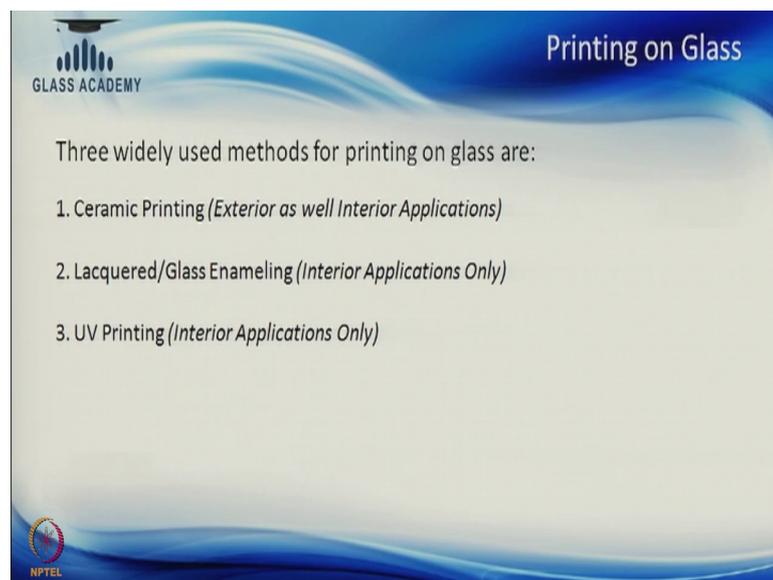


Glass Processing Technology
Prof. Mr. Pranit Malik
Department of Materials and Metallurgical Engineering
Indian Institute of Technology, Kanpur

Lecture – 59
Ceramic Printing on Glass Part-1

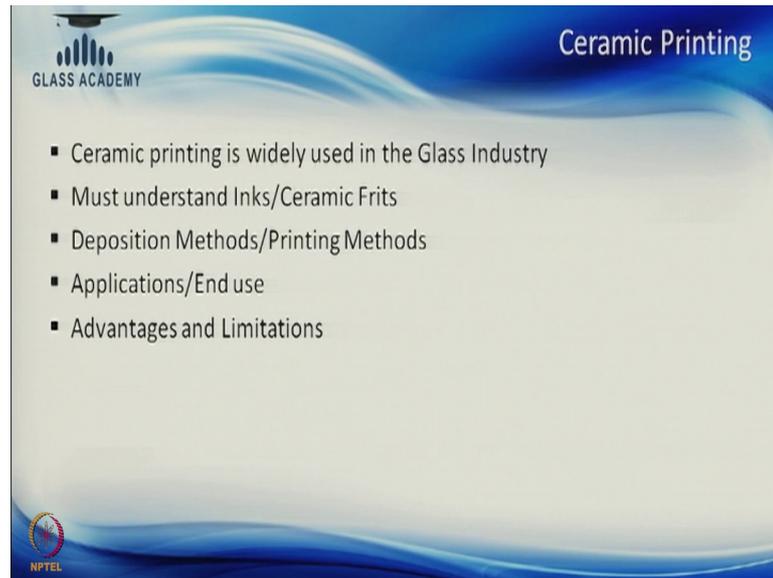
Hi, I am Pranit Malik, I am going to talk about Ceramic Printing on Glass, I have been in the industry now since 2003. So, I have roughly 15 years of experience in glass and I have been fortunate enough to work with ceramic printing for this period and I have seen various methods of printing across the time span. So, I will quickly go through what are the main ways of printing on glass so, I will get right down to it.

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So, normally when you print on glass, you can either do ceramic printing or you can do lacquering or we call enameling or you can also do UV printing. But, in my presentation I am going to cover ceramic printing which pertains to printing with ceramic frit on glass and that is the topic of my presentation.

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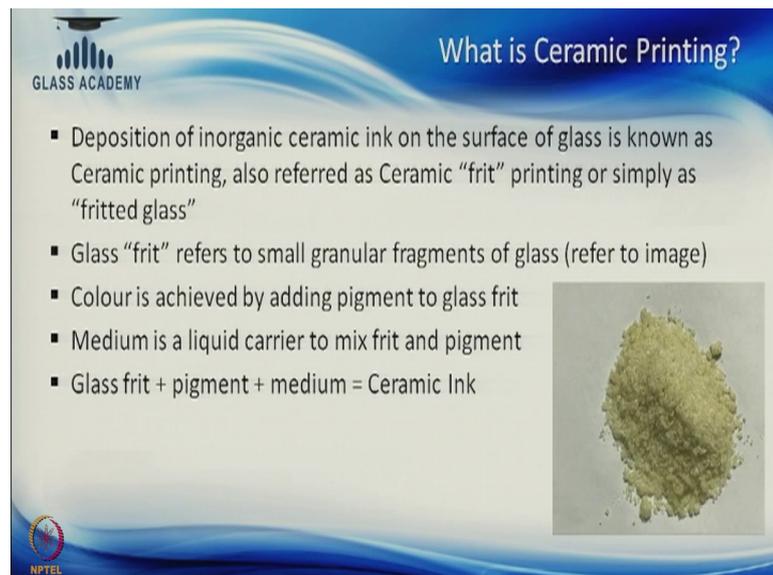


Ceramic Printing

- Ceramic printing is widely used in the Glass Industry
- Must understand Inks/Ceramic Frits
- Deposition Methods/Printing Methods
- Applications/End use
- Advantages and Limitations

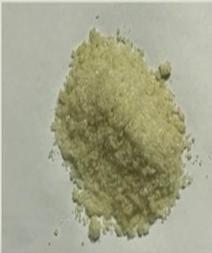
Ceramic printing is widely used in the glass industry and in order to print well we must understand ceramic inks, we must understand how they are deposited on the glass surface, their various methods to do so. And the end use of the glass will determine which methods are more suitable and which process needs to be followed, which inks need to be used. There are limitations and advantages to ceramic printing as is there with any other material so, we dwell on that as well.

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What is Ceramic Printing?

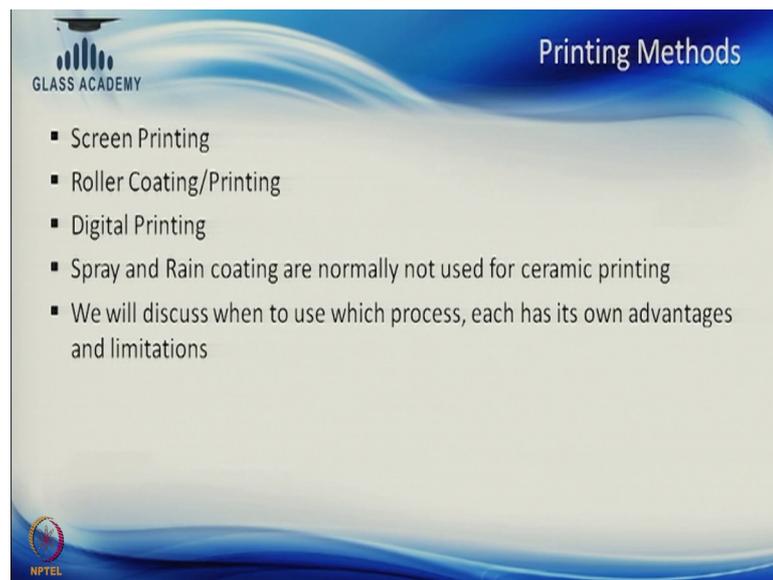
- Deposition of inorganic ceramic ink on the surface of glass is known as Ceramic printing, also referred as Ceramic "frit" printing or simply as "fritted glass"
- Glass "frit" refers to small granular fragments of glass (refer to image)
- Colour is achieved by adding pigment to glass frit
- Medium is a liquid carrier to mix frit and pigment
- Glass frit + pigment + medium = Ceramic Ink



Ceramic printing is essentially inorganic ceramic frit which is deposited on the glass surface through various application methods. Glass frit is essentially very small granules of glass itself as is seen in the image. It is crushed down pieces of glass which is then added with pigment which is an inorganic pigment which gives the color, different metals will have different colors and that will be mixed with the glass frit. And then a medium will be added which is a solvent essentially which will carry the glass frit and the pigment onto the glass surface.

So, essentially ceramic ink is glass frit pigment and medium put together. So, all of these three put together give you ceramic ink. So, ceramic ink is different than any other ink that is out there because, it will embed itself on the glass, unlike other inks which will have just a chemical attachment to the glass this will fuse on to the surface of the glass.

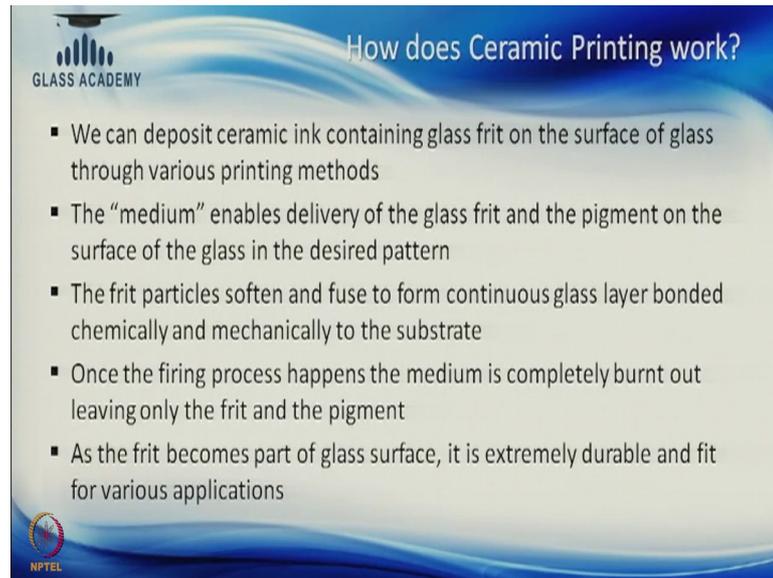
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We can print through three methods, screen printing which is better for doing patterns designs; roller coating or roller printing which is essentially if you do solids or single colors in more volumes and better uniformity. And a lately digital printing which is inkjet printing on glass which really increases what you can do with printing on glass.

There are other methods like spray and rain coating which are normally used for lacquering, but are not suitable for ceramic printing because the depositions are too thick and do not suit the ceramic rate. So, each of the processes have advantages and limitations and we will go through the processes and understand them better.

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How does Ceramic Printing work?

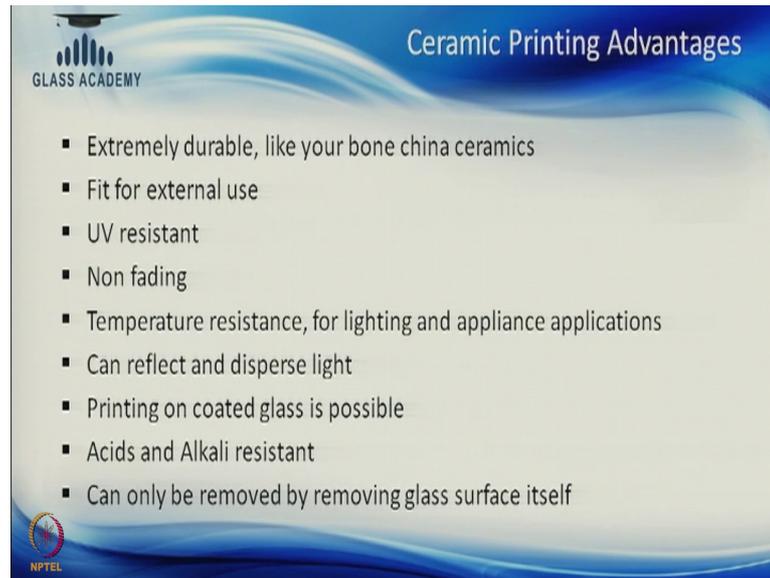
- We can deposit ceramic ink containing glass frit on the surface of glass through various printing methods
- The “medium” enables delivery of the glass frit and the pigment on the surface of the glass in the desired pattern
- The frit particles soften and fuse to form continuous glass layer bonded chemically and mechanically to the substrate
- Once the firing process happens the medium is completely burnt out leaving only the frit and the pigment
- As the frit becomes part of glass surface, it is extremely durable and fit for various applications

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The ceramic printing is different than other inks and other printing methods essentially because of the ceramic frit. So, the ceramic ink has a glass frit which is transferred onto the glass with something which is called as a medium or which is the solvent which is which carries the glass frit and the pigment on the surface of the glass.

The frit particles softened when fired at a high temperature and fuse onto the surface of the glass and form a continuous layer bonded chemically and mechanically to the substrate. Now, the hardness of this particular material makes it usable for various applications which other inks cannot be useful. So, once the ink is fired, the medium completely burns out it is just there to deposit the glass frit onto the glass surface and it makes the ink very durable and fit for many extreme applications.

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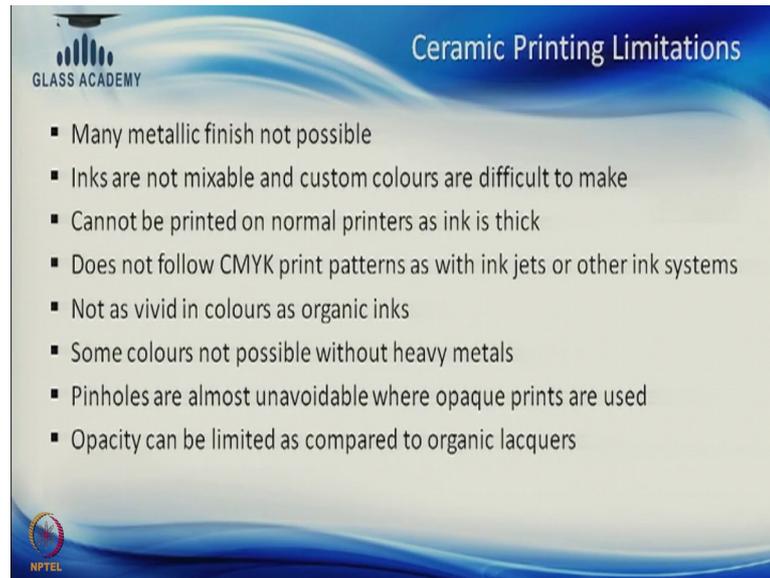


So, what are the advantages of ceramic frit printing? It is essentially like a bone China; it never loses color it never fades it fits for external use. It is UV resistant so, it does not fade if you have some other lacquers let us say on external surfaces they will fade and loose color. There are very few inks out there which do not fade with time, but ceramic frit printing, since it is a part of glass is very resistant to fading and it is also resistant to acids and alkali attacks with all the acid rain and all the chemicals out there other materials do deteriorate with time.

And you can print on variety of glass substrates you can print on coated glass, although not all coatings we have to check with the coating manufacturer before printing it on each coating and with the ink manufacturer as well. But it is definitely possible and then you know worldwide.

You can also print on side one which is the outside side, so which is also great. There are certain applications where the temperature of the glass will rise for your ovens, toasters grills for your lighting applications. So, this kind of an ink is perfect for those applications and is widely used across industries.

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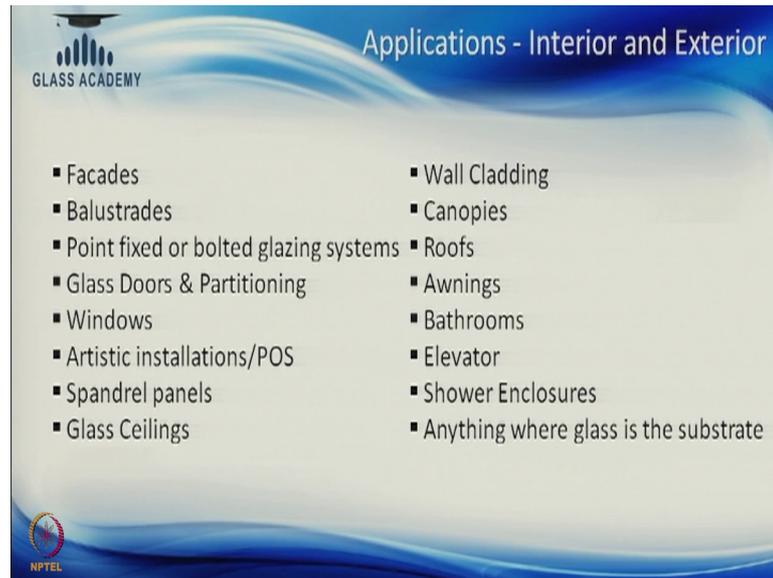


There are certain limitations for the ceramic plate as well, metallic finishes very shiny surfaces cannot be made. Inks are not essentially mixable as some other forms of ink this is due to the glass frit itself. So, because there are actual particles of glass you can understand that the glass particles will not fuse into each other. So, it is not that easy to mix these inks.

They cannot be printed with normal printers and you know conventional techniques, it does not work on a CMYK pattern that means you cannot have just four base colors and have multiple colors come out of it. So, there are limitations with the inks the colors are not as vivid as some of the organic inks, you may see certain lacquers where the reds really pop out or the oranges really pop out. It is lesser so although the inks are improving everyday and they are becoming more vivid as we go along.

Some colors will have heavy metals and because of that certain colors will not be possible in certain countries where you know heavy metals are not allowed. Pinholes and opacity in the ceramic frit is will not be the same as organic printing. This is an inherent problem with ceramic treat because, the glass frit has to embed on the surface of the glass and because of that you cannot have too much pigment going in. Opacity will be lighter so, certain applications you know it may be better to use organic lacquers where internal applications we use widely used lacquered glass for the same.

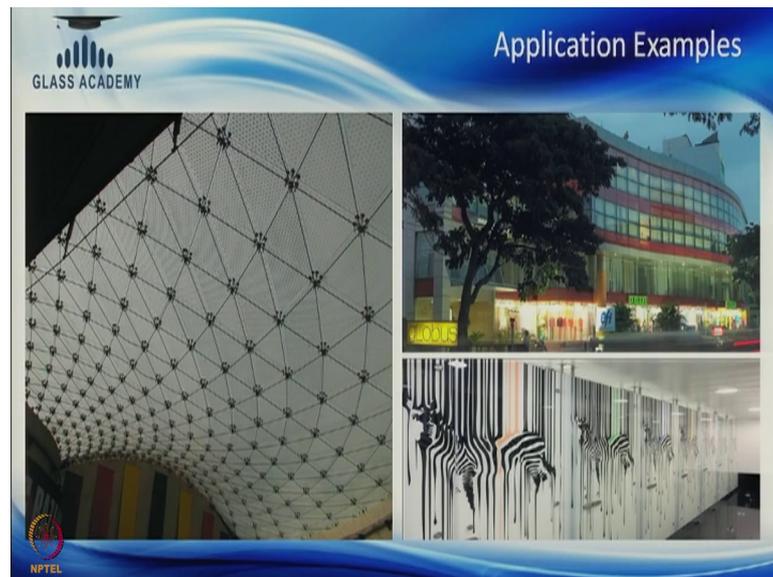
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There are a variety of applications that ceramic related glass is used for. Facades, it is used for letting less amount of heat in, it reduces the solar factor, a design factor to the glass, you can use it for wall cladding applications, various industrial applications, all your cars, all your wind screens normally have ceramic frit printing the oven toasters and grills that you use every day, the glass chimneys that you see, the glass hops that you will see.

Spandrel panels in facades is an important application, where it is being used more and more these days. And you can use it in n number of positions bathroom shower cubicles are becoming digitally printed these days which really adds to the aesthetic appeal of the bathroom. So, yes, there are many applications where ceramic foot printing is used and we be used continues to grow.

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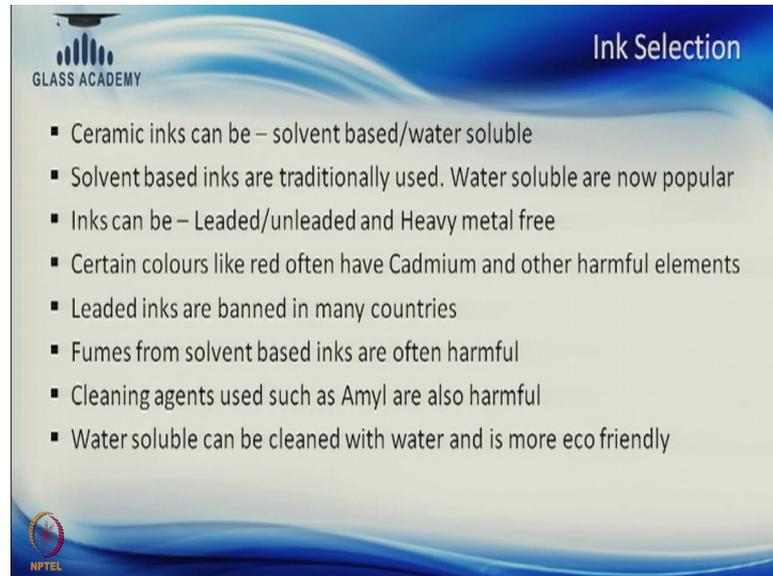
These are just a few example skylight with a ceramic frit will allow less heat and light to come in, although we can control the amount of light that is coming in. So, maybe even a 50 percent rate will allow enough light to come into the building and still at the same time it will reflect off you know 30 percent or so of the light back. So, you can have many kind of frit patterns on skylight applications and it is widely used in skylights. The other examples of wall cladding or other areas of the buildings are also shown over here.

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Digital designs can be both all throughout the building and that means, that you can have multicolored trends, you can have you know you can add a design feature to the building so, really the applications are endless.

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Ink Selection

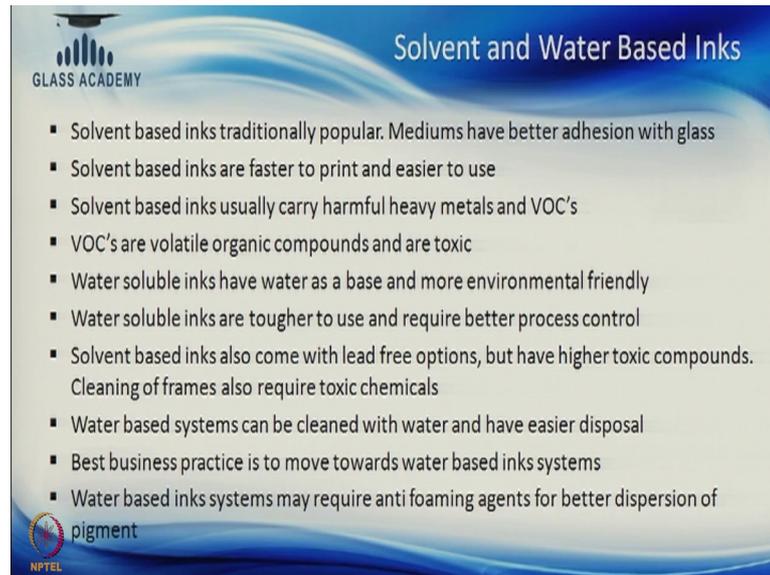
- Ceramic inks can be – solvent based/water soluble
- Solvent based inks are traditionally used. Water soluble are now popular
- Inks can be – Leaded/unleaded and Heavy metal free
- Certain colours like red often have Cadmium and other harmful elements
- Leaded inks are banned in many countries
- Fumes from solvent based inks are often harmful
- Cleaning agents used such as Amyl are also harmful
- Water soluble can be cleaned with water and is more eco friendly

Now, let us move onto ink selection so, there are ceramic frit is not just a homogeneous one kind of ink. There are many ink options available, ceramic inks can be solvent based or they can be water soluble or water based. Solvent based inks are traditionally what have been used you know since a long time and water based inks are now becoming popular.

Inks can be leaded unleaded or heavy metal free as well, but certain colors like red normally have cadmium and other toxic elements. So, it is difficult to achieve a good red without some heavy metals so, a lot of work is going on that. And leaded inks, because we know lead is toxic is banned in many countries and fumes from the solvent based inks are generally harmful.

So, you need to wear masks, you need to be careful how you handle it you need to you know have certain precautions while using the print and it is not that easy to get dispose of. Cleaning agents for cleaning the you know glass, for cleaning the frames is also harmful and that is how water based and water soluble inks have become more popular, they are more environmental friendly as compared to solvent based things right. So, solvent and water-based inks I will dwell on this a little bit more.

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Solvent and Water Based Inks

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- Solvent based inks traditionally popular. Mediums have better adhesion with glass
- Solvent based inks are faster to print and easier to use
- Solvent based inks usually carry harmful heavy metals and VOC's
- VOC's are volatile organic compounds and are toxic
- Water soluble inks have water as a base and more environmental friendly
- Water soluble inks are tougher to use and require better process control
- Solvent based inks also come with lead free options, but have higher toxic compounds. Cleaning of frames also require toxic chemicals
- Water based systems can be cleaned with water and have easier disposal
- Best business practice is to move towards water based inks systems
- Water based inks systems may require anti foaming agents for better dispersion of pigment

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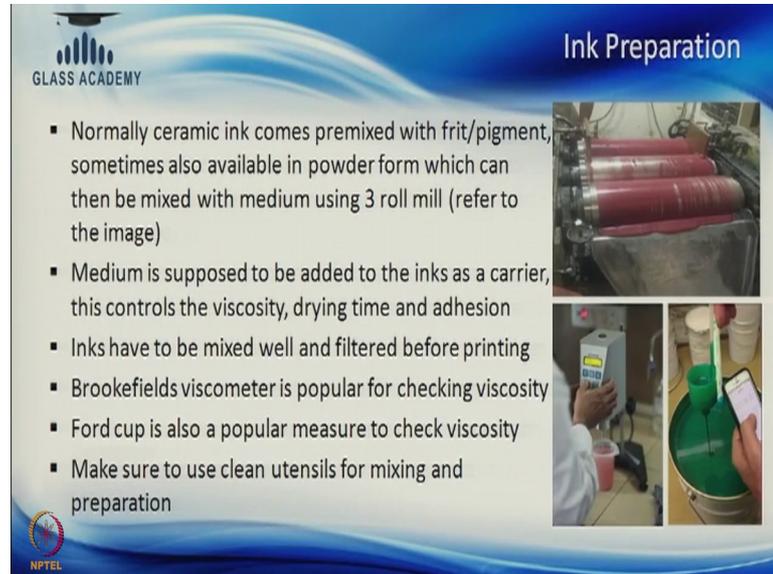
Solvent based inks are traditionally available, they are cheap, they are easy to use, they are faster to print; that means, that you can print a lot more glasses with solvent based inks before you need to change the process or change the ink. But, they generally carry harmful chemicals and they have something called the VOC's which is a volatile organic compound which are toxic. The degree of toxicity will vary on the ink that you use, so not all solvent based inks are the same there would be certain which are lead free there they would be certain which are heavy metal free.

But, when we say heavy metal free it is once again a percentage and you still need to clean it with solvents a mild the emulsions are also toxic. So, the entire ink system itself is not very environmental friendly. So, here comes the water based stains which are essentially made with water base and they have some poor solvents which may also have VOC's. So, it is not as if water based inks are completely without heavy metals, but again and there is a range of what these water based inks as well.

But, essentially what a based inks can be cleaned with water that means, that it is much easier you know much fewer chemicals are used to process it. And you get better inks with you know less heavy metal content as compared to solvent based inks. So, the best business practices across the world are moving to water based ink systems, they are harder to use, the adhesion levels between the ink and the glass is somewhat more difficult. The storage situation is a little bit more difficult, some of the processes need to

be more controlled, but they are improving everyday and it is widely used across the world.

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Ink Preparation

- Normally ceramic ink comes premixed with frit/pigment, sometimes also available in powder form which can then be mixed with medium using 3 roll mill (refer to the image)
- Medium is supposed to be added to the inks as a carrier, this controls the viscosity, drying time and adhesion
- Inks have to be mixed well and filtered before printing
- Brookfields viscometer is popular for checking viscosity
- Ford cup is also a popular measure to check viscosity
- Make sure to use clean utensils for mixing and preparation

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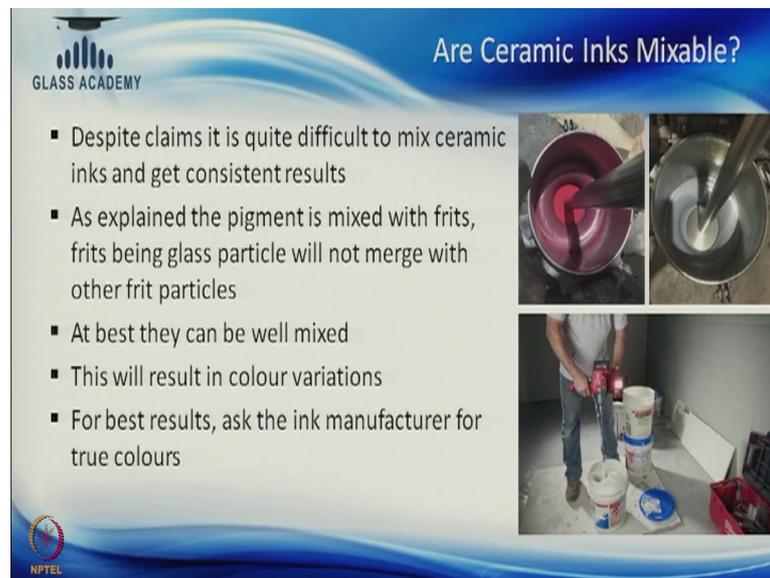
So, we talked about ink a little bit more, because, in order to get the ceramic frit right you need to get the ink right. So, because that is the material that you are printing with and if the ink is incorrect and your results will not be good. So, let us understand how the ink is made a little bit the pre mixed frit and pigment sometimes come in the powdered form.

And they can be then further mixed with a machine which is called the 3 roll mill. This is generally found with the ink manufacturer, but it is important for you to understand how this is done. So, with a 3 roll mill the glass frayed the pigment and the medium get mixed well you cannot do it with a normal stirring or a simple machine.

The medium is the carrier for the glass frit and the pigment and the ratio at which the pigment or the medium has to be added is recommended by the ink manufacturer and it is not a constant. We have to constantly see how the glass is being printed and at what viscosity we are getting the ink. So, in order to check the viscosity we have to use something called a Brookfields viscometer or a Ford cup these are essentially instruments to check the viscosity of the ink.

So, the pigment and the glass frit will come in a particular viscosity and you add the medium with it to increase or reduce the viscosity of the ink. And there are certain recommendations on what should be the viscosity. This would depend on what you are printing and which exact process is being followed, we will get into the details when we get to each process. So, for right now it is essential for us to understand that we have to control the viscosity we have to know where the ink is mixed well, we have to use clean utensils we have to check all of these things and before we start off to printing.

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Are Ceramic Inks Mixable?

- Despite claims it is quite difficult to mix ceramic inks and get consistent results
- As explained the pigment is mixed with frits, frits being glass particle will not merge with other frit particles
- At best they can be well mixed
- This will result in colour variations
- For best results, ask the ink manufacturer for true colours

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The slide includes three photographs: two showing close-ups of mixing in containers and one showing a person using a power drill to mix ink in a bucket.

Now, it is not as easy as mixing some other inks or ceramic inks like I explained have glass frits. So, they do not essentially merge into each other, you can mix them and get a certain colors, but when you print them they may appear different from different angles. So, ceramic frit printing mixing is a complex issue, there are quite many claims which say we have ceramic inks which mix well, but the results have not been consistent and it is not the easiest thing to do. Even in the same ratios, when you mix the inks the results may be different or may be viewed differently from different angles. The essential reason is that the glass frits do not merge with each other at best they get mixed well within each other.

So, there will be color variations, I strongly recommend to have the original pigment from the ink manufacturer especially in projects where the glass has to be you know our continuous glass façade. You can get pre mixed pigments from the ink manufacturer it

does take a little bit of time, but that is the most consistent way to get a uniform color. If you do mix inks, make sure that you have a single lot for a single project, otherwise the colors is very difficult to repeat. So, you will not get the same uniformity that will get with the pre mixed.

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Summary:

By the end of this video, you have learnt about the:

- Methods of printing on glass
- Ceramic printing
- Printing methods
- Advantages, Limitations and Applications of ceramic printing
- Ink selection
- Solvent and water based inks
- Ink preparation