Industrial Inorganic Chemistry
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Lecture – 55
Layers of Enamelling

Good evening everybody. So, welcome back where we are talking about the Enamels. So, enamels what we can give it in two different layers. So, when we try to prepare the two layers of enamel. The first one will be a ground coat and which is bound to the directly to the substrate and after getting that you can cover that with another coat.

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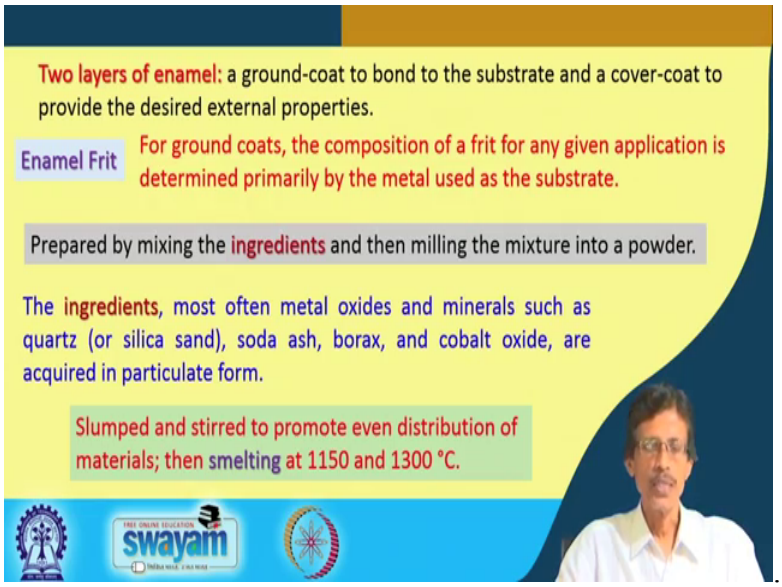

So, a ground coat to bound to the enamel and the cover coat to provide the desired external properties, because ultimately what we will be looking for is the surface. After enamel coating how the surface will look like and how it will be useful for different useful purposes?

So, like that of any painting any surface by normal paints, inorganic paints and pigments. We can always have a ground coat, because the ground coat is always required to bind the upper coat with that of your material or the substrate. So, that is why we tell here is that a ground coat to bond the substrate; that means, to fix the substrate with that of your enamel surface.

And, ultimately we can have a cover coat to provide the desired external properties or derive external look. So, what is that enamel frit? So, that enamel frit we will be using for this particular purpose and ultimately through the melting procedure we get the desired enamelling of the material.

So, when we go for that particular ground coat, the composition of the frit is important for a given type of enamel. We must have a particular type of application is determined primarily by the metallic element used for making that particular substrate. So, if we want to get a corresponding surface of that material so, the metal wood we can use for that particular frit making that we will see. So, how they are prepared?

So, the basic ingredients for making the enamel frits is by mixing some of the ingredients. So, the ingredients will have and those ingredients can be in a lump form in a very block type of thing. So, the milling of that; that means, grinding of that particular material; that means, all the ingredients first we mix it, then we go for grinding in some milling or the ball milling procedure to get ultimately very fine powder. So, powder like particles will be there. Basically, we will just then coat the entire thing with that of your powder material.

So, this is sometime we called in metallurgical engineering or any other area we know that a powder metallurgy is there; that means, something we get in the powdered form and making or obtaining that material in the powder form is also very important. Because not that that everything we can get as the powder material. So, the material the starting material, the raw materials should be in the very dry condition. No moisture or any other thing, any other ingredient or external material or the impurities should not be there such that very straight cut manner we can convert the entire material into a powder material.

So, the different types of ingredients what we can have the metal surface that we are looking for basically it can come as the metal oxides. So, if we want to have something as the corresponding aluminium, we get for the corresponding aluminium oxide and minerals; that means, other ingredients which we consider it as the mineral type material which is being added there, which is simply the quartz or the sand type of material and SiO 2. So, which we also consider as the silica sand so, the quartz will also be there because the quartz will basically ultimately giving the finishing thing. Because the

surface will be the glass like material, because the enamel what we are getting after enamelling process is basically a glass like surface.

So, the basic ingredients what we know that we can get it through that particular silica SiO 2, then the fusion of that material can be achieved by through two different types; that means, through different materials one can be your soda ash and another is the borax. Borax ultimately giving you the boric acid and that is also coming into the fusion mixture; that means, every material is being fused when we go for heat treatment.

So, heat treatment is also an important part and the ingredients can have also a temperature where we can fuse everything. Then, we can have also the cobalt oxide, because the cobalt oxide when we will consider in our future classes some of the future classes the inorganic pigments, the cobalt oxides are colored.

So, if we want to give some blue tinge to the enamel material, we can directly add the cobalt oxide which is blue in color and all of them all the ingredients we should have in our hand in a particulate form there particles like form. So, all the different particles are mixed together and the particle size basically are also important when we mix and we get ultimately all the mixtures of the ingredients. Then we basically slump them; that means, they mix together and start; that means, uniform mixing.

So, all the components is not that your silica will be at the surface such that we get a after fusion a glass like material out of only silica, but it is a basically again what we have discussed earlier that it is basically a composite material. Composite material making out of all these individual ingredients and, those individual ingredients we are supplying in the form of typically the metal oxides to your cobalt oxide, or the borax or the soda ash.

So, after stirring what we get we basically because the uniform stirring if anything when we stir a solution because we know the homogeneity should come. So, we should have a homogeneous mixture. And, that homogeneous mixtures and only be achieved, if you have some uniform stirring mechanism. So, mechanical stirring we know that in the laboratory from the top, the model is fixed and we can have at the bottom the container containing those materials.

So, in the reactors what we have in the industrial scale or industrial size is the bigger one and a mechanical stirring type of thing can be fixed from the top. So, the motor is there and the stirring rod and the stirring blades will be there which can go inside your container and can stir it uniformly.

So, once you are satisfied that you have achieved a very uniform distribution such that all the ingredients what is available for making that enamel is in uniform pattern. Then, we can go for the smelting, because the smelting we always know that is the technical term for metallurgical people, because the smelting of the ores we know, what we achieve for the iron industry or the copper industry or these the ores first we go for the smelting. The burning of the thing because some ingredients some the volatile matter can go out or you achieve something, which is in the pure form at that particular temperature.

So, for this particular case the mixture which is then undergone for smelting at a temperature in the range of 1150 to 1300 degree centigrade? So, something which can be burned basically at that particular temperature, if some volatile matter or easily burned material, which is present as an impurity, which can be converted to the corresponding oxides and can leave the material. So, at this particular point, at this particular temperature also we achieve something which is purely of those ingredients what we have used for making the enamel frit.

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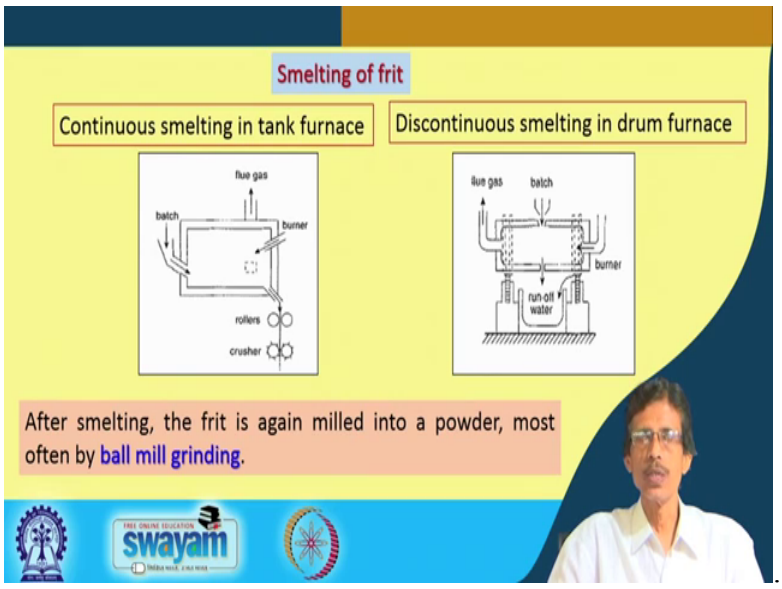

Then, once we your material is ready the ingredient the mixture of the ingredients are ready for getting you the frit then we go for the smelting process. So, how we go for that smelting? So, definitely since it is the burning process at a temperature above 1000. So, we take some furnace. And the furnace the design the shape and the size of this furnace is very much similar to that of a drum. That is why we have a drum surface and if the process is basically a discontinuous were not the continuous so and so definitely, we will have another procedure where we use the continuous smelting.

So, that is why we use the discontinuous smelting in drum furnace. So, in the drum furnace we basically use that thing so, is the drum like container. So, whatever you have this particular one the drum like container you can have and the material that mean the corresponding batch of that material; that means, the ingredients is basically fed, with this particular entry point, you can have some entry point for entering this batch material. And at the two ends you can have the burner, for hitting the corresponding drum furnace, and the material what is being burned at the particular temperature that is of 1150 to 1300 degree centigrade.

Basically as I told you that if you have some sulfur, if you have some carbon, or if you some other nitrogen type of thing the nitrogenous matter all will be burn because in air we are burning. So, they will be converted into the corresponding oxides, that mean carbon dioxide, sulfur dioxide or nitrogen oxides. So, these are known as the flue gas. So, the gas will come out from the solid material at the top and is collected and then can leave the corresponding drum furnace through this particular point or pipe. So, these basically give you. So, this is another entry point. So, this batch material can be entered through here and also from the right hand side.

So, as we have a discontinuous smelting process, we can definitely have a continuous process, continuous heating process, in smelting in drum tank furnace. So, here basically the design of the furnace is different. So, you have the burning procedure in some point; that means, some rods of the heated elements will be there, the batch entry is there from one other point and the flue gas can come out from the top.

So, when this material; that means, the frit is being formed. So, we can take out that particular material from these and through a roller mechanisms through a roller, because is basically pressed.

So, through this rolling mechanism because you can have a conveyor belt to carry that material. So, rollers are utilized for rolling or placing the thing and; that means, is the hard placing the material, and push to the crusher and crusher will then break the thing and can give you the corresponding powder material.

So, once we get this smelting process the frit is again milled. Therefore, that means, the rolling process or the crusher process. So, the frit if it is in again in some cake form or the some solidious form so, then again it can be milled into a powder most often by utilizing a corresponding ball mill.

So, the grinding the powder making procedure is being achieved through a ball mill, and ball mill grinding procedure is therefore, followed during the smelting of the frit.

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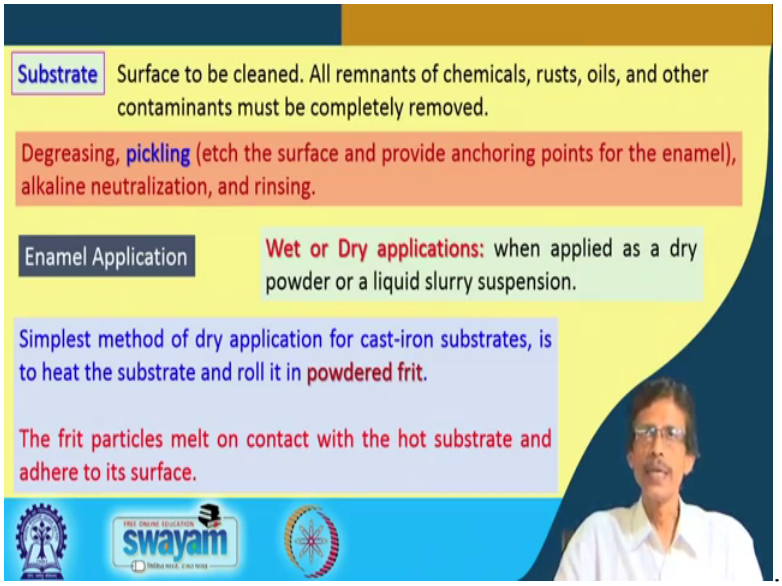

Then the substrate how you get the corresponding substrate on which you try to get the corresponding enamel surface? So, substrate you can have it can you have a very rough very bad quality iron container you can have or some aluminum container or a bad quality of copper container. Because, you want to have a good attachment, good bonding, and good surface property of that particular iron material, or say iron container say or cook wire, some cook wire we want to make on the iron container by enamelling.

First thing what we can do; that means, the any greasy material any other foreign material or the foreign particles, which is tinged on the surface is to be cleaned. So, it is

material this being cleaned. So, all the remaining or the remnant of the chemicals you can have the rusts as I told you that the material is your iron. So, if the material is kept in a air surface or in presence of moisture, you can have the rust on the surface, or some greasy or oily material is attached to it or other contaminants. So, the basic idea for this cleaning procedure is that, how you can nicely clean the surface such that you can have, very pure surface is not necessarily you can have a very shiny surface. But, the surface should be in your hand which is free from all the rust oil and all other foreign material. Such that you can have a nice bonding; that means, your lifetime for the enamel surface will be longer.

If your cleaning procedure is a nice one and is also a very fine one. So, after degreasing so, grease is there the oily material is there you remove that, you go for degreasing, then we go for the pickling. That is the most important part to attach that particular enamel material on the surface, which is known as etching. We know what is the etching process? The way we know that if you want to surf clean or etch the glass surface, we go for hydrofluoric acid.

As, we all know that the hydrofluoric acid h f can attack the surface of SIO 2 giving you silicon tetrafluoride which is a volatile material, a gaseous material which can come out. So, your surface is in that way some amount of surface material is being lost; otherwise you can have a very clean surface. So, that is basically known as the pickling.

So, basically is etching of the surface, like etching of the glass surface, which can provide you some fixing point or the anchoring point, which is being utilized for attaching the enamel material or the enamel surface to the substrate, then we can have also the alkaline neutralization. So, if you some, if you can have some acidic contaminants on the surface that can be cleaned by alkali treatment or alkaline neutralization or alkali cleaning. Then finally, whatever chemicals, whatever material we use, after all these processes which has to be rinsed or it has to be washed nicely with profound amount of water.

So, water flow will be there, and the water jet sometime we can use, and that water jet can clean the surface very nicely, then your surface is ready for your enamel procedure or enamelling or the enamel application. So now, we see how we can go for this enamel application.

So, enamel application; that means, making enameling, enamelling surface on that particular surface you can have two processes; one is the wet process; that means, wet application and another is the dry application. So, when you have already we have seen that we have prepared a dry powder. So, that dry powder we can directly put on the substrate the RN container to get a very nice looking enamel signing surface, or we can go for a slurry; that means, the powder mixed with some water or any other solvent. So, get a slurry, which is not soluble, but we get what is we get as the suspended particles in the solvent we get the slurry.

So, slurry of suspension either you can have or a purely dry powder in your hand. So, one will give you dry application and other will give you the wet application. And, the most simpler process, the simplest method is basically therefore, the dry application so, you have the dry powder. So, dry powder you can spray through some mechanism, that the dry powder the way we spray the talcum powder in our body so, the spraying of the powder.

So, spraying of the powder on the very bad quality I as repeatedly I am telling is the cast iron substrate. Simply cast iron is we can decay anytime, if you keep for some months in air and moisture, the cast iron container, cast iron utensil, cast iron kitchen ware can decay with no time that is why you want to protect that particular surface through enamelling.

So, this thing can be heated. So, heat the substrate and roll it in the powder frit. So, powder frit is there and the heated particular substrate or the container is there and is basically rolling on that particular dry powder. So, at that particular temperature you can have their fusion of that particular frit material and frit material is attached to that particular substrate. So, this is one particular technique. So, the frit particles then fuse together; that means, that is why they are melt on contact with the hot substrate, because the material is hot enough to melt your frit powder and adhere to it is surface.

So, it is very simplest technique that you have the heated substrate material; that means, heated container and is fixed with that of your powder enamelling powder.

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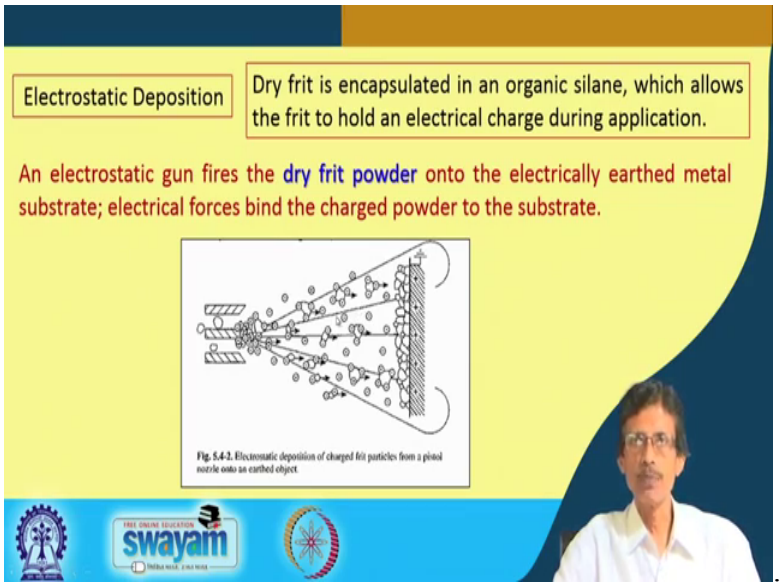

Then, another technique out of this wet and dry application is by using electrostatic deposition. If, we have something where you can have the difficulty in applying these things, through this wet application and dry applications, we can go for electrostatic deposition. So, we will take their particular charged particles. So, we have the particles which are in the powder form like that of your talcum powder, but now if we are able to apply some electric charge such that particles are charged.

So, if the substrate or the container is in some oppositely charged, if it is oppositely charged so, that will attract those charged particles and uniformly through that corresponding charged uniformity on the surface, the deposition of those charged particles will take place in a electrostatic control. So, dry frit is then encapsulated in an organic sealant material and which then allows the frit to hold the electrical charge during application.

So, if it is mixed with some organic silane, organic silane this we know that is the corresponding that material is in your organic part their carboneous part is there. So, that organic silane molecules will be then attached to that particular frit material and during that burning process or the electrostatic deposition process, it is then fired.

So, an electrostatic gun fires the dry frit powder. So, if you have the dry frit powder the electrostatic gun is utilized for firing, that particular dry frit powder onto the electrically

earthed metal substrate. So, the cast iron metal substrate or the container what you can have which have only the electrical earthing only.

So, the electrical forces bind the charge powder onto the surface. So, thing is that you have to carry those particles on to the surface of the substrate material such that you can have a uniform layering of those particles. And, those particles will be uniformly distributed on the substrate material such that, we can have after melting of those particles or the powder we get the corresponding deposited form of the enamel.

So, this is your that electrostatic deposition is taken from that bushels book again and the charged frit particles. So, you have the gun electrostatic gun on the left and this is the material that is you have the corresponding substrate material, which is in the positive end and which is there for the ground is ground; that means, basically it is earthed. So, the negatively charged all these dry frit powder materials, we are trying to deposit those negatively charged particles through a pistol nozzles. So, through these nozzles, so, we are spraying those particles; that means, that dry powder is being sprayed through a gun on the earth sub object.

So, this is the black line this black line is your earth object which is positively charged. So, all the negatively charged frit powder will be getting attracted to that particular surface that electrically charged surface and you get the deposition. So, you see these are the particles. Once it is entering with the in this particular nozzle. So, they are getting charged. So, they are negatively charged. So, mechanism or the arrangements should be such that, you can have the corresponding negatively charged particles, then you flow it. So, some force is applied some air is again passed also that such that your particles can move.

So, particles while moving on the right hand direction; that means, if you have some bigger particle you see all these are of different shapes and sizes. So, different shapes and sizes; if the particles is very small we have leveled it with one small negative charge, but if the particle is bigger of different of square type of shape we can put four negative charges, three negative charges that is all.

So, when they are reaching this particular surface, they are attracted over that particular surface, then charge is released because everything is ground. So, they are now neutral particles. So, those neutral particles one after another is deposited on that particular

surface you see how uniformly, because the packing is also nice, because depending upon the different sizes of those particles they can occupy the vacancies.

So, basically you require a very good close packing of this solid and very uniform particles, because the particles are not of regular shape they are not of circular size they are not of square type. So, they are very irregular particles. So, those irregular particles are getting deposited on the surface such that you can have uniform stacking of that particular layer on that particular surface.

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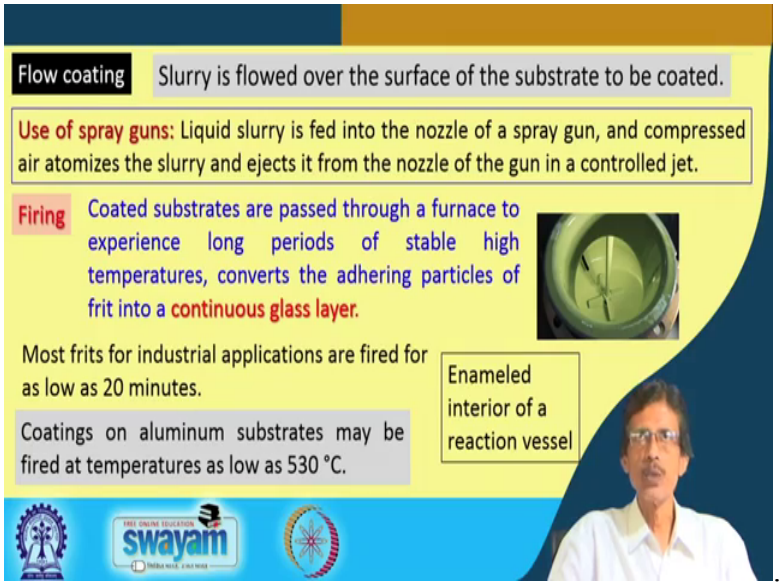

Then, we can have the flow coating also another particular coating; that means what we have seen we have seen that the slurry you can have. So, the liquid you have on the liquid you have the powder material the slurry, and if you want to flow basically the way we spraying the dry material in the similar fashion we can have the flow of that particular material which is in suspension.

So, the suspended particles in some liquid medium can be flowed in a slurry on the surface of the substance which we want to coat. So, we use a another spray gun. So, the spray gun which can handle now the your liquid slurry. So, that liquid slurry again like that of other previous thing, what we have just now seen that the gun thing; that means, you have to spray.

So, the spraying thing is that that the liquid slurry is fed into the nozzle of it is spray gun. The force is applied such that your particles will go along with now the liquid material; that means the liquid material, or the liquid solvent, or the water is your carrier, when we have the dry thing it is the air or any other gas material is the carrier.

So, the liquid which is your carrier for those particles which is flown from one direction say from left to right and then ultimately getting deposited on the surface. So, that particular surface deposition is very important. So, you can have then that the compressed air atomizes those thing and the slurry and ejects it from the nozzle of the gun in a controlled jet. So, through the jet orifice what we get we are flowing those small particles onto the surface of the substance.

So, we get so, whatever you have; that means, you have the dry you have the wet condition, you have the electrostatic deposition, or you have the flow coating. So, all the possibilities you can have, all the procedures you can have only thing that what type of thing will be available for a particular type of frit material or the frit ingredients, and also the corresponding substance or the substrate where you want to go for the enamel.

Then, the most important part is your firing at what particular temperature you can go for the corresponding firing process. So, that firing is that after coating, it can pass through a furnace to experience a long period of stable high temperature; that means, your residence time within a high temperature furnace will be high, you require some temperature such that you gets in the molten condition, then it is basically giving the uniform layer and then you go for the corresponding cooling procedure.

So, that basically converts keeping that particular material in that particular furnace, go for the adhering of the particles of the frit into a continuous glassy layer. So, from those particles as your frit powder, you get now after melt thus the molten condition you get basically a continuous glassy layer. So, basically what we are getting, we are getting a molten condition of the glass like enamel material, on the surface of very not of good quality of object that is your cast iron container.

So, for this particular use the most frits of industrial applications are fired for as low as 20 minutes. So, for during a time of 20 minutes we can go for the firing process and that firing process is basically giving you the corresponding coating of the thing, and one such example what I am showing over here is that particular container.

So, you can have a reactor, you see that it looks like that whatever I was telling at the beginning of our in this class is that you can have a mechanical stirrer. So, from the top you have the motor and the motor is connected to that of the blade. So, you see here this is the 4 blade thing. So, 4 blades are then add if you up from the top the connectivity with that of your motor. So, it you can rotate it. So, you can stir it. So, some chemically very carcinogenic or any other thing you can have very harsh material, which you want to stir within this container. So, basically is the industrial reactor.

So, within that particular reactor you can have this. So, if it is highly acidic or basic which is very your quickly can corrode the material of the container. If the material is of metallic container if so, we cannot use because the glass material and all other things are pretty expensive. So, for the industrial use most of these cases are the iron containers.

So, if this iron container, if you are able to coat it with this enamel, whatever we have learned so far about the enamelling of the surface, any other surface to protect that particular original material; that means, the iron material. So, this inside or the all other sides can be coated with this enamel material such that you can use for any purpose as a very useful reaction chamber or the corresponding reactor chamber.

So, the interior of a reaction vessel, you see that you can go for this particular part the green green is the corresponding liquid. So, the interior of this has been enameled. So, a reaction vessel, a reaction container or the reaction chamber can also be enameled which is a very useful purpose for that way. That we do not have to use the corresponding silica material or the glass material, for the reactions or making this reaction vessel or the reaction chamber, you simply go for enamelling only. So, this 20 minutes residence time is always important and this sometimes it is only the minimum time and that minimum time will give you that particular type of the corresponding coating.

So, like that of your cast iron substrate you can have corresponding aluminum base substrate also. So, when we want to have a corresponding enamel coating on this particular aluminum surface, what temperature we want to make. Because, the temperature is fixed one you can have some regular temperature, because only thing that you have to know the corresponding temperature at which particular temperature, you will be able to get a molten condition or the melt of those powdery frit. And, also the container that on which you are going for the enamel should also be heated. Otherwise,

you will have if it is not heated that frit material the frit powder will not be in the molten condition to cover it nicely.

So, if you have a aluminum substrate material in your hand a temperature of 530 degree is fine is sufficient and you can have a 20 minutes or more of residence time of that particular frit material during the firing process. So, that will give you the typical covering of the enamel material on the aluminum surface. So, in our next class we will be covering on the carbon modifications ok.

Thank you very much.