Introduction to Mineral Processing
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Lecture – 08
Particle Characterization (Contd.)

Hello welcome everyone. So, the last lecture we have started discussing about the concept of particle size distribution and I have shown you also that there a various techniques, there various sophisticated instruments they have come up to measure the particles size distributions, but I reminded you that you must be very clear what size is measured.

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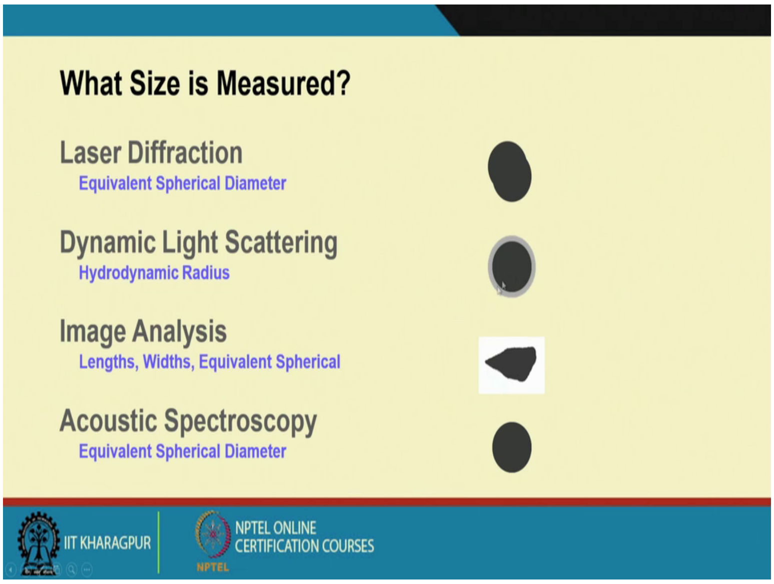

Most frequently these days the laser diffraction technique is used which essentially measures that equivalent spherical diameter, I am not getting into the details of the principle what it applies that is what is the inline physics that, but these are mostly applicable for very fine size ranges. So, these are being used the laser diffraction based your techniques are being used even for online or say on stream particle size distribution measurement purposes.

Then we have got dynamic light scattering method what essentially measures the hydrodynamic radius, the basic difference that that it has got an envelope of a thin film of water so it is basically the measuring the hydrodynamic radius of this particle. Then we have got image analysis technique which is being used these days in modern mineral processing plants for generating the instant information about the particle size, ranges being generated into the mineral processing plant at different locations or by through different machines, because the when the particles are in courses size ranges they are being transported through most common bulk material handling system is through conveyor belt. So, on top of that is I have got it camera, so you are getting the images and you are processing those images and you are sending the information to the control room that what are the size distribution of that material which is being transported.

So, it measures the lengths, widths equivalent spherical diameters, but this is more or less applicable for relatively cores sizes, then you have got acoustic spectroscopy which again measures the equivalent spherical diameter all these techniques they have got some advantages and disadvantages in terms of the bottom and the top size limits and it generates very useful information for your efficiency evaluation of your upstream processes, as well as for your quick optimization techniques or quick optimization algorithm to be developed based on this information.

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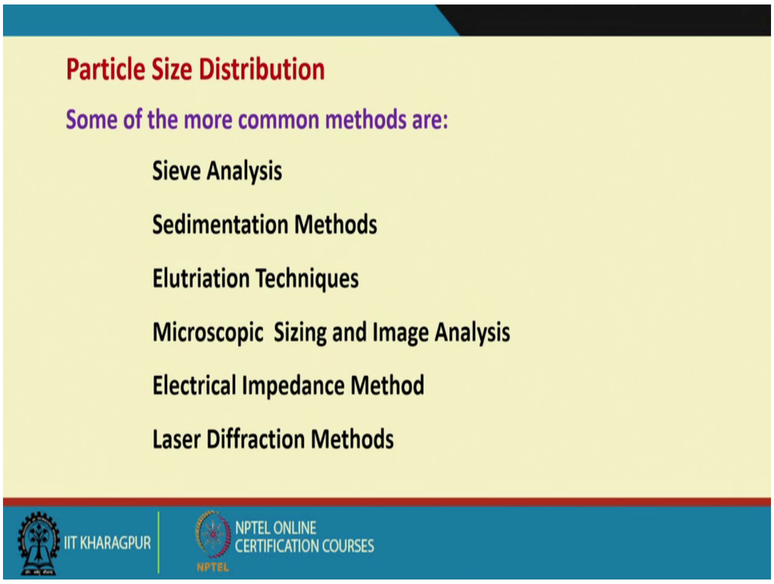

But apart from this sophisticated analysis, there are some of the more common methods are also available which are frequently used in many mineral processing plants. What is sieve analysis that is a very common one almost all the processing plants all throughout the world they use this technique, that is why we will discuss more on this technique the sieve analysis. Then we have got sedimentation methods, elutriation techniques, microscopic sizing and image analysis, electrical impedance method and we have already talked about laser diffraction methods.

So, let me elaborate more on this because there is a very common technique what do we use and most of the cases we generate our useful information for even selecting a particular processing equipment for the mineral processing plant and even we can design our likely bulk material handling systems based on this information, but what is sieve analysis and what are the precautions we must take and then what are the useful informations we can generate out of this that I will elaborate.

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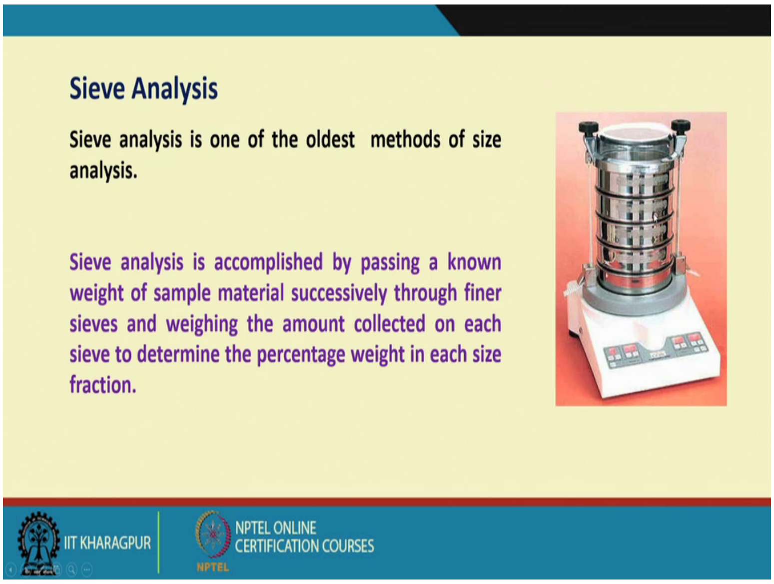

So, how the sieve analysis is performed, well the very cheap method and equipment is also very simple and the data is reproducible and reliable if the certain precautions are taken before hand or if the test is done carefully. So, you see that this is we call it a sieve shaker what do you do you have got a stack of sieves and this sieves actually start from the courses to finest, that means suppose my initial assessment of my particle size distribution looking at the particles I can have a guess that I think we have from 10 millimeter down to maybe 200 micrometers the particles. So, what I will do I was have a stack of sieve from 10 millimeter to that 200 micrometers, I will first collect a representative sample by adopting appropriate sampling technique and then put the entire mass that is small quantity of that sample here and then the machine basically shakes and they vibrates.

So, that if there is any agglomerate present they are basically is lost and vibration means you are basically trying to create more spaces by generating more void spaces, because when you are lifting you are using more volume space within the screen I will elaborate on that and after that what you do, so suppose I do it for a certain specified period of time suppose for 10 minutes I do that test and then I stop the machine, I collect the samples I say dismantle all the sieves we call it sieves and then try to take out the samples which are being retained on each sieve and then weigh them individually.

So, what will happen if I say that some materials they are reporting here they say that means definitely they have passed through that sieve otherwise they would not have reported here. So, we say that these particles they are finer than this sieve but coarser than this sieve that is how you are discretizing it and then we calculate something that I will explain to you.

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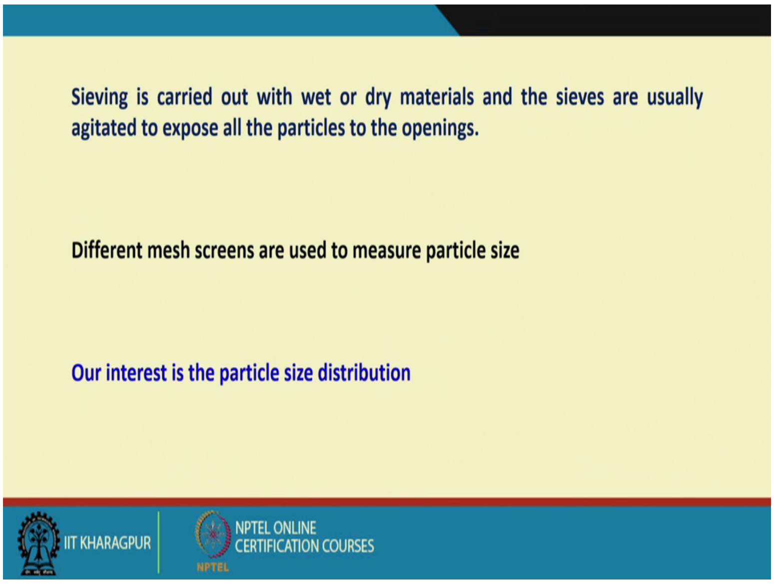

So, the sieving may be carried out in wet condition or dry condition why wet condition, but when the particle sizes become little bit finer then there is a chance of agglomeration because of the cohesive forces. So, we try to use water to disperse them and water also helps in flow ability of these particles from one sieve to another sieve. And the agitation as I explained that the if the particles are basically choking your sieve apertures, then the agitation helps to prevent my sieve apertures from choking. Now how we will select the screens or the sieves there are certain rules you have to follow or their certain reasons behind that that you must take into consideration, so what do you do that is how do we define this aperture sizes of the screens, that is also very important because ultimately as I mentioned it earlier also that we are interested in knowing the size distribution.

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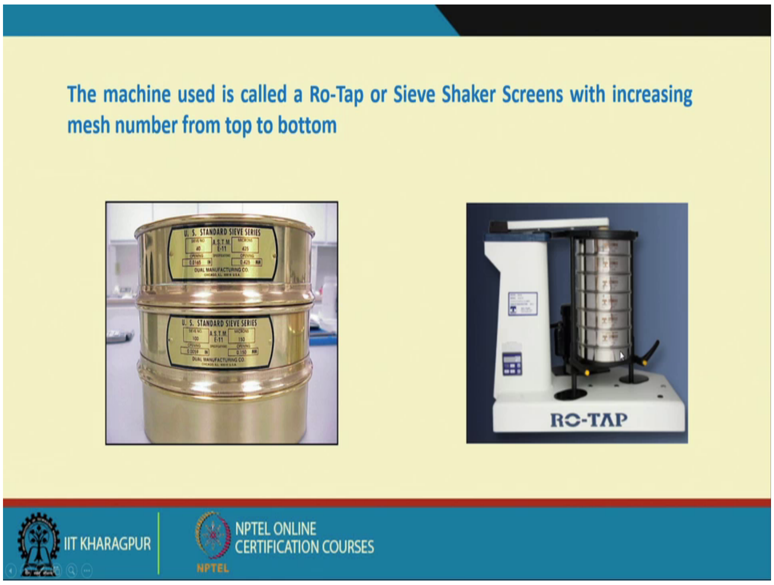

So, the machine used is called a row tap or sieve shaker as I mentioned with increasing mesh number to from top to bottom. Now you may be confused or you may be wondering that what is this mesh and all this that I will explain you, but if you look at closely to this that there is some information given on the sieves also it is written BS standard sieve series or US standard sieve series sorry it is not BS it is US standard sieve series.

So, when you are using a us standard sieve series your subsequent sieves have to be from has to be from the US standard, possibly from the same manufacturers and if you would look at more closely you will see that there at some numbers given it is saying that it is the sieve number and then there is a micron and so it may be in the millimeter range also so micron it is saying 425 micrometers, that means that sieve aperture because each aperture has to be equal the manufacturer has to guarantee that so the each aperture size is 425 micron.

Next one is showing that this is 150 microns, 150 micrometers. Now when you have a stack of sieve like this from coasters to finest easier to say, but how do I decide on what are those sieves that I should be using as I said first you have to guess that whether we have got particles in the range of millimeter sizes or micrometer sizes suppose my guess is that it starts from 600 micrometers.

So, what I will do suppose I have got 200 grams of representative sample, I will take first a 600 micrometer sieve and then we just simply weigh simply try to sieve it out by using hand. And then if you see that the material whatever is retained that is how much is the coarse are particle whose sizes are more than 600 micrometers, if they are not more than 5 percent of my initial sample weight like I have started with 200 grams and this sample weight which has been retained on a 600 micrometers, that means they are coarse than 600 micrometers and this should not be more than 5 percent of 200 grams means is 10 grams.

How do I get that because after sieving it for a quite some time and if I take the particles out and then weigh them I can get to know this. Suppose it is giving me a data of 50 grams so that is 50 grams of out of 200 grams is 25 percent. So, my size distribution information I may have some confusions that, you are saying that 25 percent of your population is having an average size more than 600 micrometers, can you guarantee me that there will not be 15 percent of them particles which have even coarser than 1000 micrometers, because by I have a different technique to handle particles coarser than 1000 micrometers. So, it is better to use the sieves in a as close size range as possible, but then there has to be availability of these sieves in the market and then it consumes lot of time.

So, you have to have again a compromise between the accuracy and the time and the cost involved. So, if the generally the it is a thumb rule that, if the coarser sieves there is the coarser sieve if the retain particle weight percent is not more than 5 percent then that is the right sieve to start with, similarly what will be the bottom sieve suppose my guess is that I have hardly any particle finer than 40 micrometers. So, what I will do I will take another sieve I will take again that 200 gram sample and I will take a 40 micrometer sieve and we start doing hand sieving.

And now instead of taking out the particles which are retained on that I will take out I will measure the weight of the particles which are finer than 40 micrometer aperture and that again should not be more than 5 percent of my total population, the reason is that suppose again this becomes 40 percent suppose I have taken 200 grams of sample and I am seeing that more than 80 grams of sample they are finer than 40 micro meters. So, that techniques what I am using for processing up to 40 micrometer particle size range they may or may not be adequate or efficient to treat the below 40 micrometer sizes.

So, once I get this particle sizes which are retained and passed through the top most and the bottom most sieves, then I get the topmost sieve and I get the idea about the bottom most sieve that is your 600 micron that is 600 micrometers and 40 micrometers.

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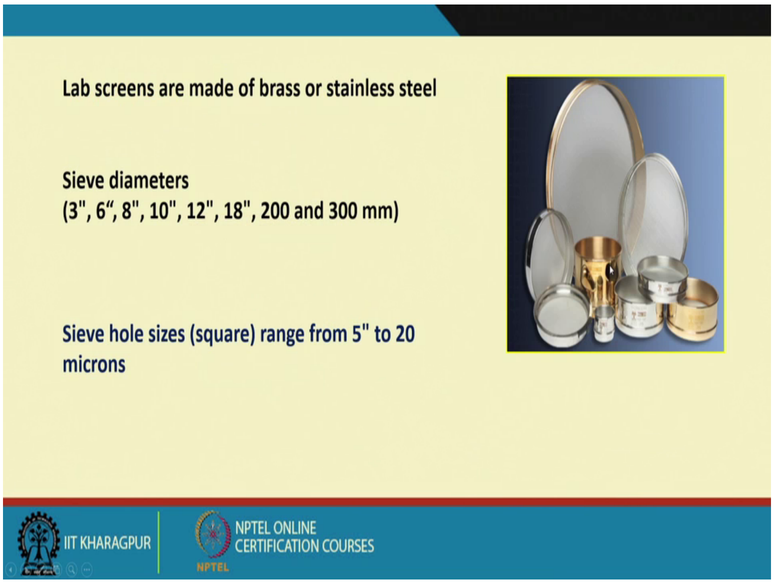

Now what will be the next size of the sieve, before I get into that topic these images are showing that your some laboratory sieves what we used, so they are generally made of either brass or stainless steel normally for dry processes we use sieves made of brass there is no harm if you use steel also stainless steel, but when you are using water that is the wait processes we have to use stainless steel otherwise the corrosion problem will arise.

Now, the sieve diameters they may range from 3 inch to 300 millimeter. So, if your sample weight how do I decide it that will be dictated by how much of sample in one go you want to do the size analysis. So, if I want to process more amount of material I have to go for the bigger sizes of the sieves, but again whether that is if I am having if I am using this so my row tab sieve shaker should be also bigger to accommodate should be appropriate to accommodate these sizes of sieves.

Now this sieve hole sizes they could range from 5 inch to 20 microns, 20 micrometers although in textbooks or although in literature, it is mentioned that even the sieving is possible even below these days even below 5 micrometers, but personally my experience tells me that, we should not use sieving below 40 micrometers the results are many times they are not reproducible.

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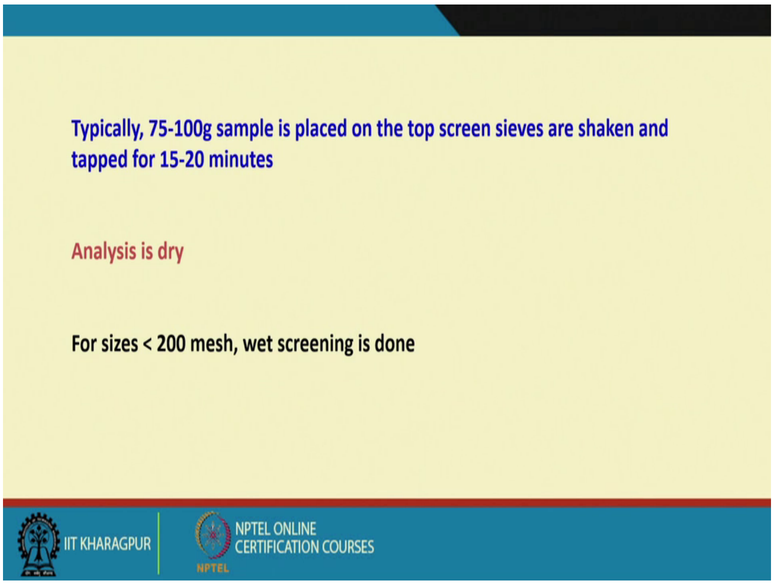

So, typically we take 75 to 100 grams of sample, they are placed on the top screen sieves I have already explained you how do I select the top sieve and the bottom sieve and they are shaken and tapped to dislodge any agglomerate and shaken means you want to try to fluidize the particle bade to have more degree of freedom for the particle to move there is what will happen if my when I am pouring this 75 to 100 grams of sample into a sieve there will be a layer of particles.

Now, if they are not shaken and if they are not basically tapped so what will happen the particles which are on the top layer they may not have any opportunity to interact with my aperture to finally decide that whether I should pass or I should retain there, that means you are sieving data will be inaccurate and that is why we want to shake it and we want to also we want to shake it and we want to say vibrate it and we want to tap it also.

Generally as I said the analysis is dry for sizes less than 200 mesh that that I will define what is the mesh, but 200 mesh is equivalent to as I remember it is 75 micrometers. So, wet screening is generally recommended that we use water also as a dispersive medium.

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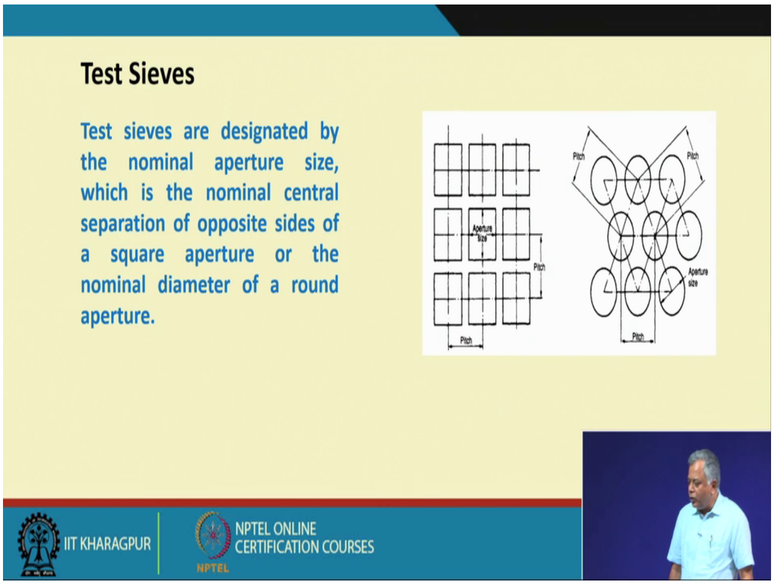

Now, if I look at closely the apertures how will you have the apertures easy to say that we will have 100 micron sieves, 100 micrometer means 100 that each aperture is exactly 100 micrometers. So, what is that 100 micrometer here, is it the if I have a shape of this aperture like a rectangle, is that is the diagonal is 100 micrometer or is the width is the 100 micrometer it is basically the width is the 100 micrometer, but again it depends on how it is being oriented.

That means if try to think of that this is a plane of the sieve and the particles are getting into from the top so what it sees that is the width, but if you change the orientation there is a length and the this is called the pitch it is shown here in the image and we can also have your say circular openings. So, that is whether we have a and we can have square openings also, so it depends on how these apertures were being made, if I have a punch then I can have a circular holes and if it is suppose I have got a plate and then I am punching it.

So, I can have your holes they are all basically a circular shape, but if I have wires and I can have the wires in this direction and wires in this direction and I if I closely tie them at fixed locations. So, that they have a shape of a rectangle or of a basically a square, then I can easily have the freedom of changing their orientation giving a shape of either a rectangle or the even the square meshes.

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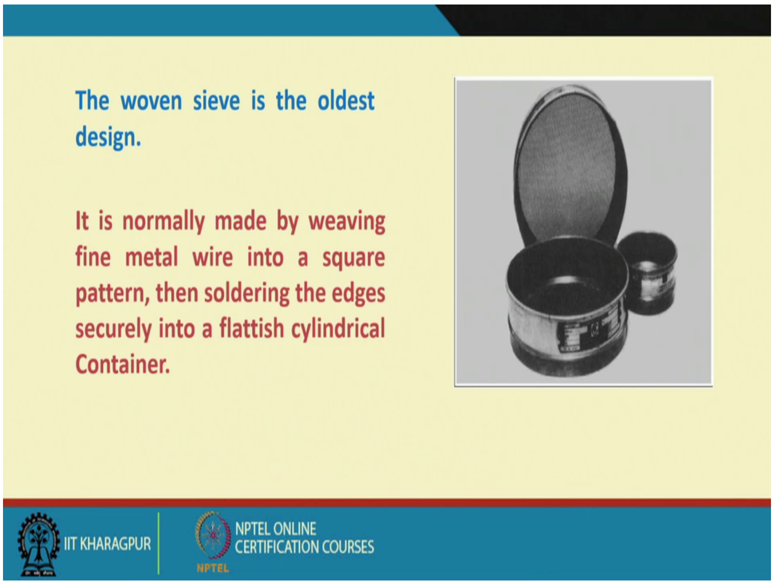

Now the oven sieve is the oldest design, this is the oven sieve we call it oven sieve that they are basically the made of wires, so it is normally made by weaving fine metal wire into a square pattern then soldering the edges securely into a flattish cylindrical container. So, that is how these sieves are being made.

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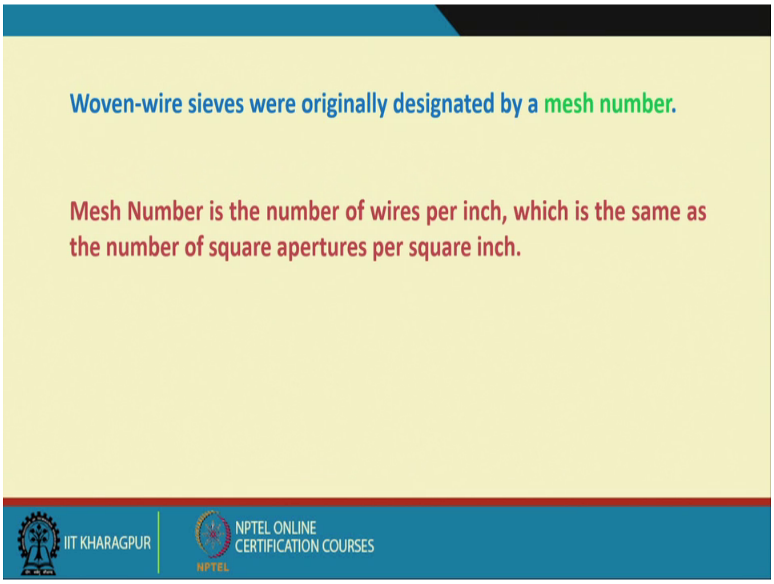

Oven wire sieves were originally designed by a mesh number now let me tell you what is the mesh number. So, mesh number is the number of wires per inch, that how many wires you have per linear inch which is the same as the number of square apertures per square inch, that means I have got a fixed diameter of my sieve and I know that and if I am equally distributing dividing it into 10 apertures and I know the width of or I know the dimensions of each wire they are of equal dimensions so I can calculate back that what is the average diameter of my wire meshes so that is called the mesh.

So, it is very important to know that what is the diameter of the wires and that is why I said that, if you are using a us standard sieve you have to use all throughout that is your in the stack all the sieve should be from us standard, because you are using the same material and the same diameter of the wires. So, what will happen now if I have a mixed up sieves from various standards like for example, say suppose if us standard sieve because your sieve diameter is fixed.

So each wire they are having a diameter of say X millimeter and now Indian standard sieve you are mixing them up they use wires having a diameter of X minus delta X. So, what will happen when you are trying to weigh it into equal suppose I want to have 10 equal apertures across a 3 inch sieve, so what will happen when I am having this is woven by X millimeter dimension diameter oven wires I will be having the different aperture diameters, then when I am using a X minus delta X millimeter diameter oven wires.

So, when I am saying that the average that the each opening of US sieve is 400 micrometers and if I am using an Indian standard sieve to reproduce that result, that may not be exactly 400 micrometers they may be 410 micrometers so my data will be erroneous.

Thank you very much.