Introduction to Mineral Processing
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Lecture - 16
Communication

Hello, welcome to this course. So, let us start a new topic which is very very important for mineral possessing. There is the size reduction, but in our language in mineral process language we call it comminution. Comminute means, breaking of the particles. So, what are my plans is that will start with the fundamentals. Then we will go for the different equipment we will discuss about the different equipment, and how do you control them, but although it is a very vast topic, but I will try to discuss only the so, most critical part or the most important part of the subject or this introductory course.

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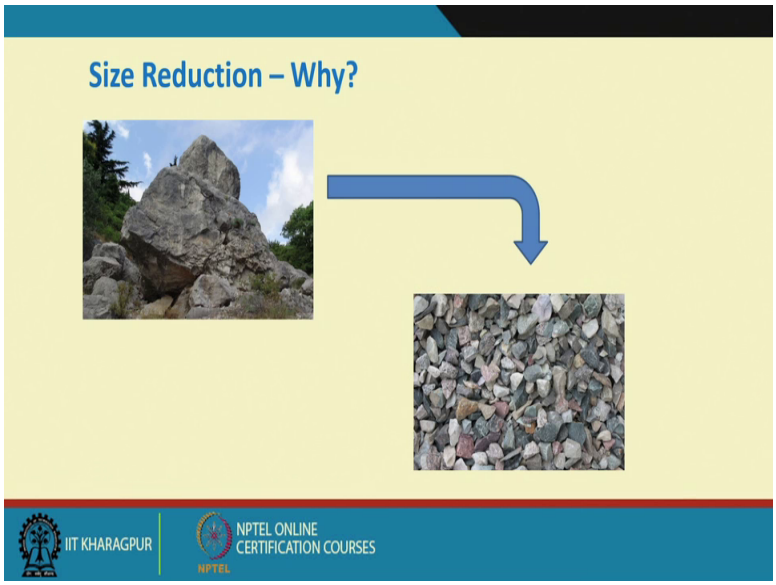

First question comes that size reduction, why? Think of this rock; the single rock and my geologist spread they say that it has got some valuable metal bearing ore in this. That is having around one percent of that material. As we have discussed that we try to do the physical separation that is separation based on physical property differences. So, one is that we have to break this particle for liberating my wanted and unwanted particles. In another case, suppose I want to transport this material, I have to transport this rock and to a place which is say suppose 500 kilometers from my mine site. Suppose, this is a mine

rock and I want to sell it to a client who is located 500 kilometers from my mine site, and that client wants a particle size that this material to be broken into a particular size. This suppose, 150 to 50 millimeter to 10-millimeter size. So, for that purpose also we have to break it.

Now, whether it is easier to transport this material from the mine site to 500 kilometers at this size or better we break the entire rock into the mine site itself. To that size, that is your 50 to 10-millimeter size, and they transport only to that client only that 50 to 10 millimeter size particle. So, it is quite evident there many a times that you will find that if I want to transport this material as it is. The material handling, that is your loading unloading even the through, which I will be transporting that is a very big issue. But if I break them to these sizes, it is much easier to handle them.

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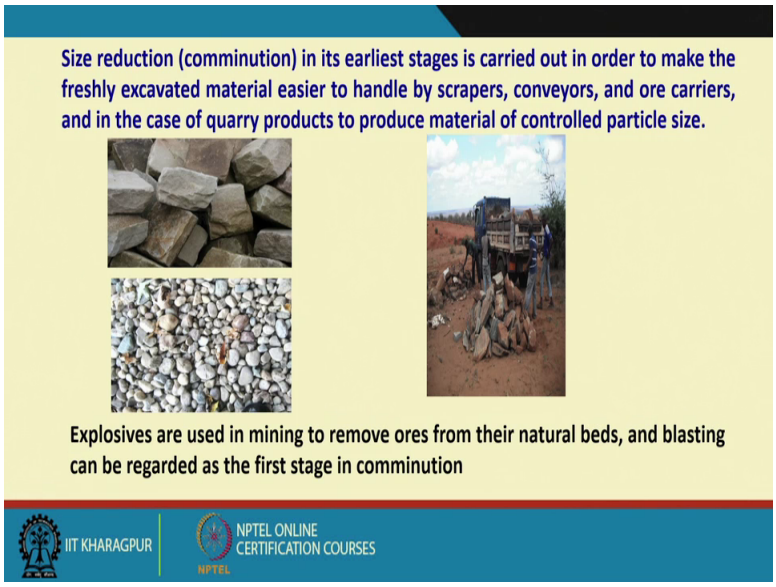

Like I am saying that, suppose if I have this particle sizes quite bigger, and if I want to transport it through a small truck, then how do I handle this? How do I load it how do I unload it? And the volume occupied that is the material quantity what I will be able to transport by each truck will be much less in comparison to if we break them into small particle sizes, and if I want to transport them.

So, it is for liberation purposes. It is for my customer's requirement. Many times that I want size particles. It may be because of transportation related issue that is your bulk material handling issues, which forces us to break those rocks into small particles even if

we look at the entire mining operation. What you try to do? We first try to blast them. By using some chemicals we call it explosives. Why you want to break them into small particles?

That is, we want to use the explosives to generate fragment sizes for which I have got the adequate numbers and dimensions of material handling systems. What are those material handling systems? It could be scrapers conveyors ore carriers, like that. So, that is why we say that although the blasting is a specific domain for mining engineers. It is not under the domain of mineral processing engineers, but our comminution process starts from the mining site only, because you have started doing the fragmentation.

So, that is the first stage in comminution although that is not part of the mineral processes responsibility as of now in most of the cases. In mineral processing industry, let me recapitulate that that we are interested in concentrating my wanted materials. So, for that I have to liberate them.

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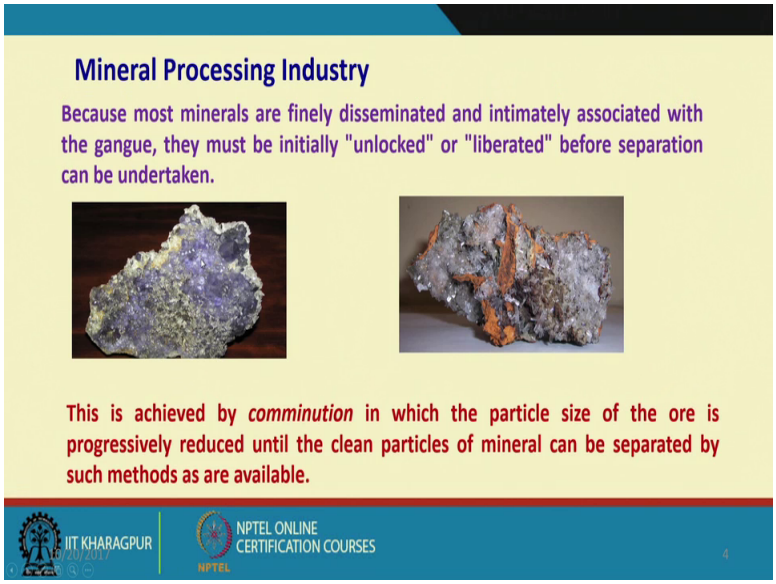

Example suppose in this rock mass, only a particular portion that is of different colors a specific colors say suppose this is the violet color, and these colored particles only I want to concentrate. That is my desired material. But when they are in locked stage, I cannot use the differences between the grace and the violet colored particles physical properties like your density or hardness or some other properties.

So, I have to first free them from each other by breaking them into small forces. Similarly, here you suppose this is my wanted material. So, I have to dislodge it from the entire assemblies. So, we have to unlock or liberate them. Before we go for separation these a very important word here that this is achieved by comminution. So, the definition of comminution is it is the process through which the particle size of the ore is progressively reduced, until the clean particles of mineral can be separated by such methods as are Apollo. This progressive is a very important aspect of this comminution. A this is the fundamental difference between your a blasting engineer and a mineral processing engineer's role during the fragmentation process.

I have try to explain it a bit more that, why do we need a progressive breakage; because the minerals being crystals have a tendency to break into endless numbers of sizes and shapes. Every time they are introduced to some external energy, there is a common observation that if I have a piece of rock and if I take a hammer, and made an impact with that can we guarantee that, what particle sizes will be getting? What do we want to what do we want to do? Why we are hammering? We were to reduce the size, but if I ask anyone that I do not to want any particle finer than this size, or I want the force to be applied in such a manner that I will have a particle size in between 100 millimeter to 1 millimeter. Can you do it? And that is the challenge imposed on the mineral processing engineers.

While blasting the mining engineers are probably restricted to the top size, that your top size should not be more than this, because your other bulk material handling system cannot accommodate particles coarser than that size, but there is no restriction about the how much of fines you are generating. But in mineral processing case you will have to break the particles to a size what is only necessary to have an effective separation. Because if you remember, when we started discussing about particle size what you said that particle size is a single most important physical characteristic. Because as a size which dictates that whether my body forces will be more pronounced or my surface forces will be more pronounced whether particles are very very fine sizes. They might surface forces become active more active more dominant than my body forces.

So, mineral processors objective is to apply more of a body forces-based differences. Than the surface forces because, when the particle sizes become more finer the surface

area you are generating is used, and it is very difficult to handle them also. But it is also the liberation size of the particle which also decides that what size you have to break it.

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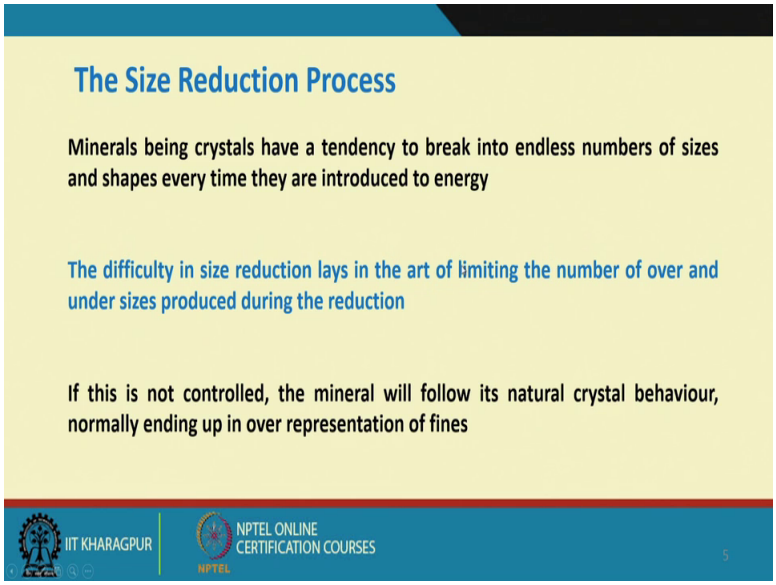

So, the difficulty in size reduction lays in the art of living limiting the number of over and under sizes produced during the reduction. Why we are seeing atom limiting? Why not science? Because the mind sample mind materials are heterogeneous. It is very difficult to predict what will happen.

So, although we are doing it in a scientific manner, but still there are many questions which are unanswered. That is why it is better to say that it is art of limiting the number of over and under sizes produced during the reduction process size reduction process. If this is not controlled, then what will happen? The mineral will follow is natural crystal behavior in the next slide I will show you what is do I mean by natural crystal behavior. Normally ending up in over representation of points; let me explain it through this.

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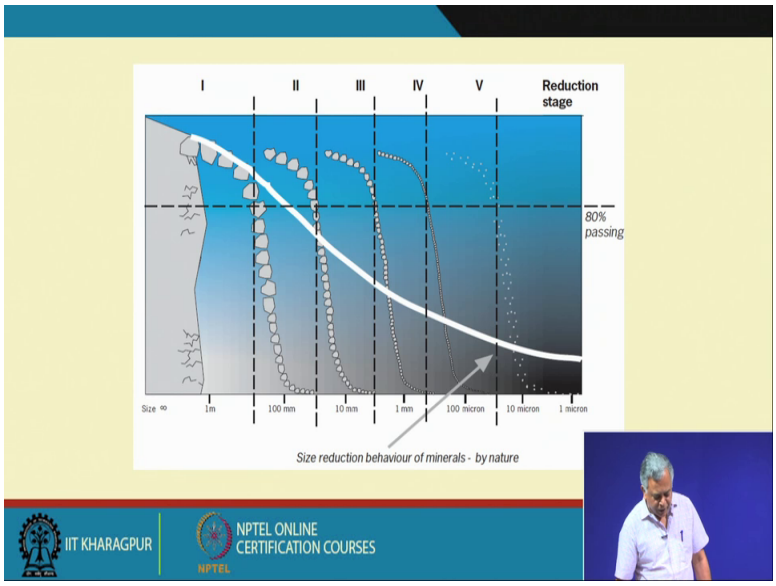

That is if I try to break it in an uncontrolled manner, there is a size axis and this is the weight percent passing size, what will happen? In a single stage that is normally a fragmented rock coming from your blasting, the size axis may be different, but it has got a profile like this that there is a huge range between your courses and the finest particles.

Now, just suppose for my mineral processing operation separation processes, it is adequate at the optimum size you have decided, that it should be in between this 100 millimeter to 10 millimeter. So, if I comminution process generates more than more finer material than 10 millimeter. I am ending up with unnecessary generation of fines, which is conserved not only more of energy. But it will create lot of difficulties into the downstream processes.

Maybe many times just for example, for iron ore industry they want lumps minus 40 plus 10 millimeter, but at present because of mining operations mechanized mining operations, because of your class seeing grinding that is your breakage maker is a part of the breakage. A totality in most of the cases we are ending up with generating up around 40 to 50 percent of fines, which are basically the definition of fines for iron ore is less than 10-millimeter sizes.

So, to bring them back to again to a size coarser than 10 millimeter, we need again artificial energy in terms of your sintering or pelletizing. So, what the mineral process role is, that how to make this carve much more steeper like this. And if I want only say

suppose a size from 10-millimeter 200 millimeter, why do not you do it in stages, that is if I have a starting rock of one-meter diameter. First you try to break it up to below 100 millimeter maybe up to 50 millimeter. The next stage that 50 millimeter you try to break it up to 10 millimeter. Do not try to do it in one go that entire thing I will break it from one meter to 10 millimeter. Otherwise, you will not be able to control this natural your profile.

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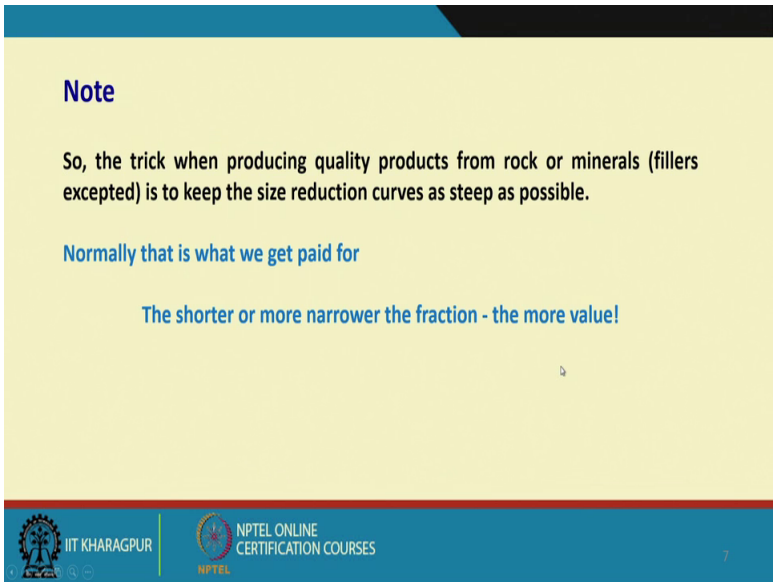

So, the trick, when producing quality products, from rock or minerals is to keep the size reduction curves as steep as possible. And normally that is what the mineral processors are getting paid for this is how do we do it. And this is what we are going to discuss under this topic comminution. The shorter or more narrower the fraction the more value.

Again, I am coming back to the ironer that if we can generate if we can reduce the generation of fines in combination of mining and mineral processing operation, we save some more money for my industry.

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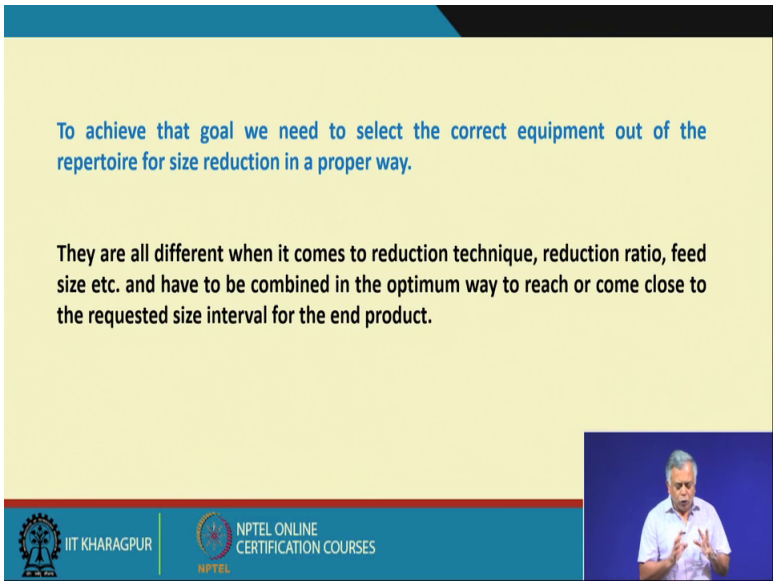

So, to achieve that goal, we need to select the correct equipment out of the repertoire for size reduction in a proper way; there is so many equipment available in the market. But which equipment I should select keeping that factor in mind that I should have a size distribution or say closely sized products out of that. And with a minimum input energy, and there are various techniques there various ways of reducing the particle sizes.

So, how do we know that whether we need this technique or that technique for my size reduction. That will be dictated by your characteristic of your material what do you want to break. And you should also know what is that equipment is doing. The scale of operation, what is the capacity of that machine does it match with the capacity what I require. What is the feed size distribution because we are not breaking only a single particle, we are breaking large turn edges of material coming out from the mind. So, they are also you have got a size distribution.

So, all these are basically part of this subject. That is why at the beginning I said that is a huge subject.

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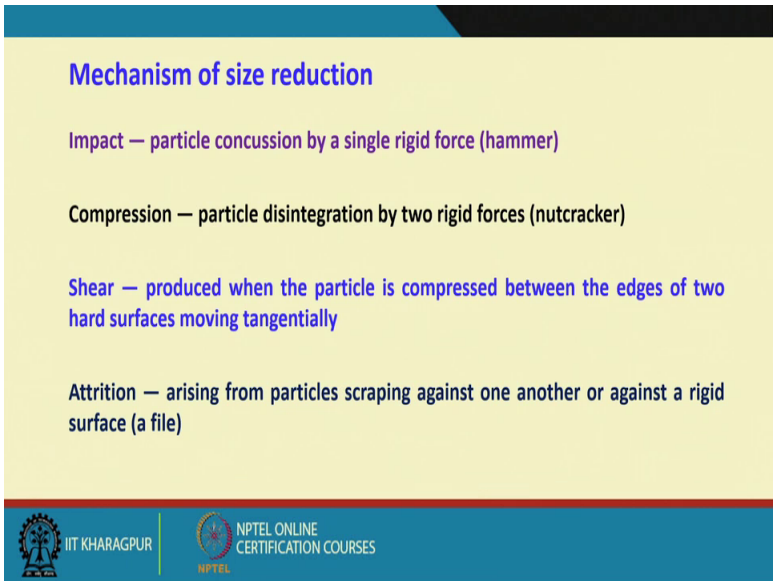

So, if we look at the mechanism of size reduction. And how can you have a size reduction? That means, what are the different machines they are designed based on what mechanism. What is the impact? That is particle concussion by a single digit force like a hammer. So, it is an impact.

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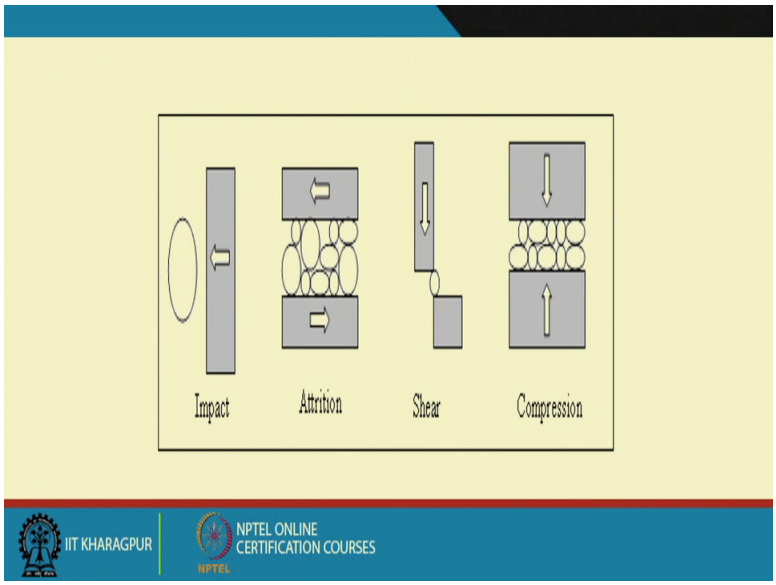

Then we can have like this is an impact, that you are hammering it. Then you can have compression. Like, you can squeeze them the particles in a compressed atmosphere, like I want to break something we use our 2 hands and then try to squeeze it.

So, that is your compression. So, this is also being done mechanically by some machines. Then we can apply shear forces. Like, we keep the particle into a rigid platform on top of that, and then I put some shear force onto that. Then it can be attrition like you are rubbing. So, it is attrition. So now, the question comes, that which technique I will use for what we did here in what condition.

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Now, if you will get into this impact, what type of impact? It can be gravity impact. In gravity impact, the pre falling material is momentarily stopped by the stationary object. Like a material is flowing like this, and it is stopped momentarily, and then you are putting a putting an impact into that.

I will show you in due course of time what are the machines which works on this principle. And very simple example is a particle dropped onto a hard surface, hard steel surface. Coal is naturally friable. So, if you drop a coal particle into a hard steel surface from a height, you may get the particle breakage of your desired size. But can you cope up with the rate of production rate of your capacity what do you want. So, for that we need some need to have some kind of your mechanization of that.

So, we need an equipment even to do that job.

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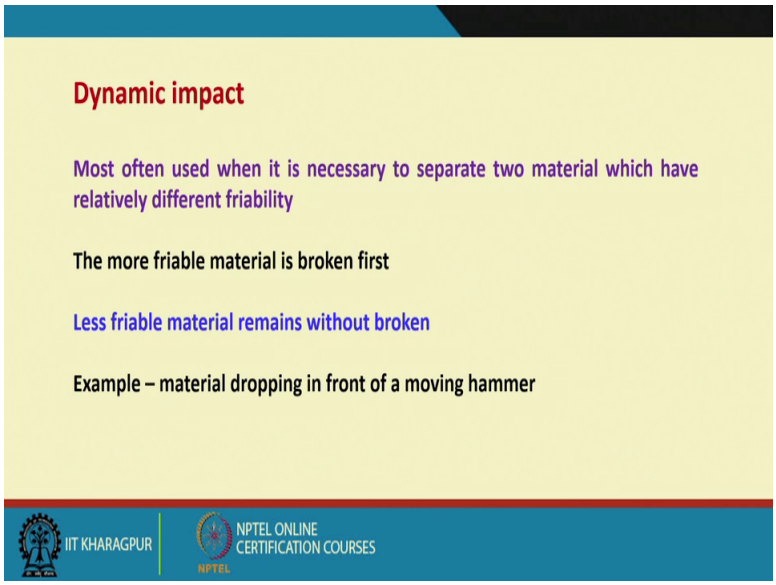

Then we can have dynamic impact. Most often used when it is necessary to separate 2 material, which have a relatively different friability. Like I know that I have got a heterogeneous particle assemblage, but one material is friable another one is hard material is not friable. So, there we can have a dynamic impact. Because what will happen the more friable material will be broken for us, so that means, we are having a preferential breakage.

Suppose I have got a coal particle and I have got a hard-shell particle and if we go for a dynamic impact my coal particle will be broken into a very finer sizes and this in relation to my relatively harder material, and then after that we can have a screening operation. So, we know that finer particles they are concentrated more on the carbon rich part. Example material dropping in front of a moving hammer suppose a hammer is moving and then a particle is particle stream is getting is being say dropped from the top and then you are hammering.

So, both are basically in a dynamic condition. So, particle is also in dynamic condition your hammer is also in a dynamic condition.

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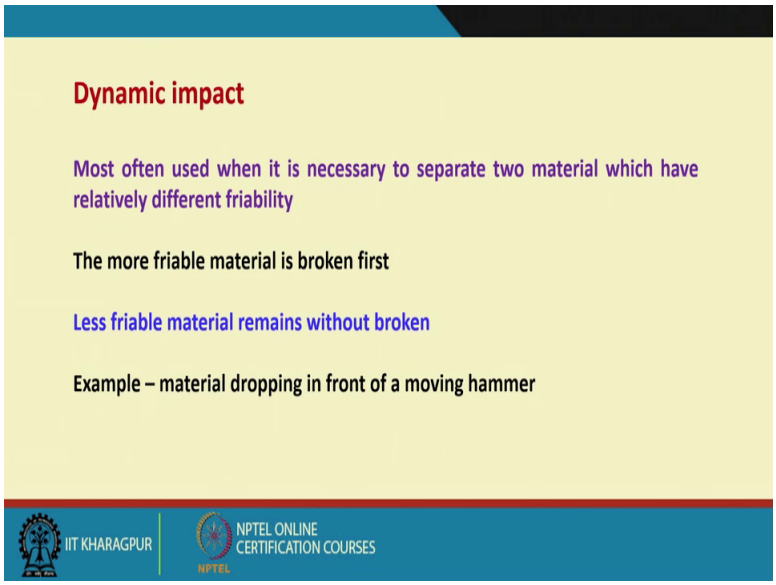

will show you some equipment into course of time. When do we need compression forces? Now if the material is very hard. If the material is abrasive, if the material is not sticky, because what will happen if the material is sticky because we are trying to compressed it. So, if the material is sticky. So, what will happen? Some portion of this material will get added to the surface of that you are breaking up that material through which you are trying to break the particles; so the relative.

So, that next time when you are getting a new material. So, this surface is no longer very rigid you are basically being coated with the sticky material and your efficiency of compression will go down and your efficiency or breakage will go down. Well the previous product is to be relatively coarse in size, with compression when we need now when we try to generate some relatively coarser sizes. Because when you are compressing it inside the particle whether the weakest zone the particle will try to break into that direction that, what I tried to mean that divide a particle and if you have a crack inside and when you are compressing probably that is the weakest zone and the particle may have broken into 4 5 pieces through that.

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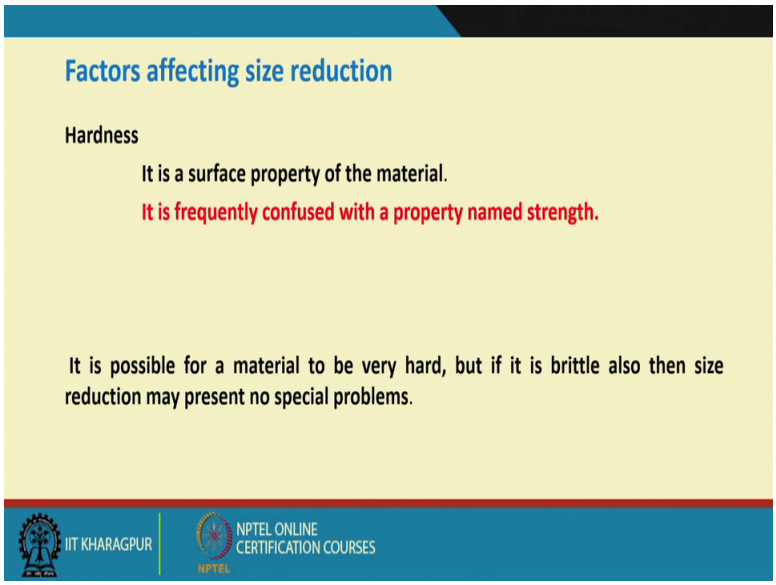

So, what are the factors that affect size reduction? One is hardness. So, it is a surface property of the material. Hardness is the surface property of the material. It is frequently confused with a property named strength, hardness and strength should not be confused. You should not get confused. It is possible for a material to be very hard, but that material may be brittle also. Then size reduction may present no special problems. It may be hard, but if that is brittle. Then you can easily break it into pieces.

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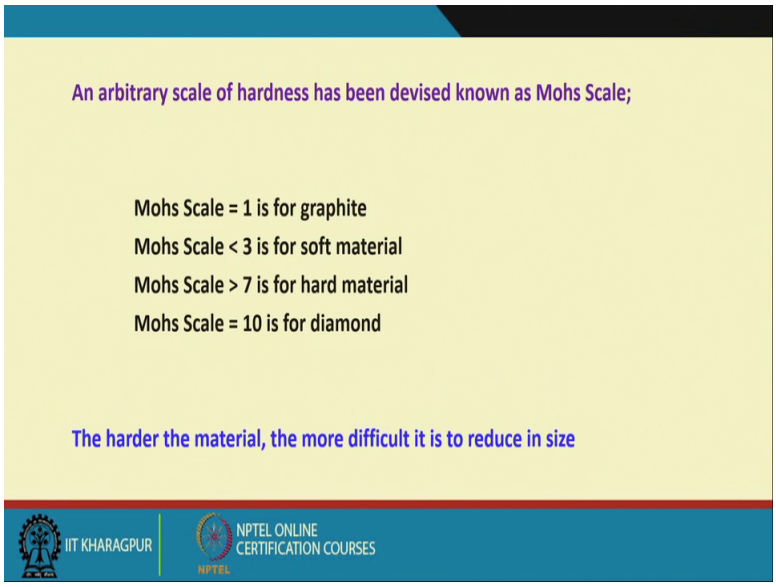

How do we know how hard is that? Normally an arbitrary scale of hardness has been devised known as mohs scale. What is that mohs scale based? That means, if I have 2 particles. If I can have a if I can have a scratch on the surface of another particle, which is visibly identifiable, then we say that this particle is harder than that particle on which surface there is this the scratch is visible.

So, based on this a scale is proposed by mohs. So, most scale is equal to one for graphite that is considered to be the softest material or mineral. Then it is less than 3 is for soft material mohs scale evidence greater than 7 is considered to be a hard material, and mohs scale evidence is equal to 10 it is called the hardest material, that is the diamond. That is why many times when we try to cut many things we use a diamond tip because this is the hardest material you can have a scratch of the surface. The harder the material the more difficult it is to reduce in size. But if it is brittle, then there is no problem.

So, we will discuss further in next lecture, till then.

Thank you.