Theory of Production Processes
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Lecture – 08
Molding sand ingredients and sand testing methods

Welcome to the lecture on Molding sand ingredients and sand testing methods. So, in this lecture we will discuss about the compositions of molding sand which is used for purposes in foundries and also the routine testing methods for checking the usability of sand so that there is no defect which can come because of the sand or the molding material.

So, the molding materials which are typically used are sand metals and alloys, plaster, ceramic, graphite, rubber these are the normal, normally used molding materials for casting any material, now we will discuss about first of all the qualities of the sand molding methods. So, in that we will discuss about the sand and as we know that because the most of the foundry products and maximum of the cast units they are made in sand casting because sand is easily available. We have somewhat discussed about the properties of sand or properties of molding material what is required for being a molding material and it should be basically cheaply available, easily available.

So, that is why sand fits into it, sand is available at most of the places and mostly for very large castings sand is the one which you can use for economical purposes. So, sand is normally used, there are other qualities like you it has the low coefficient of expansion it has refractoriness qualities. So, this makes it suitable for maximum use as molding material. Now, molding sand as we discussed: so as we discussed now that major production of casting is done in the sand mold.

And as you know that when you have a pattern, pattern is surrounded by mold packed from all the sides and then we are removing the pattern from inside that and then we generate a cavity and in the cavity we are putting the molten metal which gets solidified. So, typically for 1 ton of casting we require normally maybe from 4 to 5 tons of molding sand and normally the this sand metal ratio may vary from 10 is to 1 to 0.25 is to 1.

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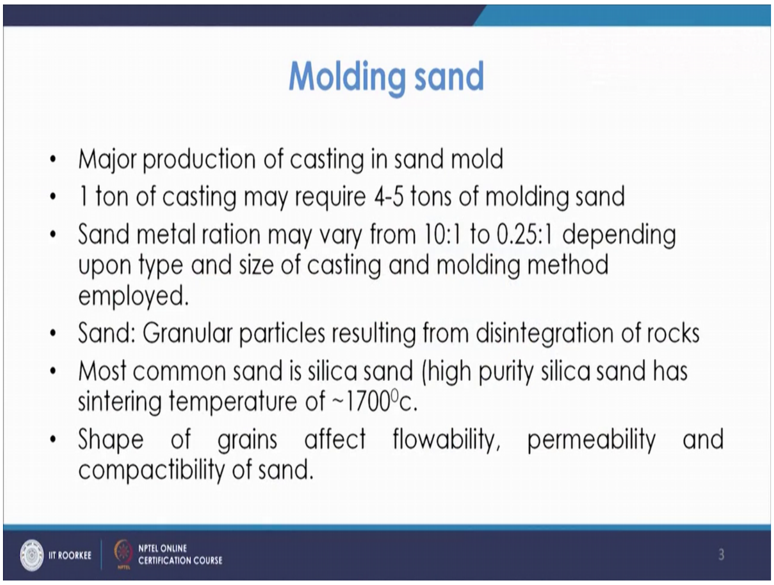

That depends upon the type and size of the casting and different type of molding methods.

In many of the molding methods where we use the sand as the molding material we may require large amount of sand and in many methods we require low amount of sand. So, basically it depends upon what kind of method we are using, if we use the normal green sand casting we may use more quantity of sand because once you use more quantity of sand then it will give enough strength to the mold to withstand the metro static forces.

Next if you go for using the sill molding or if you use the other binders other than clay or so in those cases the sand qualities less required because the strength is quite high in that case and so low amount of sand is required. So, sand metal ratio will vary depending upon the type and size certainly when the size is more, the sand requirement is more, but then the type of molding method which you use that also determines that what should be the sand metal ratio. Sand is what? Sand is basically they are the granular particles which are resulting from the disintegration of rocks. So, we get that as sand because the you can see on the riverbeds that you are coming through the mountainous regions, the rocks are disintegrating and then they are coming and getting deposited on the riverbeds and these contain some different types of minerals like you have silica is there, oxides different oxides are there as the minerals which are dissolved into it and then they are coming to certain size, small size you can say when it goes to very fine then we call it as silt or even then otherwise it may be even smaller than that.

So, these sand is collected from the riverbeds and they are basically the disintegration products of the rocks and they are found. So, once you collect them you receive them, you clean them and then you use them. So, basically when you collect the sand, the sand will have the different shapes and the different shapes which are basically defined are like angular grains, you have sub angular grains, you have round grains, you have mix type of grains like that.

So, this will be the shape of the grains and why this shape is important because they are the ones which basically control the most of the properties of the molding sand like you have the flowability, how it will flow inside the casting and go to the intricate positions. So, that you can get that cavity of that shape, how it can allow the gases which are generated inside the cavity to go from I mean through it to towards the atmosphere or how it will be compacting, how the hardness will be generated this all depends upon the shape of the grains.

So, how the shapes are there if suppose you have round grains. So, round grains if you have it will have the list suppose interlocking is not there. So, it may give you optimum type of permeability, we have sometimes very sub angular or mix type of grains they will interlock into positions and then that may decrease the permeability and they are also strengthened every properties depends upon the shape and size of the grains coming to the desired properties of molding sand.

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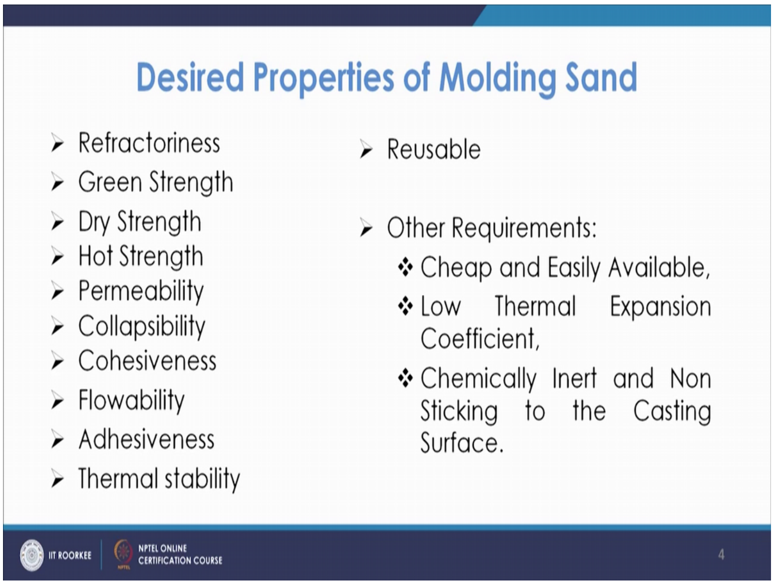

So, I hope that you have gone through these things at an elementary level of manufacturing process course, but still we so discuss something about it. So, as we know that when we talk about the molding sand for any molding material in particular the refractoriness property is basically applicable, but then we talk about the molding sand. So, first property which makes it suitable for the casting is refractoriness. So, refractoriness means a it is ability to withstand the high temperature this is refractoriness.

So, because its fusion temperature will be quite high and most of the metals which we pour, it will have the melting temperature if we take non ferrous it may start from except for the very low melting point alloys you have, copper as more than 1000 aluminum has close to say 700 iron has close to 1600 or so and if we go for other metals even if it is more and more.

So, basically at that temperature when you are pouring the material must maintain its identity at that high temperature. So, that property to resist the fusion at very high temperature is known as refractoriness. So, the sand must have this refractoriness property and this sand which you are using like silica sand, we are we are going to discuss about the different kinds of sand silica sand or jarcon sand olivine sand or so. So, you have different varieties of sand and this sand has this quality that they can withstand high temperature that is why they are suitable to be used as the molding sand.

Then the regreame strength, dry strength, hot strength these are about the strength to sustain its, I mean the different forces or its own weight or shape. So, green strength means normally when we use the molding sand we need a binder. So, that it will bind them together and then we also so in binder we have normally clays which we use. So, that is also a variety of you know refractory material itself, but it has the lesser refractory, you know frozen point. So, that is clay it has very fine size and it has other properties that we will discuss.

So, when what we do is normally the sand will be used with binder and hardener. So, the first thing is that you have to bind them and then you have to hard them, make them hard. So, hardening action may be done either by some means like you may dry them or hardening action may be because of some other reactions or so.

So, green strength is, green is means green state means it has the moisture in it. So, when you use the binders which has moisture, in that case when it has a strength adequate strength to have in a particular shape. That strength is the green strength then dry strength is basically when the moisture is driven off the strength that is known as dry strength. Hot strength will be that when you are pouring the liquid metal and the metal is still hot in that case to withstand the hot you know metal static pressure, the strength which is required is known as hot strength. So, these are the different kinds of strength which a molding material must have because when you are pouring the liquid metal it should be able to sustain that pressure, then only the solidification will start.

Then you have permeability. So, permeability is the another material I mean property of the molding sand, as we discussed that in the permeability case we need to have the property of this sand so that they can allow the gases which are generated inside the cavity to go out. So, this property is known as permeability. So, when we are making the molding sand, then in that case the sand shape should be chosen. So, that the gases have the way to go out. So, that, that is how when it is going out is it is said to be permeable and if it is not it is impermeable. So, if the permeability will be less than required in that case the gases will not be able to go out and they may generate the gaseous kind of defects inside the casting itself. So, either at the surface or inside the casting, so that is permeability.

Collapsibility is the property of the molding material because once you have the solidification taking place in that you have expansion as well as contraction and after that you have to remove the you know molding material. So, once you are taking out so in that case this should be better, better way it should come and be in touch with the co casting surface it should be collapsible, it should. So, what will happen? It will crack. So, that quickly you can remove them.

If not collapse collapsible if it is not tough, you can say in that case toughness is different anyway collapsible means what happens that when you put the hot metal it will expand and then when it will solidify it will shrink. So, in that case the surface where the sand is in touch with the liquid metal first of all it will go away and then it has to come back, it has to be collapsible there must be spaces in between and this is basically. So, that it will come back to its normal position it will have some cracks in between and so that when you are removing the mold by taking the man casting out, that time it should basically we quickly coming out ,otherwise if it is not following that casting during its shrinkage or so in that case it may tear.

So, some defects like hot tearing that may come. So, that we may discuss when we are discussing about the casting defects and this is basically achieved by putting certain additives, which are basically there inside the molding material they will burn and then they will provide that cushioning type of effect. So, that is known as collapsibility.

Cohesiveness means, cohesiveness is as we know cohesiveness is that property where the sand grains have the tendency to bind to each other. So, that is cohesiveness probability means it is flowing like fluid, it will go into the every corner easily. So, if it is more flowable it will go easily into the, you know cavity at different places. So, suppose you have the sand you are adding the clay and water. So, if you increase more water the flowability will be more it will go easily into the cavities.

Adhesiveness is required because when we are making the mold, in that case you have the molding box and around the pattern we are putting the sand. So, the sand has basically has to stick to the pattern as well as sand has to stick initially to even the molding boxes, because once you are taking the molding box it your inverting it or whatever you are doing it must stick up to certain extent so that property is known as adhesiveness.

Thermal stability means at higher temperatures should be stable should not lose its properties, reusable this is very much important because we are using the molding material and the sand has this quality that it can be used many times except for certain you know, up to certain depth if the material temperature is very high certainly some of the sand which is in immediate contact with the hot metal. So, that may lose its property that may fuse even and in those cases it cannot be reusable, but majority can be used. So, that is reusable property and for certainly you can maintain its property by adding suitable additives or so.

So, these are the desired properties of molding sand, other requirements are that it should be cheap and easily available. It should have low thermal expansion coefficient, it should be chemically inert and non sticking to the casting surface. So, these are the different you know requirements desired properties of a molding sand.

What are the ingredients of molding sand? So, as we discussed the molding sand will be mixture of 3 or more ingredients one is. So, most common sand is the silica sand and it is consisting of mineral quartz that has a specific gravity of 2.6, then you have green sand. Green sand means clay plus water plus milik silica sand and in the molding sand you have silica is 50 to 90 percent of different shape and size and apart from that silica you will have clay water and additives.

Different types of molding sands are like silica sand which has maximum of silica, that has the maximum refractoriness larger will be the silica larger will be the refractoriness of silica sand and apart from that you have the oxides of different materials like aluminium sodium or magnesium which are working as impurities. It should not be more than 2 percent because more is the impurity, more will be basically less will be its fusion point. So, normally source is river and shape of grains may be anything likes from angular to sub angular to round or so.

Similarly, you have different kind of sand that is all even signed. So, that is basically from the mineral, fosterite and fayalite.

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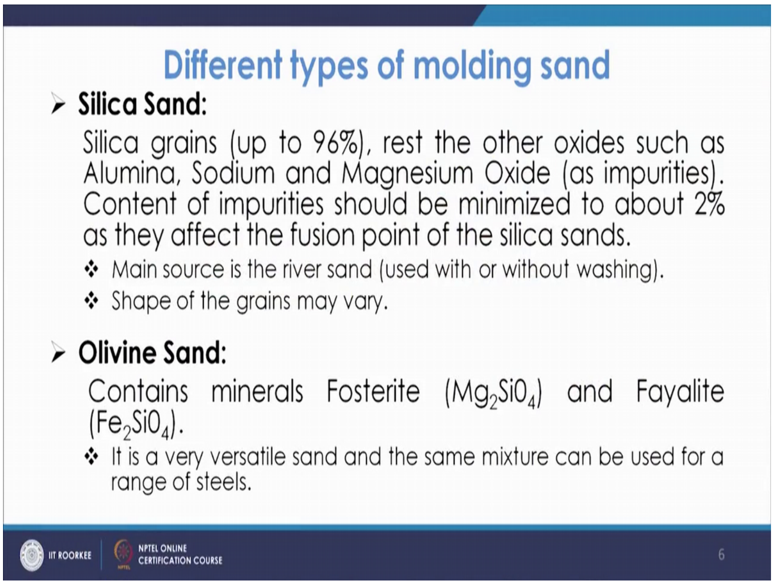

So, basically it is versatile sand and the same mixer can be used for a range of steel. So, that it has the special quality.

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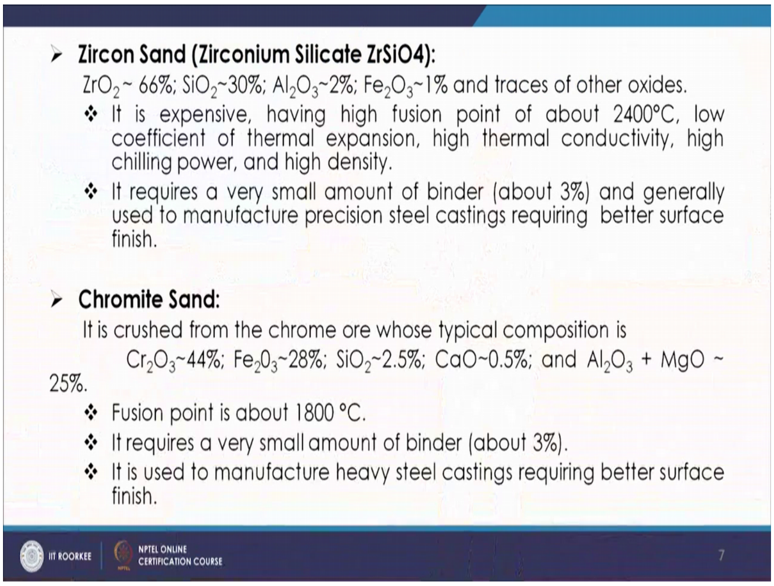

We have the concerned that is basically you have zirconium oxide, silicon oxide and other oxides to lesser extent, its property that it is having large fusion point although it is little bit expensive and it has high refractoriness point of about 2400 degree centigrade, then it has low coefficient of thermal expansion, high conductivity, high chilling power, high density. So, that makes it very special kind of sand which is costly and it also requires very small amount of binder and normally used for precision steel castings on better surface finish.

Then the next type of sand is chromite sand which is crushed from the chrome ore and it has the chemical composition it is given something close to Cr 2 O 3 is 44 percent, iron oxide 28 and there is other oxides like silicon oxide or calcium oxide or so. So, they are there. So, this way you have the chromite sand whose fusion point is 1800 degree centigrade, small amount of binder is required and for heavy steel castings it is used.

So, these are the different kinds of sand, apart from sand you have the clay. So, clay is the binding isn't and that basically binds the sand grains together and normally the clay which are used are like you have fire clay, you have bentonite. So, you have montmorillonite group of that clay that is known as sodium bentonite or calcium bentonite, sodium bentonite is western bentonite and calcium bentonite is also known as southern bentonite, apart from that you have fire clays.

So, bentonite and the sodium and calcium bentonite has different qualities one can absorb more water like.

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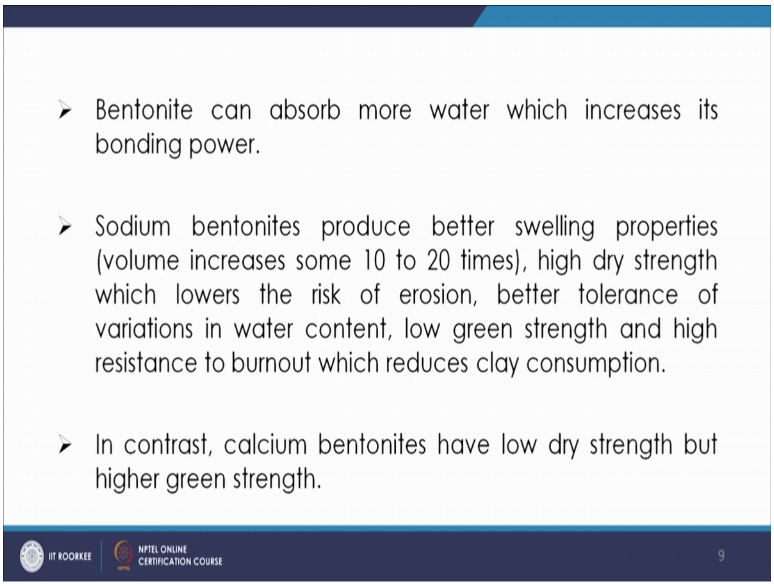

So, bentonite has the property that they can absorb more water, increase the binding power it has the, it is it will be producing the swelling properties. So, volume will increase and then it gives sodium bentonite gives the high dry strength which lowers the risks of erosion better tolerance of variations in water content like that. So, you have the low green strength or so. So, these and in contrast you contrast you have calcium bentonite which have opposite properties. So, like that.

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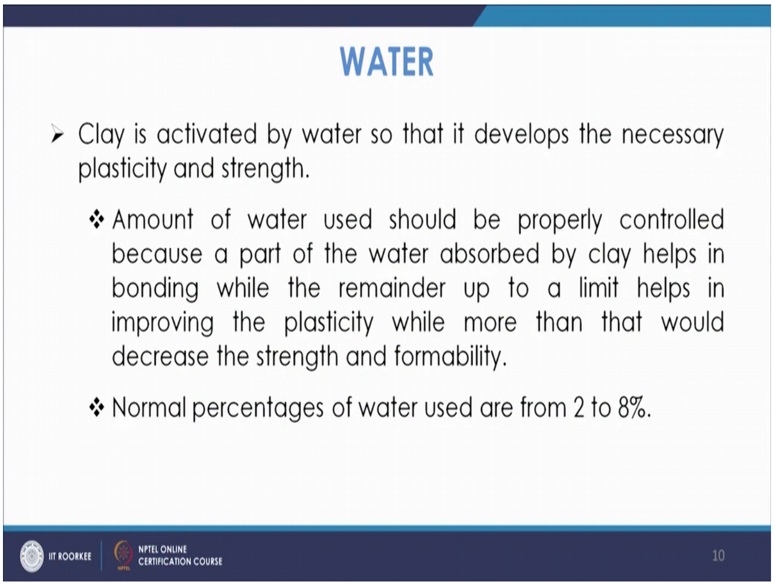

Water is basically, clay will be activated by water. So, that the binding is between clay and clay using water. So, what happens? The clay will surround the sand particles and they will be binding between water I mean clay and clay particles. So, basically that is activate clay is activated by water and you need one temper water that is required for binding, more water will provide more plasticity and that basically increases the permeability or flowability are decrease the strength.

Flowability will be increased, but strength will be decreased. So, normally range is from 2 to 8 percent.

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Additives are there you have special additives used for special properties, like you have cereals there they are used for basically increase collapsibility, pitches there asphalt sea coal. So, these are the additives which are giving specific properties like hot strength like page asphalt or so. You have the hot hardness provided, I mean hot strength is provided, you have silica flour is there which gives better finish you have wood flour which is you giving the collapsibility. So, do you have these different kinds of additives which are used you must have studied about it. So, these are the things.

Now, we will discuss about the sand testing methods, what we discussed in earlier was that what is molding sand you have, you have the molding sand of different type you have silica sand or zircon sand or so. And then we have to see that how it will behave, how much it is useful for basically doing the molding purposes. So, you have different kind of tests. So, the need for systematic evaluation of the working qualities of molding materials under foundry conditions has to be tested and that is why a range of test are advocated are suggested which the if the sand is passing that test or if you find certain parameters by doing these tests we can say that that sand is of that particular quality.

So, based on you know concerning some basic chemical or physical properties, we have the different kinds of test where we normally measure the bulk properties and normally what we do is for many cases we have the standard specimen which is 2 inch dia and 2 inch of height of cylindrical specimen is prepared by making the sand and doing certain standard. You know method of making this is specimen also that you have with this ramming, you have to get this kind of shape and then you can do the test from onto this specimen.

So, the different testing methods, different type of tests which are carried out are the grain fineness test, you have clay content test, you have strength test, permeability test, moisture content test, shatter index test, mold hardness test apart from that you have special other tests also. So, that you can study and we will discuss about these tests.

First of all we will let us discuss about the grain size test or grain fineness test.

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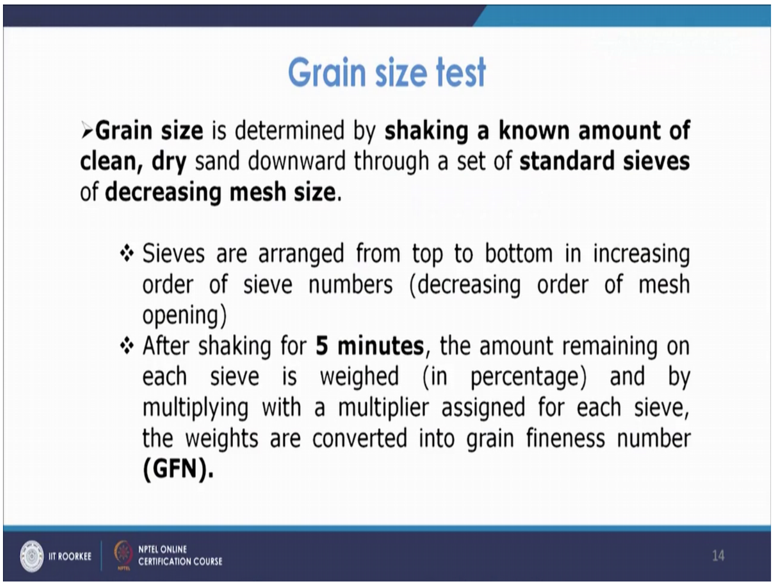

So, as we discuss that the grain which you collect you are getting you know collected from the riverbeds or from any other source they are of different sizes and shapes. Now, the size basically grain size affects the properties of the molding sand like its refractoriness permeability strength or so. So, we need to have standard where we can say that yes this is the size which is suited for that purpose.

Or if you have certain sand, you can say by doing the statistical analysis that yes this is a sand which is either suitable or not suitable. So, for that a grain fineness number that is advocated by American fundament society has been advocated. So, the grain fineness number is nothing, but a number is there this number, higher will be the number lower will be the size of the grain. So, basically for that you have the sieve and on the top you have the sieve with minimum clearance and in the bottom you have sieve with maximum clearance in between it is you know threads or so.

So, you have a circular type of sieves you have you may have certain sets of sieves maybe 7 to 9 or 10 or 1 you have different kinds of sieves and every sieve has a number. So, and then what we do is you have certain quantity of sand. So, you will tri put the sand on the top sieve. So, here what we see is in this case what we see, that you will have. So, let us see you have sieves are arranged from top to bottom in increasing order of sieve numbers so and decreasing order of mesh opening.

So, mesh opening will be high I mean lower, mech opening will be less increasing order of sieve numbers.

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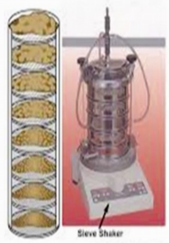
ASTM Sieve No	Mesh opening (mm)	Multiplier
6	3.327	3
12	1.651	5
20	0.833	10
30	0.589	20
40	0.414	30
50	0.295	40
70	0.208	50
100	0.147	70
140	0.104	100
200	0.074	145
270	0.053	200
Pan		300



Grain Fineness Number = Total product/Total percent retained

So, as we see sieve number will be more and as the sieve number is more, the mesh opening will be lesser are lesser then we are basically. So, once we are putting the sieve the sand on the top sieve and then we are vibrating it on a machine known as sieve shaker and this see, after some time maybe standard time of 5 minutes we will see that what is the number of, what is the amount of sand which is retained on each of the sieve.

So, we find the percentage of the amount retained on each sieve so that is what it is. So, after shaking for 5 minutes the amount remaining on each sieve is weighed and by and every sieve has a multiplier number. So, as you now you see you have the sieve number

6, 12 you have 20, 30, 40 actually they tell about the in every inch, how many number of sieves are there. So, based on that you will have the mesh opening, every linear inch you will have a how many number of sieves are there, based on that you have these sieves defined because you have sieve as well as you have the wire. So, getting together the 6 sieve should come to 1 inch. So, that way it is and every sieve has a multiplier. So, this sieve has a multiply of 3 this sieve has a multiply of 5 or so.

So, once you have the quantity of sand you put on that suppose you have 50 gram of sand, you put on that sand and then it is vibrated and maybe that on some numbers, some number sieves you will have some quantities like 10 gram 20 gram and 10 gram or something like that it is accumulating on certain numbered sieves every sieve as a num. So, percentage will be calculated by multiplying with 2 and then that percentage will be again multiplied with the multiplier. So, this multiplier and then it will be added. So, this total product will be added and this product will be added and after that it will be define divided by 100 that number will give you the grain fineness number.

So, if you have, suppose the most of the grains are in 40, 50 and 70 suppose. So, certainly the grain fineness number will be close to 40 50 or 70 depending upon relatively how much of amount has amount of sand is retained on these sieves. So, that way we calculate the GFN, number larger will be the GFN number it will be. So, as you go lowering and lowering, you see that opening is mesh opening is decreasing means if the large amount of sand is retained in this side means the sand is very very fine. So, that way we define this GFN number and maybe that you can get a curve and the curve may so either a single model or y model or so.

Because it may be so that if you have some mode coming in 20 and some more coming in 140 means the sand is of mixed size and because some are very fine and some are very coarse. So, that is known as bimodal multimodal or so. So, that depend depending upon the amount of sand deposited on them you can have these calculations then you have clay content test.

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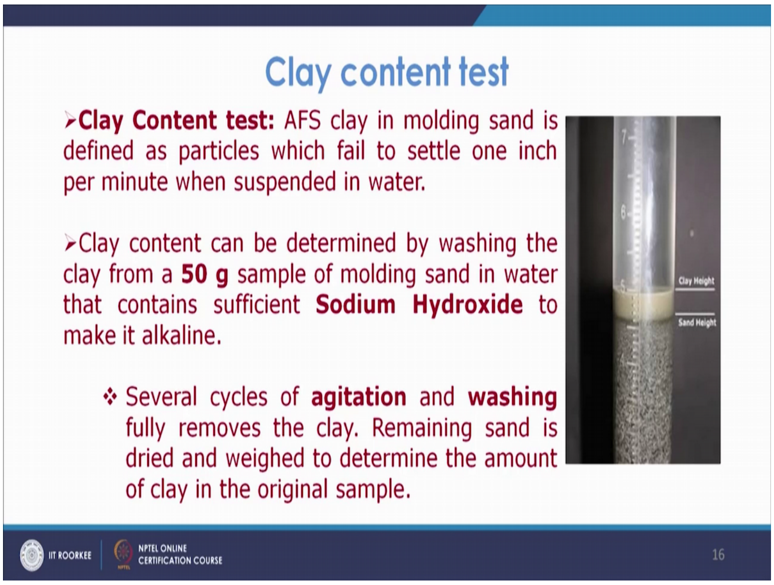

So, clay is basically defined as that particular you know particle which basically settles which is not which is failing to settle at certain rate.

So, that is how clay is defined. So, that is failed to settle one inch per minute when suspended in water. So, what will happen once you have the clay, if you look at this picture what you see is that the clay will still be suspended, clay water sand is first settled then slowly clay will settle slowly very slowly so it will be there. So, what happens we put in some certain quantity of water suppose 475 normal practices in 470 ml of water you have you give some has sodium hydroxide and you give the sample 50 gram sample of sand agitate it.

Then in the beaker you give the six inch of height by putting the water and you allow 5 minutes. So, in the 5 minutes it should settle up to 5 inches, if it is sand the sand will settle and in that case you can remove the top 5 inches. So, whatever is not settled is clay. So, this is basically repeated many number of times and then it is further washed dried and that will tell you, so difference will tell you the amount of clay. So, that is how the clay content test is carried out.

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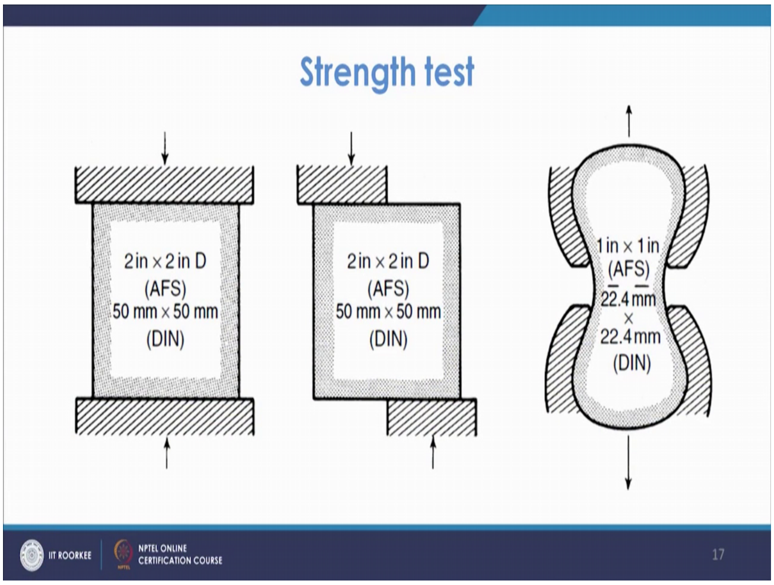

A strength test as you know you have the different kind of strength like you have tension test, you have compression test, you have shear test. So, this kind or as you see the first picture will tell you about the compression test second picture is going to tell you about the shear test. So, you have the cylindrical specimen of 2 inch by 2 inch and then the loading is carried out, as you see that you have for tension test you have the different type of gripping you are making and then you are doing the tension test. So, that talks about the different kind of green compression strength, green tension strength. So, different dry strength or so you all the test type of strength test you can do for checking the strength of the mold.

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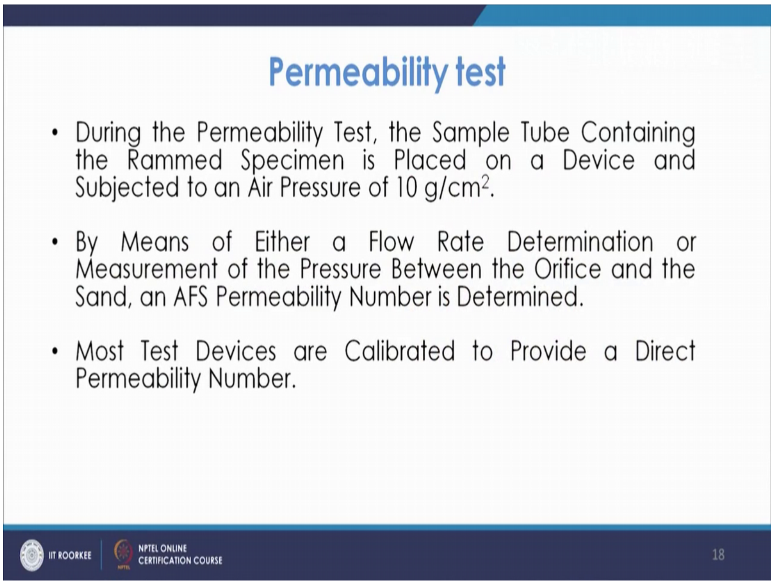

Permeability test is basically done in an apparatus where you have the standard specimen and you allow the air to pass through it. So, depending upon the time it takes to pass the air at certain pressure so on that you find the permeability. So, that way you have the expression v h upon p a t. So, volume of air you are allowing certain volume of air of certain height of the specimen with certain pressure and area of standard I mean you have area of the specimen that is there for standard specimen as we know and t is the time; so based on that you have you get the permeability number.

So permeability number and that will be indicative of the permeability level of the molding sand, similarly a moisture content test which talks about the moisture.

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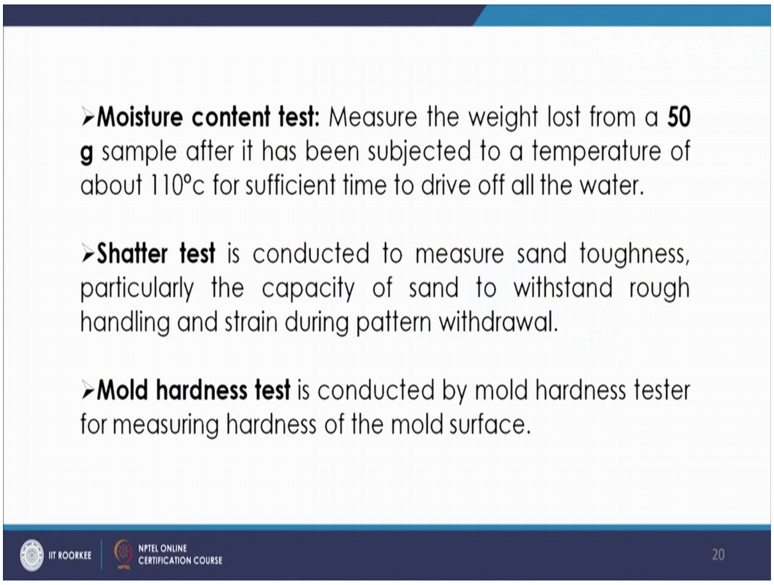

So, you are heating it for certain time moisture will be gone at 110 degree (Refer Time: 33:00) for sufficient time and the difference in the weight will talk about the moisture content test.

Shatter test is something about measuring sand toughness because when you are using particularly withdrawing the mold that time the toughness is required. So, for that we do the shatter test the sand sample is allowed to fall from certain height and then the amount collected based on that shatter test is carried out, mold hardness test we have mold hardness tester, we have indenter which will indent and depending upon the indentation you can go for getting the mold hardness test.

So, this way the different types of tests are carried out and we judge the suitability of the molding material to be used for the casting of the material into the mold.

Thank you very much.