Introduction to Mineral Processing

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Lecture – 07
Particle Characterization (Contd.)

Hello welcome to this 2nd lecture of this week. So, in the previous lecture we have discussed about the importance of defining the particle shape and the size. The particle shape we have shown that for irregularly shaped particle, we use a definition called sphericity and for particle shape particle size when we are discussing we have also discussed that, what are the properties that is being influenced by the particle size and why we must know that what is the size of a particle I am going to create.

But friends it has got the identical problem with our irregularly shaped particles like where do we encountered while defining their shape.

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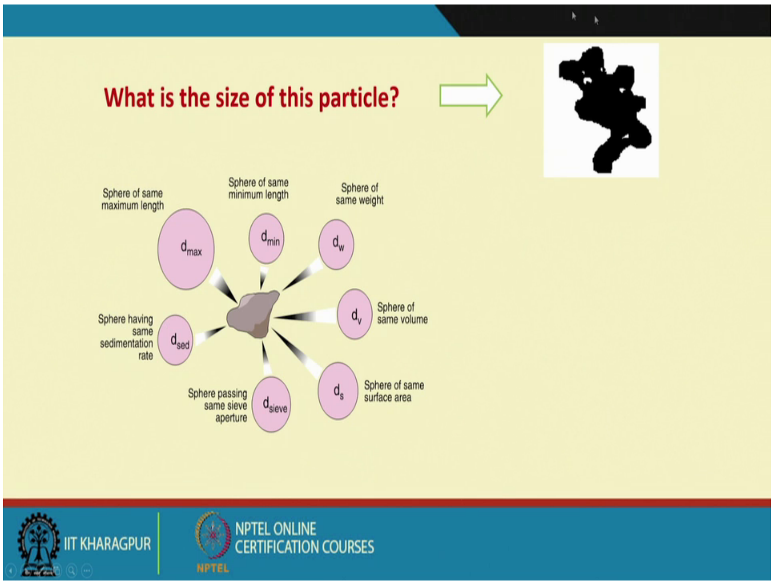

Now, say suppose this is the particle irregularly shaped particle which commonly we get from the mine products as I keep kept on saying repeatedly. Now what is the size of this particle, we said that for defining the shape of this we have got some kind of compromise solution or the definition that is call sphericity. Now as the size defining size is very important there are many definitions given I am just highlighting the few of them, but because of the paucity of time I am not going into the details of all these definitions.

But just for your information check that I am going to show you that what are the popular definitions? And if you have interest to learn more about this I would request you to go through some of the recent textbooks. Now sometimes it is called a sphere of same minimum length; that means, what is the minimum length of this particle and what will be the basically the a sphere of that. So, if I imagine that I am having a spherical particle having identical properties with the minimum dimension of this, sphere of same weight like we are always comparing we are trying to define the size in relation to a known shape that is where we need only one attribute to define that is the your diameter or radius normally these to the diameter.

So, sphere of same weights, sphere of same volume, sphere of same surface area, sphere passing same sieve aperture, that this this one I will elaborate more and then sphere having same sedimentation rate. Same sedimentation rate means that if I drop this particle into a fluid medium and say suppose this velocity is one centimeter per second and I know the density of this particle is 2500 kg per meter cube. So, what would be the equivalent size of a sphere which has got the same settling velocity the identical settling velocity?

And then sphere of same maximum length like that, but you see that when there are some proposed definitions there must be some reasons. So, when we are dealing with this particle just.

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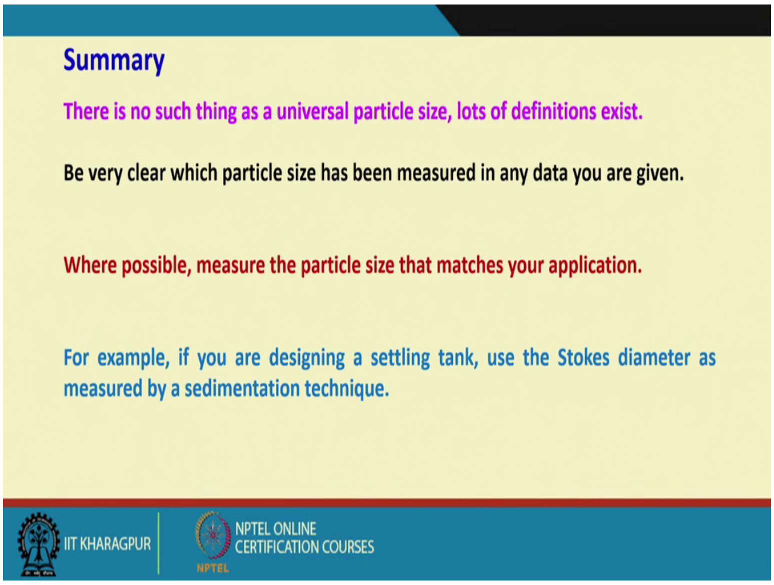

For example like when we are trying to design a settling basin where we want to know that what are the settling velocities of these particles? So, maybe the definition of your based on sedimentation rate may be more appropriate, but say suppose the particle size we want to go for a size separation a physical size separation then that definition has got no relevance your sedimentation based definition.

So, use some other definition. So, friends if we summarize we say that there is no such thing as a universal particle size lots of definitions exist. Now to define a single parameter of anything if you have n number of definition; that means, there is no common agreement between the scientists or between the practicing engineers or practicing people that this is the definition which is the best and which appropriately define my particle characteristic. So, what is the message here that be very clear which particle size has been measured in any data you are given this is a very important issue.

And so this is very very important for practicing engineers, many times we say that there is a size of the particle, but what size how it is being measured how do I define. So, that is what I am trying to suggest that be very clear which particle size has been measured in any data you are given. Then what I have to do there where possible measure the particle size that matches your application; that means, the suppose the example is here the particle size was measured by based on the sedimentation velocity that is the example I have given and my application is related to packing density. That is I am trying to find out a place or maybe I want to design a basically a container where I want to like we call it beam that where we want to store say suppose 10,000 tons of these materials.

So, as I said the packing density will be dictated by the particle size and the particle shape. So, whether what will be the dimension of that beam that will be Dict that for that I need to know the size, but the size particle size information whatever I have got that is basically the definition based on the sedimentation velocity it does not have any relation to that. So, please ensure that the definition of that size exactly matches your application otherwise your calculations your designs may be wrong.

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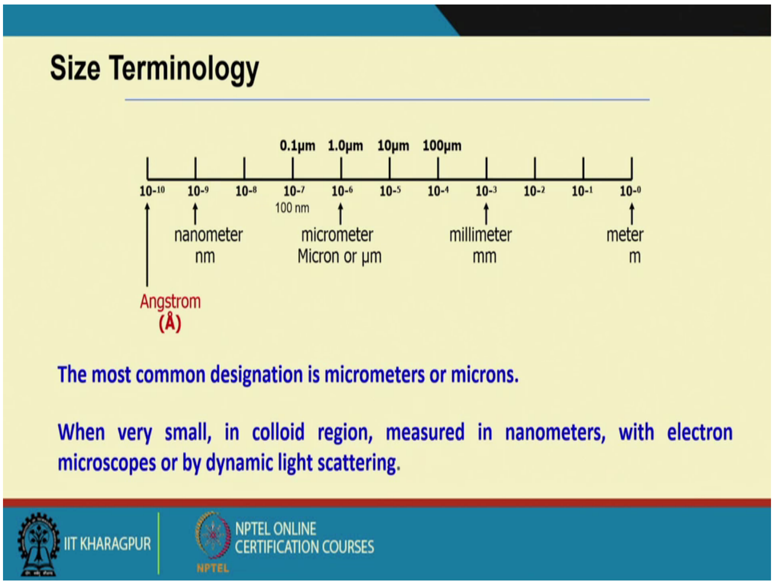

If we go to the next thing that is what are the units I will use to define the size, it can start with the kilometer to meter and even up to angstrom, but this course is related to mineral processing. So, a general curiosity of all of you would be that what is that maximum size in terms of unit and the minimum size we encounter actually, when we are dealing with the mine product when it is directly coming from mines we may have to start with meter then the centimeter millimeter and we stop here micrometer we do not deal with this Nano particles and your angstrom sizes particles.

But these days some mineral processing engineers, they are researching on the application of some mineral processing techniques to even generate Nano particles that is they are involved in nanotechnology based research, but a common mineral processor they encounter the particles size ranging from in terms of unit that is your meter to micrometer sizes. And most commonly we use the micrometers, because if you remember our discussion on the liberation because our low grade we are mining such a low grade ores these days that you have to grind the rock to very fine particle sizes. And you have to define them in terms of micrometers they are not even in the millimeter sizes many a times that is their liberation that is dictated by their liberation behavior.

When they are very small that is in this range the colloid reason measured in nanometers. So, how do we measure can I use the same identical technique to measure the particle sizes from the meter to angstrom or nanometer sizes no. So, we use different techniques to measure them like I am just giving you an example that for a nanometer sizes particles or angstrom sizes particles, we use electron microscopy transmission electron microscopy sometime dynamic light scattering. So, there are various techniques available.

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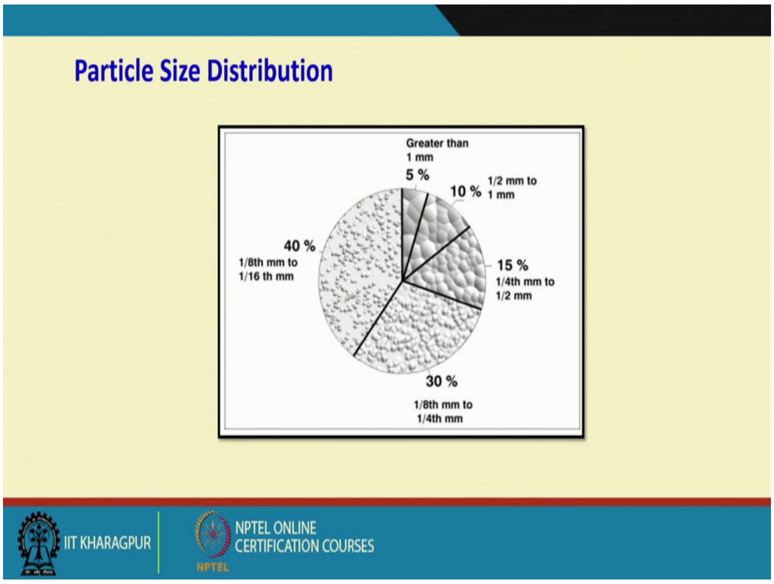

And for coarser particle sizes we use different techniques which we will discuss very soon, but before we go to this that how do we measure the particle sizes, which are available in assemblages. Let me elaborate this point as I kept on saying that we are not interested in knowing in most of the cases the individual particle characteristics because we are not dealing individual particles we have to deal with bulk commodities. So, how the bulk material they behave that is what is most important characteristics a any mineral processes would have to know otherwise you cannot design you cannot do anything with the subsequent downstream processes.

As an example so what we do that we try to group them into different discreet ranges, like this example here you see that this is an assemblies of relatively sub coarser particles down to that this particle sizes are more than one millimeter and you find that you have this particles which are even up to 1 by 16th of a millimeter. So, we have got a assemblage. Now what will be the characteristics of this suppose I have got 500 grams of this material how will they behave. So, that will again be dictated that what are the relative distributions of the each size ranges.

So, we cannot define as by single size that is we cannot say that it is a one millimeter particle, because not all the particles are having exactly one millimeter size some particles may be 0.98 millimeter some particles may be 1.01 millimeter. So, what do we do we try to put them into a range. So, ranges like this half millimeter to 1 millimeter, 1 fourth millimeter to half millimeter, 1 8 millimeter to 1 fourth millimeter like that. And then we try to identify some easier technique which is fast, which is cheap, which will give us a segregated information of this assemblage like that this particle classes I have I am showing it as an segregated version.

But eventually they were basically mixed now I have grouped them now say suppose out of 500 grams material I see that 5 percent of these materials they are greater than 1 millimeter sizes I am not giving any guarantee that whether we have got any particle more than 1.2 millimeter or 1.3 millimeter, but what I am saying that the 5 percent of the total population is greater than 1 millimeter, then this one I am saying the 10 percent of this population is within a half millimeter to 1 millimeter, like that we are saying 15 percent is 1 4th to half millimeter, 30 percent is 1 by 8 to 4 4th millimeter and remaining 40 percent is 1 by 8th of a millimeter to 1 by 16th of a millimeter.

Why do we do this that is a very important question? Now the very first reason is many times my client for whom I am processing they say that we are interested only on the size ranges between 1 by 18th to 1 by 4th of a millimeter we are not at all interested in buying these sizes we are interested in this. So, when I have your when I am mine when I have a mined product which is having this type of your mix sizes. So, I know that whatever I have mined I can sell to maximum of 30 percent of that material to this client 1 by 18th of one by 4th millimeter.

But then also that information also tells me that if I mine at a rate of 100 tones per hour I will be able to sell the 30 tones at a rate of 30 tons per hour to the client one who will accept 1 by 18th 2 1 by 4th of a millimeter particles. So, I have to plan beforehand before setting up that processing plant of a capacity of 100 tons that what I am going to do with the remaining 70 tones material, which are being produced per hour the first thing what do you have to do that is whether there is any buyer for this particles or if you find that there are no buyers. So, how do I dispose it off what do I dump it will there be any environmental related problems and all these.

What would be the material handling equipment and all? So, all sorts of information you can have when you have this prior information that what is the relative distribution what you call it that this is called the particle size distribution. So, as a mineral processing person mostly we are interested in knowing the particle size distribution not the individual particle sizes sometimes we may be interested in knowing individual sizes, but in most of the cases we want to know the particle size distribute how they are segregate how they are distributed in discrete size ranges, that is why we choose certain methods to quickly generate this information out of my mine product.

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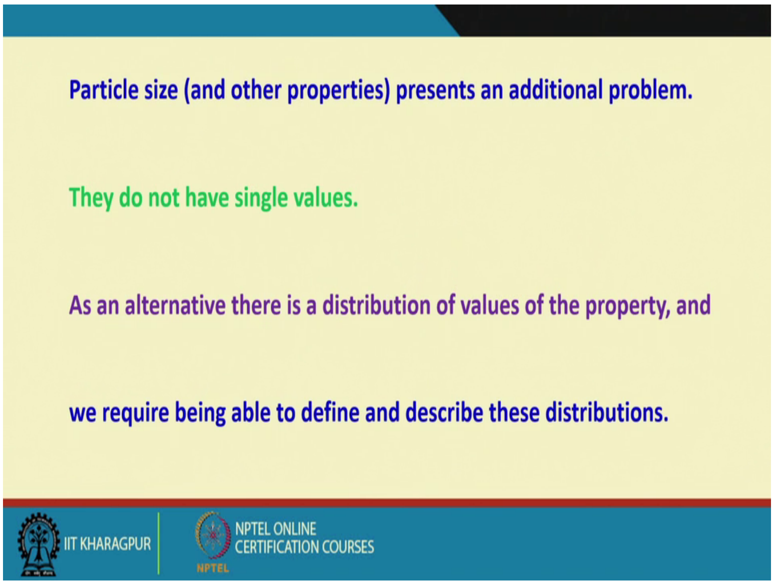

Now another thing is that that particle size and other properties presents an additional problem they do not have single values like shape like those particles what I had shown you in the previous slide that. We are not interested in knowing the individual shapes of the particles, because it is extremely difficult, but sometimes we may need to know that whether these particles are in general flaky type or what type of shape it has got or what is their sphericity because now say suppose if I go back to this example. Now I am producing this material I am mining and I am processing it sitting in say Kharagpur and my client wants it to be delivered in a place in Mumbai which is around 1800 kilometers from this place.

So, I have to think of that how do I transport it. So, the mode of transportation will also be dictated by the particle size I already know, but what are their shapes suppose we plan to have a pipeline transport through as a slurry. Now if I have a flaky particle I have a different problem if they are spherical particle I have a different problem. So, my design characteristics will definitely be dictated by their shape distribution. So, that is why saying that the particle properties and particle like your particle size and shape they presents an additional problem they do not have single values. So, that is why we always give emphasis on a particular property in a distributed manner that is what is the particle size distribution, what is the particle density distribution like that.

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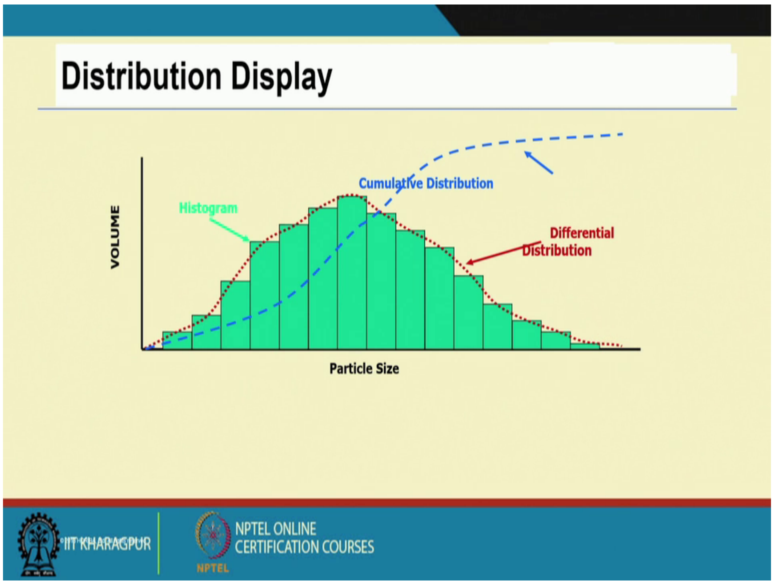

Now say suppose we have a distribution like this. So, we want to gather more information out of that distributed value. So, what do we do? So, many times we plot like your particle size versus say as volume versus particle size or maybe weight percent versus particle size and we may plot a distribution in the form of basically the histograms. So, from the histogram if we look at the histograms we know that these are the suppose the coarser sizes. So, this is the coarsest particle it does not have much of it has got very little percentage in the entire assemblage.

Similarly, we can get to know that the finest particles that have relatively finer particles their contribution on the overall assemblage very less. So, what are those particles that is basically controlling the most of the so majority of the assemblage it has this range and what is the most common particle size, which is being reported. Same data if we link together we can have a differential distribution plot, but in mineral processing area we commonly use the cumulative distribution plot we will have to discuss more on this point.

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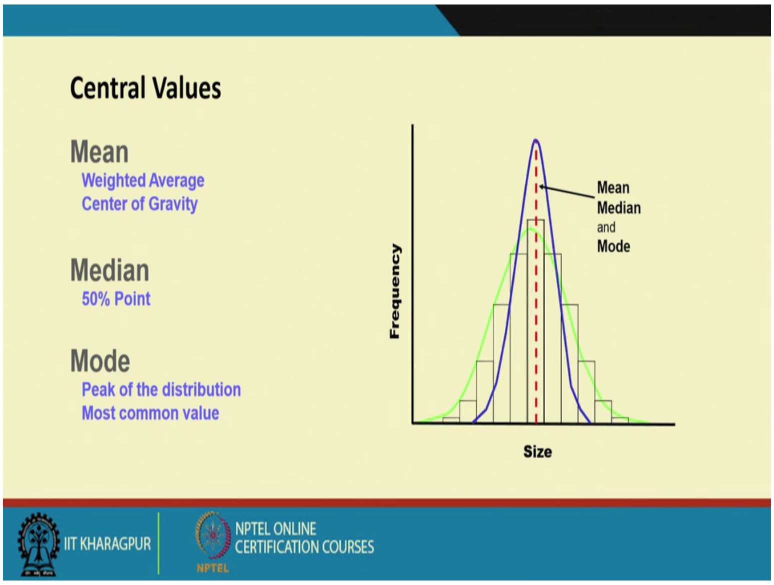

What is the meaning of cumulative distribution before that let me explain a little bit of for your say searching for your say division of your basic knowledge about elementary knowledge of statistics?

That when we have a distribution plot. So, we also get to know that what is the mean value; that means, what is the weighted average center of gravity; that means, what is the mean value mean value suppose if I have a distribution plot like this. So, the mean value is somewhere here is the median is the 50 percent point; that means, it is the point where the entire area is equally divided into 2 parts and mode that is a peak of the distribution that is what I said that the most common particle which is reporting.

So, as the peak of the distribution that is the most common value now if I have a distribution like this then all 3 this mean median and mode they coincide here, but in some cases sorry in some cases you may have this distribution plot like skewed towards left or towards right. So, then your mean median modes are different. So, when I look at the shape of the distribution curve I have some kind of your basic information about the particle size distribution of that assemblage.

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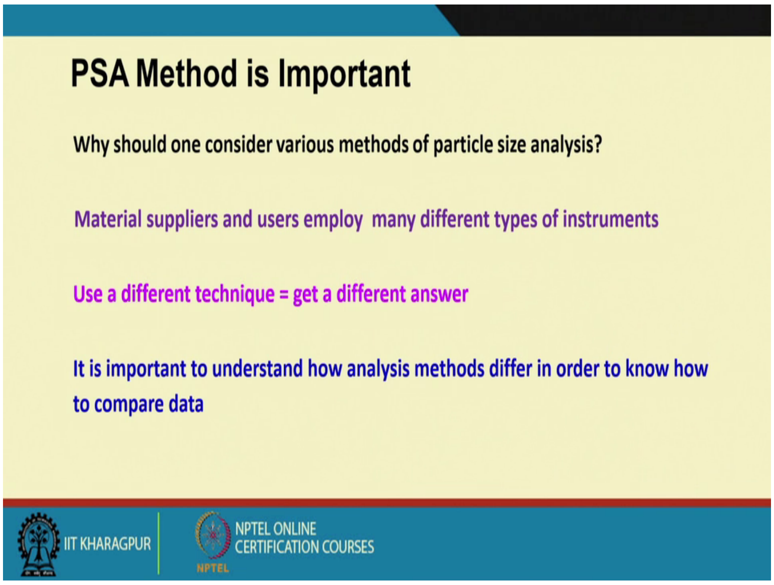

So, the techniques what we use in mineral processing that is to determine the size distribution not the individual sizes very rare occasions we are interested to know mostly in research in academic research we try to have the information on the individual sizes.

But as we are dealing with bulk commodities we are more interested in knowing the particle size distribution in state in in place of knowing the individual sizes. So, that is called the so the analyzer we call it particle size analyzer in short term it is called PSA. So, again what method we are applying it because our increasing definition of size is different it differs from the technique to technique. So, what is that size it is measuring to get me the information about the size distribution. So, that is very important.

So, what is that method we are using; obviously, the question will come that why should one consider various methods of particle size analysis, the reason is the material suppliers and users employ many different types of instruments and you will definitely get different answers when you use different techniques. So, it is important to understand how analysis methods differ in order to know how to compare data what I am trying to say they hear the suppose you get me a data telling me look this is the size distribution, I am getting and he tells me that this is the size distribution I am getting I bought it is this same sample why we are getting the different data.

My first question will be to both of you that how do I ensure that it is the same sample; that means, what is the sampling error and next question would be how did you measure the size distribution if your techniques are different; that means, you have used you have measured different sizes. So, definitely they will differ. So, that is why I would suggest you that you should be very clear, that what is the definition of the size or what is that it is measuring, which is telling me that this is the particle size or the particle size distribution that is what is being measured by that technique. So, that is very important the analytical methods you have used.

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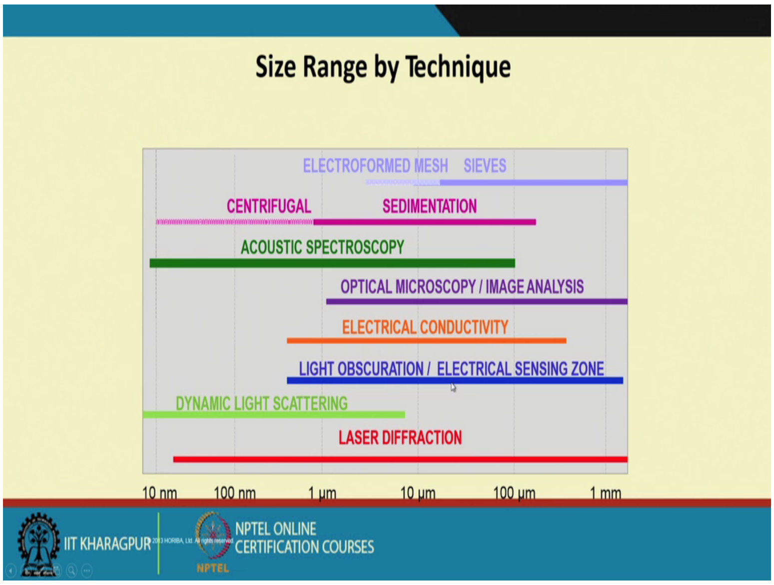

So, I will just give you some kind of your summarized information I cannot elaborate on all this because if I want to elaborate all this this itself will become a thirty years course thirty hours course. So, you see that it is the different techniques also they have an upper limit of particle size and the bottom limit of particle size restrictions. Like laser diffraction technique they can go up to millimeter to some kind of your nanometer scale, but if I want to measure one nanometer particle size probably it is not reliable dynamic light scattering light obscuration.

So, this summarizes that what is that size range it can build. So, how does it help you this summary now if you are interested in knowing the particle size distribution within a range of say suppose your one micron to 100 micron particles to design your settling basin for dewatering purposes maybe for water treatment purposes, then the laser diffraction also can do that one micron to 100 micron even all these sorts of techniques they can give you the size distribution about this, but again I am repeating are they really close to the size what you are looking for while designing a settling basin; that means, why you want to know the size of the particle because how do they travel into a fluid medium. So, I would say that use a technique which is based on sedimentation principle because that closely related relate to your process will continue this in next module.

Thank you very much.