**Introduction to Mineral Processing**
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**Lecture – 20**
**Crushers**

Hello, welcome, so we are discussing about the comminution processes. So, we have discussed so far about the fundamentals of comminution. Now we start with the comminution devices or the comminution machines.

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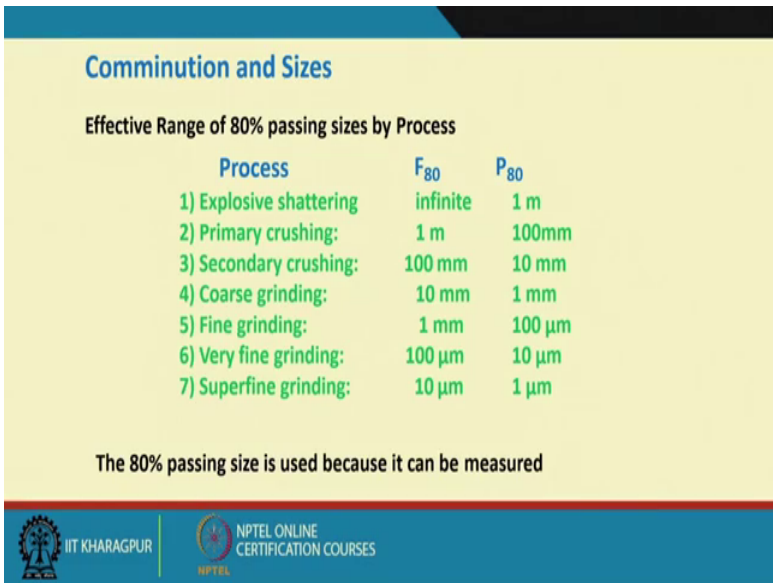


Now, if we look at; we use different terms or the different terminologies are used based on the size range of the particle we deal with. That means, what is the fit size and what is the product size we aim for? Because, we have to reduce it progressively and we always use 80 percent passing size by that process.

So, it is a blasting operation that is the explosive shattering, it is F 80 could be infinite; up to P 80 of 1 meter. We try to do it through blasting, which is the purview of mining engineering community. Now we call it primary crushing, where the F 80 starts from 1 meter that is; it is a basically a linkage between your mining operation and your processing operation. So, 1 meter to 100 millimeter, these are only the general terminologies; we call it primary crushing operation. From 100 millimeter to 10 millimeter; we call it secondary crushing operation. And then we call it coarse grinding

from 10 millimeter to 1 millimeter; we call it fine grinding from 1 millimeter to 100 micro meters. Very fine grinding; we call it from 100 micrometer to 10 micrometer, super fine grinding 10 micrometer to 1 micrometer.

And even we can go for the nano sizes and all this; which is again not under the purview of so called mineral processing engineers, they become the part of material scientists. So, why 80 percent passing size is used? Because it can be measured easily in a laboratory process; where we have the sleeve shaking machines say and we call it a row tap sleeve shakers and all this and we have already discussed it.

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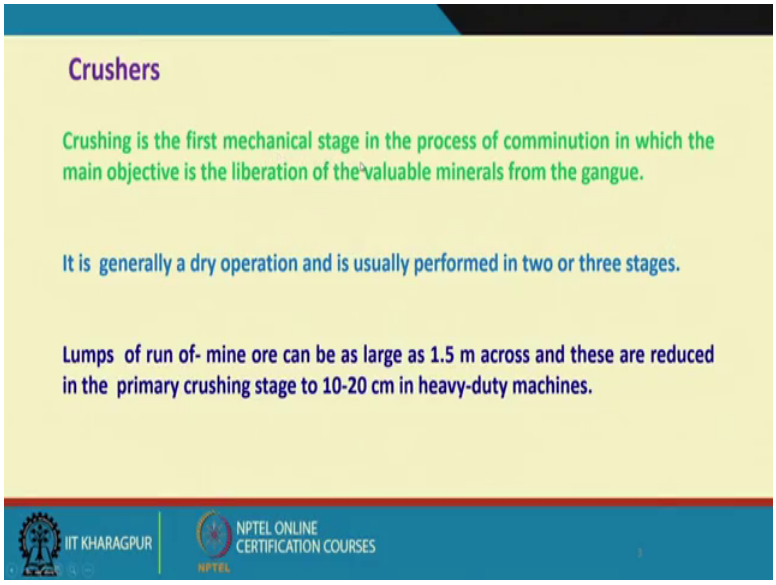


Now first stage is the crusher, we will start with the crushers; so, crushing is a first mechanical stage in the process of comminution, in which the main objective is the liberation of the valuable minerals from the gangue. Actually as I had said already that entire comminution process is primarily focused on liberation of materials where we talk about mineral processing operation. That means, you are preparing your material for subsequent separation.

So, crushing is the first mechanical stage in the process because in blasting operation we use the chemicals. It is generally a dry operation and is usually performed in two or three stages; that means, we can have primary crushers, we can have secondary crushers, we can have tertiary crushers. So, what happens in a crushing operation; the lumps of run of

mine ore can be as large as 1.5 meter across. And these are reduced in the primary crushing stage to 10 to 20 centimeter in very heavy duty machines.

Why we need heavy duty machines? Because the crushers capacity has to match with your; the rate of production of your mining activities and mining activities are generally a huge production rate we have; it involves huge production rate. So, if they are not synchronized; so, what will happen? You should have some kind of your as a mined material; you must have some place to stack. One practical thing I must tell you that normally the mining operations are carried out in two shifts.

And another shift is basically kept reserved for preparing the mining operations; like you have to drill the holes for blasting operations and all this. But the crushers are normally used because the meander processing operation is a continuous one and the crashers are the first machine; in that entire chain of mineral processing operations. So, the crushers are normally selected based on its 24 hours operation; whereas, the mining is essentially 16 hours operation; so it has to match with that.

So, in between there are some basically the material storage type of your say mechanism should be there or the storage places should be there. And how you will be feeding the crusher and all this decision has to be made; which probably I will not be able to cover in this lecture series.

Why it has to be heavy duty machines? Because as I said that it has to be high capacity and the materials which you are getting, they are around maybe the particles could be as large as 1.5 meter and they are poured into the machine from a height. So, it has to with stand that much of your stress, so it has to be very heavy duty and robustly built machines.

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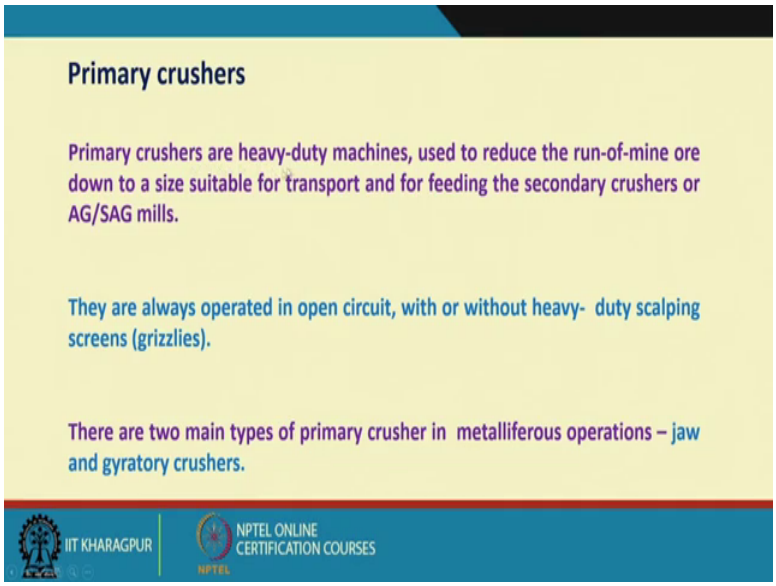


Now, primary crushers they are basically used to reduce the run of mine ore; down to a size, suitable for transport and for feeding the secondary crushers or auto genius grinding or semi auto genus grinding mills; which will discuss in due course of time. So, these are basically used to reduce the run of mine ore; down to a size suitable for transport.

That means the material has to be transported from one unit to another unit. So, first you try to break them to a size; which is transportable by a common means like your conveyor belts like that. And then you are feeding it to another crusher like that it goes on. They are always operated in open circuit; that means, the crusher products are never recycled back, because the crushers when you are selecting you know that no particle through the discharge will be coarser than whatever you desire. So, with or without heavy duty scalping screens that is the grizzlies.

So, normally what happens before say suppose; if I have a crusher and that can accept a top size of a particle up to 1 meter. But in mining operation when you are doing blasting, you may not be able to guarantee that no single particle will be coarser than 1 meter. So, what will happen? If I have a particle which is around 1.5 meter and your crusher can accept the maximum size of 1 meter. So, if that material goes into a crusher; so it will block your passage of your crusher and then you need manual intervention to take it out.

From that and then there will be some intermittent stoppage of the crushing operations; so a entire meal will start for your feed materials. So, to check that what we have? We

have got a fixed screen; this grizzlies we will discuss in detail when we talk about industrial screen.

So, you have got a size control device that is called a special screen; the called grizzly, which ensures that whatever material is fed to the crusher, they are not coarser than the maximum size limit it can accept. There are two main types of primary crusher in metal affairs operations; one is called jaw crusher another one is called gyrated crusher. So, let us discuss both of them briefly what they are.

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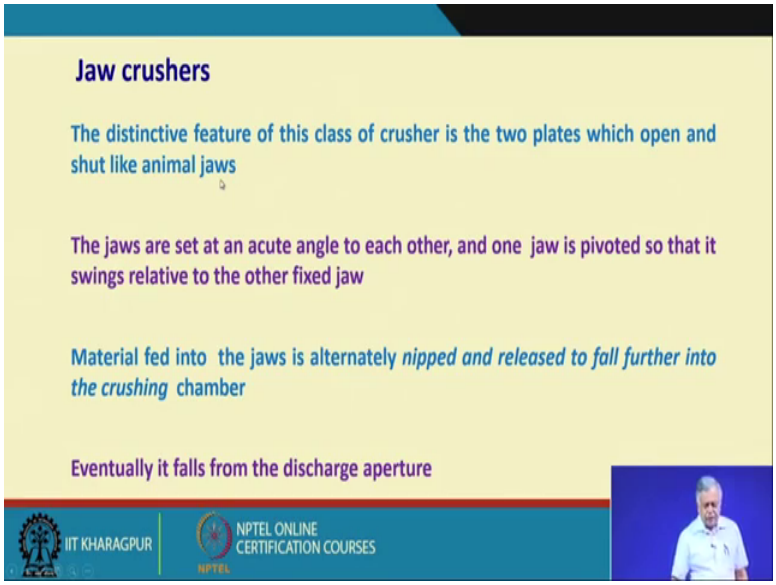


So, jaw crushers is basically the name has come; it has got similarity with the animal jaws. The distinctive feature of this class of crusher is that two plates which open and sort like animal jaws; like even our own jaws; like one jaw is fixed and another jaw is moving and that is how we cross and we have got our teeth to break that particles.

So, the jaws are set at an acute angle to each other; probably I will go to the next slide which will explain it that how it works.

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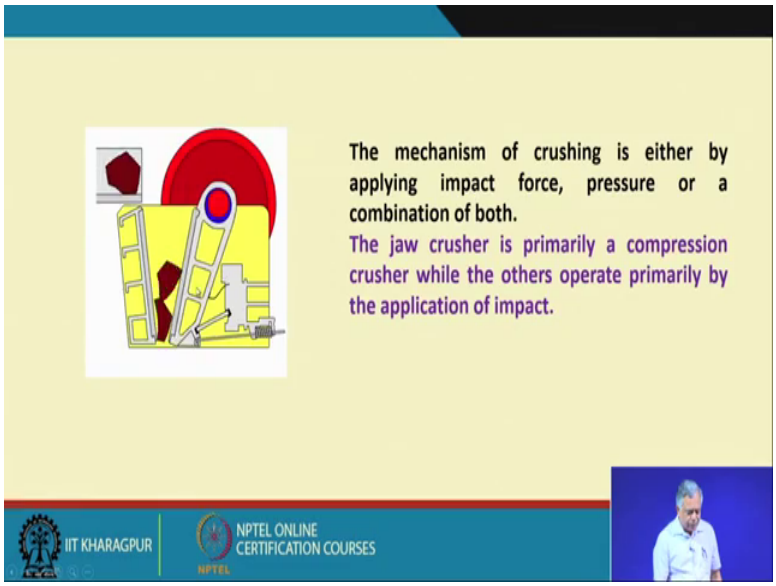


So, this is an animation of how a jaw crusher works; I got it from the open source. So, here you see that this is a fixed jaw and this is a moving jaw and the particles are coming like this. And then they are basically experiencing some kind of your force in between your fixed jaw and the moving jaw. And this opening is called the gate and this discharge; this distance is called the set.

If you look at closely; you will find that there is a; some throw; which is basically making some room for the particles to pass through. Otherwise what will happen, the particle may get choked here and your entire crusher may be choked. So, I will come back to this again, but before that let me go back where we had stopped. So, the jaws are set at an acute angle to each other and one jaw is pivoted so that it swings relative to the other fixed jaw.

So, it swings like this and make some kind of your compressive force to that material. So, material fed into the jaws is alternately nipped; that means, they are pressed and then they are dislodged and then the released because of the throw. So, fall further the crushing chamber; it means when the material is coming like this, so material is falling. So, it is weighing the compressed and then you are releasing it because if they are already broken they will now travel to the next portion so, to have further fragments of that particle.

So, when it is basically smaller than your discharged one that is the set; so then it will pass through that jaw crusher. So, the mechanism of crushing is either by applying impact force, so you are having some kind of a impact and then you are having a pressure or a combination of both. That means, when you are hitting it; so there is a; some kind of impact is there and you are also squeezing it so there is a pressure also; so the particle may get broken because of that two forces also many times.

Jaw crushers are primarily a compression crusher, while the others operate; that means, other crosses operate primarily by the application of impact. Here interestingly you can see that all most 50 percent of the time of the jaw crusher is being utilized for the material flow. So, 50 percent of the time it is withstanding that your; compressive force or the impact. And then it is getting broken and then the remaining 50 percent of the time, you are making the passage for the particles to pass through that.

And this is a swinging jaw and you will see that this is basically a pivoted here and then there is a flywheel which is basically helping it to move across.

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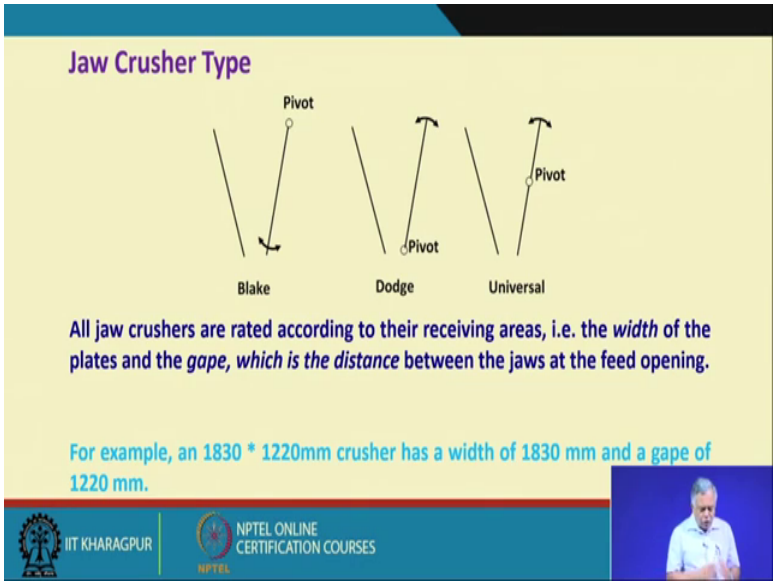


So, jaw crusher type depending on how the movable jaw is pivoted; it can be pivoted at the top. So, when it is pivoted at the top and it swings like this; so the swing that how much it will go that is called the throw and at what frequency, it will move that is called the speed of the moving jaw.

So, this is called a Blake type of jaw crusher; when it is pivoted at the bottom it is called the dodge type of jaw crusher and when it is pivoted at the center that is called a universal jaw crusher. Now, where do I use the Blake crusher? Where do I use the dodge crusher? It is not very commonly used because of many problems associated with it.

Now when it is fixed at this point; so what we are trying to do? We are basically accepting a particular feed size, which is finer than that this your gape size; that means, if a particle is coming which is coarser than this dimension, will essentially sit on this top and that is what we are basically controlling through a screen beforehand.

So, normally this Blake type of crushers and then this swinging job is basically helping the particle to pass through. So, it is here you have got a wide size distribution of the product because you cannot control the product size distribution so closely. And normally, it is used in the industrial applications. Here when it is pivoted at here; you can control the product size distribution because no particle coarser than this can pass through that.

Here a particle little bit coarser than that can pass through this; your discharge because during the throw. It expands because the set is not a fixed work, but here the set is fixed whether the gape is basically a variable. So, normally in a laboratory crushing operation; where we want to have a particular size reduction for a very small quantity of material, we normally use a dodge type of jaw crusher; for laboratory operation.

And for industrial scale operation because if I use this type of crusher in industrial application; there is a chance that my crusher may be choked here; that is a particle, if it is broken that your bigger than this size and it may not be broken further. So, it may choke my entire crusher and it is very difficult to prevent this choking and then it will create some maintenance related issues. So, that is why the Blake type of jaw crushers are most popular in industrial applications.

Then all jaw crushers are rated according to the receiving areas; what is the deceiving area? Now there is only two dimensional one.

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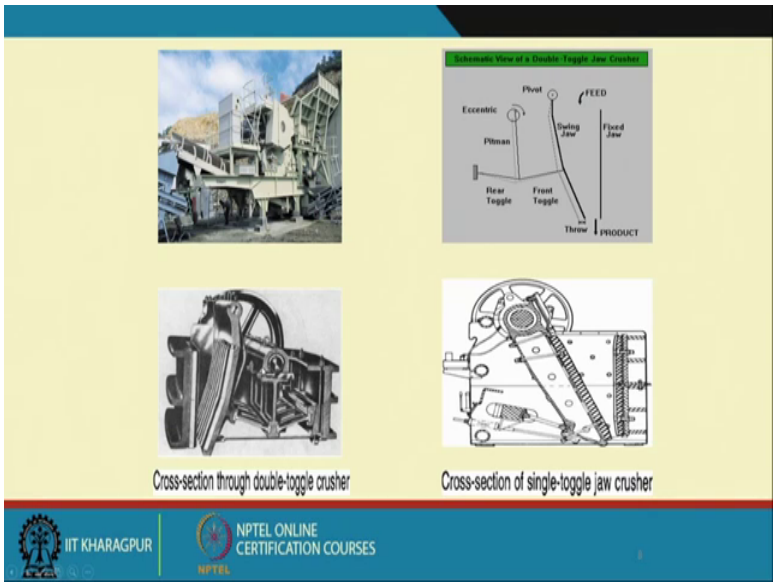


So, if you look at this that this is the call that is seeping area, so this is a basically a jaw crusher and this is the width of this jaw crusher. So, what is the width of that jaw crusher? And to their receive me that the width of the jaw crusher and the gape; that means, what is the basically the distance between the two jaws. So, that is the gape and that is what the width is there; so, you get a cross sectional area of that.

So, for example, normally when we say designate a jaw crusher; we write it like this 1830 by 1220 millimeter crusher. What is the meaning of that 1830 by 1220; that means, it has a width of 1830 millimeter and a gap of 1220 millimeter. So, many times when you look at the specifications of a (Refer Time: 18:03) processing plant you may be told that it is a 1830 by 1220 millimeter jaw crusher.

So; that means, 1830 is the width millimeter and 1220 is the gape. These are some of the pictures, I have taken it from the open source that is I said at the beginning that this primary crushers are basically a robust; rebuilt crushers. And you need a lot of civil engineering also for the foundation work and you see that how gigantic they are. Because it has to come up with the capacity; the capacity has to be very high to cope up with the production rate of sub mines.

Now if I look at the schematic of a jaw crusher; you see that this is called the toggle which is basically helping the moving jaw to swing. So, that is a fixed jaw and this the feed is coming at an acute angle and then this is the product discharge. And this if you

remember the animation, it is basically the moving jaw or we call it swinging jaw and there is a throw.

So, how much distance it travels that is while swinging; so, that is called a throw and how it is being basically the swinging what mechanism? So, we have got a flywheel like we call it eccentric and this is called the pitman and this is called the toggle. So, this is a double toggle we call it this is the rear toggle, this is the front toggle and so now, if I go back to that; your animation again, you see that the flywheel is moving and because of that your lateral displacement of my moving jaw.

So, now this is basically the toggle and so what will happen? That we can have a double toggle though here you have got two toggles. So, we call it double toggle jaw crusher and you can have a single toggle also like this; we call it single toggle jaw crusher. So; that means, we can have a single rod to move it; that is your for this swinging jaw to operate and we can have the double toggle also.

And if you look at closely that these plates; that you can have different types of your; in the jaw surface, you can have a different types of materials. You can have some say tooth also; tooth separate material to cement, your surface also, you can have this type of your plate like surfaces; so these are generally very hard surfaces.

So, because if your surfaces through which the material is broken that has to be much harder than the particle which you are trying to break. Otherwise, the surface would be ore out and that may contaminate your particle also and also it may damage your crusher. So, where should I use single toggle jaw crusher? And where should I use double toggle jaw crusher?

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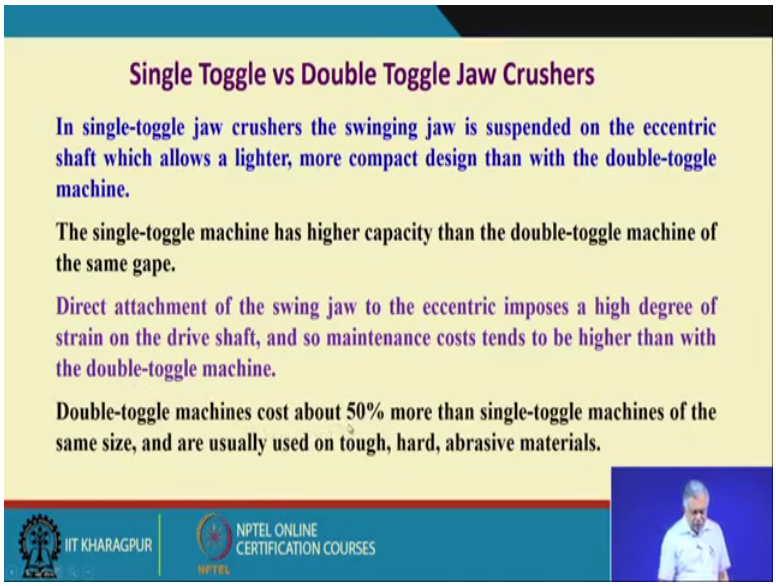


In single toggle jaw crushers, the swinging jaw as I explained is suspended on the eccentric shaft which allows a lighter, more compact design than with the double toggle machine. Because when do we have two rods connecting each other, then you should have a much bigger; your say design or say bigger surface area for the machine to be accommodate it.

So, that is much more a bigger machine than a single toggle one. So, single toggle is basically a lighter one and it is more compact in design. But then what is the need for double toggle jaw crusher? That I am going to answer. The single toggle machine has higher capacity than the double toggle machine of the same gape. Because it does not have to; your delay time between the; your say actually the compression action and then the release action is much less because you have got a single toggle. So, that is why you can process per unit time more material than the double toggle machine.

Direct attachment of the swing jaw to the eccentric imposes a high degree of strain on the drive shaft. What will happen? When the particles are getting broken because of this compressive process, there will be lot of strain will be induced onto the toggle. So, what will happen? If I have a single toggle, it will be prone to breakage so; that means, the maintenance cost are much higher than with the double toggle machine because of that design the strain is getting distributed in different manner. So, that is the mechanical engineering aspect.

And the material selection is also very important for your toggle selection also. So, harder the material; the more robust it has to be, otherwise my toggle will have breakdown and you will have maintenance related issues. Double toggle machines cost about 50 percent more than single toggle machines of the same size and are usually used on. So, when we will use? Even though it costs you 50 percent more than the single toggle machine and its capacity is less than the single toggle machines.

But still for a very tough, hard and abrasive material because what will happen when the material is very hard and tough? So, the strain induced on the toggle is very high. So, the material for the toggle is prone; will be susceptible to be broken. So, what will happen? It will damage your crusher and you need lot of say maintenance work to be carried out. And because of that your entire productivity will suffer; not only for the crushing circuit, but the entire downstream processes, that is the mineral processing circuit will suffer.

Because you are basically feeding the mine ore directly through the crusher to the bender processing plant.

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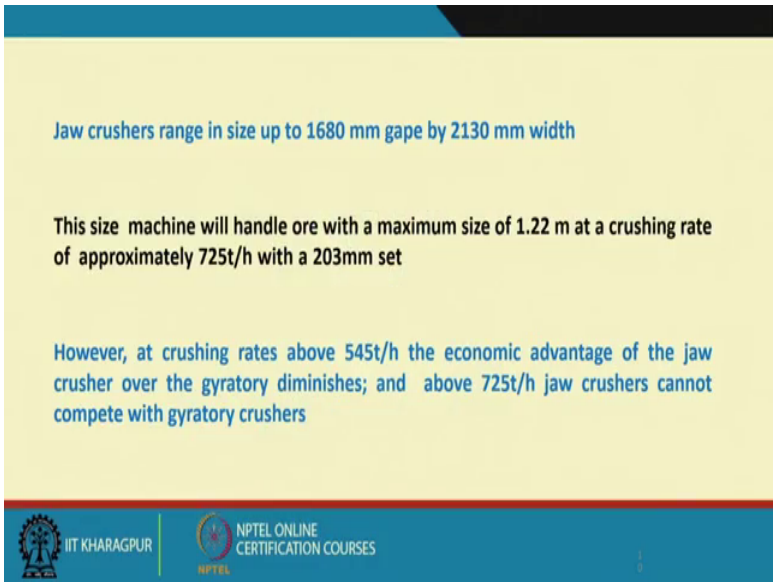


Jaw crushers generally range in size; that means, what are available in the market up to 1680 millimeter gape by 2130 millimeter width. These are what is available as far as I am concerned that is available in the market. This size machine will handle ore with the maximum size of 1.22 meter; that means, the rom ore, which is having a maximum size of 1.22 meter. It can accept that if you have a 1680 millimeter gape and 2130 millimeter

width; that means, this specification is 2130 by 1680. And its capacity is around 725 tons per hour. Just imagine 725 tons per hour material can be broken through this gigantic machine, where with your 203 millimeter set size.

However at crushing rates above 545 tons per hour; it has been shown by many people, by many researchers that the economic advantages of the jaw crusher over the gyratory crusher; that is what we are going to discuss next; there is diminishes. And above 725 tons per hour, jaw crushers cannot compete with gyratory crushers. That means, when you need more productivity, then probably you have to switch over from jaw crusher to gyratory crusher.

Because the problem with the jaw crusher is that; it is an intermittent breakage, it is not a continuous breakage machine. Because we have seen that; there is a basically a swing in jaw; so when it is withdrawn that is when there throw in this direction, there is no breakage; it is basically you are making passage for the particle to pass through that.

So, that basically ultimately reduces the capacity of your mid scene.

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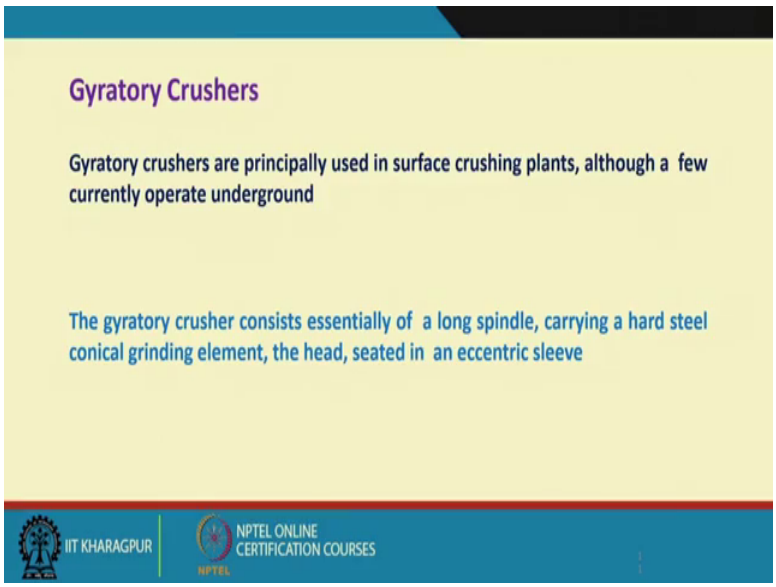


So let us discuss now what are the gyratory crushes? And then we will come back again to this discussion that is, where I should use a jaw crusher? Where I should use a gyratory crusher? So, what is the gyratory crusher? Now gyratory crusher are principally used in surface crushing plants; although if you currently operate underground. That

means, even the gyratory crushers these days, they are being used in underground operations also or breaking the materials; why the crushers are used underground?

Normally, the jaw crushers are used underground for the ease of your transportation of the mile materials. Because whatever the transportation systems are there; if the particle size days are broken down to a say below a particular size, then the bulk material handling system is easier to design and you can work with that.

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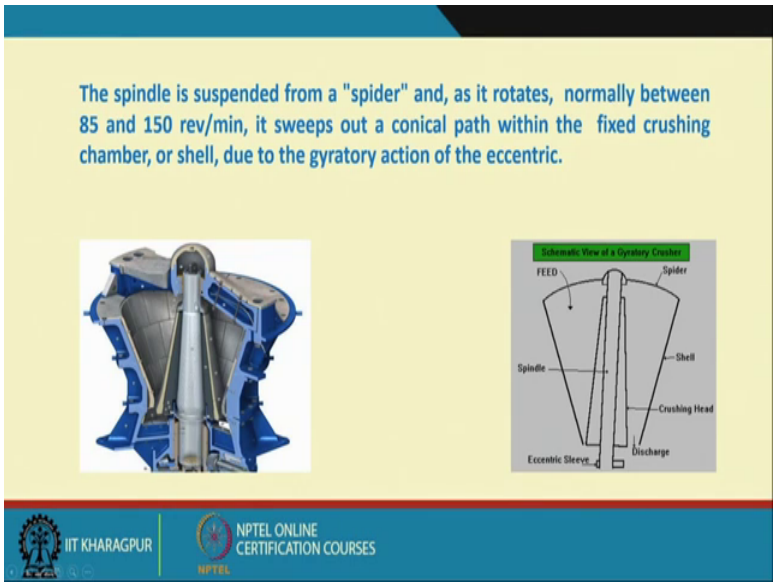


The gyratory crusher consists essentially of a long spindle; I will show you that there is the log spindle and what happens? Sorry I do not have any animation here. So, you have got a very rigid, you have got a very hard surface inside and here also you have got a very hard surface and then this spindle is basically rotates. So, what will happen? This is only a cross section of that. So, the material is fade through this and you see that there is again an acute angle through that and the materials are squeezed.

So, they are basically again witnessing the huge compressive forces and the materials are ores are progressively broken and then this is the discharge. And then through that; it is going out the material which are already finer than this; they goes out. So, this is a continuous machine because there is no swinging jaw here.

You are basically, you have got a gyration like; you have got in this section and then you have got a spindle and then essentially you are trying to rotate it and you are squeezing

it; so the particles. So, you are introducing a huge compressive force and then you are forcing them to pass unless and until, they are broken down to a particular size.

So, the gyratory crushers consists essentially of a long spindle; carrying a hard steel conical grinding element. The head seated in an eccentric sleeve that is the mechanical aspect of that; so, the head is here and it is basically helping it to rotate. Now this is called a spider and this is the feed is basically say feed into this gyratory crusher through that and this entire this assembly is called the shell and this is the spindle and this is the crushing head.

So, this is the crushing head and this is the shell and then this is the discharging and this is the eccentric through which you are basically rotating. The spindle is suspended from a spider and as it rotates at what speed? It rotates normally between 85 to 150 revolution per minute; that is rpm. It sweeps out a conical path within the fixed crushing chamber or shell due to the gyratory action of the eccentric.

So, you see that when the particles are in bigger sizes they are basically witnessing the compressive forces and as they are broken down; so they are again basically witnessing the further compressive forces unless and until they are broken finer than this. But what can happen? That a particle, that is say suppose you imagine three particles they are already finer than this, but if their array in a series. So, they may be acting like a single particle and you may have more breakage of that, so you can generate more fines also.

So, but the essential criteria is that this material surfaces should be very hard in comparison to the material what you are breaking. So, the weir is a very big problem for both the jaw crusher and the gyrating crushers. So, we will continue this discussion into the next lecture, so till then.

Thank you very much.