Introduction to Mineral Processing
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Lecture - 17
Comminution (Contd.)

Hello everybody. So, the last lecture we have started discussing about Comminution. We discussed about that; what is the importance of this in mineral processing, and we have started discussing about what are the important properties of minerals that dictate the methods of comminution devices or the comminution techniques.

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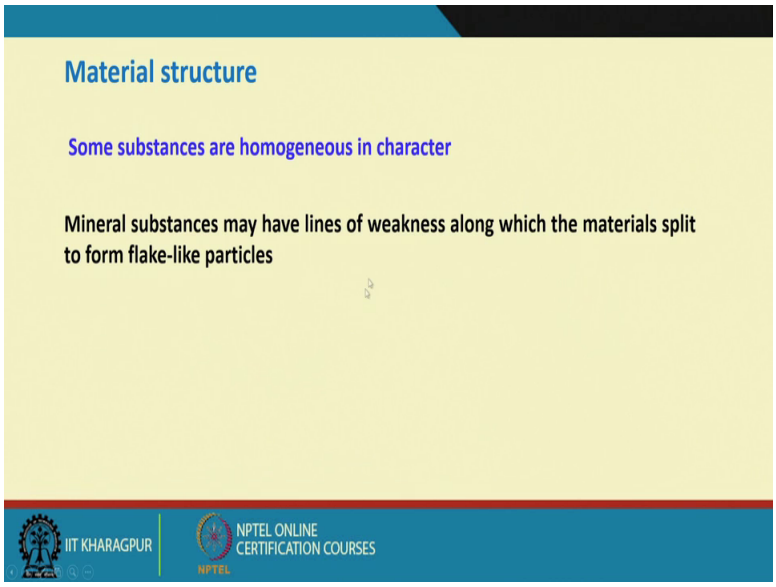

So, another property or another characteristic of material is the material structure. Like, it is the internal structure, that is what we discussed in the any fast class that although the graphite and diamond the chemical composition is identical by the provisional properties are different because it is the crystal structure; which dictates that physical properties.

So, similarly some substances are homogeneous in character; that means, if I have a large piece of rock if it is homogeneous. So, whatever the property I will get here I may get the property similar property here. So, in that case probably it is much easier to break it. Because I know exactly what is how much of force it is required. As you have already discussed that mineral substances specifically when they are in relatively much coarser

sizes, they have got lines of weakness like a faults. Along which the material split to form flake like particles.

So, for large particles when it is coming from a mine site, they may have internal cracks or flaws or faults like that and if we correctly decide that which direction my forces should be applied to have the optimum breakage and the minimum input energy and by doing so we can optimize the energy utilization for the desired amount of or as a desired level of particle fragmentation.

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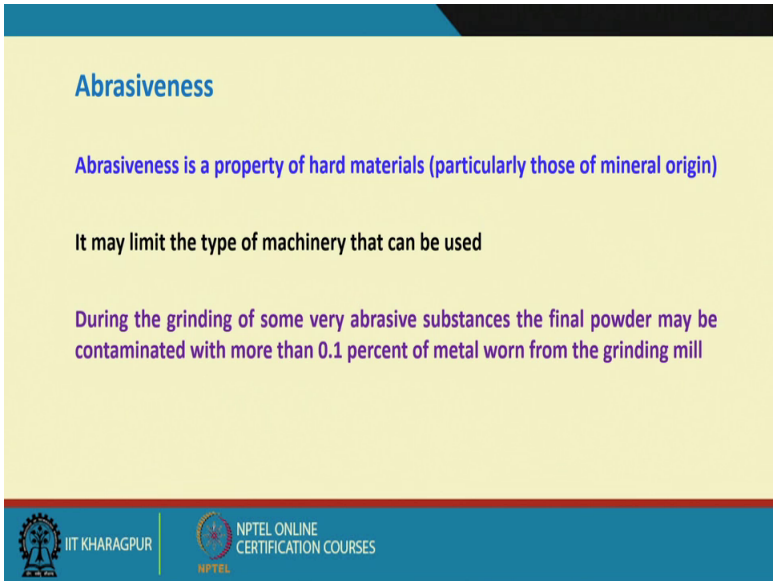

Abrasiveness; abrasiveness is a property of a hard materials, particularly those of mineral. Origin if the material is abrasive. So, it may limit the type of machinery that can be used. Because is the where of the material surface through which I am trying to break that material.

So, the maintenance related issues, the capital investment of that equipment on that equipment. So, must be very careful about the material properties if it is abrasive I have to take precautions to the while selecting the equipment that whether it can it can accept, or it can reduce the sizes even though it is abrasive like during the grinding of some very abrasive substances. The final powder even this is the another problem it may be contaminated with more than point one percent of metal worn from the grinding mill, grinding means when you go for very finest sizes. Suppose for 1 mineral we arrived at a conclusion that the liberation size should be 40 micrometers. By mining engineers, they

have same with samples starting from 1 meter to maybe 10 micron, 10 micrometers, but I want everything to be broken down to 40 micrometers.

So, we have to use some kind of you are a technique we call it grinding. So, we will discuss it in due course of time. But what will happened during that course, if the material is too abrasive then my metal surfaces with start getting odowd and that may contaminate my material also. So, it is not only the maintenance issue of my equipment. That is also the contamination related issues of my material which will create problem, in the downstream processes to our friends to in metallurgical industries.

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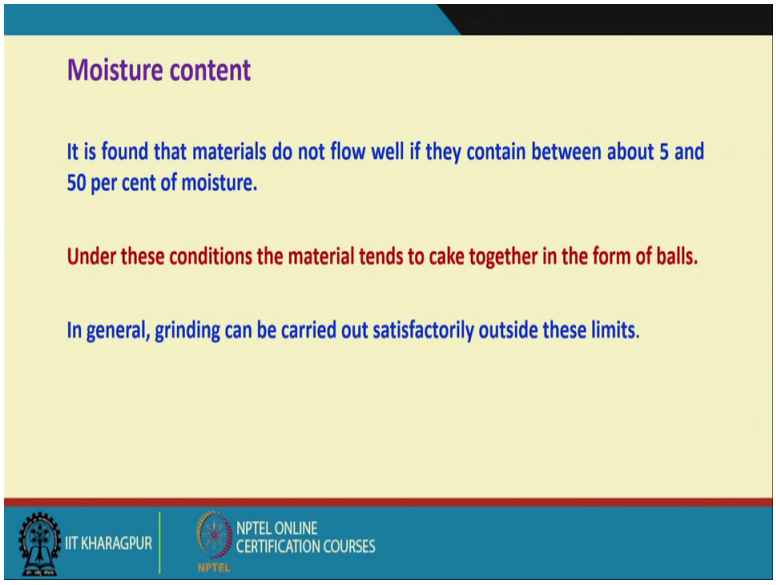

The moisture content it is found that materials do not flow well if they contain between about 5 and 50 percent of moisture. As I said that the comminution is basically we try to do it in a progressive manner. That means we have got 3 4 different types of or maybe different dimensions of your equipment. So, your material has to be carried from one equipment to another equipment. In between we have got a material handling system. And material will be transported much easier if the flow ability is not affected.

So, when we have moisture material, when we have moisture content inherent material the natural flow ability of this material is lost. And it has been found that if we have around 5 to 50 percent moisture the natural flow ability is lost. If I have more moisture than 50 percent then it started, behaving like a pulp or a slurry where they in the flow of water will try to transport my material also.

So, under these conditions, the material tends to cake together in the form of balls and they try to form like your agglomerates. And in general, when we go for fine particle breakage that is you are grinding, that it should be done either in dry condition that is below 5 percent moisture or maybe one wet condition more than 5 percent 50 percent moisture. Otherwise, we have problems.

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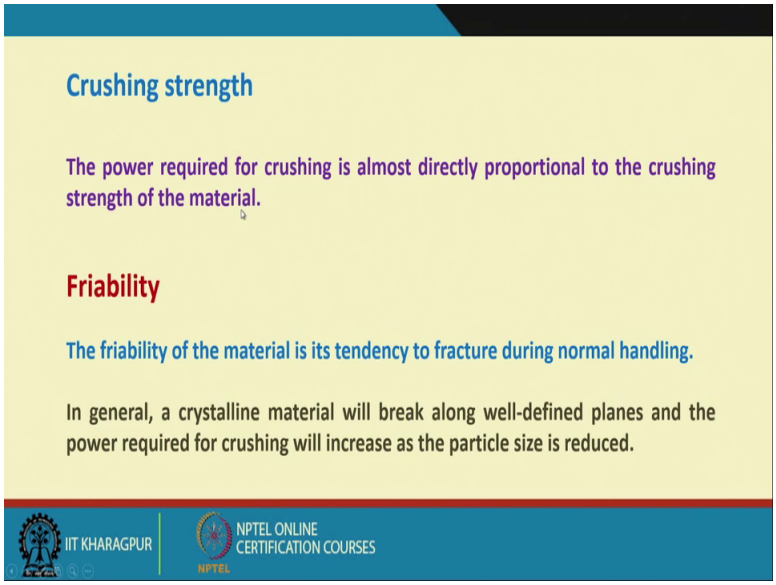

There is another thing called crushing strength. What is the crushing strength? That the power required for crushing is almost directly proportional to the crushing strength of the material.

So that means, how much the power is required we will discuss also this aspect very soon. It is a function of what is the crushing strength of that material, is not a single particle we are talking, we are talking about your large volume of material, that is a bulk commodity then the friability issue. Friability means, if the material has got a natural tendency to be broken, during handling stages also. The friability of the material is it is tendency to fracture during normal handling.

So, in general a crystalline material will break along well defined planes and the power required for crushing will increase as the particle size is reduced. So, friability is also very important issue, we have to take care of that.

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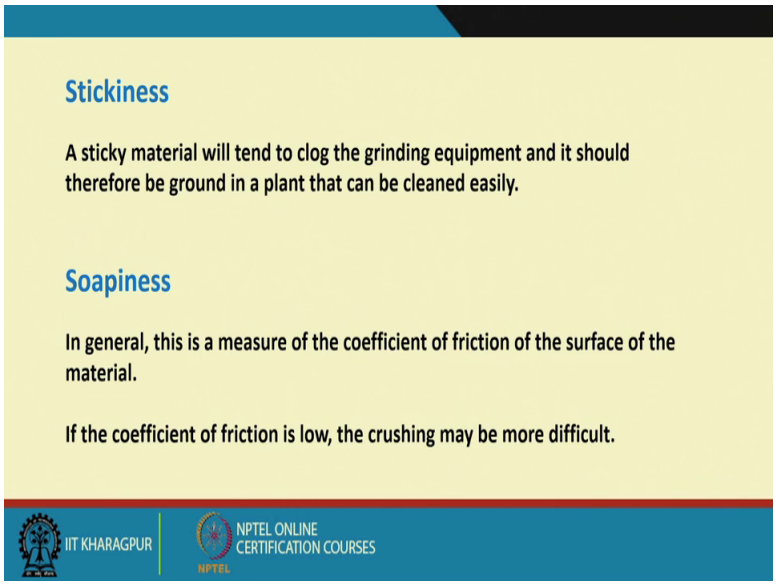

Stickiness we have already discussed, that is sticky material will tend to clog the grinding equipment or say breakage equipment, and it should therefore, be ground in a plant that can be cleaned easily; that means, how do I clean the surface of my equipment through which the basically the force is being applied to break my particles. Otherwise, the applied force may not be transmitted to my particles and the particle breakage will not be satisfactory.

Soapiness, in general this is the measure of the coefficient of friction of the surface of the material. If the coefficient of friction is low the crushing may be more difficult then explosive.

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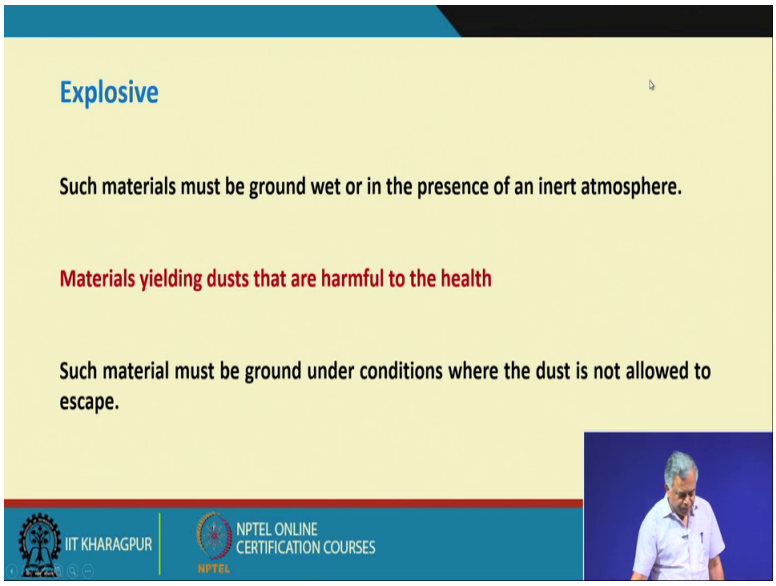

Such materials must be ground wet or in the presence of an inert atmosphere whether the material is explosive in nature. So, in that condition, maybe depending upon the nature of that your root causes for that explosiveness of that material we have to find out. And then depending on the need we may have to process that material either in inert atmosphere or maybe in wet condition.

Then materials yielding dusts that are harmful to the health that is, when you are breaking the material to say suppose even though your aim is to have a size range in between 40 to 10 millimeter, but as I said at the beginning that is art that it is not the science which has helped us to perfect this. We are trying to optimize the processes, but still we will be there is no way that we can ensure that no fine particles, no particles finer than 10 millimeter will be produced. But in the process if we generate also very ultra-fine particles like, less than 10 micrometer sizes which are maybe airborne and that may be injurious to that may be having adverse effect to our health.

So, that also we have to take precaution. Otherwise we are not doing right thing to our society and it is not permissible as per environmental law also. So, such material must be ground under conditions where the dust is not allowed to escape. So, you have to take sufficient measures to capture the dust before it becomes airborne.

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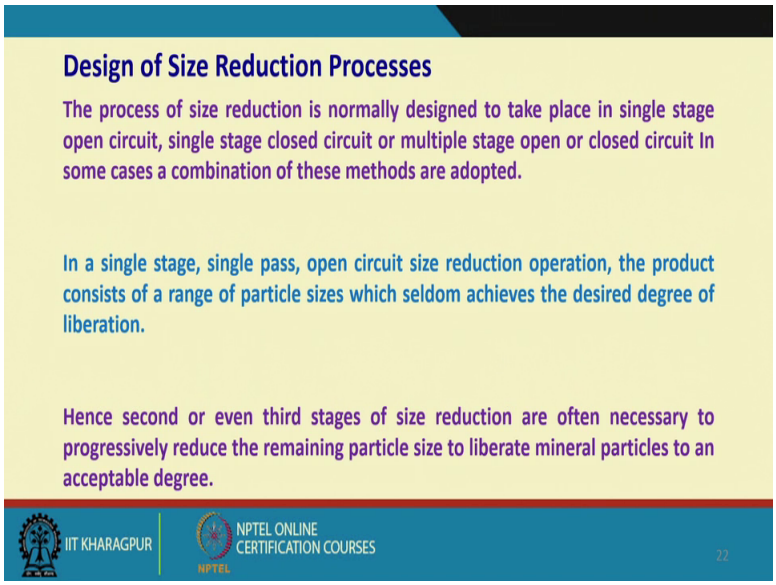

Now coming to this point; that is, how do we design the size reduction process then? The process of size reduction is normally designed to take place in single stage open circuit. Or maybe single stage closed circuit. Or multiple stage open or closed circuit. In some cases a combination of these methods are adopted.

So, what is this open and closed circuits? Just why we are calling it circuit when we are talking about only one equipment. Actually, what we do; suppose, I have got a material I am feeding it into a machine which is supposed to give me particles that is your discharged particle I want to have a size in between 50 to 10 millimeter, but how do I ensure that material whatever I am getting that is within that specified limit? That is, within 50 to 10-millimeter sizes.

So, we have to use screens at the discharge it. We need 2 screens or 50 millimeter and 10-millimeter sizes. So, only in between the particles that is what is reporting, that what is finer than 50 millimeter and coarser than 10 millimeter that is my desired product. So, very often you may find that you are getting all the particles which are finer than 50 millimeter. So, in I do not have to send any material to the to that equipment again for further breakage.

So, then I will send the below 10-millimeter particles, I will take out the minus 50 and 10-millimeter particle for my as a product, and below 10-millimeter particle probably I

will send it to some other downstream processes or maybe I will dump it somewhere. So, that is called the open circuit crushing.

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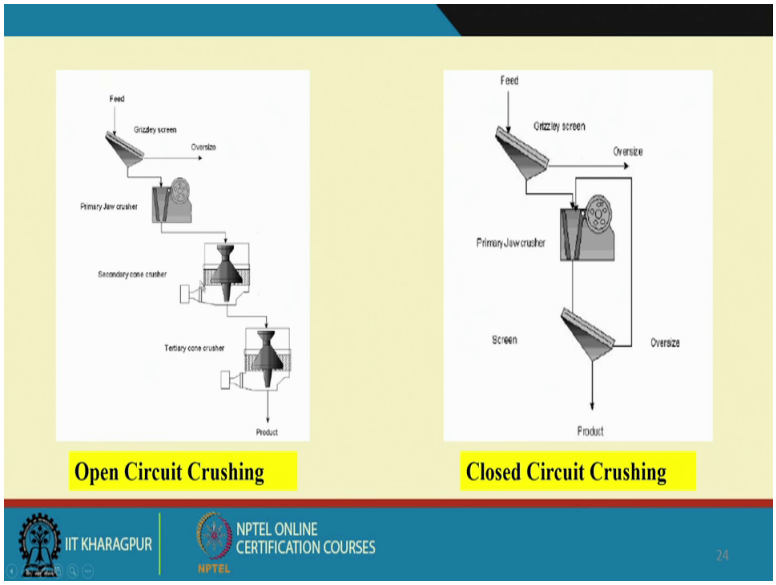

Like these an example of that, and say suppose so, will discuss about industrial screening and later stage, that suppose this is a crusher whose job is to break the particles. And why do we need a screen before that? Because the crusher can accept only a top size say suppose 1 meter.

Now, a mine sample when it is coming. Suppose this is a mine material rom run of mines we call it. If the mine trains in mining they cannot ensure if they cannot guarantee me that there will be no particle which is coarser than 1 meter. Then what I will do? I have to put a screen here, which will be called as oversize that is the particles which are coarser than 1 meter they will be called as oversize and that I will break it by some other means, but only the material what will be fade to this crusher that is finer than this 1 meter then. Otherwise what will happen? If the opening is 1 meter here, and if I have a particle which is 1.2 meter; so that will just simply sit on this and it will choke my crusher.

now this crusher you see that discharge we are not trying to analyze that what product, we have got because we have very sure that whatever discharge sizes, I want it I have got all that. Suppose I want the mine material to be crush to below 10 millimeter. I know that this crush are discharge can give you the largest piece of particle which is 40 millimeter. And this speed can accept easily below 1-meter sizes. So, if I seed back this 40-

millimeter size here. So, unnecessary they will be just travelling through this and pass this.

So, what I will do? All the particles which is coming back coming through this I will send it to a next crusher. And next crusher product will be said to a another crusher. And maybe here I will have a screen to check or maybe if I am very sure will say that these are all below 10 millimeters. So, that is my product. So, when it is done like this in stages, there is progressively we are breaking, but nowhere we are checking. That whether I am getting the particle size what I wanted. So, that is called the open circuit crushing.

But many a times we are not very sure and this is normally we done when the material with think the properties are well known and they are to some extent homogeneous material. This closed-circuit crushing, what I do here, that is we are not very sure what is the product is coming through this discharge. So, we may have some oversize material. Now I wanted to have a size in between 40 to 10 millimeter. So, I have got 2 screens here. So, whatever particle coarser than 40 millimeter I may send it here for further breakage because I want all the material to be finer than 40 millimeter.

So, I will do it again and again unless they are crushed to that limit. So, this is called the recircled product or recirculating load. So, when it is done that is called a closed-circuit crushing. These days whoever had done some computer programming what we do we write a flowchart. A many times you go for iteration method; that is, we try to test that is we numerically we want to solve it numerically, and to put some limit and the convergence criteria. So, the screen is basically a convergence criteria type of say analogy you can draw, that it satisfies your condition, then you print your output or otherwise you reiterate it. So, that is called the closed-circuit crushing, in a single stage single pass open circuit size reduction operation, the product consists of a range of particle sizes, which seldom achieves the desired degree of liberation; that means, I know that my liberation size I want below 14 micrometer, but the crushers what I have selected my job is to break it below 10 millimeter.

So, I want all the particles to be crushed to below for 10 millimeter. So, why do I need a your screen. If I am very sure that each crusher is doing it is job and finally, we will be getting 10 millimeter below 10-millimeter sizes. And then we need ultimate breakage

into another equipment where I will try to break it down to 40 micrometers. So, that is my liberation size, but many a times my customer wants a size product that my payment will be reduced if I am generating more of finer sizes than they are recommend then they are specified sizes. So, there I want to control the sizes the discreet sizes quite closely so that I minimize the generation of fines there is fines definition means which is finer than my optimum size of my client specified size. In that case probably we have to go for closed circuit crushing.

So, how many stages we want? It depends on what type of equipment you are using, what are the material characteristics, and how accurately you want the data. And how accurately you want this data to be generated? So, hence second or even third stages of size reduction are often necessary to progressively reduce the remaining particle size to remain to liberate mineral particles to an acceptable degree; that means, although I want 40 micrometer size, but it should be just below 40 micrometer. If I do it upon one stage I may end up generating more particles which are less than 2.5 micrometers; that is, we call it pm 2.5 micrometers particles, which may be harmful for our health. And it is unnecessary wastage of energy.

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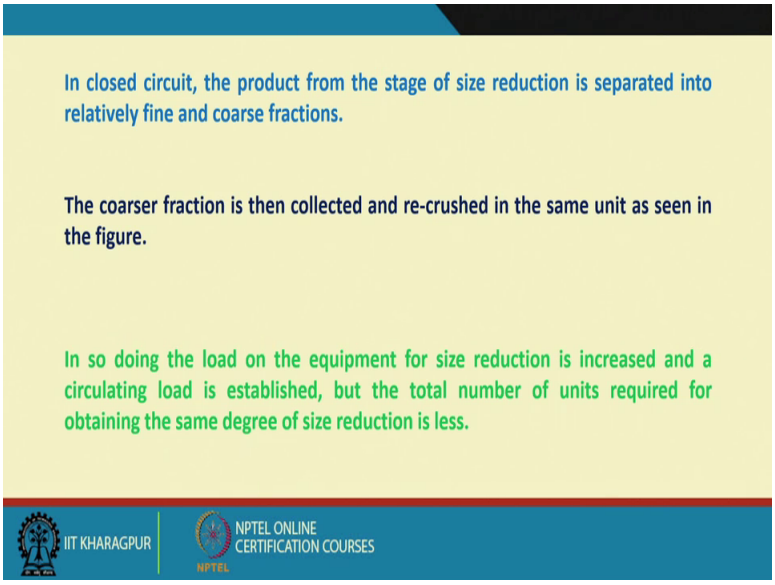

So, in closed circuit, the product from the stage of size reduction is separated into relatively fine and coarse fractions. The coarser fraction is then collected and re crushed in the same unit as seen in the figure I have already discussed it. And while doing so

what we are doing? That you are the load on the equipment what size reduction is increased; that means, suppose my crusher capacity is 100 tons per hour, but my recycle material is 30 tons per hour. So, my crusher can only crush the fresh material at the rate of 70 tons per hour.

But if my requirement is to have a very close size control, I may have no other option than doing that. So, this is the challenge to a mineral processer, then how do I decide.

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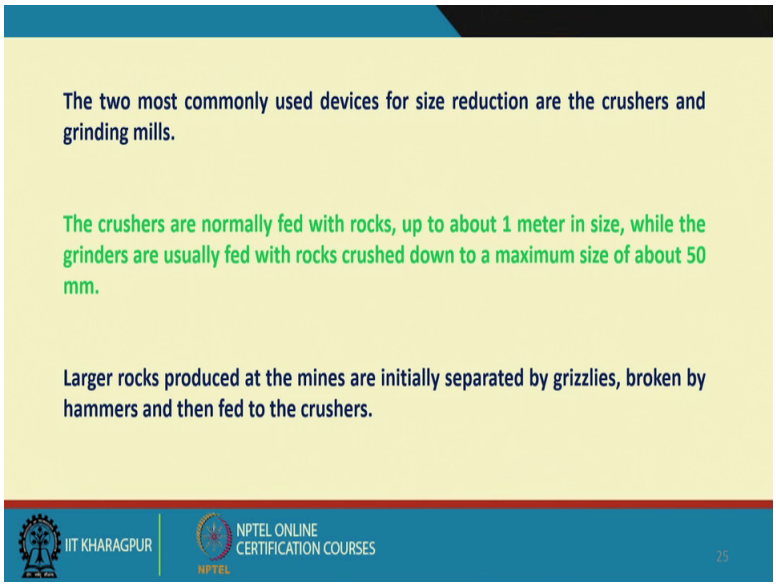

The 2 most commonly used devices for size reduction are called the crushers, and grinding mills. Crushing means relatively coarser sizes, when we try to break the particles at relatively coarser sizes, and grinding means as a relatively very finer sizes. The crushers are normally fed with rocks up to about 1 meter in size while the grinders are usually fed with rocks crushed down to a maximum size of 50 millimeter. And the other difference is that the energy consumption in grinding mills are much more higher than the crushers.

And so, to improve the grinding efficiency, we try to use a combination of different techniques that will discuss in due course. Larger rocks produced at the mines are initially separated by grizzlies that are a screen a special type of screen. We discuss it we will discuss it at when we discuss about industrial screens broken by hammers and then fade to the crushers.

Thank you very much.