Introduction to Mineral Processing
Prof. Arun Kumar Majumder
Department of Mining Engineering
Indian Institute of Technology, Kharagpur

Lecture – 06
Particle Characterization

Hello everyone. So, welcome to the next week course the second week of this course we are starting with the module 1, in the previous week we have discussed about the definition of minerals and ores and briefly about liberation characteristics what is the meaning of liberation, then we have also discussed about the metallurgical efficiency the concept of grade and recovery. Now this week we will discuss about the Particle Characterization particle characterization is itself very wise subject. So, we will focus only on those important aspects of the particles what we must know or optimizing our processes.

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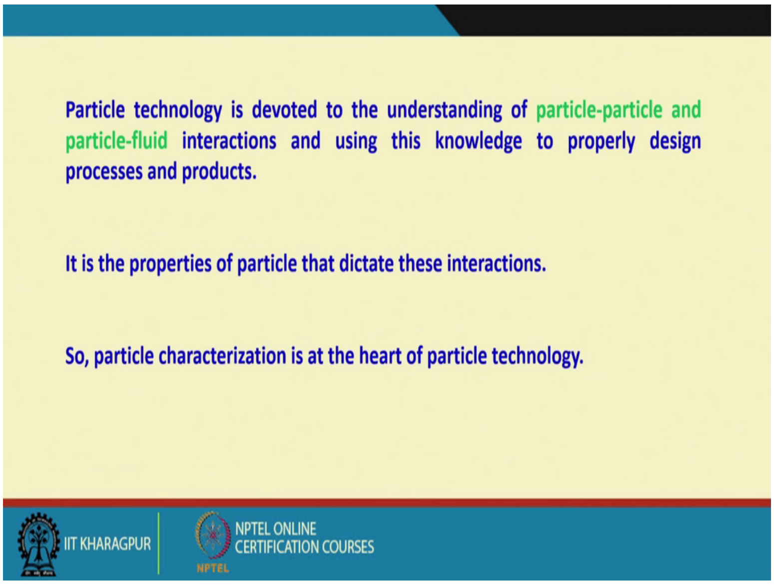

Now, before we go to the actual characterization part let me explain you that why it is important to know, the particles behavior. If you look at this a technique there if in the applied for particle technology, they are mostly related to the particle interaction or and particle fluid interactions. What I try to mean that in any process where we are involving particulate matter of various characteristics, we must understand the what are the difference scenarios, when they particle hits another particle or when a particle encounters a fluid and this is a prerequisite knowledge we should have to properly design the processes and to have our the best products.

Now, what is that basically the particle property that basically controls these interactions and we said that particle interaction and particle fluid interactions. So, to understand that we must try to understand properly that what are those properties, which are essential to evaluate that dictates the these those interactions.

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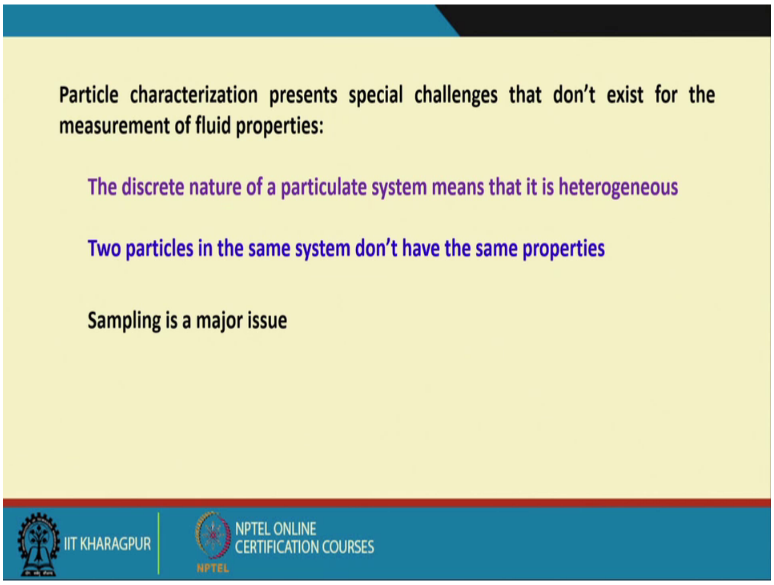

Now, this particle characterization also is not a very easy subject is it presents special challenges that do not exist for the measurement of fluid properties right. If you look at the discrete nature of particulate system it means it is heterogeneous what does it mean that is 2 particles if you have collected from the same system, they will not have identical properties and as we discussed in the previous week that we are processing in hundreds of tons of material per unit time.

So, it is impossible to know the or to determine the individual particle characteristics. So, what do we have to do the we have to collect a representative sample which represents the entire population and then we have to characterize that representative sample. So, in summary so sampling is a major issue although this week we are not going to discuss sampling we will deal with this subject sometime later.

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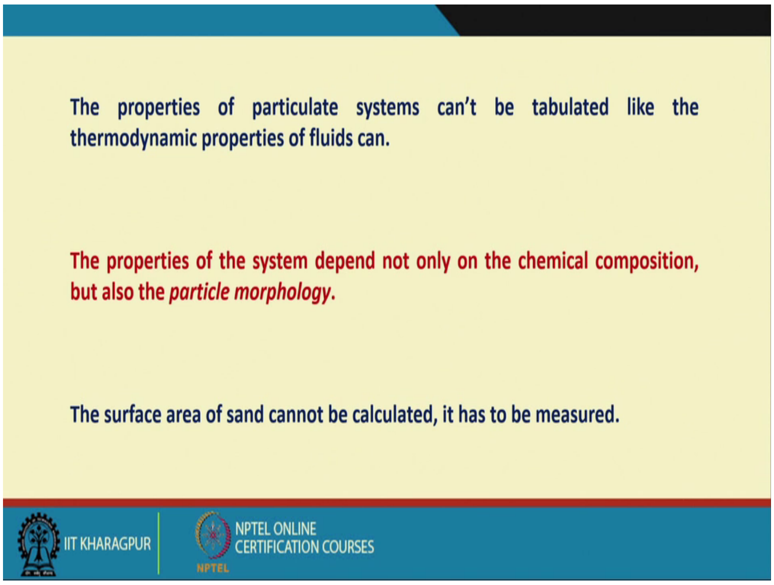

Now, what is the difference why did I say that particle properties are basically very difficult to characterize when we compare with the fluid properties? Fluid properties are basically well tabulated these days you pick up any fluid mechanics book, you will get to know the fluid properties at different temperature that what will be their density what will be it is viscosity and even some of the thermodynamic properties also we can tabulate we know, but for a particulate system it is very difficult to quantify like that.

Suppose if I give you this example that if I am giving you 100 grams of sand, can you tell that what is the average chemical composition, average chemical composition probably it is possible, but if I say that what is the individual chemical composition it is time consuming and it is very difficult to do. So, the properties of the system depend not only on the chemical composition, the chemic chemical composition of all these particles the sand is basically silicates, but at the particle morphology that also controls the properties of that bulk solids that is accumulation of all those sand particles they have a different property that is has a buck solid than the individual particles.

The surface area of sand cannot be calculated it has to be measured, why know the individual sand grains they may have different say I am just giving for example. So, your surface area will change depending on the what is the variation in the shape we cannot predict it.

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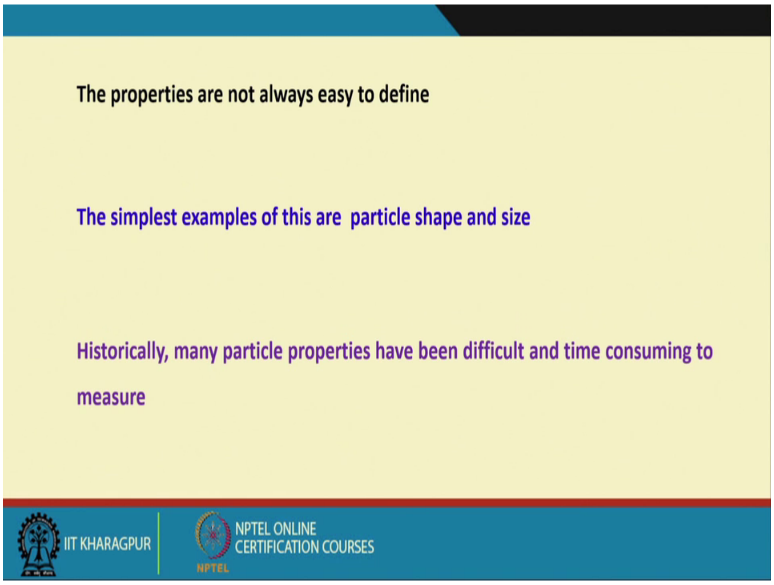

The properties are not always easy to definable I just show you the example, that where we are even for the very basic elementary properties of particles still we do not have a general consensus that yes this is the definition we accept.

Simplest examples of these are particle shape and size I try to explain more on these 2 and this lecture. Now what used to happen that because of these inherent difficulties in measuring the properties and even earlier days not many instruments were there to measure the different properties of the particles? So, and so what used to be done by many industries that they had some rituals, that if these are the mine product coming from this X mine. So, their behavior will follow like this type of thumb rule and we used to the plan operations used to be optimized based on those guesstimated values.

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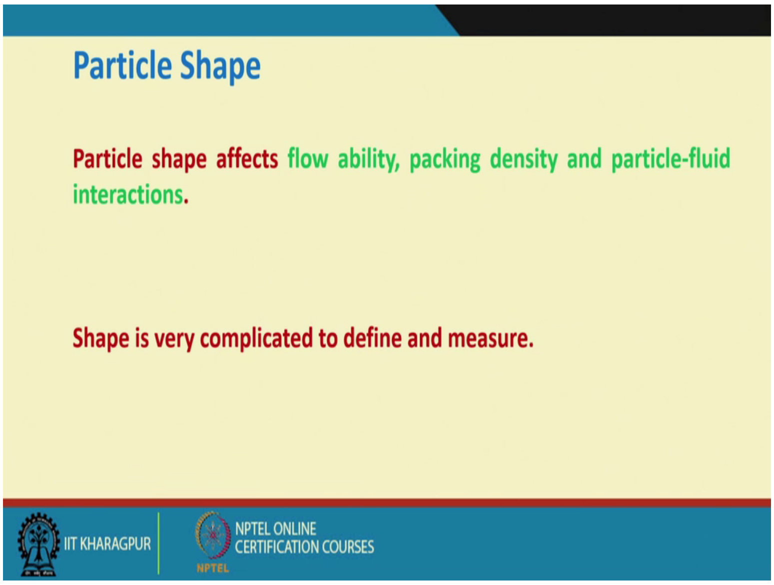

But now with the availability of the sophisticated instrumentation, techniques even online offline sensors, we can measure the particle properties with much more precisely than we used to have, that is why there is a saying it is called that do not part from rituals means that the properties.

Now, let me show you that we always when we deal with particle we always talk about shape and size. Why should we be worried about particle shape as a mineral processor at the most fundamental question do you really worry yes we do, because particle shape effects flow ability what does it mean. Suppose I have got a container filled up with water I drop 2 particles having identical chemical composition, but one is flaky and another one is spherical. Definitely their behavior into the fluid medium at what rate they will travel through that that is call we call it septic velocity they will be different the spherical particle will travel faster than the flaky particle and that is what is basically affecting the flow ability.

So, the proud knowledge of particles say is a mast if you are dealing with the flow behavior of a particle and fluid mixture. Second is packing density what does it mean suppose I have got one liter volume of a container and I want to pour rice grain. Now the rice grains they are inherently they are little bit of flaky type. So, how much of rice grain I can accommodate into a one liter container, that will be entirely different than how much of sugar I can accommodate into that or if we take lentils, if you take different other grains and if you compare it with sand.

So, it is not only their individual density which is basically affecting it is also their shape, because that is particle shape also affects your the volume of individual particles. How much it will be consume inside that container when they are in a say packing condition and whether the packing is what type of packing we have; that means, how much of void spaces we will have that will be dictated by what are the shapes of the particles.

Then I have already given you the example about the particle fluid interactions question comes how do we measure shape is very complicated to define and measure that you will realize when I take you through the slides.

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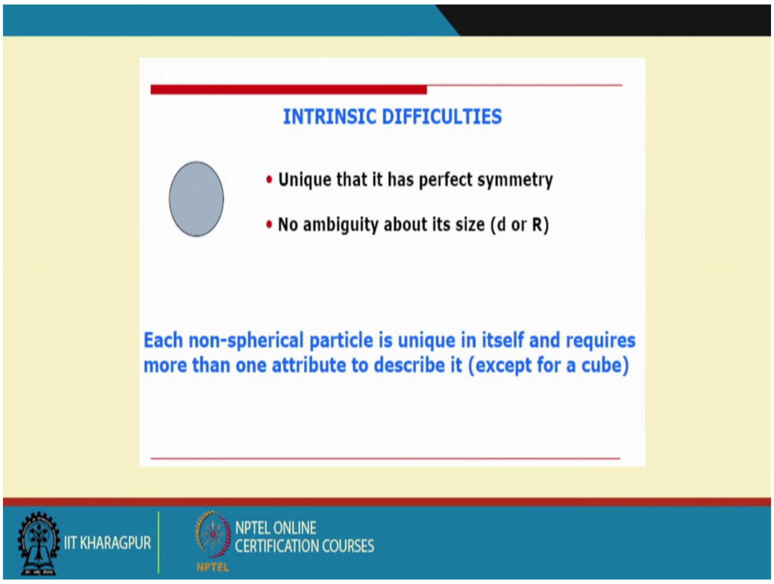

Look at if I have a spherical particle all as spherical it has got what is the uniqueness of this shape though it has got perfect symmetry, there is no ambiguity about it is size; size you can define it as the diameter or maybe in terms of radius also, but when we have non-spherical particles most of the cases which we encounter. We hardly get spherical particles on the when we are dealing with the mine products. Each non-spherical particle they are unique and they require more than one attribute to describe itself only exception is a cube.

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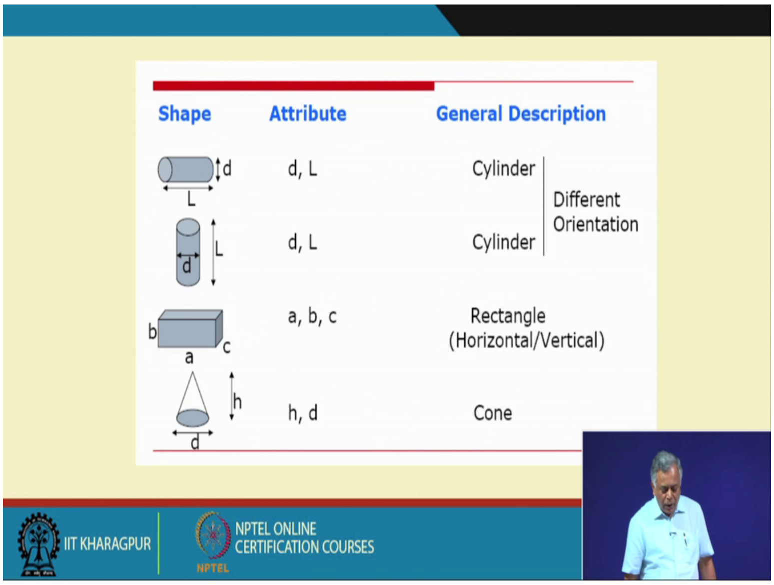

Like if I have a even a cylindrical particle, I need 2 attributes that is d and L which is shown in this figure, but think of this spherical say cylindrical particle now just assume that this is a cylindrical particle this pen. So, if you drop the pen into a fluid medium a container having your water and if you drop it like this it will have a different traveling velocity to reach the bottom.

So, this is the l and this is the d, but if you drop this it will have different velocity this thing we will discuss more when we talk about solid fluid interactions in subsequent lectures. So, this d and L although they are fixed, but whether we should define the shape of these on the basis of your L or d and then that will depend on where it is being used. Similarly if we have a rectangle it can have it has got 3 attributes a, b, c and even the for a Cone it is h and d that is a height and a diameter. So, we can define them for the regular shape, but even in a dynamic condition when they are moving; that means, in a mineral processing plant I said that there are n number of unit operations.

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So, the particle has to travel along that.

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So, when they are moving so; that means, their orientation also will dictate that what is that attribute of that particular shape is basically affecting my solid fluid interaction or solid interactions.

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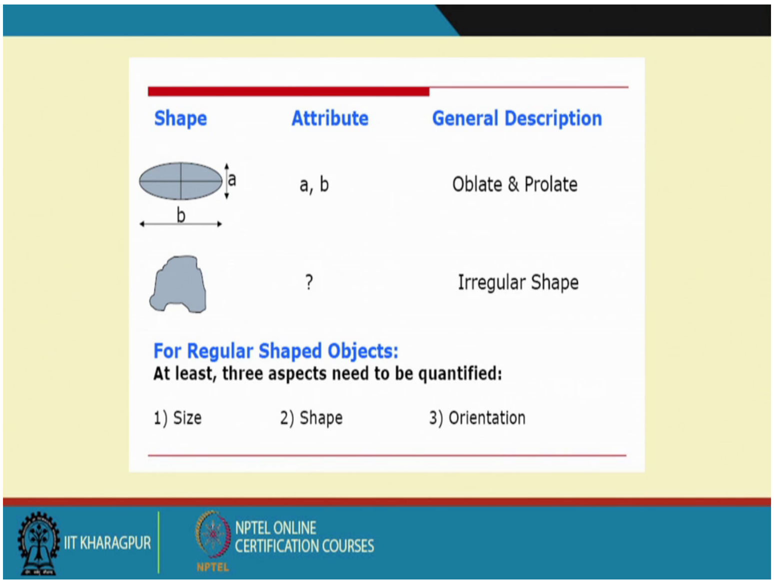

Evidence of this same we call it Oblate and Prolate you can define it by a and b, but what about this irregular shaped particle. Which we commonly encounter when it is coming from a mine product because you have blasted the rock or you have mine it through heavy missionaries you do not get even regular geometry. So, we normally get particles having irregular shape, I remember we are talking about millions and billions of particles even for an individual particle how do I define it what is the shape of this.

So, as I have discussed that per regular shaped objects we need at least 3 aspects that is size shape and orientation to quantify it and for irregular shape we still do not know how to do it. Although they will look at textbooks there are various definitions given for defining shape.

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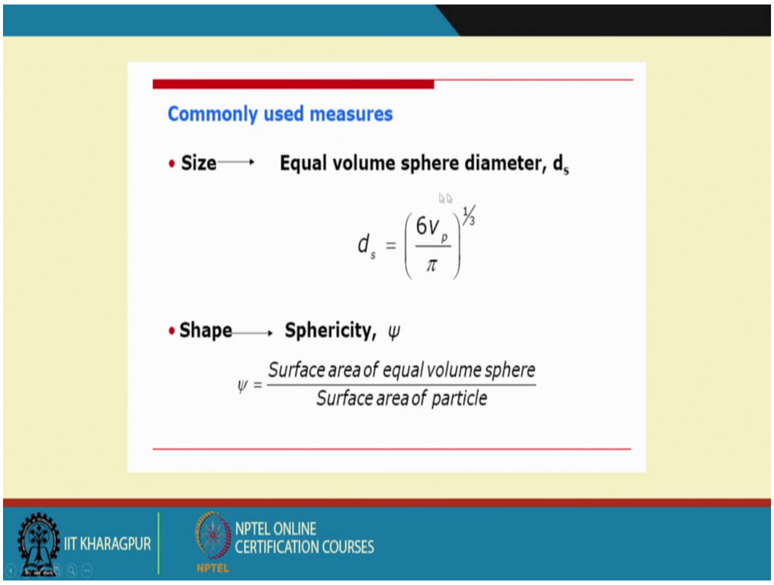

But what is the most commonly used measures are that is you first calculate, that what is the equal volume spear diameter of that particle when we talk about size we will elaborate more on these, that is you take that irregularly shaped particle and you displace a fluid normally we do it with what are if the particle is sufficiently large and how much of fluid has been displaced. So, then we can then calculate it back that if I have a spherical particle of that identical density, what would have been the size equivalent of that particle to have the similar amount of volume which is displaced.

So, we can write based on this formula that what is the equal volume sphere diameter that is for size we will elaborate more on this on my next say the topic. So, shape is basically their concept of defining it has come from the definition of size. So, it is called the Sphericity. So, Sphericity is defined as the surface area of equal volume sphere; that means, you have got the ds that is what is the size what is the size of my the equal volume sphere; that means, what is the equal volume spear diameter d s is equal to 6 V P; that means, how much of volume of the fluid you have displaced with that irregular shaped particle divided by pi to the power one third and it is coming from say your the basic calculations of your so volume calculation of spherical particles.

Now, once I know the d s. So, I can calculate that what would be the surface area of equal volume sphere; that means, the ds particle what will be the surface area of that and what is the surface area of my.

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Particle whose shape I do not know. So, the question comes how do I know the surface area now there are surface area measurement instruments available I am not getting into that now.

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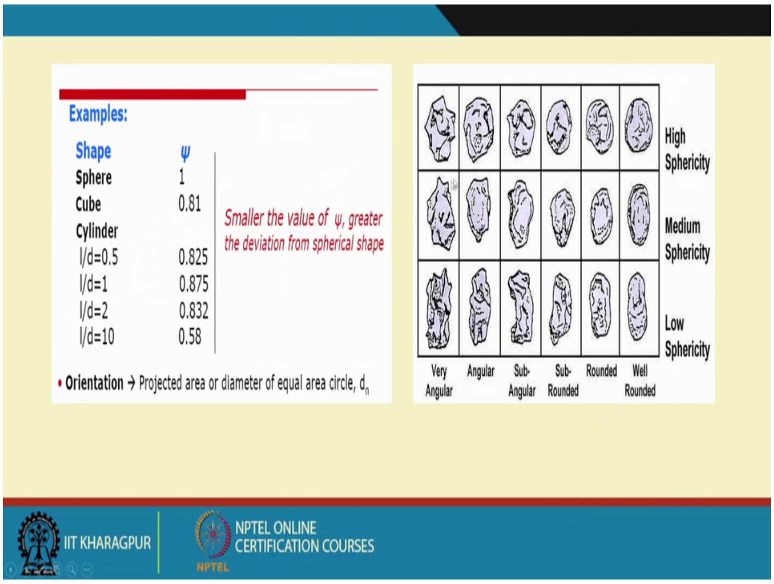

So, that is one definition which is commonly used while dealing with irregularly shaped particles in mineral processing. Now I will show you that how do I use this like if you look at these particles and if you basically calculate and if you look at even under microscope, they are very close to your spherical shape and. So, in is for a perfect sphere this value of psi that is the sphericity should be 1.

So, the more departure from one towards the 0; that means, it is far from spherical shape; that means, it is going towards the flaky nature. So, like that with these images you can see that that you are having a high sphericity particles medium, sphericity particles and your low sphericity particles. So, how do I define it now that is based on the sphericity equation? So, for a cube you get a psi value of 0.81 for cylinder it depends on the l by d that is the orientation. So, if your l by d is 0.5 then it is and the dimensions of that that what is the length and diameter. So, it varies like this so smaller the value of PSI greater the deviation from spherical shape.

So, orientation is the projected area or diameter of equal area circle that is another definition let us not get into that topic because it will unnecessarily confuse you.

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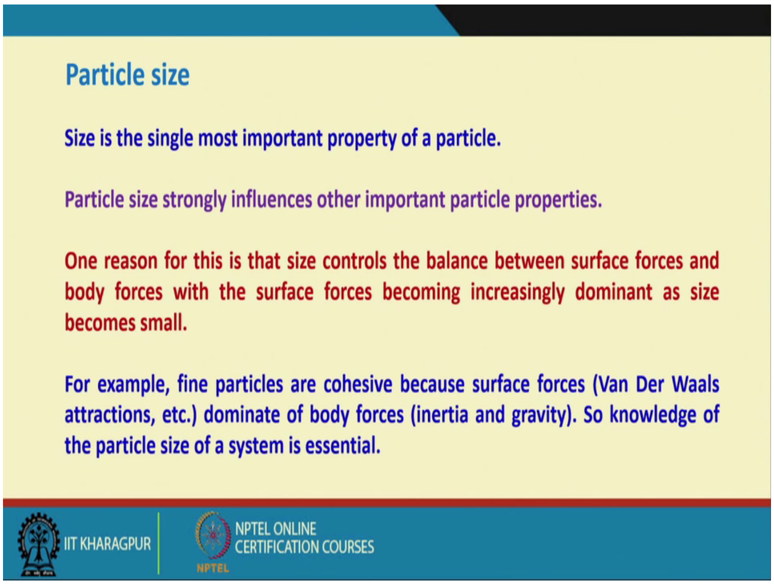

So, I hope that it is clear that what are the challenges even with the defining the particle shape, but the question is that definition acceptable in all the cases, no because we are assuming that it will be able I get equal volume sphere it may not. Like the example is that we have got irregularly shaped particles and we want to pour them into a container. So, what will be the packing density that is not identical with if I have the similar particles having spherical shape? In some cases yes you may apply it, but that is how we are basically making compromises even with our your say process simulations or process optimization techniques and all this.

Now, let us move to the second topic that is the particle size, this is extremely important property I would say that this is the single most important property of a particle why? Why I am saying that this is particle size is the single most important property of a particle, because the particle size strongly influences other important particle properties how? if you look at the particle size that it controls the balance between the surface forces and body forces.

So, when the particle size become smaller and smaller the surface forces they become the dominant forces example of surface forces a Van Der Waals forces and they are much more.

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Dominant, than the body forces Dieci or inertia or gravity.

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So, like your fine particles suppose I have got 10 micrometers particles or all the particles are finer than 10 micrometers. So, then what are the particle interactions that will be dictated by the.

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Mostly by the Coisy process, because surface forces they dominate body forces where their individual mass is almost negligible in relation to their surface forces, but if I have 50 millimeter particles the body forces start dominating the body forces are much more dominate than your surface forces; that means, their individual mass is so high.

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That.

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They take the dominant role.

So, this example validates my statement that your particle size strongly influences other important particle properties. So, friends we must know that what are the particle size I am going to treat, before we decide that how we are going to process it. If you do not know this particle sizes we are not sure that what are the particle properties? I am going to apply to have an separation between your wanted and gangue minerals. If they are verified we have to add up a different technique in relation to while dealing particles having relatively course sizes so will continue this talk and the next module also.

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That how do we define particle size and there are other issues also even when we have a bulk material, it is not the individual particle size what is important it is what is that entire bulk, how they behave and what are the basic properties that will be influenced by the variation of the particle sizes. So, in conclusion I would say that knowledge of the particle size of a system is essential to be a good mineral processing engineer.

Thank you very much.