process module configuration, where this entire process module is maintain entire the high vacuum environment. We will see here know the pump compartment as well as the cathode compartment. As I told this is the entire process chamber is maintained under high vacuum. The unique feature is know this is the universal chamber it can be it can accommodate both the pump as well as cathode compartment, and it can be reconfigured as per the needs of the process and also the product needs.

So, and the compartment lids are equipped with know with removable and cathode are pump lids can be removed with the crane and they can be taken for maintenance and the replenish back. And all the utilities are needed for the process into the process gas, the cooling water, and the electrical power are connected directly to the cathode cover.

So, this is generally how the process the entire process module configuration is built.

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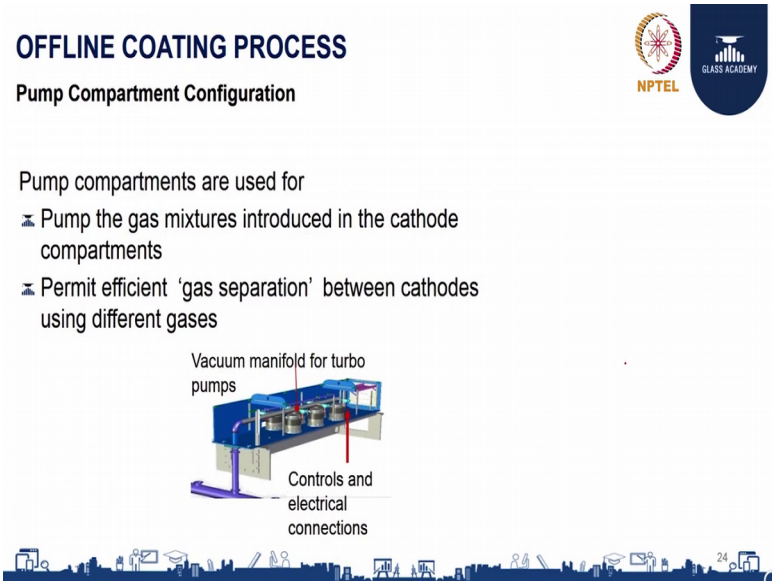


And let us study the pump compartment in more detail. The pump compartment is the one which maintains the vacuum process vacuum and also ensures that the there is a good gas separation between the cathodes, which use different process gases. So, it has you know it has the pump pre vacuum pump pipe which is directly connected to the, you know pumps which is mounted onto the lids.

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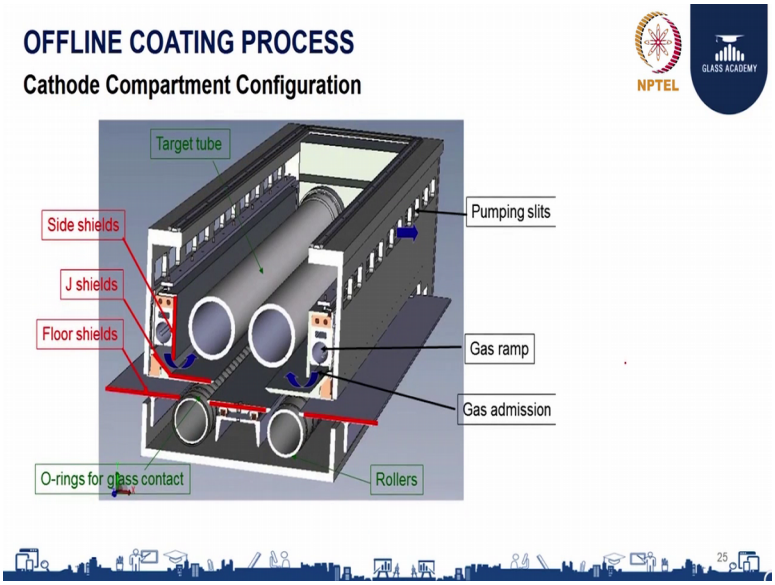


Next is the cathode compartment. Here you see the section of the cathode compartment. As you can see the bottom rollers are the ones which are cunning the glass at a fixed line

speed. The two cylindrical tubes that you see in the top, these two tubes these are the ones are the target materials subcomponents of these tubes has the target material that needs to be deposited on the glass.

What we also see here is the environments where we have the shields which are protecting the sputter the sputtering actually focusing on the actual width of the glass that needs to be exposed. And we also have a protection shields in terms of flow shields which protect the coatings from falling onto the rollers and also to the surrounding environment. And we see the pump slits which enabled the process gas to be pumped out to the adjacent pump compartments. And the gas ramps these are the gas ramps through which we pumping the gas that is required for the process. And yes, and know the process rollers has a o rings which ensures that the minimum contact of on the glass.

So, this is the basic you know sectional view of the cathode compartment.

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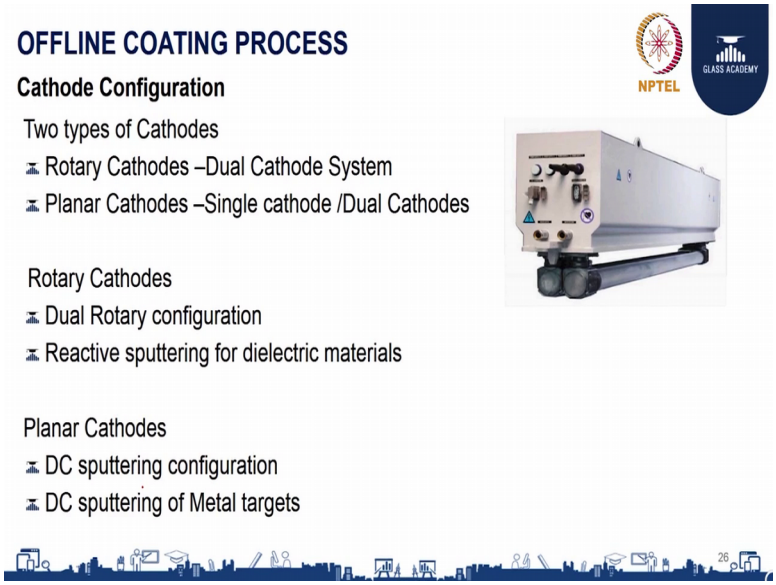


In terms of cathodes we have two types of cathodes: one is the rotary cathode which is the know dual AC system and second is the planar cathode which is the single or you know which can be single or dual system.

So, generally the rotary cathodes are used for reactive in the sputtering of dielectric materials. And this is the typical know cathode rotary cathode that you see in the picture here. And planar cathodes they are generally used for metallic know sputtering.

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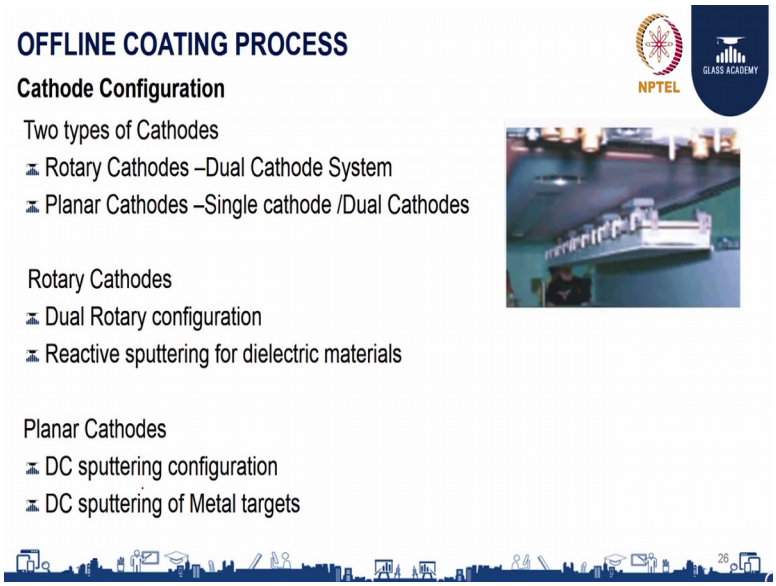


And this is a typical section of the know planar target that you see. And this is the specific material that needs to be deposited in the glass. This is fixes the rectangular tile on the planar cathode surface.

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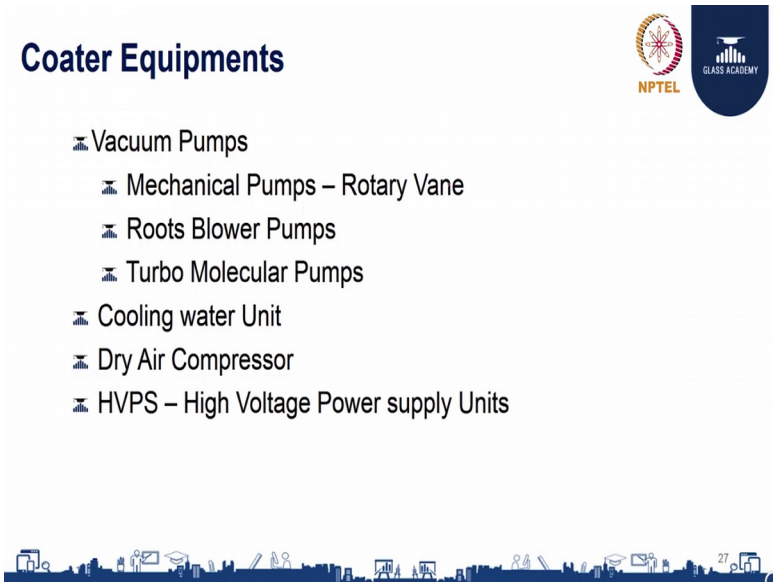


Moving on, supporting the basic coater we have vacuum pumps which we needs to be in 3 stages. We have first the mechanical pumps which are rotary generally rotary vane pumps that operate from the atmosphere to a know 10 power minus 2 range and from there the roots blower pump which support the backup which acts as a backup pump for

the mechanical pumps. And in that pump lids we have thermo molecular pumps which maintain the high vacuum of 10 power minus 6 millibar range.

And since this process happens also generates heat inside the coating chamber we have a cooling water unit that is supplies a cooling water to the coating environment the shields, and also to the pumps. And also the power supply units. The dry air compressor this is needed for to know for a vending cycle that is at the both entry chamber as well as the exit chamber.

And power supplies this is for connected for each of the cathode has the individual power supply unit connected and this is could be either AC power supply or a DC power supply depending on the cathode configuration.

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