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

Lecture – 21
Crushers (Contd.)

Hello welcome, so in the previous lecture we are discussing about the gyratory crushers.

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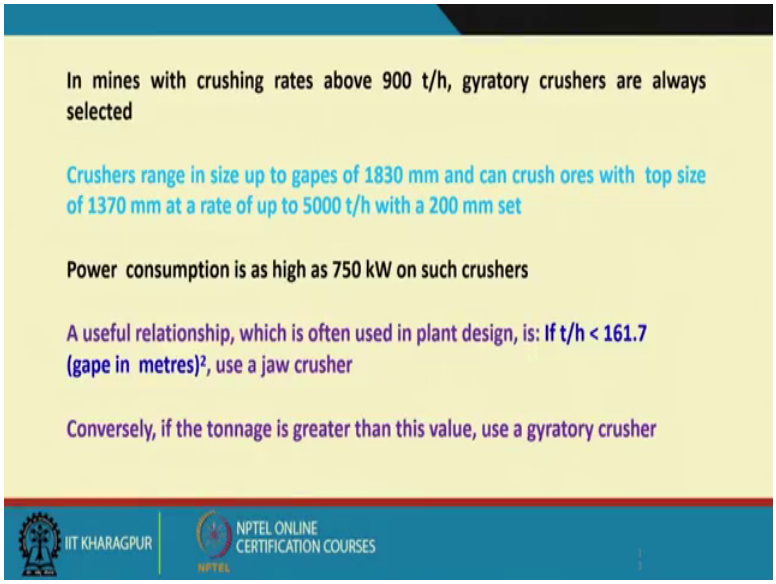

Now, we are making a comparison now; that is where should I use a jaw crusher? Where should I use a gyratory crusher? In mines with crushing rates above 900 tons per hour; gyratory crushers are always selected. These are like your thumb rules because the experience says that; it is more economically viable than the jaw crushers. Crushers range in size up to gapes of 1830 millimeter and can cross ores with top size of 1370 millimeter at a rate of up to 5000 tons per hour with a 200 millimeter set.

That means gyratory crushers they range in size up to gapes of 1830 millimeter; the same terminologies we use, that is a gape is the opening dimension and the set is the discharge dimension. And can crush ores with top size of 1370 millimeter; at a rate of 5000 tons per hour with a 200 millimeter set. Imagine how robustly built it is; it has to be very very robustly built and if the capacity is less, there is no point in using a gyratory crusher. Because the capital investment for a gyratory crusher is much higher than a jaw crusher;

power consumption for this size of gyratory crusher is as high as 750 kilowatt on such crushers.

Now, a useful relationship which is often used in plant design is if tons per hour, that is if your productivity or if your capacity of your crusher is less than 161.7 into gape square, where gape is a meter, then use a jaw crusher. That means, if you are say suppose gape in meter is 1 so; that means, 1 square. So, if it is less than 161.7 tons per hour; you use a jaw crusher, otherwise you use a gyratory crusher.

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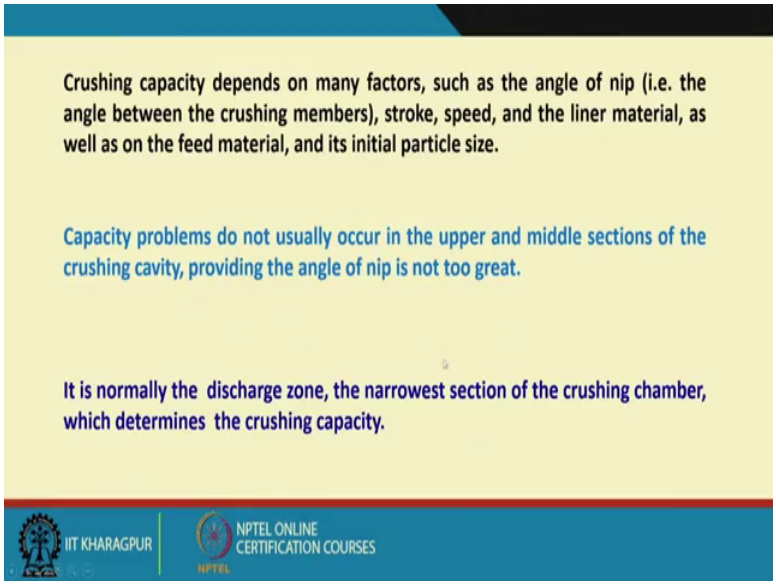

Now, that is about the; we are saying your capacity. But what are the factors that essentially contributes to this capacitor; that is the crushing capacitor? If I have a single machine can I have the identical capacity irrespective of the material characteristics? No. So, which must know that what are the factors? Mostly coming from the material and the design aspect of that crusher.

So, crushing capacity depends on the angle of nip; there is an angle between the crushing members that what is that angle? Because what will happen; if the angle is too less. So, the particles will be broken to a very finer size; relatively finer sizes, but it will require more time for that particle to be broken, so your capacity will be less.

Then your stroke length; what is the throw? That is the stroke length, then speed at what speed? The liner material which material of that your; crushing surface you have; as well

as on the feed material; that means, what is the crushing strength of that material? And its initial particle size; what are the initial particle sizes? Why the initial particle size will control the crushing capacity?

Now say suppose I have got a set of 230 millimeter and I have got around 50 percent of my rom ore, which is below 230 millimeter and I am feeding that into the crusher. So, unnecessary my crusher is basically fade with the material which is not required to be crushed; so my effective crushing capacity will be reduced.

And if I have a very big sized particle; suppose I want from 1 meter to 20 centimeter; so, the reduction ratio is very high. So, the retention time of that particle inside the crusher, it will not pass through unless and until it is broken to a size below the set size so; that means, it needs number of times to be hammered or say to be compressed. And essentially you are reducing the capacity of that machine.

Capacity problems do not usually occur in the upper and middle sections of the crushing cavity, providing the angle of nip is not too great. Because what will happen? If you remember that your action because when it is basically hitting the material and it is coming down and ultimately, which controls the capacity that is at what rate it is going out from that crusher?

So, when the particles are being broken to a relatively finer sizes. So, they may be because of your orientation problems, they may be locked to each other and they may not go out of the through the discharge. And because of that say; it is the shit that is how the material is getting discharged, so that at what rate? So, that will be essentially control your capacity of your machine.

That is why I have written that; it is normally the discharge zone, the narrowest section of the crushing chamber which determines the crushing capacity.

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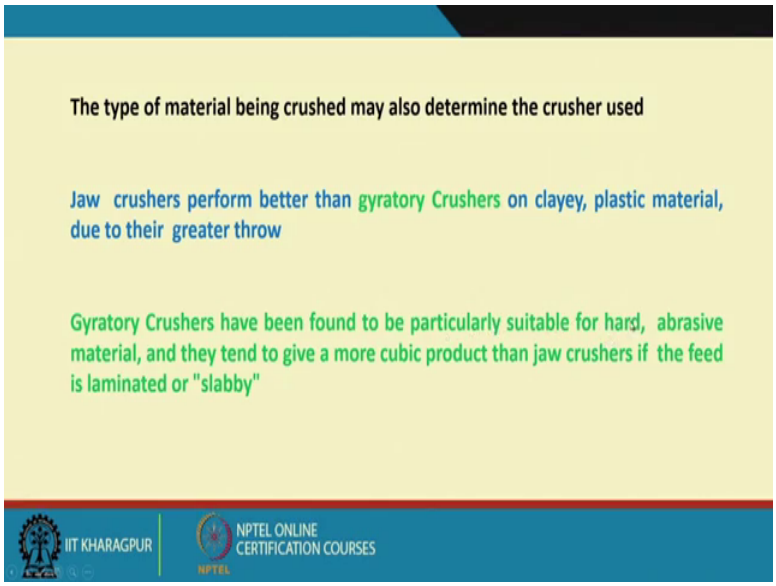

The type of material being crushed may also determine the crusher used. Now, if you look at the jaw crushers perform better than gyratory crushers on clay, plastic material due to their greater throw. Now what will happen? If I have for example, say suppose if I have a clay material; now in a gyrator reaction, when you are rotating this your say spindle.

So, that crushing surface is now being coated with that clay material because you are continuously compressing it. So, after some time because it is a continuous operation the crushing surface may be coated with the clay particles. And because of that coating of clay particles; your hardness of the crushing surface will be reduced and then the efficiency of your machine will drastically reduced. But in a jaw crusher, what is happening? Because you have got a throw and you are allowing the particles to go out of the system through the discharge.

So, when the clay particles are basically hammered like this and then they are basically allowed to pass through that; because you are releasing that you are moving jaw. Gyratory crushers have been found to be particularly suitable for a hard abrasive material. As I said that; it does not have a toggle. So, it does not create induce any strain on your toggle and it is basically a continuous operation and you are continuously squeezing it; you are not withdrawing your forces; what you have observed in a jaw crusher.

And they tend to give a more cubic product than jaw crushers if the feed is laminated or slamming. So, when should I use a gyratory crusher and jaw crusher; one is dependent on what capacity? For that I have given you a relationship that is if the tons per hour less than 161.7 into your gape in meter square is, then you use a jaw crusher.

And another constraint is that; that is if you have a clay material and plastic type of material, you should use a jaw crusher. So, now if I want a 5000 tons per hour of capacity of jaw crusher, I cannot use a single jaw crusher; then I need a number of jaw crushers a working in parallel; otherwise to cope up with that to your say capacity.

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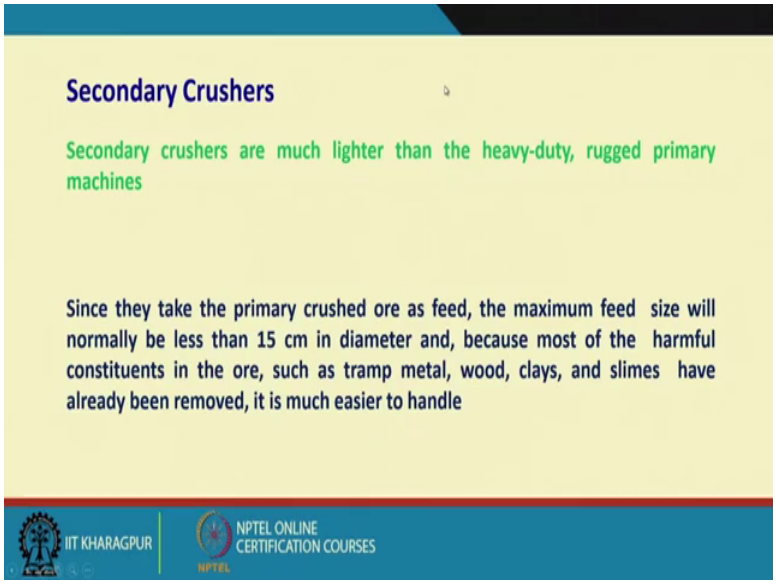

Now, let us talk about secondary crushers because we have already shown that what are the ranges or the particle size it can handle; that is from a top size to your bottom size. Because again and again I am repeating this that we are aiming for a progressive breakage of the particles, so secondary crushers because they are already crushed material; it is coming from the primary crusher.

So, primary crusher product that is whatever is has been discharged through the primary crusher; you are now feeding it to the secondary crusher so that top sizes of the particle are much smaller than the top sizes; what I have fade into a primary crusher. So, because of that the secondary crushers are much lighter than the heavy duty machines and since they take the primary crusts ore as feed, the maximum feed size will normally be less than 15 centimeter in diameter, it can be matched with the set size of my primary crusher.

And because most of the harmful constituents in the ore; such as tram metal, wood, clays and slimes have already been removed; it is much easier to handle.

This point let me discuss a bit like many times; it has been observed that as because your primary crushers are accepting the ore directly coming from the mines. So, and you have not have any control on that what you are feeding it to the jaw crusher. So, the modern day plants, what happens that many times during mining operation; there may be some broken metal pieces because of some your machine parts, they may come and then you may have some your metallic pieces; which were available into the; as a basically your unwanted material, along with your mine material because of some other reasons.

You may have used some wooden support for your mining operation; for that also you can have wooden material. And then so because of that and you may have some clay particle very fine particles also because of the geological formation of material, but still they are basically being fed to a crusher. So, what do you normally do; to control it what will happen? If you are feeding a metallic material to a primary crusher; that metallic material may damage your crushing surfaces.

So, in a modern day plant; when you have a chance, when the mining engineers they cannot guarantee that we will not send any metallic material, then you can have some kind of your magnets put on top of your say your grizzly; that is where you are basically through which you are feeding the material to the primary crusher. And when you have a metallic material, so that can be trapped and you can just take it out from your material which are being fed to the crusher.

Similarly, if I have wooden pieces they will be broken to vary finer sizes and then they will be very difficult material to be broken; even into a paramedic crusher because of many reasons. But these wooden materials essentially when it goes to your separation processes, they will try to always in a float fraction because you will be using water as a separating medium and they may create problems in downstream processes. So, many times you can have some kind of your optical sorters; when you are sorting device identifies that there is a wooden material, you may have some kind of mechanism to take it out from this your feed stream.

Similarly, when you have clays and your slimes; that is very fine particles coming along with your rom ore, you may just put it into a screen and then with some kind of vibration

mechanism. Or maybe you can some other means; you can remove those clay materials or slimes materials to improve the efficiency of your crushers.

So, there is no fixed rule for that; it depends on what kind of material you are processing; so the material characterization is very important. Now, what I try to say here that when; and these are the precautions whatever I have written that you have already taken while feeding your run of mine ore to primary crushers. So, the secondary crushers you do not have to worry because of your metallic materials, wooden materials, clays and slaves because that has already been taken care of by the upstream processes; where you have used a primary crusher.

Therefore, it is much easier to handle; so, because of you are relatively finnier sizes you are using and then you are almost guaranteed that these materials are free from all these harmful materials; harmful constituents, which may damage your crushing surfaces. So, it is much easier to handle the secondary crushers.

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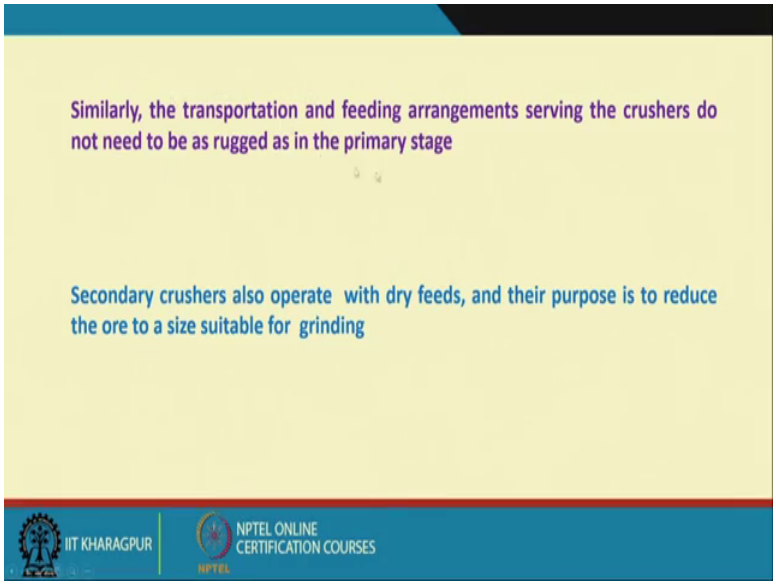

Similarly, the transportation and feeding arrangements serving the crushers do not need to be as ragged as in the primary stage. Because in the primary crushing stage; when we say that it can accept up to 1.2 meter of a particle; so how do you handle these sizes of material in large tonnages like a 5000 tons per hour.

So, your bulk material handling system has to be your very robustly built and rugged, but whereas because of the fineness of the material; you can easily transport the primary crusher product through a conveyor belt and you can feed it to a secondary crusher. Secondary crushers also operate with dry feeds and their purpose is to reduce the ore to a size suitable for grinding.

So, normally the secondary crushers are put into a closed circuit operation because many a times, this secondary crosses discharge is fed to a grinding mill; grinding is relatively finer sizes. There also the grinding miss they can also accept a maximum size of the particle.

So, you must ensure that whatever material is being fed to the grinding machines; they are not coarser than the prescribed one. So, normally the secondary crushers are used in a closed circuit.

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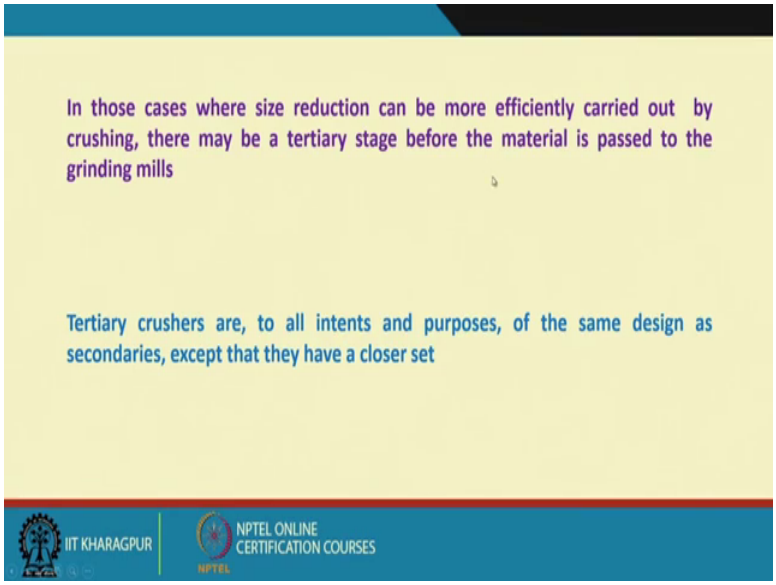

In those cases, where size reduction can be more efficiently carried out by crushing; there may be a tertiary stage before the material is passed to the grinding mills, towards the end of this lecture on your crushing devices; I will show you that how will you decide that how many crushers we require? How many secondary crushers you require?

But actually what happens before we go to that; let me tell you for continuation of this discussion; that many times these size reduction because as we keep on saying that it has

to be progressively done. So, we try to have your one feed size to another product size at a; in your secondary crusher, then I put that secondary crusher discharge to another set of secondary crusher; much smaller sizes than the first series of secondary crushers and then try to break it to a relatively finer sizes, so these are called tertiary crushes.

Tertiary crushers are to all intents and purposes of the same design as secondaries; except that they have a close at set. That means, you have got a relatively much closer set because we want to control the discharge sizes.

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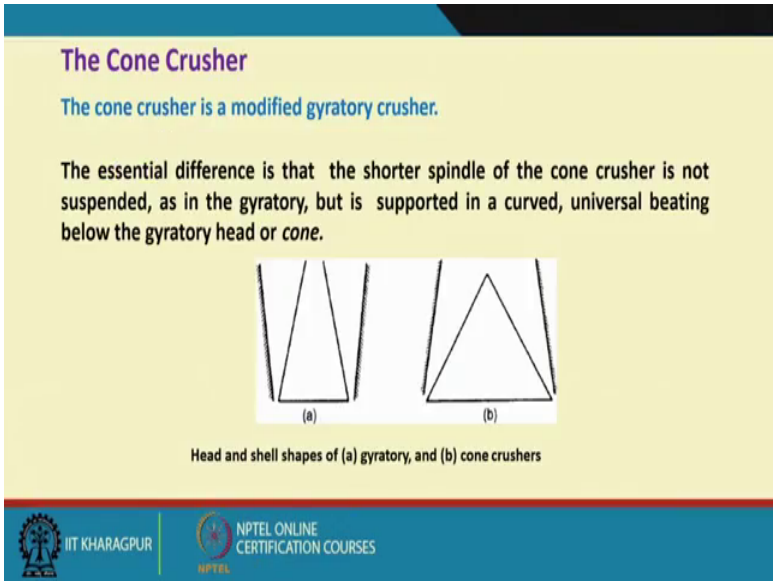

Now, let me show you some of these secondary crushers; one very important and widely used secondary crusher is a cone crusher. Cone crusher is nothing, but it is a modified gyratory crusher; that means, as breakage mechanism is almost similar to your gyratory crusher; there are some differences.

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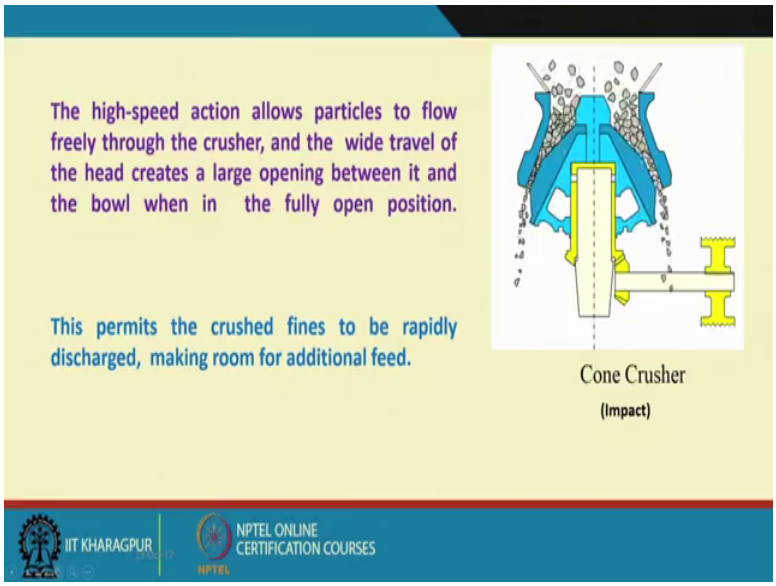

But before I describe this slide; let me show you this, this is a basically a cone crusher. So, now you see that show it works that you have got again; your say spindle and then it is basically this is the fixed your say jaw you can say or the say actually fixed crushing surface. And then this surface is basically hitting the particles and then there is an accurate angle of this.

So, what is happening? It is basically hammering; it is basically having an impact type of crusher. So, it is not because of gyration though this is the fundamental difference between your gyratory crusher and a cone crusher; apart from the design aspect of that. So, it is basically trying to break the particles because of impact and whereas, the gyration is basically trying to break the particles because of your compression.

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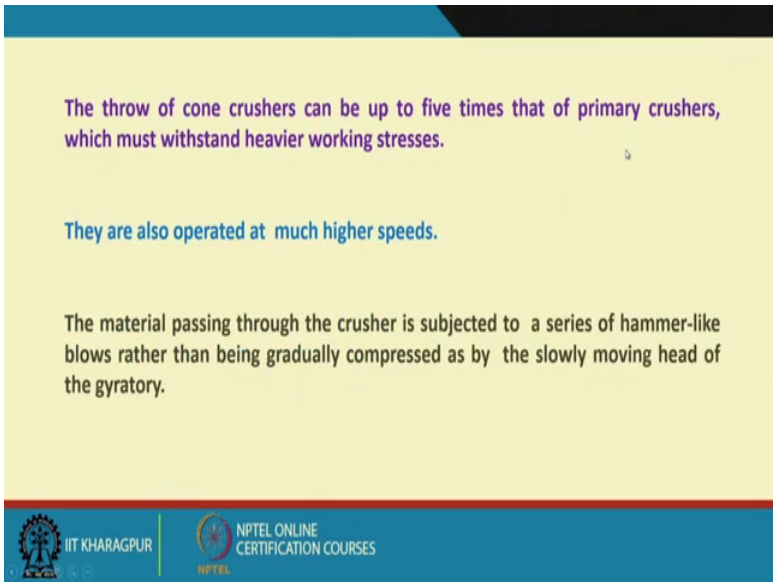

So, if you remember this animation; then we can go to this slide, we can come back to this first slide. That the essential difference is that the shorter spindle of the cone crusher is not suspended, in a gyratory crusher it was suspended but is supported in a curved universal beating; below the gyratory head or the cone, it is supported from the bottom.

So, this is a gyratory crusher and this is the cone crusher; is this schematically it is basically showing the differences; that means, here the spindle is hanging from here, but it is supported from the bottom. The throw up cone crushers; that is you remember that it is also throwing, if you do not remember let me come back to this that there is a throw also. The throw is for making room for the particles to get discharged through that; which is already broken below your set size.

So, the throw up cone crusher can be up to five times that of primary crushers; that means, in a jaw crusher or whatever the we have seen the throw; in a cone crusher it can be up to five times of that, which must withstand heavier working stresses. That means, when it is basically you have a higher throw so; that means when you are impacting it; it should have your much more stresses induced on the surfaces of that; through the surfaces of that.

They are also operated at much higher speeds; at much more higher speed it is baking.

The material passing through the crusher is subjected to a series of hammer like blows like. If you look at it closely that it is working like just like an hammer, so it is like a hammering action; that is your impact you are having. So, rather than being gradually compressed as by the slowly moving head of the gyratory; that is the difference as I have already explained that in a gyratory crusher, you are gradually compressing it but here it is your impacting it like this; in a cone crusher.

Now, the high speed action allows particles to flow freely through the crusher and the wide travel of the head creates a large opening between it and the ball, when in the fully open position. So, it can prevent the choking of the crushing messages; this permits the crushed fines to be rapidly discharged making room for additional feed that is how we can increase the capacity of that.

Because if I do not have a higher throw; the fine material they may basically help in agglomerating the relatively coarser particle sizes and that may choke your discharge; that is the set size, that is your discharge in. So, it can prevent that your crusher from choking.

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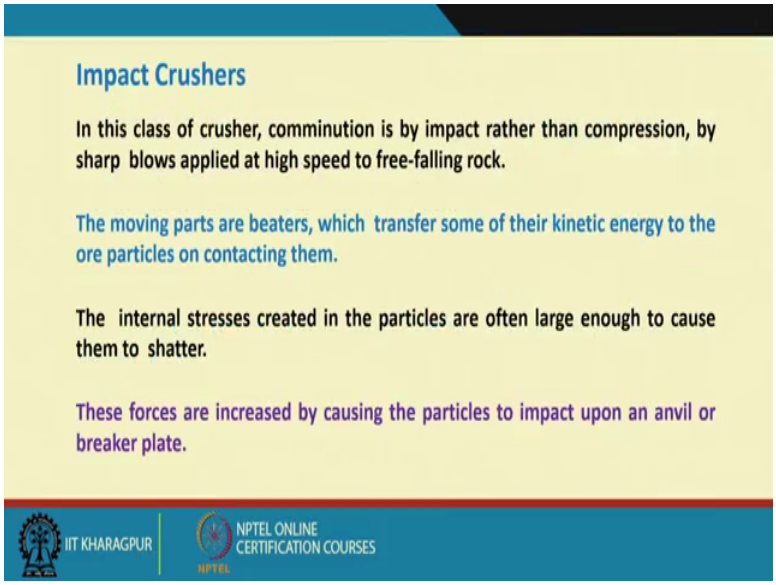

Now, there are also another set of crushers; which are called impact crushers. In this class of crusher, comminution is by impact rather than compression; by sharp blows applied at high speed to free falling rock, again it would be easier to explain if we look at this animation.

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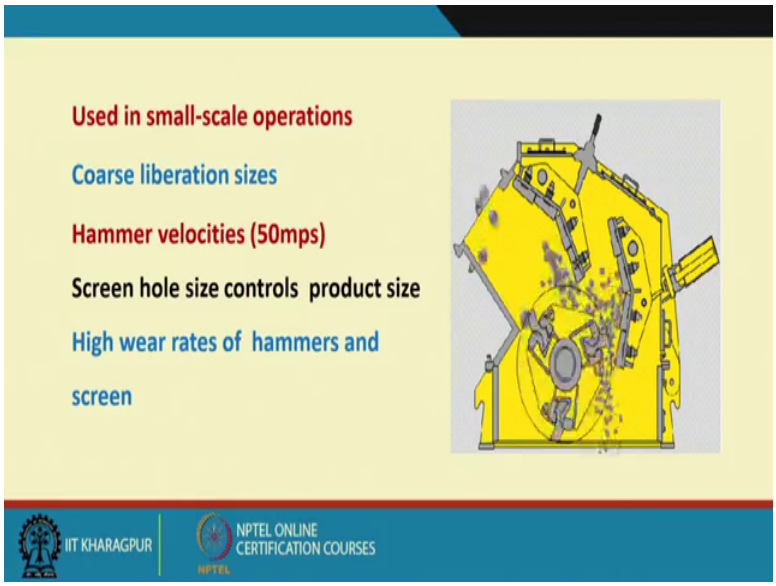

So, this is an impact crusher; you see that the material are free falling and you have got some kind of your excavated type of thing; that is you are basically lifting the material and throwing it and to a very hard surface and it is like your hitting some particle to the wall. That is being done by the mechanically through this machine.

So, look at that the particles are coming and it is lifting the particles and at a very high velocity it is hitting this surface. So, similarly these are all arranged at different angles and below this you have got a screen type of your apertures. So, the materials which are already finer than the screen aperture, they will be going out of the system. And otherwise which are basically the material which will be coarser than your aperture size, there will be again lifting back and then they will hit this.

And then that is how you are basically having a breakage of the particles; now let me go back to the previous slide. So, that is why I have written that in this step; in this class of crusher, comminution is by impact rather than compression; by sharp blows applied at high speed to free falling rock. The moving parts are, it is called beaters; that is what is basically, which transfers some of their kinetic energy to the ore particles on contacting them. So, these are the beaters which are basically lifting it and then throwing it to the scimitar surfaces.

The internal stresses created in the particles are often large enough to cause them to setter. It is just similar to that is you have a mechanical device and you are throwing it

and you are hitting the material to a very hard surface; like your wall made up says suppose steel. And the higher the velocity and the more the finer will be the breakage. So, it is that your velocity you have to control to have a proper size distribution of your discharged product.

These forces are increased by causing the particles to impact upon an anvil or breaker plate. So, that is the breaker which is basically lifting it and then your breaker plate where the rigid surface, you are basically hitting that. So, that is basically you are hitting surfaces; that is your breakage. So, this surface has to be very hard otherwise if the particles may not be broken. And this design is very critical that at what angle they should be placed so that the surface area of your bidding surfaces are properly utilized.

But the limitation is that as the very small capacity operations because you cannot, if I have a large capacity. So, it is very difficult to lift them up and give the adequate momentum for the particles to be hit to this your crushing surface. Used in small scale operations as the cores liberation sizes; that means, when I want a coarser particle that is your discharged particle to be relatively coarse. Then we use this liberation, we use these hammers hammer mills or say called the impact mills because it is; you are basically trying to break it because of the impact.

Hammer velocities are around 50 meter per second, screen whole size controls product size I have already said that there are screens here; which controls the product size distribution, but high wear rates of hammers and screen because if the material is abrasive, so there will be high where between the in the hammers and the screens.

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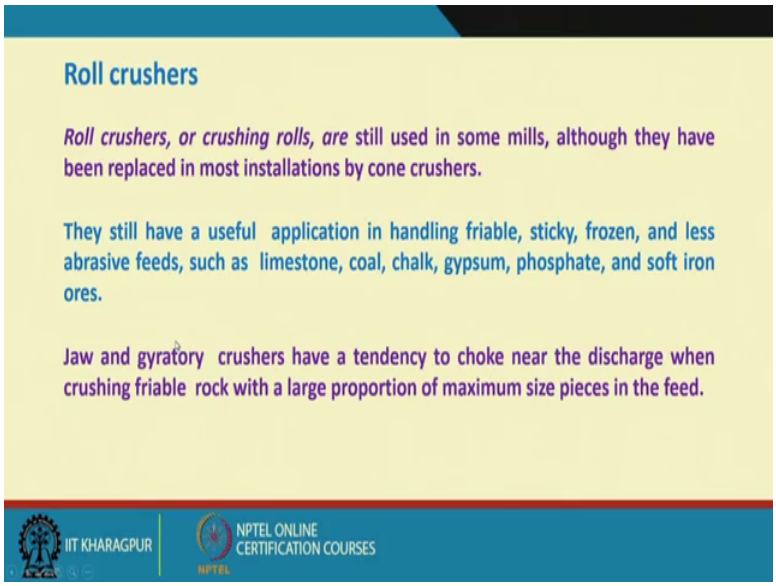

Then there is another group of crushers; these are secondary crashes these are called roll crushers how it works?

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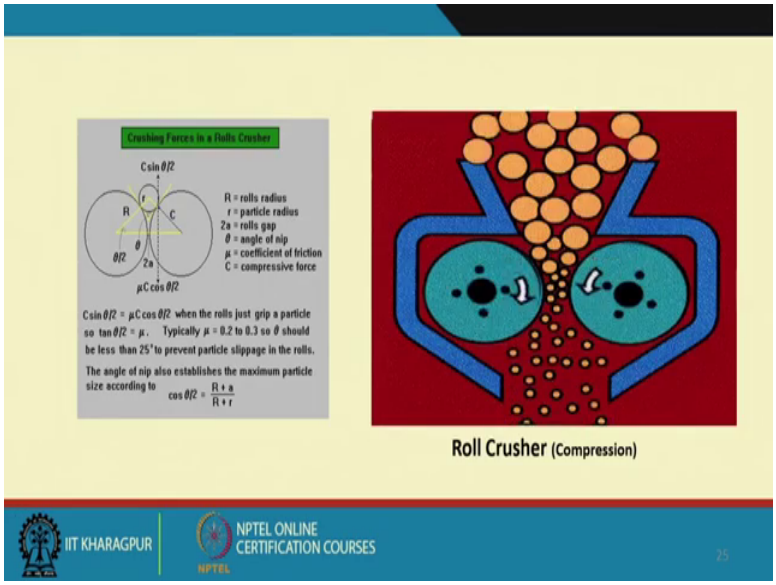

Now, I will show this animation first; that you have got this is a double roll crusher, you can have a single roll crusher also that is your single roll may be fixed and this role may be moving. So, this is a double roll crusher; which are having your two your rolls and then they are moving in opposite direction in like this. So, whatever material is coming in they are basically nipped and then they are under a compressive force and they are

getting broken. So, this is how a roll crusher works and you see that this contact area is only up to this. So, and here through this your say point of contact; you are having a compressive force induced on the particles and then the particles are getting broken because of that.

So, roll crushers or crushing rolls are still used in some mills; although they have been in most installations by cone crushes. That is the roll crushers, now the cone crushers they have replaced most of the roll crusher operations, but they still have a useful application in handling friable ore. Because what will happen if I have a very friable ore and in the cone crusher because of repeated hammering or repeated compressive forces, it will be broken down to very fine sizes than what we desired. Sticky material; same reason because of your cone crusher; the surface may be coated with the sticky material and then your crushing efficiency may be reduced.

Frozen material and less abrasive feats such as limestone, coal, chalk, gypsum, phosphate and soft iron ores; for this we can use the roll crushes. The very popular application for roll crushers is steel on the coal breakage because coal is essentially a friable material and many a times; the coal is associated with the clay materials because of his geological formations. So, that is why it is being widely used in coal processing industries; whereas, it is also used in limestone, chalk and gypsum and phosphate processing industries also.

So, if we look at that your comparative; your statements that jaw and gyratory crushers have a tendency to choke, near the discharge when crushing friable rock with a large proportion of maximum sized pieces in the feed. That means, when we have a basically a friable rock then the jaw and gyratory crushers have a tendency to choke; that is why the jaw and gyratory crushes are not regularly used in coal processing.

Now, so next lecture we will try to explain you that is the; how the role crushers are basically being designed. And then what are the calculations, we can make that is what is the maximum size of particle it can accept as a feed with; what will happen if I have a bigger size particle then what it can accept into a role crusher through some force balance calculations, I will try to show you that till then.

Thank you very much.