Industrial Inorganic Chemistry

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Lecture - 51
Glass Fibre Production and Construction Materials

Hello everybody, welcome back where we are talking about the inorganic fibers and we have seen that how we can make a particular type of optical fiber.

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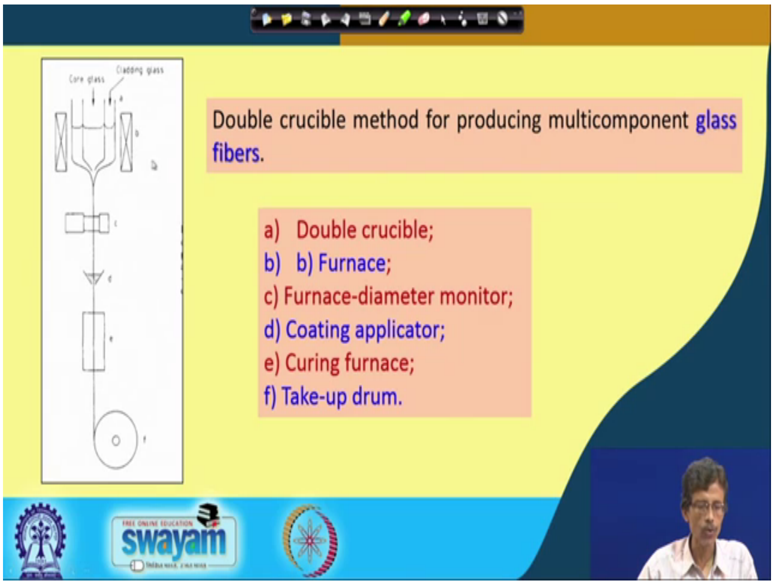

So, the thing is that is required for a crucible method that we are discussing last time when we have the double crucible method for producing multi component glass fibers. So, if we have something that we can have a particular type of glass fiber we know that it is very much useful for communication purpose. So, optical glass fibers are very much required. So, how to make that? Since it is a particular type of material where we have the basic component is here only the glass material. So, how to utilize that particular glass material is therefore, important.

So, what do we have? So, look at the name only first that would be always very important, that it is a double crucible method, so you require 2 crucible. So, 2 concentric crucibles can be used for producing a multi component glass fiber. So, you see now you have 2 different or more component for making that particular glass fiber.

So, if you consider that we have something as the core and which is covered by some other materials. So, you see you have these two concentric crucibles, these are the two concentric crucibles one is there which is the bigger one and inside you have another one.

So, when we put, so you have this particular pores also the pores are there, so through that pore the melt is basically coming out and that melt will be frozen and then ultimately it will be spinned. So, the basic concept behind this double crucible method is that you have 2 concentric crucible and you just if you heat it you will get the corresponding melt of the 2 components. So, consider it is that you have a 2 component situation.

So, in the concentric part you put the core glass material, so the core glass material will be the molten condition also and then you have the cladding glass material; cladding glass material will be the covering material which will cover the core glass material. So, you see that once this is coming out and also the other part, so this at this particular point so this is basically giving you this particular formation that being the central core formation and will be covered along with these things. So, is the material wise what you see that when it is in the semi melt condition, the code is there and code will be covered by this particular type of cladding glass material.

So, you have a to f, so that all the different components is equally, so this is the flow diagram or the block diagram you may consider and that block diagram will have a situation where you have this concentric crucible. So, is a double crucible a is therefore, the double crucible arrangement where you have the melt code glass material and melt cladding glass material. Then you have the b; b is the furnace, so you have the furnace on both sides. So, both sides you have the furnace such that the thing will be in the molten condition.

Then c is the corresponding furnace diameter monitor, so this particular thing can be is the monitor, the corresponding diameter or the aperture through which the material will come out. Then d is required for coating applicator, so if you require that you have a core glass, then cladding glass and then finally, you can put something else as the coding coating material. So, d will give you the corresponding application of the coating material and then e is nothing, but your curing furnace.

What is that curing furnace? So, whatever material you have is that should be cured, that should be in the finals position or the final shape. So, if it is coming out as the melt condition it should be frozen and it should be in the solid form because the glass material will be in the solid form. So, after this curing furnace the material will come out from that curing furnace and will be with that of your spinning wheel.

So, f is your corresponding spinning wheel and you can consider it as the drum also, so is a take up drum. So, take up drum will take the entire glass fiber into it and we can have the final form. So, you can basically in the form of some bobbin type of thing where we know that the thread can be winded. So, this particular taken drum can also wind that particular type of material; that means, the glass fibers and it can be removed after when it is filled.

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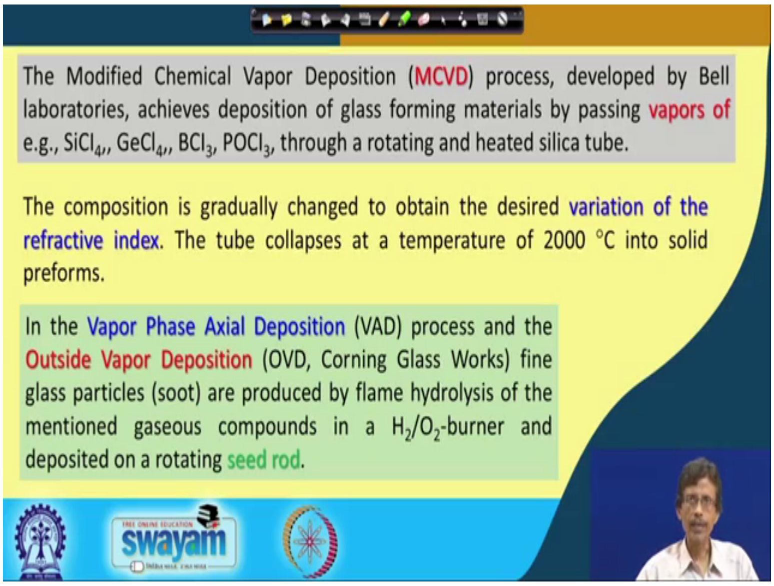

So, these things we see and now we just consider one other important combination that what we can have, that one particular type of thing the chemical vapor deposition nowadays is very useful and you can have this particular thing also for making the different types of glasses. So, if you have a particular type of glass forming material what you do? You must have the corresponding chemical vapor. So, material can be in the liquid form or material can be in the solid form, but it can be taken in the vapor state.

So, is chemically when it is there we know the corresponding boiling point and the freezing point, so all these basic information can give you at what particular temperature the corresponding material will be vaporized. And the vaporized form can now be uniformly deposited on some material or on some surface.

So, when it is the chemical vapor deposition we consider we call it as a CVD technique and when we go for improving or some kind of modification that will give you the corresponding modified chemical vapor deposition technique and it is we all know you all know that the bell laboratories are very famous for achieving all these things.

So, they have achieve the deposition of glass forming material by passing vapors of 4 different compounds chemical compounds all are chloride salts, one is your silicon tetrachloride, then germanium tetrachloride, then boron trichloride and phosphorus oxychloride. So, these can be obtained through a rotating and heated silica tube. So, the material is there and the rotating and heated silica tube can produce all these things all these in the vapor condition and that can be deposited in some material or on some surface. So, that will give you something such that you can modify the corresponding glass material even it is the corresponding glass fiber material.

So, when we have the core and when we have the cladding glass and then finally, the cover of this thing also that how the composition of this particular material can be changed such that we can have a variation of the refractive index. That is important because we want to have the total internal reflection when the corresponding signal is passed through that particular optical fiber or the particularly the signal is in the form of light. So, that will be passed and we only expect that there will be total internal reflection, such that no loss will be there in terms of its corresponding refraction or reflection.

So, there will be a desired variation of the refractive index, so that can be obtained. So, when we obtained the final tube the tube basically collapses at a very high temperature, in the range of 2000 degree centigrade into the solid preform or the solid material which can be obtained at the initial stage of your work.

So, another particular type of deposition which is also of the similar type like your MCVD which is known as VAD and then OAD, so all the different modifications one after another can be achieved, when we have the vapor phase axial deposition. So, basically we know that one particular axis we consider is the axial one and that the base can be considered as the equatorial one, where the axis is perpendicular to that of your equatorial plane, but the deposition can be achieved in the axial position; that means, when the thread is coming out, when the corresponding glass fiber is coming out.

So, in the axial position deposition can be achieved, again through a vapor phase axial deposition or VAD technique and outside vapor deposition; that means, you can have the other side; that means, the coverage of that particular material is obtained by OVD. And like that of your bell laboratories it can be achieved and it was first time tried by the corning glass works, corning you know there is a famous company which are making for the glass works the laboratory and the industrial purposes.

So, fine glass particles in the powdery glass material which is known as soot are produced by the flame hydrolysis of the mentioned gaseous compound, so we can have starting from your silicon tetrachloride to POCl 3. So, those conditions of those compounds in the gaseous states into a hydrogen oxygen burner so the burner mixed with both the two gases; that means, the hydrogen and the oxygen and can be deposited on a rotating seed rod.

So, if you have a seed rod it can be from the pure glass material and which can then be coated with that of your all these material which are in the vapor state. So, that will give you all these chemical vapor deposition techniques. So, different types of chemical vapor deposition technique can be obtained to get very high quality of these glass fibers.

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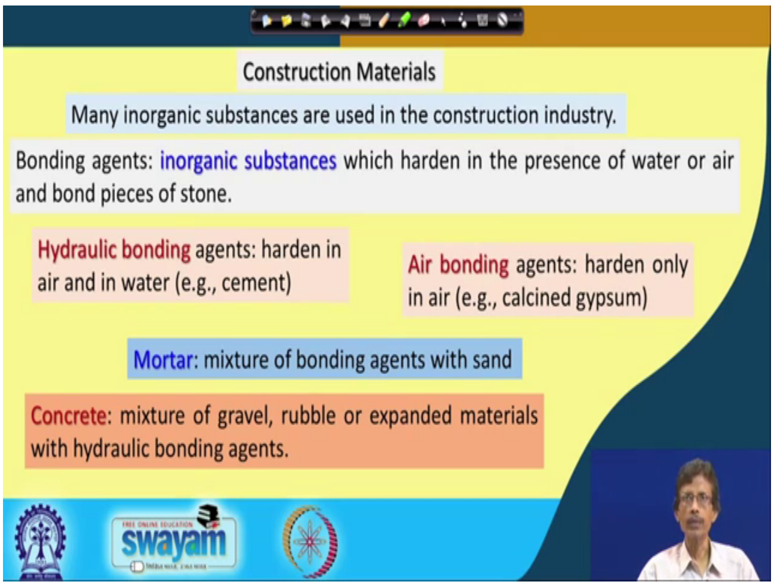

So, now, we just move to a another chapter or another part of our studies, where we can consider very important one is our construction materials, the building construction, the bridge construction, the road constructions. So, it can be a very useful part where the industrial inorganic chemistry can contribute particularly in the area of civil engineering, in the area of architectural engineering and also the manufacturing engineering in terms of the construction of different buildings and all other things.

So, what we basically use there? So starting from the filler material to the brick material to that of our cement material and the plaster of Paris coating and all these things; so, many large number of inorganic compounds are involved, so many inorganic substances are used in this area of construction industry. So, construction industry is very much benefitted through the knowledge of industrial inorganic chemistry.

So, what we get that? We can have the different types of bonding agents. So, when he makes cement, when he make the plaster of Paris for the building purpose or the construction purpose. We know that this can bind something, this can bind or fix to bricks or it can bind the gravels or the stone chips such that you get the corresponding mortar for making your building bridge or any other construction.

So, these inorganic substances which harden in the presence of water or air and bond pieces of stone. So, it is a very simple and very important definition in terms of as is the bonding agent, the way we chemists talk in terms of the bonding between 2 atoms like that of your water, since we are talking about water also here. So, you have oxygen and which is bound to 2 hydrogen atoms giving you the H 2 O or the water molecule.

So, here also that particular substance which can be hardened in presence of water and air to bond 2 pieces say of the stone. So, how to fix 2 pieces of stone or 2 full bricks? So, you have to put something as the cementing material, so the cementing material is nothing, but the corresponding inorganic bonding agent which can be hardened or which can attach these 2 material through something where the reaction is taken place by the slow use of the water and the air.

So, in presence of air and water only this hardening process can take place and we get the corresponding bonding agents, but if we simply consider in terms of its definition you should also remember all the time, that what should be the corresponding bonding agent and what should be its definition?

So, if we have something which can be caused due to the presence of the hydras agent or the water agent or the hydraulic bonding agent. So, in presence of water, water vapor or moisture we get to have the corresponding hardening process and this hardening process in presence of air, so air also have some moisture; so, in presence of air and water if something is going on there to make you a typical bonding agent and we get that as the corresponding hydraulic bonding agent.

So, we know by definition what is your bonding and next what should be your hydraulic bonding agent, so the best example will be the cement material. Then if you have only air, no moisture no water, so this will be known as the air bonding agents. So, compared to this hydraulic bonding you can have only air bonding agents and harden only in air, so if we have the calcined gypsum. So, calcined gypsum is a powdery material and it is in the anhydrous form; that means no moisture is there.

So, this anhydrous form when takes up air as well as water vapor from there; so, water vapor is not there only air is sufficient and it can be hardened through that air, so we will known as air bonding agent. Then what we how we get the corresponding mortar? Mortar is a very important material what we get for making the corresponding concrete.

So, is a mixture of bonding agents with sand so you mix cement or you mix the calcined gypsum with sand you get a corresponding mixture or the slurry. So, is basically some kind of a gel or sol, so sol gel process will also be helpful when you get this as the corresponding mortar. So, term wise these definitions are important what is hydraulic bonding, what is air bonding and what is your mortar?

Then with the use of this mortar we will get the corresponding concrete. So, concrete what how we get the concrete? So, reinforced concrete or the pure concretes, we know that the concrete is the main material for the building for the bridge and all other cases. So, concrete is nothing, but a mixture of gravel you take the gravel, you take the rubble or some other expanded material with the addition of your cement.

So, cement is your hydraulic bonding agent. So, hydraulic bonding agent when added to all these solid material. So, you get a huge stone like structure and that stone like structure will be hardened with time and you get the ultimately with the concrete structure.

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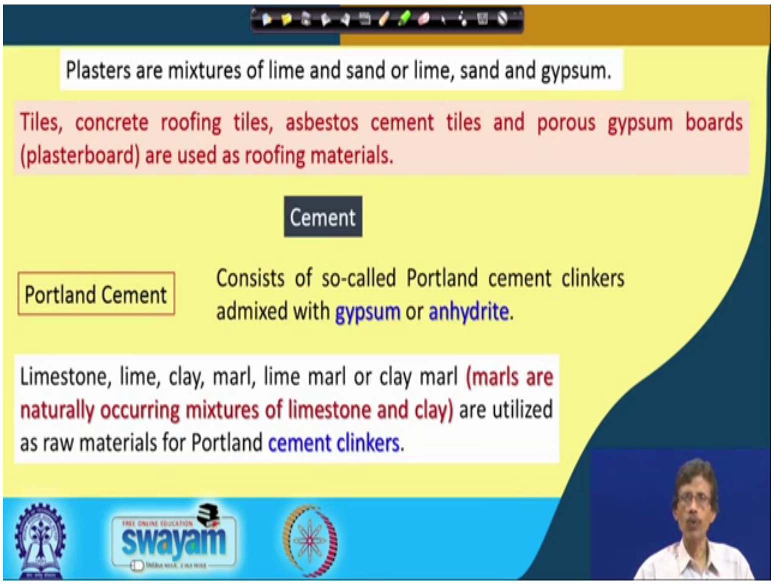

So, then once you get that particular type of concrete you have to have the corresponding plaster because the we cannot expose the concrete to the corresponding moisture, to the corresponding environment because the environment will degrade that particular thing that will not be very much stable. So, what we get? We get some coating agent.

So, coating with that of your plaster, so you make the plaster then finally, you coat further with that of your plaster of Paris or the corresponding lime also, the lime pasted over there the lime cream basically pasted over there and finally, we will go forth and again another coating through. That of your paints that will consider lastly through our this particular codes where we talk about the different types of inorganic paints and all this.

So, how we get these plaster? Plasters are again now nothing, but your mixture of lime and sand or lime sand and gypsum. So, this particular method of mixing all these things and you get the corresponding slurry and slurry can be put on the concrete material. Then with these we can have the tiles the use of these so tiles, the concrete roofing tiles, asbestos cement tiles and porous gypsum boards which are known as plaster boards are used as the roofing material. So, not only the wall, not only the floor material, but also if we get these material in sums of some blocks or some chunks or some tiles we can get these as the corresponding roofing material also.

So, the roofing tiles are also very much useful by making these with that of the use of the cement only and now also will see that we can add also some naturally occurring material which we have discussed earlier is that of your asbestos as the fiber. So, fiber reinforced cement which is nothing, but your asbestos cement and that asbestos cement can give you the corresponding tiles which will be known as your asbestos cement tiles.

So, you have the roofing tiles, asbestos cement tiles and you can have some gypsum boards. So, you can support this with any other kind of board or any other kind of some support you put gypsum, so those can we put placed over the walls for some other special purposes to use these as the corresponding gypsum board. So, that it can a very good material for absorbing the sound, there will be no echo in a particular room or auditorium or the hall.

So, we get this, so how we get the very important material which is your cement, so cement how we make? So, cement material the one well known and most possibly the best known material of cement is your Portland cement. Because we know that several other types of cements are known, when it is mixed with asbestos it will be your asbestos cement, when you get the slag material from the iron and steel works that particular slag material for getting the pures iron from the iron ore. So, that is slag material can be utilized for making the slag cement.

Then fly ash from the thermal power plant can be utilized and those thermal power plant can give you then that fly ash cement. So, the first one, the most pure one and most useful one is your Portland cement. So, by doing so what we get? We have to make the corresponding clinkers; clinkers are nothing, but a mixtures.

So, this is basically a mixture, so consist of so called Portland cement clinkers at mixed with, so you have the basic ingredients of these cement clinkers which can be mixed with gypsum which is known as the corresponding anhydride. Because this material is only will be in the anhydrous form and the anhydrous form will be converted to a solids material, solid stone like material when it is absorbing the moisture and the air.

So, what we take? You take limestone, you take only lime not the calcium carbonate, the calcium oxide also, the clay material, kaolinite etcetera, the marl, then lime marl; lime marl and the clay marl. So, either pure lime or the lime marl or the clay or the clay marl, so marls are nothing, but naturally occurring mixtures of limestone and clay. When we get limestone and clay together because we cannot separate out limestone from the clay we can put it together.

So, either the pure form of these two; that means, limestone or clay or a mixture of these two which is known as the marl can be utilized as the typical raw material for making the cement. So, which we are very much fortunate such that we get all these as the very cheap natural sources; so, these are very usefully used as the raw materials for the Portland cement clinkers.

So, you see only the idea, only the expertise can tell you that how the naturally available raw materials because we are not producing from any other industry, we are getting it from the natural sources and the natural sources will give you all these material, only thing that is the typical firing process, typical the drying process we get some useful powder for making this particular very useful material for our civilization.

So, then we must have if we intend to make Portland cement we must have the corresponding Portland cement clinkers. So, the mixtures of all these things which is basically the starting point of making cement.

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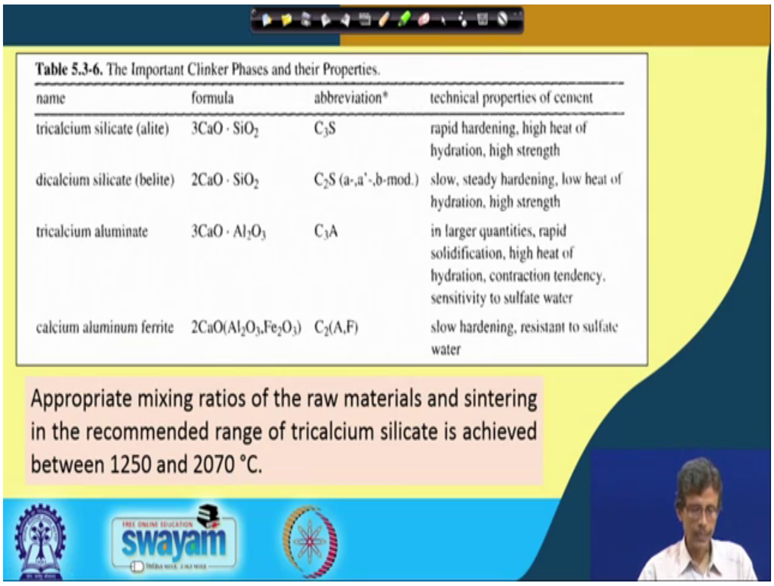

So, if we have the different clinkers, so the important clinker phases and their properties. So, chemistry wise or rather inorganic chemistry wise how we consider these as the corresponding material as your clinkers? So, first one is nothing, but your tricalcium silicate. So, by looking at the name because the subjects civil engineering or the science which will be with the building or the construction, industry they will be talking in terms of the C 3 S material.

Because these are some kind of trade naming of all these things, but the basic compound you should know when you are talking with a particular inorganic chemistry or inorganic chemistry applied to industry you should know what can be there in terms of the corresponding chemical formula.

So, the chemical formula wise you can have something which is again a abbreviated form not the full form, not the full chemical composition we write it as 3CaO center dot is not a full stop, not a decimal place it is the center dot SiO 2. That means, a particular composition where you have 3 moles of your calcium oxide mixed with one mole of your silicon dioxide which is nothing, but your silica.

So, tricalcium silicate, its geological name or the mineral name is alite. Alite you can have so you get these, so tricalcium silicate so if you get the whole formula that we will also see, that your formula will be then your Ca 3 Si how much will be there? SiO 2 plus 3 of these oxygen so Ca 3 SiO 5. So, that will be the formula the chemical formula of your tricalcium silicate.

And the technical properties is that when you use only one of these component because it's a good list of 4 material again taken from the corresponding book we every time we refer. So, this particular composition, so the typical composition will have the different parts of this tricalcium, dicalcium, tricalcium aluminate and the calcium aluminum ferrite; so, our aluminum or alumina ferrite is sometimes we write as aluminum ferrite or alumino ferrate.

So, the first one will have a power of rapid hardening, high heat of hydration because most of the time when we put cement like that of your calcium carbonate or calcium oxide is highly exothermic in nature for its reaction which is nothing, but your hydration reaction, but has a very high strength. When you go for the dicalcium, only the calcium oxide content is less, which is C 2 S which is slow, but have a steady hardening and low heat of hydration and high strength.

So, these two are you see in terms of strength it both will have a high strength. So, only thing that it takes more time because the slowly hardening time, so the hydration technique; the hydration will be a very important technique or important part of your cement in organic chemistry.

Then along with silica we bring also alumina, so tricalcium aluminate is another component which is C 3 A in larger quantities, rapid solidification, high heat of hydration, contraction tendency, sensitivity to sulfate water because when you use this, if your water is there because most of the time we use a particular type of water. And for the building purposes also we never know we do not bother about the quality of the water what we are using for your construction.

So, if you have huge amount of sulphate in that particular water. So it will react immediately with that of your sulphate present in the water. So, determination of sulphate from the water material is also important because we know that as a drinking water sulphate is not good, as well as for your concrete health also the building health is also dependent on that particular amount of the presence of your sulphate. So, we should also be very much careful to know that how much sulphate is there in that water which water is used for making your concrete out of that if your C 3 A.

Then you have C 2 A F or C 2 A F is the calcium, so dicalcium again and alumina as L 2 O 3 and iron as Fe 2 O 3, it is again further slow hardening property and resistant to sulphate water. So, it will not react with the sulphate present in the water. So, it will be very useful compared to your C 3 A component for making this cement, but it will be very difficult to control all these things simultaneously because what you find that one after another because it will be a typical mixture. So, how to control that particular type of mixture will be difficult, so we try to reduce one part which will have more sulphate sensitivity rather than the other part.

So, what we get? We get that approximate or the appropriate mixing ratios of the raw materials and sintering of the recommended range of tricalcium silicate is achieved. So, only if you take the tricalcium silicate, so the corresponding heating up that particular one and then sintering because this will everything is lost the gaseous material, the moisture everything will be lost and if we heat the material from 1250 to 270 degree centigrade.

So, above 2000 degree centigrade if you heat that material you get the corresponding cement material. So, cement factory will be largely heat expensive industry, so energy consuming also. So, that is why if the cost will be related to that of the amount of energy we what you can use.

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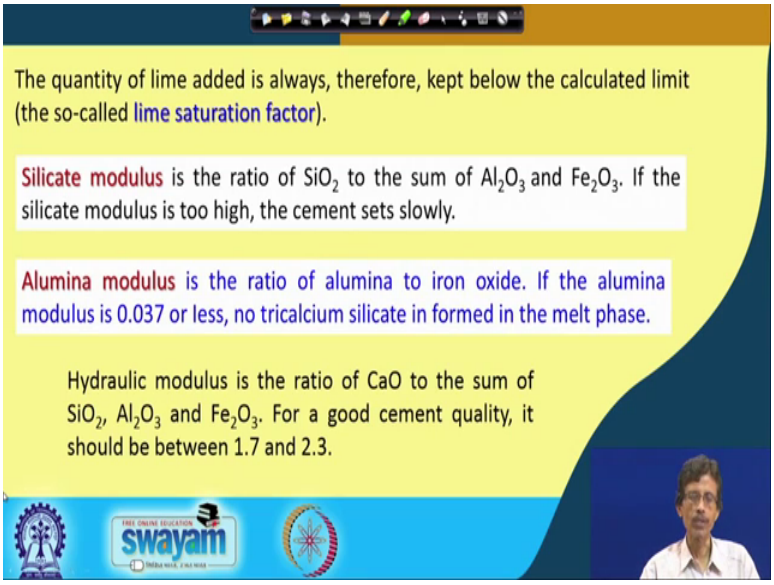

Then how much lime; that means, the calcium oxide should be there in your cement material? We always try to keep it below that particular calculated limit which is known as your lime saturation factor. So, the you must have a balanced amount of lime in the material such that, what we control with that is that you should not have more amount of lime because it will be quickly taking up water and your heating will also be more. So, the lime saturation pack factor will also decide the quality of your cement material.

Then the amount of silicate, these are the 2 basic things what we are talking about only one is calcium oxide and another is your SiO 2. So, silicon modulus is also will be telling you that how much SiO 2 is there, to the sum of Al 2 O 3 three and Fe 2 O 3 because in one case instead of silica you have l 2 in another case you have both Al 2 O 3 and Fe 2 O 3.

So, if the silicate modulus is too high the cement sets slowly. So, the depending upon the amount of silica content your nature of the cement will vary. Then likewise you just simply see that what how these things has been categorized. The first thing what we consider is the calcium oxide, second by knowing the silicate modulus thing is your SiO

2 thing and third is simply the alumina modulus; that means, the alumina the third part, is the ratio of alumina to iron oxide because we are mixing together in the fourth component what we are using the basic calcium aluminum ferrite.

So, the calcium aluminum favorite thing you have both, so the ratio of aluminum to iron oxide. So, this modulus is only 0.037 or less and no tri calcium silicate is formed in the melt phase. So, when you get as the melt phase no tricalcium silicate will be formed during this particular saying at corresponding aluminum modulus.

So, the hydraulic modulus which is giving us the corresponding hydraulic cement will also be determined by knowing the ratio of calcium oxide to the sum of SiO 2, Al 2 O 3 and Fe 2 O 3. So, the 4 components what we are dealing with this cement material is your calcium, silicon, aluminum and iron based oxides and for a good cement quality it should be between 1.7 to 2.3. So, that ratio it should not be less than 1.7 and it should not be above 2.3 to get a very good quality of your cement. So, quality control in the cement factory will also be determined by all these things.

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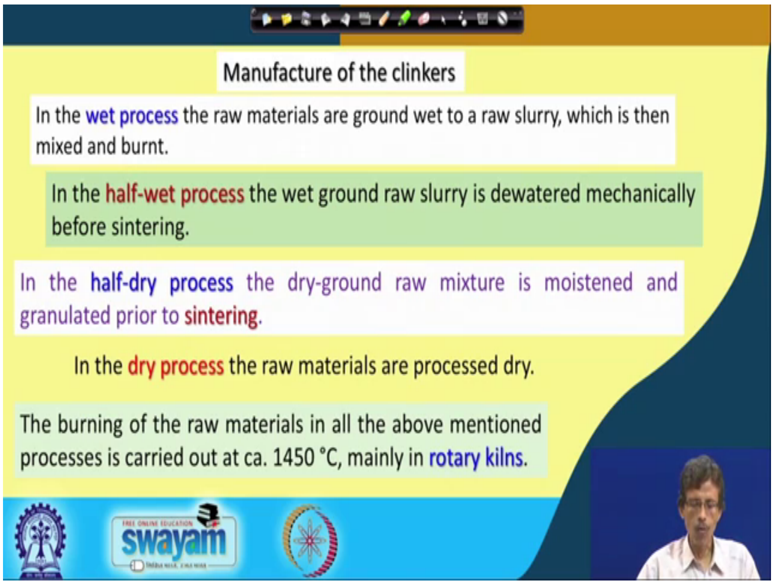

So, next at the end of this particular class or we will continue it in the next that how you get these particular clinkers. So, manufacture of the clinker, so what we get in the wet process the raw materials are making a powder or ground weight to a raw slurry, so when you is in the wet process; that means, the water is there. So, what we get? So, in the ground condition; that means, when you making the powder it is in the wet condition and we get the slurry which is then mixed and then burned.

So, the individual slurry the individual components are mixed together and then it is burned. So, it is the typical full wet process, the complete wet process then one particular technique is known as half wet process, you have again the ground wet process raw slurry is d watered mechanically before sintering. So, some amount of water will be removed which is the process known as dewatering process mechanically can be separated out by the contention or filtration some point of filtration or the removing basically it is that decantation only. So, is the mechanical dewatering process before it is going for sintering.

Then half wet, then half dry not full dry. In the half dry process the dry ground raw mixture is moistened and granulated prior to sintering. So, before sintering every different processes are you can have. So, depending upon the material, depending upon the type of the cement what will be produced whether you are producing slag cement or whether you are producing the fly ash cement or the pure portland cement, the different processes can be achieved or can be obtained to improve the quality of the cement.

And finally, from wet process to the dry process, so these are the 4 different techniques of dry process the raw materials are processed dry. So, when we considered the burning of the raw materials in all the above mentioned processes. So, you have 4 different processes and you have the raw materials and those raw materials are then taken together and we just go to a temperature which is above 1200, but it is not 2000 it is only 1450 centigrade. So, 1450 degree centigrade is a very useful technique and where we do this particular process or particular process of making this thing is in the rotary kilns.

So, rotary kilns we will see in our next class that how we can use that particular rotary kilns at least you should know the corresponding geometry, corresponding nature by looking at from an outside of an cement industry, you should be able to tell that you see that is your rotary kiln. So, that must be a cement industry which is producing cement for us; so, that we will see in our next class.

Thank you very much.