Inorganic Chemical Technology
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Lecture - 32
Whitewares and Structural Clay Products

Welcome to the MOOCs course Inorganic Chemical Technology, the title of today's lecture is Whitewares and Structural Clay Products.

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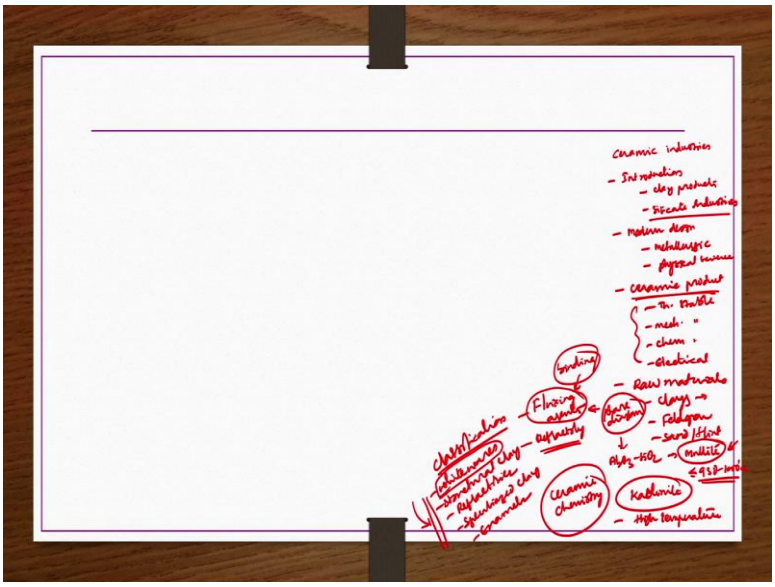

In the previous class we started discussions on ceramic industries, then we had a brief introduction about ceramic industries, what were their conventional traditional names like a clay products etcetera or silicate industry etcetera. These kind of titles were there for you know ceramic industries traditionally.

But however, you know modern products or designs have been developed you know for that you know collaboration of ceramic industries with metallurgical industries have been taken place and then some amount of information from physical science have also been coming into the picture for ceramic industries. So, then because of that reason calling these industries a ceramic industries is inappropriate.

And then coming to the products point of view what you see in a ceramic product is primarily how much is it, thermally stable. How much it is mechanically stable, how

much it is chemically stable, alright what are the electrical properties etcetera those kind of things you know one has to look into the properties.

If you are selecting a product as per your requirement or these are the primarily requirements of any ceramic products that there should be thermally mechanical and chemically stable. And then electrical properties should also as per the requirements ok. So, then these products have been developed by different types of raw materials, but three of these raw materials are essential and then almost common in almost all ceramic products they are nothing but a clays and then feldspars and then sand or flint ok.

So, clays different types of clays are there and then what are their properties etcetera those kind of things we have seen so. And then we have also seen some kind of phase diagrams for this clays, so that to realize you know how that information may be utilized for the ceramic industry point of view.

So, when we had discussed AL 2 O 3, SiO 2 phase diagram then we have seen that mullite is one of the refractory that that can be produced by the combination of this material or white composition range even when the temperature is less than 950, 2000 degree centigrades, that is what we have seen. So, then this has led to you know revolutions in refractive industries that is what we have seen.

And then out of the clays, Kaolinite is one of the most common one, but there are other clays as well. So, these things we have seen. Then you know these ceramic products are usually produced when these raw materials are mixed and then treated at high temperatures. So, when they are under high temperature applied conditions then definitely chemical reactions takes place. So, then what are those ceramic chemistry etcetera those kind of things we have seen.

In addition to that one we have also seen the raw materials not only these three raw materials there are several other ingredients are also there like fluxing agents and then refractory materials etcetera these kind of things are there. These fluxing agents what they do? They reduce the reaction temperature or vitrification temperature etcetera for those purpose these are used not only for that purpose for the binding purpose also they are used.

Why binding purpose? Because these fluxing agents usually get fused if you heat them beyond the 950 or 1000 degree centigrade so, then when they are fused, so then they will keep the materials binded together whatever the mixture material is there that would be kept binded because of this fused fluxing agents that is the another advantage of this having fluxing agents refractories they provide required thermal and mechanical and chemical stabilities etcetera those things we have seen in the previous lecture right.

So, then we have also then the classification of ceramic products then we have seen different types of products are possible or groups are possible like a whitewares structural clay products, then refractories, then specialized clay products, then enamels or enameled metals etcetera these kind of products classification we have seen.

Now, in this lecture what we are going to do? We are going to start discussion on manufacturing processes of these you know different types of ceramic products ok. So, let us start with the production of whitewares. Now, we start discussing about the whitewares alright.

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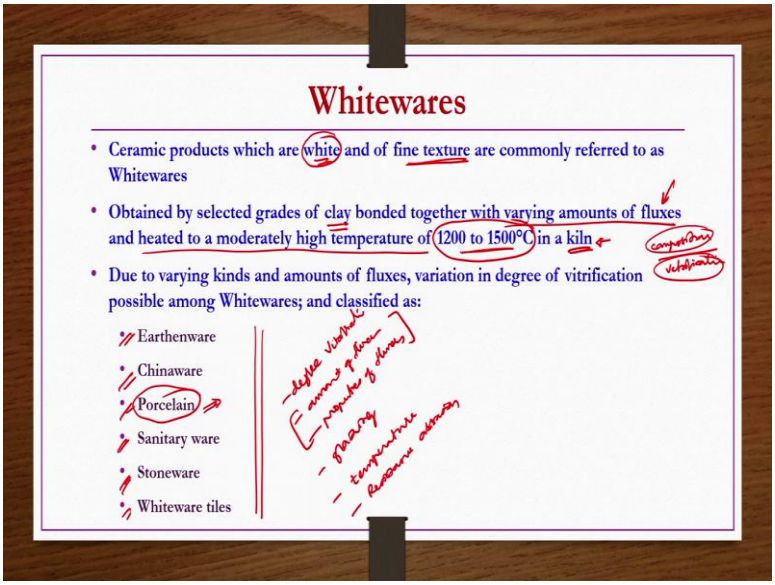

So, a ceramic products which are white and of fine texture are commonly referred to as whitewares. So, most of these products are mostly white in color. So, that is the reason they are known as the whitewares there may be fine textures etcetera are also possible, but despite of that one they are called as whitewares because primarily they are white in color.

These are obtained by selected grades of clay bonded together with varying amounts of fluxes and then heated to moderately high temperatures of 1200 to 1500 degree centigrades in kiln. So, now when you have a different grades of clay, so then you are also having different amounts of fluxes and then you are heating it wide range of temperatures as well.

It is not a narrow range of temperature, wide range of temperature. So, depending on the composition and or proportions properties of fluxes or composition of these fluxes along with the temperature they will lead to certain degree of vitrification right. So, based on the degree of vitrification and then composition and then applied temperature these whitewares may be further classified into several different types right.

So, they are earthenware, chinaware, porcelain, sanitary ware, stoneware and then whiteware tiles. So, primarily these classifications have been done you know what is the degree of vitrification and then amount of fluxes, properties of fluxes are also playing role in this degree of vitrification.

So, in addition to that one glazing is also taking place what is the glazing and then what is the applied temperature to get the required vitrification or glazing and then what is the resistance to abrasion? Based on these characteristics these classifications of whitewares have been done. So, now what we do? We see a few details of a degrees of vitrification glazing and then you know abrasion resistance to the abrasion etcetera for each of these products before going to the production of these types of whitewares.

Obviously, we cannot go into the details of production of each and every of these types of a whitewares, but what we do we take a porcelain material and then try to find out how these porcelain how these porcelain whitewares are manufactured industrially. So, now degree of vitrification and then resistance to the abrasion and glaze etcetera those kind of properties how are they varying for each of these whitewares now we will see ok.

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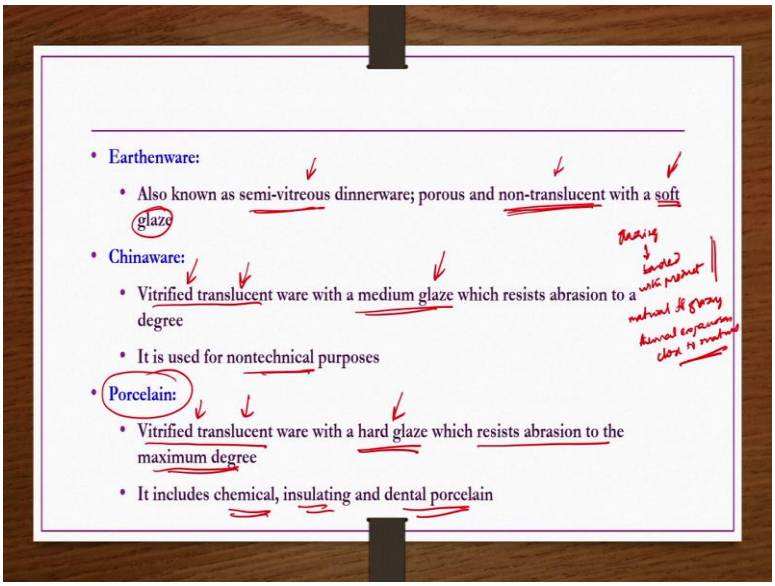

So, let us start with earthenware. They are also known as semi-vitreous, dinnerware they are not completely vitreous, semi-vitreous if you are saying they are semi-vitreous. So, then; obviously, the applied temperature would not be high would not even be moderately high ok. So, these are porous and non-translucent right. So, they are; obviously, they are not completely vitreous, so then; obviously, they will not be translucent as well.

In the sense what happens you know the material will able to pass the light, but that light will be diffused because of that diffused light you know the objects other side of the these products you know they will be you can realize that there are some objects and persons other side of this product, but you cannot identify clearly, ok.

They are also softly glazed ok. Glazing is nothing but you know coating, coating material with some kind of glass right. So, that is you know that that will provide some kind of you know glassy appear and look to the product.

So, most of the ceramic products nowadays if you see they are you know initially they are very looking like you know very shiny glassy kind of thing that is because a thin layer of a glass is coated on the products that is nothing but glazing. And then when you do this glazing one has to make sure that is properly binding with the product right when you do this glazing this should be properly bonded with the product ceramic product

whatever final ceramic product tile or tableware dinnerware etcetera whatever you are going to have.

So, this is possible you know material that you are selecting for a glazing that should be have thermal expansion coefficient close to material, then only that will stick because after applying this glazing what you are doing? You are going to do firing at high temperature in kilns. So, when you do the firing at that high temperatures. So, vitrification of product will be taking place and then calcining of the product will also be taking place.

So, during that firing period if it is not properly bonded with the product then what happens? Some kind of shrinkage shivering of things may takes place and then surface will not be smooth enough ok. Next one is the Chinaware; these are vitrified translucent ok.

So, you can see other side of the product you know some kind of objects or persons are there that you can realize, but you cannot identify because they are translucent. So; that means, that will allow the light to pass through, but that light will be diffused. If the light would be diffused you cannot identify the objects of the other side of the this Chinaware products ok. So, they are vitrified, but translucent ok.

And then glaze is medium glaze which resist abrasion to a certain degree only. It cannot resist abrasion to a larger degree, but to some extent to some degree it can resist. It is used for non-technical purposes because it is translucent and then it can assist abrasion only to a certain degree only. Next one is the porcelain right. So, it is vitrified translucent vitrified translucent as a Chinaware, but it is with hard glaze. Since the glaze is hard it can resist abrasion to the maximum degree ok.

So, what you can see? The presentation of this classification of whitewares also in a sequence; in a sequence in the sense earthenware are semi vitreous, but Chinaware and porcelain are vitrified material. Earthenware is non-translucent whereas, these Chinaware and then porcelain are you know translucent ok.

And then glaze also earthenware is having soft glaze whereas, the Chinaware is having the medium glaze whereas, the porcelain is having the hard glaze. So, if the degree of glazing is increasing, so then resistance to the abrasion will also increase, so that is how

they are produced. So, then you know nowadays mostly whitewares are porcelain type of whitewares. It includes chemical insulating and dental porcelain as well.

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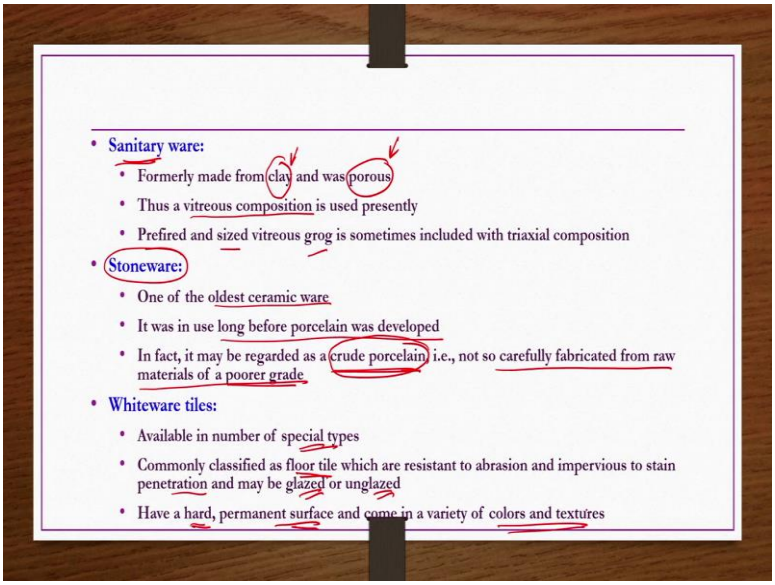

Next one is sanitary ware. Formally these are made from clay, so when they are made from the clay; obviously, it is possible they are porous, but if the sanitary ware if they are porous. So, then it is not good because seepage of a sanitary ware may be gone into the sanitary ware. So, then that will destroy or you know lessen the strength of the sanitary ware a sanitary ware over the period of time. So, then because of that one you know people started having a vitreous composition in the sanitary ware at present ok.

So, that once you have the vitrification done, so what happens you know almost non porous layer kind of thing forms on the surface of the product ok. Prefired and sized vitreous grog is sometimes included with triaxial compositions also if required. Next one is the stoneware. It is one of the oldest ceramic ware and then it was used long before porcelain was developed.

In fact, the stone ware may be said as a kind of a unprocessed porcelain or incomplete porcelain or imperfect porcelain kind of title may be given to the stone ware. Because you know it is not carefully fabricated from raw materials of a poorer grade alright. So, that is the reason they are also known as the crude porcelain ok. Then whiteware tiles, so, these are available in number of special types which include you know floor tiles etcetera ok.

So, these are commonly classified as floor tile which are resistant to abrasion and impervious to stain penetration and may be glazed or unglazed ok. These have a hard permanent surface and come in variety of colors and textures as well.

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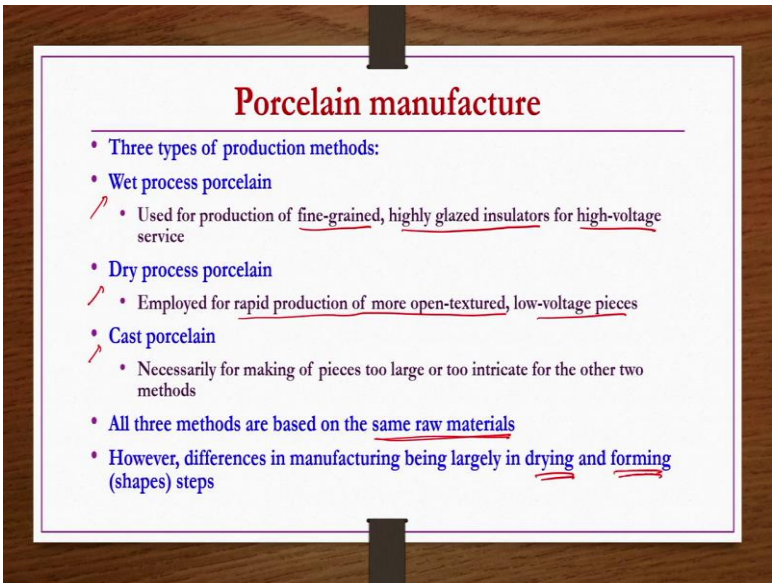

Now, we discuss about the manufacturing of porcelain. Three types of production methods are possible for the manufacturing of porcelain; one of which is wet process or wet process porcelain. It used for production of fine grained highly glazed insulators for high voltage services purpose. Second one is the dry process porcelain. It is employed for rapid production of more open textured low voltage pieces whereas, third one is cast porcelain.

If you if your pieces are the material that you are going to produce if they are too large or too intricate to prepare by these two methods, then cast porcelain method is used ok. All these methods are based on the same raw materials actually, but; however, then why the differences are coming these differences in these three process are coming based on the method of drying and then forming steps.

Forming in the sense shapes formation right you have moldable ceramic clay mixture, then you have to forming structure of as per your requirement whether are you making a cup are you making a plate saucer or are you making some other kind of tiles etcetera So, then they have to be the moldable or workable clay plastic whatever is there that should

be you know formed in that particular structure, then it will be dried and then you know vitrification would be done ok.

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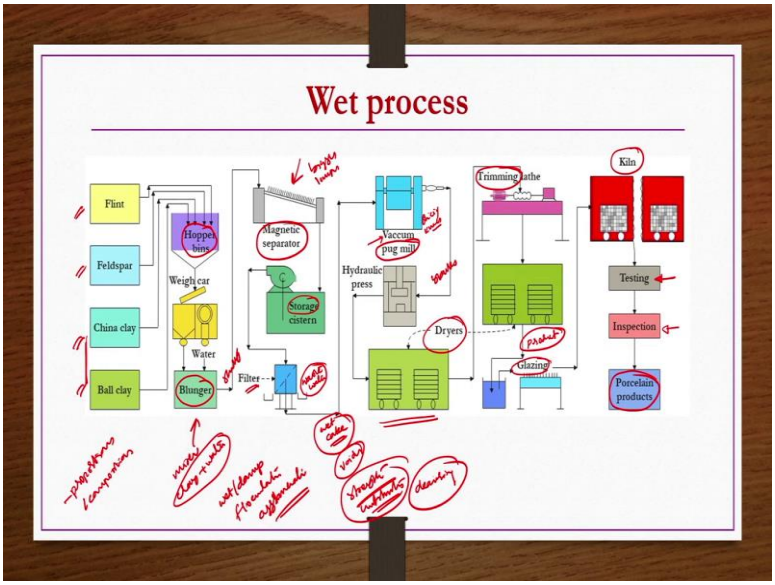

Now, we see one of the processes that is wet process we see for the porcelain production. Let us start with a flow sheet for this process. Here the raw materials are clays, feldspar and then flint. What are the clays?

For the porcelain, China clay and ball clay are used. They are taken to hopper bins actually here only one hopper is shown, but they are taken in different individual hoppers right and then as per the proportions or compositions these are weight and then taken to the weigh car then they will be taken to a blunger.

Blunger is nothing but a kind of a mixer which mixes the clay mixture plus water. So, to this blunger water is provided alright. So, as we have already discussed in the previous lecture you know these raw materials mostly, they are wet or damp. When they are wet or damp what happens? They form flocculate flocculations may take place or agglomeration may take place right. So, these things should be avoided.

So, for that purpose this mixing or you know processing in ball mills or pebble mills etcetera are being done or even agitation is also done right. So, after that also there may be some kind of flocs or you know bigger kind of you know material would be there may not be suitable for production of you know a required ceramic product right. So, then

they have to be removed for that purpose you know what you do this slurry whatever coming from the blunger that will be passed through a screen followed by a magnetic separator.

The screens will remove the bigger size lumps etcetera right. This magnetic separator will remove the material, which are having magnetic properties if at all they are present in the raw material. In the raw material let us say iron oxides etcetera are there they may not be you know impurities for other industries, but they are impurities for this ceramic industry, so they should be removed. So, that for those purposes this magnetic separators are also utilized.

So, once removing these bigger lumps etcetera and then magnetic materials etcetera this slurry is stored in a storage. So, this itself directly may be taken for a you know shape formation in molds or you know they can be passed through a pressure filter where most of the waste water is removed or most of the water from the slurry is removed and they discarded that water as waste water whereas, the wet cake whatever is there that wet cake is taken to a pug mill.

This pug mill is also provided with vacuum and then it is also having slicing knives also. So, this pug mill is again like a cylindrical vessel in which you know to which a vacuum is provided and then slice and then knives are also there. So, when this cylinder rotates this mill rotates the slides will move in a one particular direction and then that impact or cutting impact would be provided on the materials.

This will make the slurry much more uniform or wet cake whatever coming out from the filter pressure filter that will become much more uniform, alright. In this process you know in the wet cake voids would be there definitely. We know that this void percentage in general cakes that are coming out from the filtration process is very high up to 30 40 percent.

So, if that much voids are there the strength of material would decrease right also uniformity will not be there. So, in order to improve the uniformity and then improve the strength of the material or the final product that is coming. So, this voids has to be removed for that purpose vacuum is applied, so that to do de-airing.

So, this vacuum will be used for de-airing purpose. So, that you know voids would be reduced and then material will become you know a uniform and then product prepared using that material would be you know having a good strength. So, this wet cake after de-airing and then further making uniform in this pug mill.

Now, that material would be taken into blanks in hydraulic press or by hot pressing and then after that those material would be dried in a dryer followed by trimming if at all required that trimming will be done. And then they will be they will be further dried further dried in a another dryer and by this time whatever the product is there you know almost like you know in a good condition only thing that you need to do is glazing and in firing at high temperature.

So, that product whatever the plates, saucers etcetera or any tiles etcetera that are coming out of this dryer they will be glazed they will be glazed in a glazer right. So, how they will be glazed? They will be a glazing is nothing but some kind of glassy coating using you know glass material right. So, then once you do this glassy coating that is nothing but glazing that material would be taken to kiln where they are fired, so that to required vitrification can be done.

Once the material have been vitrified that would be tested for its electrical properties etcetera inspection would be done if the product is found to be good, then that product would be taken to a you know storage tank storage vessel or for subsequent consumer required they will be transported. So, whatever we have discussed in the flow chart same thing will be having a recapitulation here as a text.

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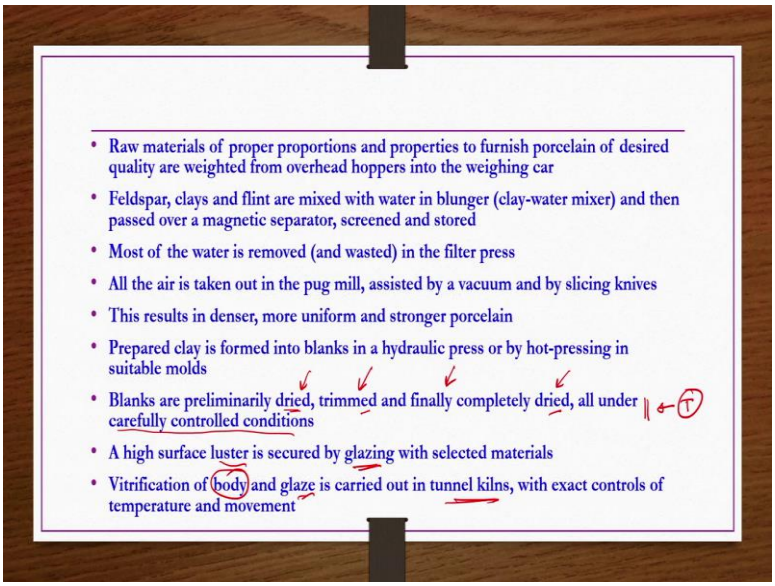

Raw materials of proper proportions and properties to furnish porcelain of desired quality are weighed from overhead hoppers into the weighing car Feldspar clays and flint are mixed with water in blunger and then passed over a magnetic separator screened and stored. Most of the water is removed in the filter press and then water is discarded as wastewater.

All the air is taken out in the pug mill assisted by a vacuum and by slicing knives this results denser more uniform and stronger porcelain. Prepared porcelain clay is formed into blanks in a hydraulic press or by hot pressing in suitable molds. Blanks are preliminary dried trimmed and then finally, completely dried, but all under carefully controlled conditions.

So, for these operations you know temperature has to be properly controlled what should be the temperature in the primary dryer, how the trimming has been done what should be the temperature in the final dryer. So, all these things are carefully controlled otherwise you know when you do the improper or very rapid drying you know the shape deformation may takes place.

Similarly, trimming if you are doing inefficiently, so then breaking or you know or destroying the edges of the products may be taking place ok. So, these operations should be done very carefully under controlled conditions, then after that a high surface luster is secured by glazing with selected materials.

Vitrification of body as well as the glaze body in the sense whatever the ceramic product you are preparing let us say you are preparing a cup. So, that is a cup here or mug, so that would be body is the mug. That mug would be glazed and then glazing is carried out internal kilns with exact control of temperature and movement.

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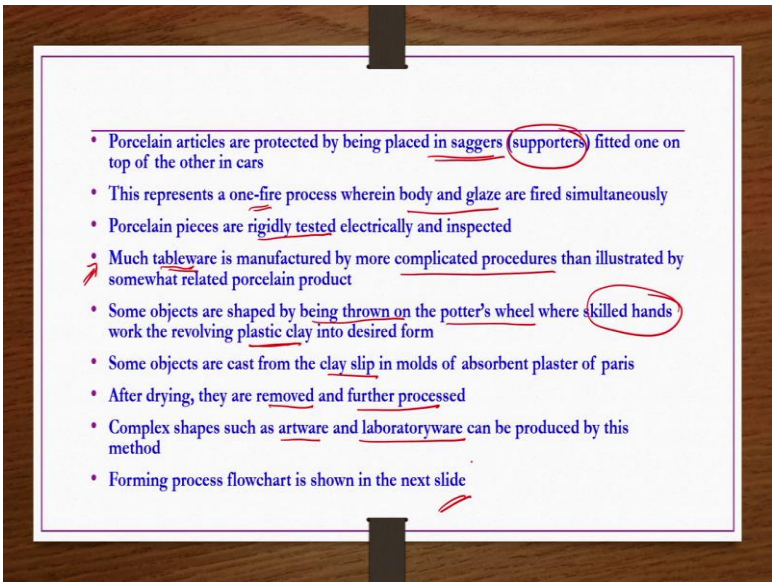

Porcelain articles are protected by being placed in saggers. In saggers which are nothing but supporters fitted one on top of the other in cars. This represents a one-fire process wherein body and glaze are fired simultaneously. Porcelain pieces are rigidly tested electrically and inspected alright.

So, that is how porcelain manufactured now, but much of the tableware is manufactured by more complicated procedure than what we have seen in the flowchart ok. Some objects are shaped by throwing on potter's wheel where skilled hands work the revolving plastic clay into desired form.

This plastic clay in the sense whatever the mixture of clay, feldspar and then sand etcetera along with the water after uniformity or you know required agitation etcetera removing wastewater etcetera. Once everything is done whatever the clay that you are having that is workable or moldable clay or plastic clay that is what it is.

So, here what happens in this pressure? The you know objects are shaped by being thrown on the potter's wheels where skilled hands work the revolving plastic clay into

desired form as per the product structure. Some objects are cast from the clay slip in molds of absorbent plaster of Paris. After drying they are removed and further processed. Complex shapes such as artware and laboratory ware can be produced by this method as well that is clay slip method.

Forming process flowchart is shown in the next slide. So, these are the like you know whatever we discussed we discussed about the you know porcelain manufacturing, but forming is very much important because forming by forming method you give a proper shape to the object, which is going to be your final object after required glazing and vitrification. So, the forming is very important step. So, then we are going to see how the forming is done in general.

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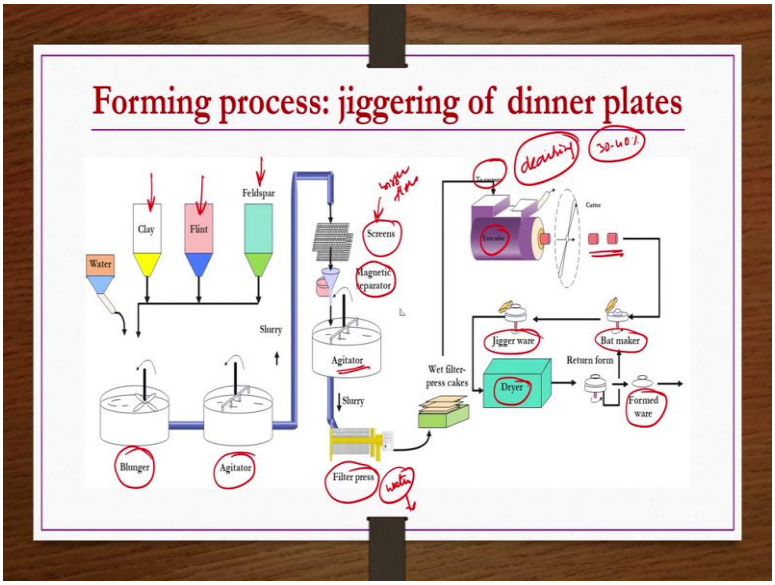

So, forming process here we talk about jiggering of dinner plates. Now, flow sheet here if you see up to getting a slurry wet filter cake the process is similar whatever we have seen in previous steps, but; however, we have the details here. So, the clays flint and feldspars are taken as per the proportions required or as per the composition into a blunger to which water is also provided the blunger is nothing but a kind of mixers.

So, here thorough mixing of these raw materials along with water would be done if required to have some fluxes they will also be added. So, after the blunger slurry is taken to a agitator where further agitation is taking place. So, that to make slurry as much uniform as possible without having any flocculants because here in this case we are not

adding any flocculants as of now. Alright flocculants are being added you know in the porcelain manufacture and then other purposes ok.

So, the slurry coming out from the agitator would be passed through screens and magnetic separator to remove you know bigger flocs etcetera or you know agglomerates etcetera they are still there even after you know enough blunging and then agitation ok. So, they would be removed by the screens and then if the clay or flint or feldspar is having any kind of magnetic impurities or having a impurity, which is having magnetic property they would be removed by passing through these slurry through a magnetic separator.

So, magnetic particles would be or particles with magnetic properties would be attracted towards the magnet and then remaining of the slurry will pass to another agitator where further agitation will takes place. So, that to make sure you know uniformity or denser kind of a slurry you can get, this slurry will be passed through filter press pressure filter. So, that to remove water as a wastewater because this water cannot be reused and then it is not having any dangerous chemical. So, probably it can be discarded as it is alright.

So, then after removing the water whatever the wet filter cake is there pressure filter cake is there. So, that is taken to a extruder. Here this extruder is doing a part of you know de-airing duty also because it is having you know vacuum provision also. De-airing is very much important as I already mentioned because the air is being occupied between the particles of the slurry or interstitial spaces of the slurry, which is having you know up to 30 to 40 percent of the void volume so, that much you know voidage is there.

So, then product that you are going to get would be very porous and then will not have the required structure. So, that is the reason de-airing is required before passing this material through extruders to get a definite shape and size of the product right. So, that de-airing would be done by applying the vacuum. Once vacuum is applied and de-airing is being done. So, then material will be passed through extruder to get the finite shape and size of this product alright.

So, this clay mixture having definite shape and size that will be passed through a bat maker followed by jigger ware, here jigger ware where you will be making the shape of the material you know product whichever product you wanted to make. Let us say you wanted to make a plate. So, plate should be made here in the jigger ware and then those

would be passed through a dryer and then it is tested further if it is if it is found good. So, then it will be taken as a form ware otherwise you know it will be sent back to back maker ok. So, this is the forming process or jiggering of a dinner plates.

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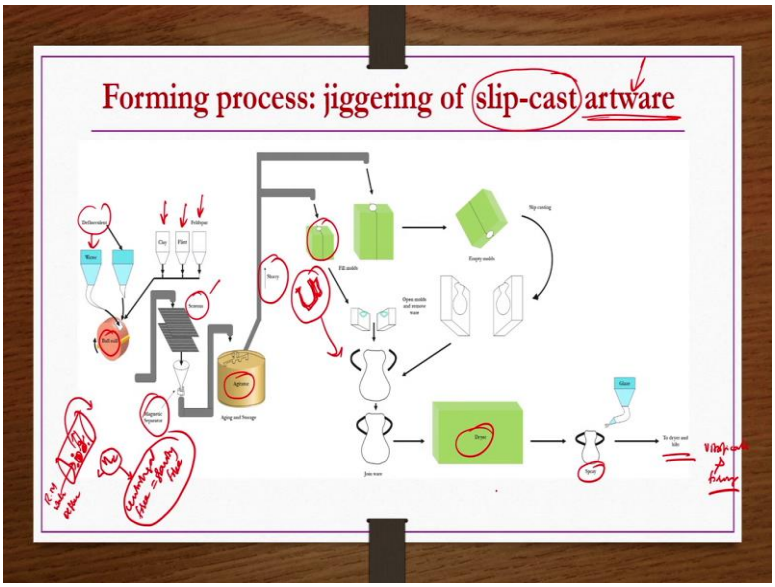

Now, another forming process we see which is nothing but jiggering of slip cast artware because artware, laboratory ware etcetera for that purpose this slip cast method is applied ok. So, more or less it is similar only that molds etcetera are molders etcetera are coming into the picture how to utilize them that is what it is important here. So, the flow chart is provided here again.

So, here whatever the raw materials clay, flint, feldspar etcetera are there along with the water they and then deflocculant they are taken into a ball mill. Ball mill is also like a cylindrical vessel right. So, it will be rotating it will be rotating in a particular direction right. So, in this mill what you do? You take balls now here it is ball yesterday we have seen pebble mills, so there we have pebbles. So, here balls of different material like you know it may be wooden ball it may be metallic ball depending on the application.

These balls should be of different sizes also they are bigger balls there would be smaller balls medium size balls etcetera would be there. So, this mixture here whatever is there that is coming in like you know raw materials, water and then deflocculating agents are taken here and then these rotates.

This rotates at the speed less than the critical velocity. Critical velocity is the one at which centrifugal force generated because of the rotation of the cylinder is balanced by the gravity force experienced by the material that is present in the cylinder. So, why it is required? If you are operating at a speed more than this balance then what happens? The material would be rotating along with the periphery of the cylinder without being contacted, so that is the reason it is required.

So, when it rotates at a velocity less than the critical velocity or critical rotational speed of the machine. So, then moment this material let us say moves up while rotating then because of the gravity they fell down. When they fell down impact will taking place some kind of grinding would also be taking place.

So, because of that one not only size reduction breaking of the flocculants etcetera may also be taking place. So, then uniformity of the product will increase alright. So, this slurry coming out of the ball mill would be taken to next level that is passing through screens and magnetic separator. Again, these screens let us say even if you having deflocculant agents and then processing this mixture through ball mill still if you have any lumps or you know flocculants etcetera they will be removed by the screens.

And then if the raw materials if at all they are having you know particles of magnetic nature. So, then they will be separated by the magnetic separator. After this slurry would be taken to a agitator where ageing and storage will take place. Now, this slurry can be taken to different types of molds right let us say these molds are there you know in that one the material is taken.

So, these molds would be having a structure let us say if you wanted to have a mug if you wanted to have a mug like this. So, inside this structure would be you know molds would be like that you know vacant space of mug shape would be there. So, when you take this slurry inside this molds, so then this vacant space you know occupied by this slurry right.

So, after sometime what happens? It will be dried and then when you open the molds. So, then you can have a material of shape like mugs like this alright. They will be further dried in a dryer and then if at all glazing is required, they will be glazed by a spray glazing and then they will be taken to dryer and then kiln for a proper vitrification and firing ok.

So, empty moles may be taken the similar way and then here again you can do slip casting. So, empty molds you do here and then you make a similar kind of process you can do here and then you can get the similar kind of products and then you have this one also. These are usually used for the art ware kind of products and then laboratory ware kind of ceramic products this method is used ok. So, now a few steps of jiggering process that we have already discussed is presented here in the form of text.

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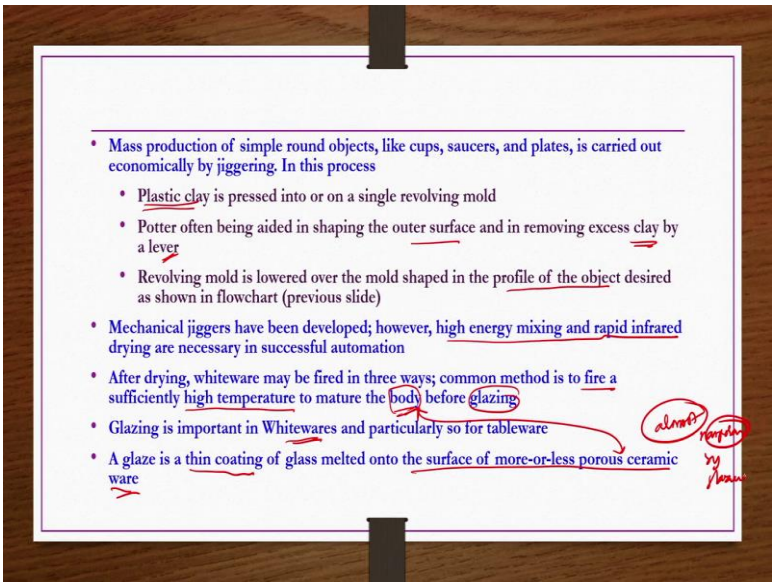

Mass production of simple round objects like cups, saucers and plates is carried out economically by jigging. In this process plastic clay plastic clay is the one after you know removing the flocculants and then removing the magnetic particles etcetera or materials having magnetic characteristics once you remove them.

Then drain out the wastewater and filter press then whatever the cake that you are having wet cake is nothing but the plastic clay and then it is in a condition that in a moldable right or workable conditions right the clay is pressed into or on a single revolving mold.

Potter often being aided in shaping the outer surface and in removing excess clay by a lever. Revolving mold is lowered over the mold shaped in the profile of the object desired as shown in the flowchart. Mechanical jiggers have been developed; however, high energy mixing and then rapid infrared drying are necessary in successful automation.

After drying whiteware may be fired in three ways common method is to fire to a sufficiently high temperature to mature the body. Body is nothing but the product before glazing you know let us say you are trying to make a mug. So, that mug is the body you know before glazing. So, this body would be glazed if required. Glazing is important in whitewares and particularly, so for tableware.

A glaze is a thin coating of glass melted onto the surface of more or less porous ceramic ware whatever this body is there we cannot call it a final ceramic product because this has to be glazed because this product is even if you do de-airing and all that that will be more or less porous only alright. So, that porous nature has to be you know controlled or reduced by doing a glaze coating. When you do glaze coating the material will become almost non-porous by glazing that is the reason glazing is very much important.

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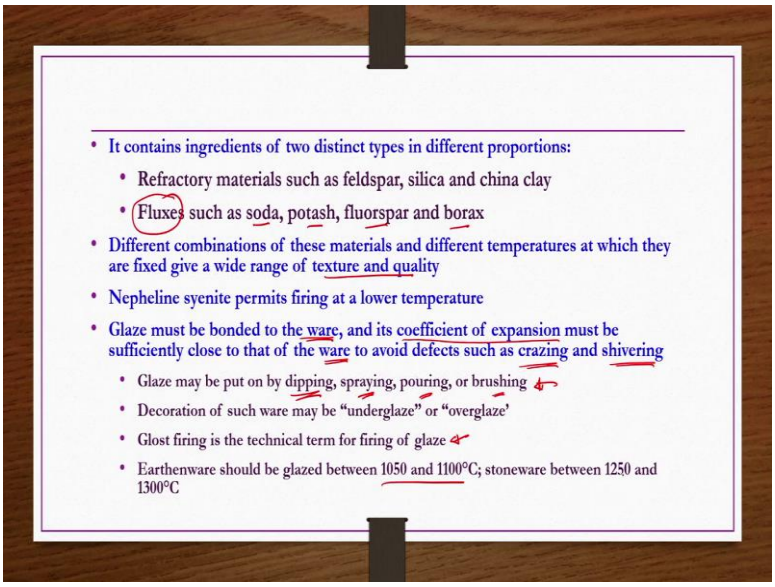

This glazing contains ingredients of two distinct types in different proportions. Refractory materials such as feldspar silica and china clay and then fluxes such as soda, potash, fluorspar and borax. Refractory materials provide thermal stability, chemical stability whereas, the fluxes they reduce the reaction temperature as well as the vitrification temperature.

Further they also you know fusible, so they keep material binded together ok whatever the clay mixture, clay, feldspar and then sand mixture are there. If you wanted to keep them binded together these fluxes are very much essential because this fluxes they get

fused at temperature around 800, 900 degree centigrades and when they become fused they will keep the material binded together.

Different combinations of these materials and different temperatures at which they are fixed give a wide range of texture and quality. Nepheline syenite permits firing at lower temperatures as well. Glaze must be bonded to the ware and it is and its coefficient of expansion must be sufficiently close to that of ware or the body to avoid defects such as grazing and shivering while you do vitrification or firing in kilns.

Glaze may be put on by dipping, spraying, powering or brushing so, but; however, when you apply any of these methods the products often either over glazed or under glazed. Glost firing is the technical term for firing of glaze and then earthenware should be glazed between 1050 to 1100 degree centigrades whereas; the stoneware should be glazed between 1250 to 1300 degree centigrades. Now, we talk about structural clay products.

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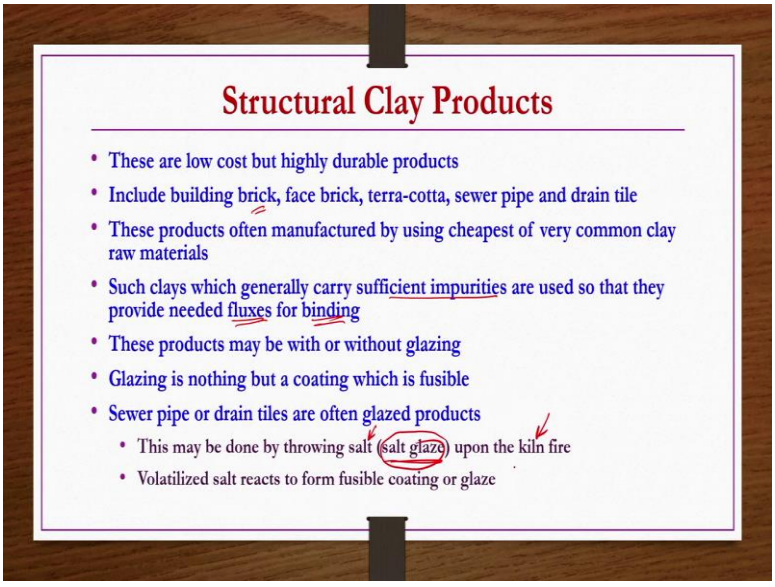

Structural clay products in the sense making some kind of bricks etcetera like you know for the construction or face bricks etcetera, so that a proper structure of requirement can be made. So, since they are used for making structural constructions they may be produced for from the impure clay itself which is which may be low considered as a low grade clay. Even the low grade clay can also be utilized to make such kind of products.

These are low cost, but highly durable products including building brick, face, brick, terracotta, sewer pipe and drain tiles etcetera are you know prepared or come under the structural clay products category. These products often manufactured by using cheapest of very common clay raw materials such clays which generally carry sufficient impurities are used.

So, that they provide needed fluxes for binding fluxes not only reduce the reaction temperature and then vitrification temperature, but they also provide required binding because when they fuse, they keep the materials binded together because of their fused nature. These products may be with or without glazing.

Glazing is nothing but a coating which is fusible. Then sewer pipe or drain tiles are often glazed products. This may be done by throwing salt or salt glaze upon the kiln fire when we do firing in kilns you know what you do some kind of salt is thrown alright. So, by that one you know glazing would be done. So, since it is done by throwing salt. So, this glazing method is known as the salt glaze.

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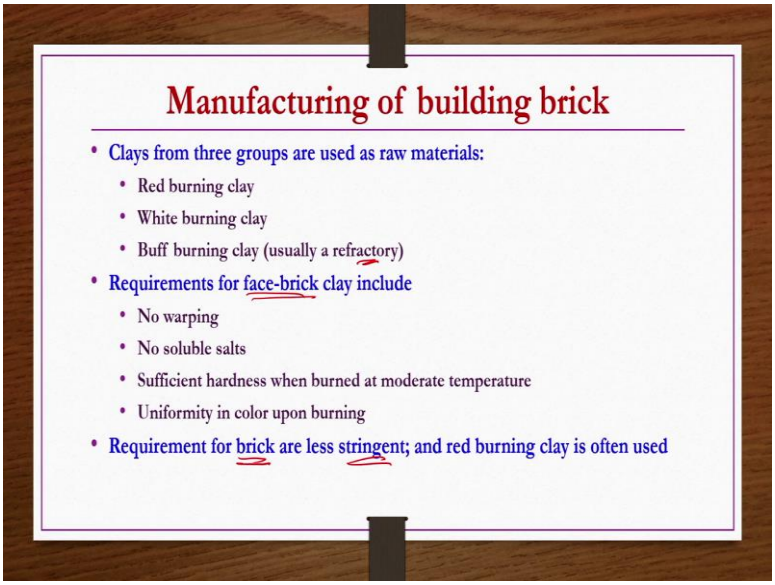

Volatilized salt reacts to form fusible coating or glaze. Now, we talk about manufacturing of building brick. Clays from three groups are used as raw materials these are nothing but red burning clay, white burning clay and buff burning clay which is usually a refractory. Requirements for face brick include several stringent conditions like

such as no warping, no soluble salts should be there and then sufficient hardness should be there when burned at moderate temperature.

Uniformity in color upon burning should be there. So, such kind of requirements are there for the face bricks. However, for the construction bricks other kind of bricks you know these conditions or requirements are less stringent and red burning clay is often used for making of a construction bricks or building bricks.

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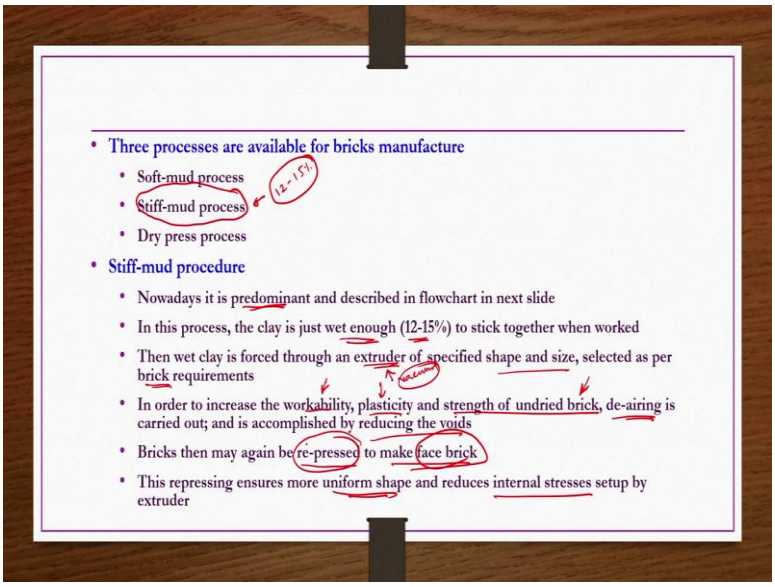

Three processes are available for bricks manufacture also what are they, they are nothing but soft mud process, stiff mud process, dry press process ok. So, we will be discussing about a stiff mud process what it is. Stiff mud process in the sense it will be having only limited water it will use only water of up to 12 to 15 percent. So, that to you know make a the raw materials mixed together.

For that purpose, only it is used soft mud process it contains much you know slurry you know kind of thing which is having more water, dry press process where more or less you know we do not have any water by the mixing and then dry processing would be done to get such kind of bricks ok.

So; however, stiff mud procedure is very famous. So, that we are going to discuss now. Stiff mud procedure it is the most predominant method that is followed nowadays to make bricks or construction bricks and described in flowchart in the next slide anyway.

In this process the clay is just wet enough by having 12 to 15 percent to stick together when worked. Then wet clay is forced through an extruder of specified shape and size selected as per brick requirements. These extruders as expected they should be having provisions of a vacuum. So, that to de-airing can be done.

In order to increase the workability, plasticity and strength of undried brick de-airing is carried out and is accomplished by reducing the voids by providing vacuum in the extruders. So, when you do the de-airing not only the uniformity and then strength, but also workability and plasticity increases for the un dried ceramic product.

Here in this case undried brick is the product. Bricks then may again be repressed to make face bricks if you are trying to have the face bricks, but when you do this repressing what happens? The shape will become more uniform and reduces internal stresses while passing through the extrusion.

When the material or the plastic clay or whatever the mixture is there, cake mixture is there that when you pass through extruders then internal stresses would definitely be developed. They will also be reduced and then shape will become uniform if you do the repressing of this bricks ok.

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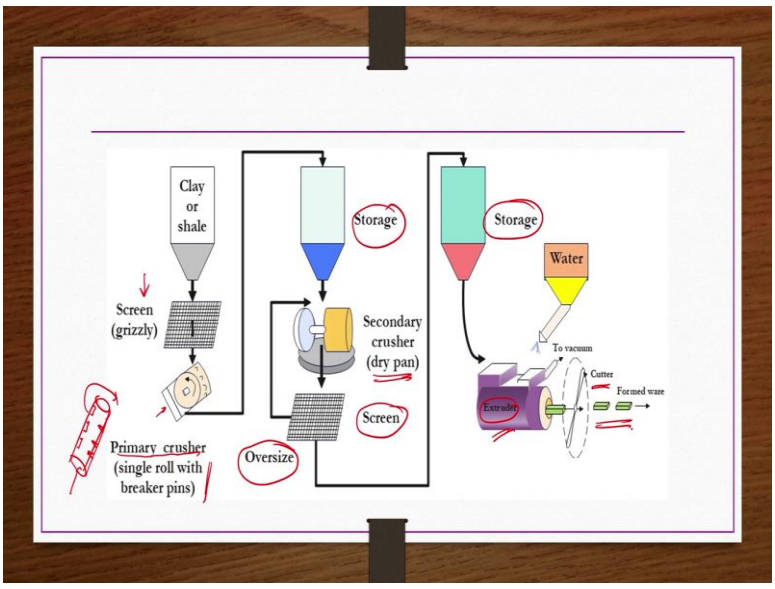

So, flowchart is shown here, so whatever the clay or shale etcetera. Raw materials are there, they will be passed through screens, grizzlery kind of screens. So, that to remove

bigger particles or unnecessary particles of different shapes etcetera alright or you know needle kind of particles etcetera all those kind of things are removed here.

Then they will be passed through a primary crusher which is nothing but single roll with breaker pins shown here. So, breaker pins in the sense here this is again it is having a cylindrical vessel and then inside the internal periphery of the cylinder what you have? You will be having pins which will be you know interacting with the material that is coming in when this rotation when rotation of this you know crusher takes place.

So, then when this impact when they interact with each other when the material come in and then rotates. So, on the rotation they will interact with this breaker pins and then size reduction will take place or you know breaking of flocculants would take place. That material will be taken to a storage. If required that would be passed through secondary crusher which is nothing but dry pan crusher that is you have a pan kind of system on that material is coming in and on to the material crushers are being rotated ok.

So, that you know reduction will takes place. So, then material after this step secondary crusher step will be passed through screens again to check if at all over sizes are there. So, those over sizes would be sent back to the crusher again and then desired material will be taken to the subsequent storage vessel hopper or silo and then this material mixed with water and sent to extruder and then in the extruder they would be mixed properly or before sending into the extruder they will be mixed together and then sent to the extruder.

Here the deairing would be done by applying the vacuum and the material you know pass through the extrusion and then after coming out the extrusion cutting is done as per the required size and shape of the brick. Extruder shape is also in a way such a way that you know the shape of the brick that you want ok. Cutters is applied to cut them into the pieces smaller pieces as per the size.

Shape is made in the extruders or while the material passing through the extruder the shape is developed and then size is reduced by the cutter by cutting into the smaller pieces as per the requirement. So, then such smaller size reduced bricks they should be dried ok.

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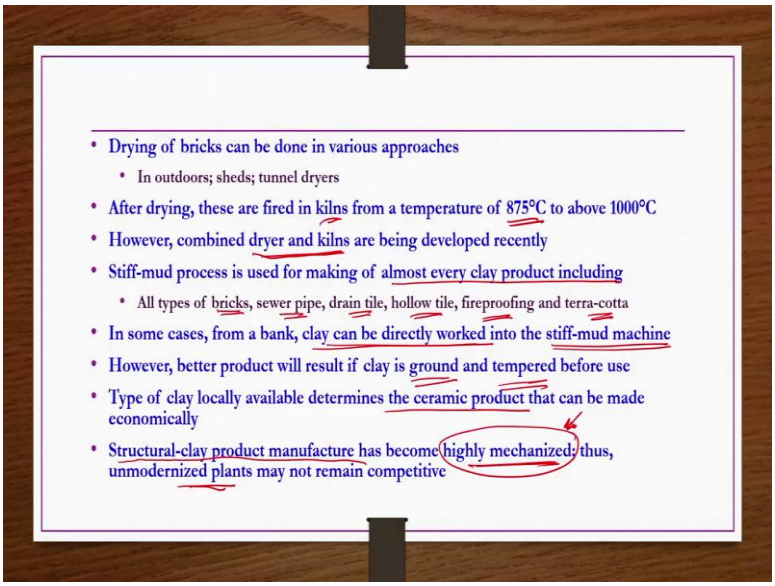

Drying can be done in various approaches. Three most important approaches are in outdoors, sheds or tunnel dryers. After drying these are fired in kilns from a temperature of 875 degree centigrades to 1000 degree centigrades. However combined dryer and kilns are also being developed recently. Stiff mud process is used for making almost every clay product including all types of bricks, sewer pipe, drain tiles, hollow tiles, fireproofing and terracotta.

In some cases, from a bank, clay can be directly worked into the stiff mud machine to get the required bricks, but you know whatever the product that you get by this way will not have sufficient strength and uniformity.

So, then what you have to do if you do you know the clay is grounded in a proper size and shape and then you know size reduced and then screen and magnetic separation, mixing with water, deflocculant agent etcetera. All those steps whatever we have discussed. So, if you follow all those steps and do the temp required tempering before making bricks in a stiff mud machine you know that product would be good.

However, the clay directly that you get from the bank that can also be used anyway ok. So, but that depends on the requirement and applications. Type of clay locally available determines the ceramic product that can be made economically or not. Finally structural clay product manufacture has become highly mechanized.

Earlier these were made manually especially in several countries including India also. But nowadays these bricks have become or brick manufacturing have become highly mechanized. So, thus un-modernized plants may not remain competitive. So, this is all about manufacturing of white wares and structural clay products.

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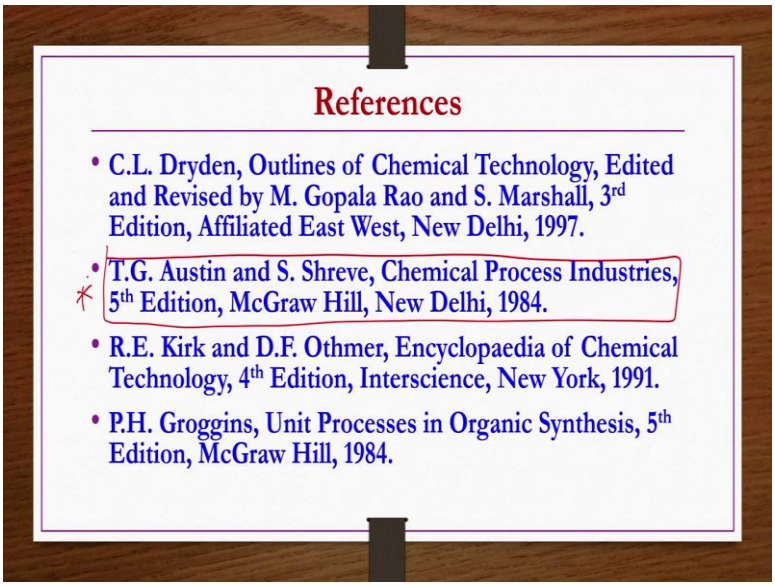

The references for today's lecture are provided here, but; however, the entire lecture slides are prepared from this reference book.

Thank you.