Fundamentals Of Particle And Fluid Solid Processing

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Lecture - 44
Particle size reduction (Contd.)

Hello everyone and welcome back to the another class of Fundamentals of Particle and Fluid Solid Processing.

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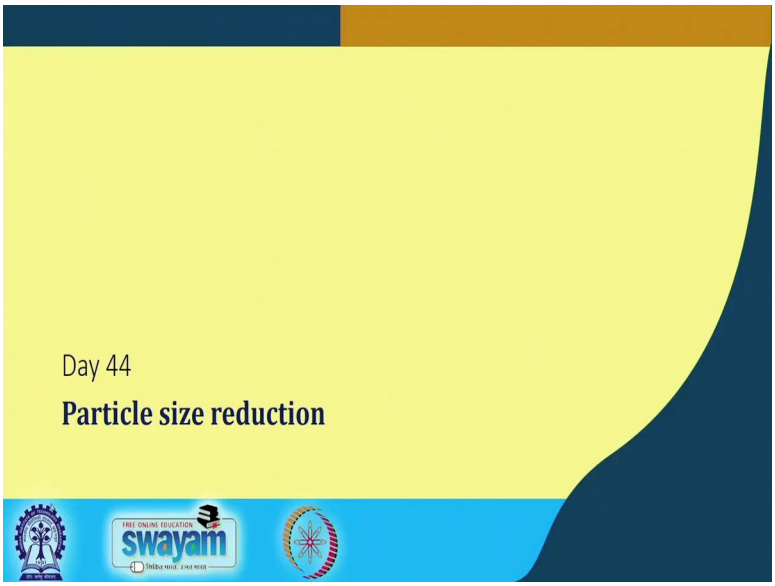

So, we were discussing about the particle size reduction, we have seen the energy requirement, we have started to see the different equipments that are typically used in these size reduction process.

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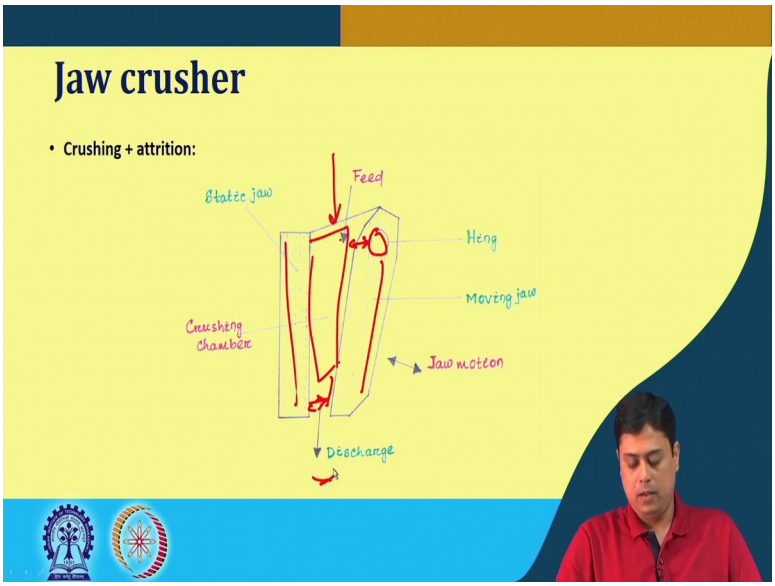

And we have seen this initial couple of three couple of slides, three equipments that started with a jaw crusher. So, here the dominant mechanism, the stress mechanism was crushing plus attrition. So, here what was that? That we had two rigid jaws and sorry this is one rigid jaw and one jaw that is hinge at this position which has a jaw motion like this. So, it crosses the particles that comes in between this crossing chamber and the discharge is collected from this side. We mentioned that based on the distance between these two jaws, the discharge particle sizes are influenced.

So, depending on the size that we require, we can adjust this hinge position and accordingly this hinge position can be adjusted and then this gap will be automatically adjusted. So, here this is the crushing chamber this portion, this is the static jaw another moving jaw, the feed comes here and the discharge goes out.

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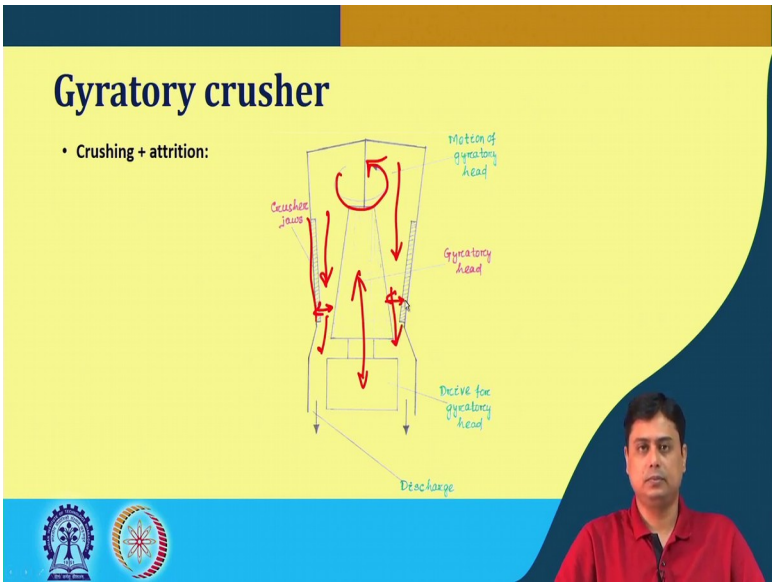

The other equipment that we saw was the gyratory crusher. So, in this case we had a chamber a static chamber, where the lines the inside lines of the walls were lined with this jaw material, ribbed portions and we have a kind of a gyratory head, this conical section which can be position, can be adjusted by moving it in upward or in downward direction.

So, here by this adjustment we basically can adjust the gap between this static chamber and this gyratory head which then rotates this gyratory head rotates and it crushes the particles. The grinding happens when the particles flow through the gap between the solid wall and the gyratory head. So, depending on this gap we basically have different types different sizes of particles.

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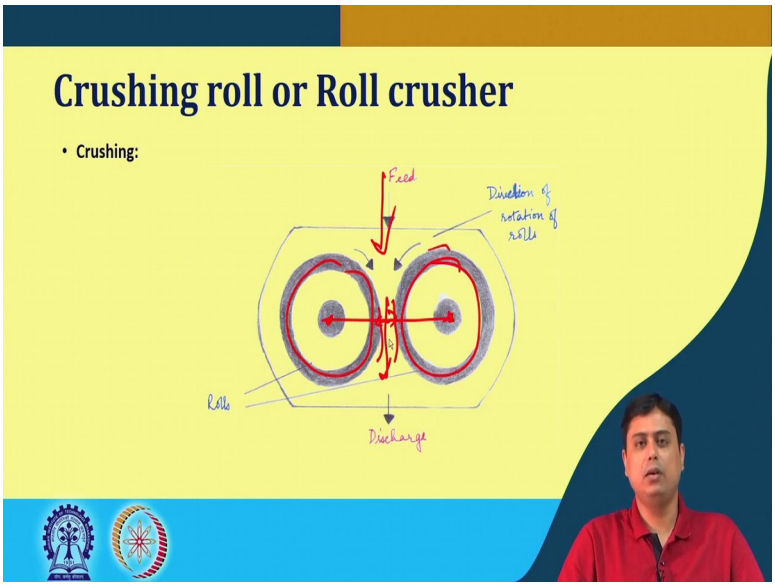

The third one that we saw was based on this crushing stress mechanism was that we have two rolls, this two rolls are rotating in opposite direction and it attracts the feed into this gap between this two crushing rolls and here also in this case this distance between the two crushing roll can be adjusted and by doing so, we can have a specified gap in between the two rolls and the particle size that goes through the rolls those have the particle sizes lesser than this gap.

So, by adjusting this gap we are automatically adjusting the particle size distributions or say the size is at least that the reduced particle sizes will not be bigger than this gap size. So, here all the three equipments had one thing common that we had two rigid surfaces to grind the solid particles and that is the crushing mechanism.

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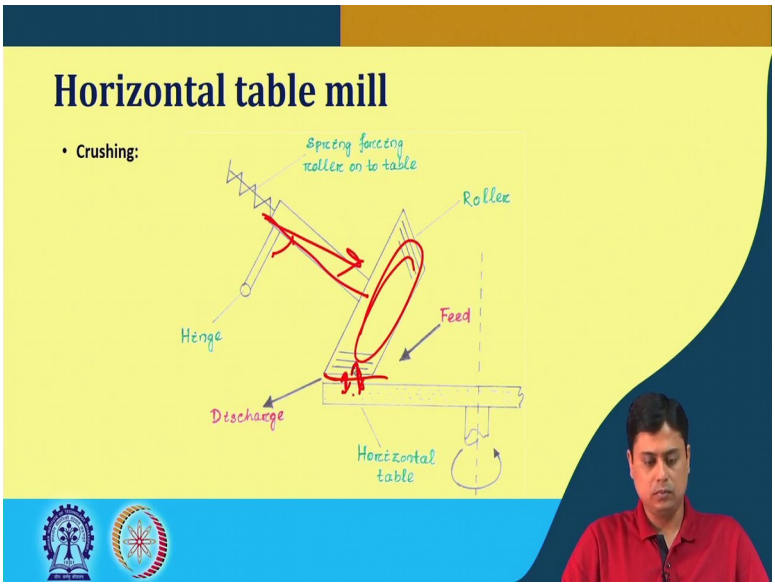

The other crushing mechanism is found in this horizontal table meal. So, here what happens we have a rotating disc kind of a plate, horizontal plate and roller with a certain angle and hinge at certain position is also rolls as the feed goes inside between the spaces of this rotating plate and this roller. So, what happens here that this horizontal table rotates about this axis. So, the feed that comes in on the plate is accelerated by the centrifugal motion, it tends to move outward and as it moves outward and it can only passes through this gap and that this gap is created between this crushing roll and this plate. As it passes through this gap it is crushed, the size is reduced and the discharge is collected.

So, basically here also the sizes of the product can be controlled by controlling the gap in between these two rigid surfaces and that can be adjusted with its slope. If we have a bigger slope we can create a larger gap between these two positions. So, based on the feed size to the product size distribution that is required we can adjust this gap and we can have our desired size of the product. So, this spindle also rotates when this goes through, this gap between this roller and this horizontal table.

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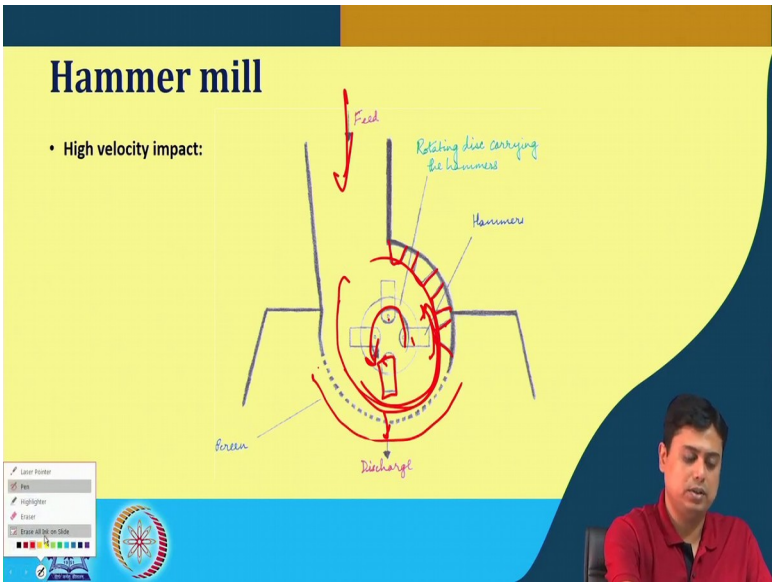

Now, based on the second mechanism or the second mechanism that we discussed, that this first four equipments that we have seen is based on the crossing mechanism; that the stress mechanism the dominant part is the crushing. The other mechanism can be the impact, impact plus attrition. Now, here is an equipment called hammer mill, here we have this high velocity impact as the dominant stress mechanism that acts on the particle. So, here what happens this cross sectional view of the equipment is something like this, where the feed comes in and here we have some rotating disc where the hammers are attached.

So, this rotating disc rotates and these are the hammers that is attached to that disc and in this surface we have other static surfaces extrudes which helps in crushing the particles when it goes through this space. At the bottom we have our desired screen sizes and the discharges are collected when it is sufficiently lower than the size of this screen sizes. Until, that time it circulates in the chamber and while it passes through it is crushed in between these two surfaces that is shown here.

So, feed comes in this disc is rotating in this direction. So, the particles are carried in this portion and when it goes through between this surface, where the hammers are attached and the rotating disc were also the hammers are attached. When so, it passes through this gap and the particles are grinded. So, which means here the particle sizes or the product

sizes can be controlled by the gap in between these two spaces; that means, the disc where the hammers are attached and the solid wall where these protrusions are there.

Once it is fine enough, the finer particles are discharged because at the bottom we have the wear of screens. So, here it is the high velocity of this rotating disc that impacts again and again repeatedly on the particle and creates the final particles. So, this is the example of high velocity impact on the particle. So, here the dominant mechanism of stress is the high impact velocity although there are particle-particle attritions are there, particle-solids, particle and the solid wall attritions are there. So, attritions are there but the dominant mechanism is the high velocity impact.

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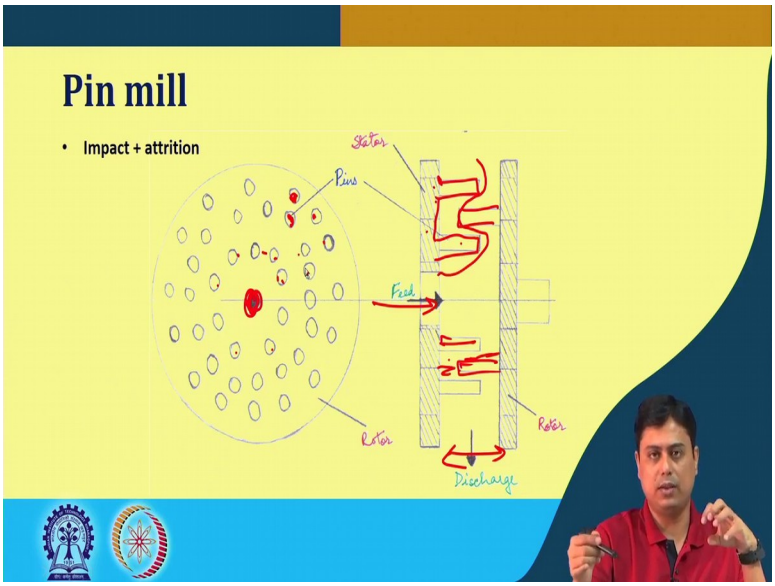

The other one is the pin mill. So, in pin mill this is a side view of the pin mill, it is a kind of two discs facing each other and when we see the side view these are basically pins or very sturdy solid extrusions like we saw in this case as well in the hammer mill, this kind of a protrusions. So, these are attached to this wheel or say the circular disc and the opposite one is arranged such a way that it can move through this spaces, that is created in between two extrusion of the two pins on the other side of the plate.

So, basically these are the two moving wheel rotating against each other and these have teats attached to their surfaces and in alternate position. So, that there is a smooth rotation of the disc can happen. So, quite naturally the pitch of these tooth positions or say the pins will be one of the design parameter and through this position the feed goes

in. So, as the feed goes in, rotating disc again it is having the outward motion of the particle.

As it tries to go out, it has to pass through this tortuous path and it is crushed while it passing through these spaces. So, depending on the loading of the solids concentration, solids size the position of these two plates, the distance between that these two plates can be varied or has to be varied because it has to withstand these teeths should be able to withstand that much of wear and tear while moving and crushing those solid particles. And, this gap width basically dictates that how much loading of the solids it can handle. So, here we have impact of these teeths with the solid particles as well as there are attritions between the solid particles.

So, the dominant mechanism here is the impact plus attrition. So, once again this is a rotating disc, we have pins attached to this, on its opposite surface we have another rotating disc that has also some pins attached to that but in such a position that it can move freely but there is a very narrow gap in between the teeths or the pins. This gap dictates the size of the product, this also dictates the loading of the solids that it can handle and by adjusting this gap we can adjust the product sizes, here the discharge is collected.

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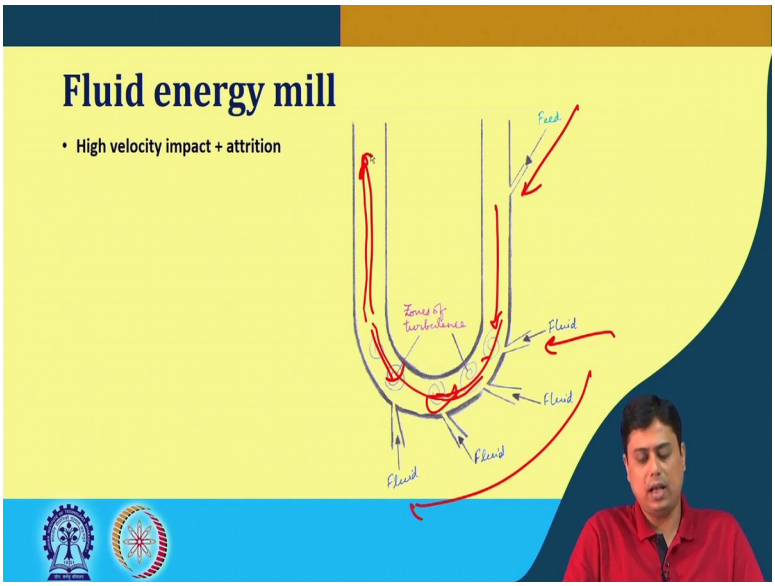

In case of fluid energy meal, here we have very high velocity impact plus attrition. How it works? The feed comes in such cases and then it comes with a very high velocity, the

fluids are injected at a very high velocity. So, this fluid or the carrier fluid that also carries the feed, as it comes with a very high velocity it creates zones of turbulences. Now, as it happens the particles are falling and it is being hit by the jets of this fluids which means a very high impact.

And, in the zone of turbulence and the wake this party solid particles has this chaotic motion and in between the particles they are attrition and with that attrition the sizes are reduced. So, which means we have here with the creation of this turbulence zone by in letting this high velocity fluid at different location, we create zone of turbulence and there the feed feels high velocity impact plus the attritions in between particles.

And, as the particles becomes in small in size it is collected in its upward motion, it is carried with the fluid and the heavier ones or the higher bigger ones still remains in this section and until and unless it reaches a certain value the force balance we have seen, due to this falling velocity, buoyancy and the gravitational force until a such critical condition is achieved; that it is not alliterating with the fluid.

It remains in the zone of turbulence and the size is reduced further and further. So, this is how the fluid energy mill works. So, this is the second category of stress mechanism that we defined earlier, that is the impact plus attrition. So, last three equipments that we have seen that dealt with this kind of mechanism that is impact plus attrition.

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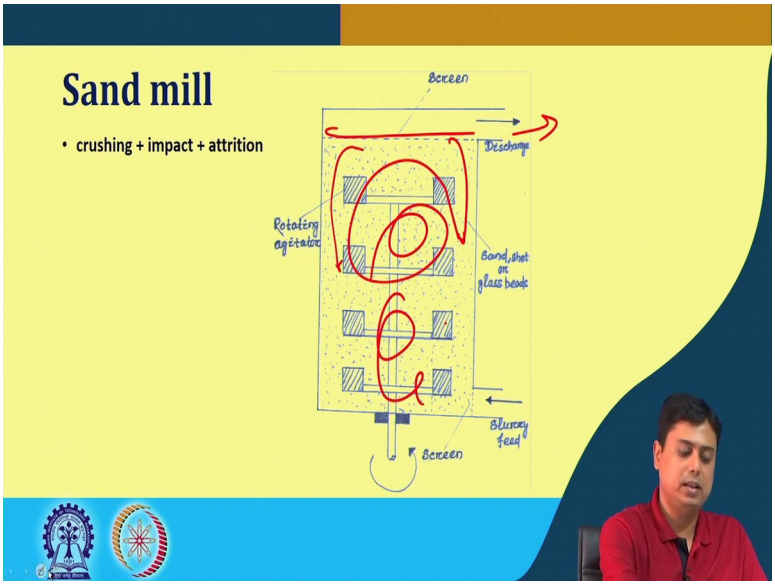

We then have the combination of these two mechanisms that we have seen that is crushing plus attrition, the second one was impact plus attrition. Now, here we have crushing plus impact plus attrition and that happens in a sand mill. So, here we have a bed of sand or very fine glass beads and then we have a rotating agitator. So, these are the rotating agitation at agitator and here we have a screen at the outlet, at the inlet as well as at the outlet where the discharge is collected.

So, we have screens on both the positions that is at the inlet and at the outlet because of sufficiently small size. So, that this sand or the glass beads can be retained in the bed that is one of the parameter, one of the point. The other point is that when we will see that this slurry comes in of certain size that is also dictated by the screen size; it goes inside in the bed of sands or the glass beads; and here what happens?

It is crushed between the surfaces with the impact as well as the attrition between the sand particles, glass particles or the inter particles movement; due to this rotation of this agitator and when it is sufficiently fine enough the fluid is basically taken out from the top. It goes out with the fluid which is further screened at the top, this is the screen position where the discharge is collected. So, which means the sizes that are greater than this screen size of the outlet will be retained in the bed and will have its crushing operation of the grinding by these mechanisms again and again.

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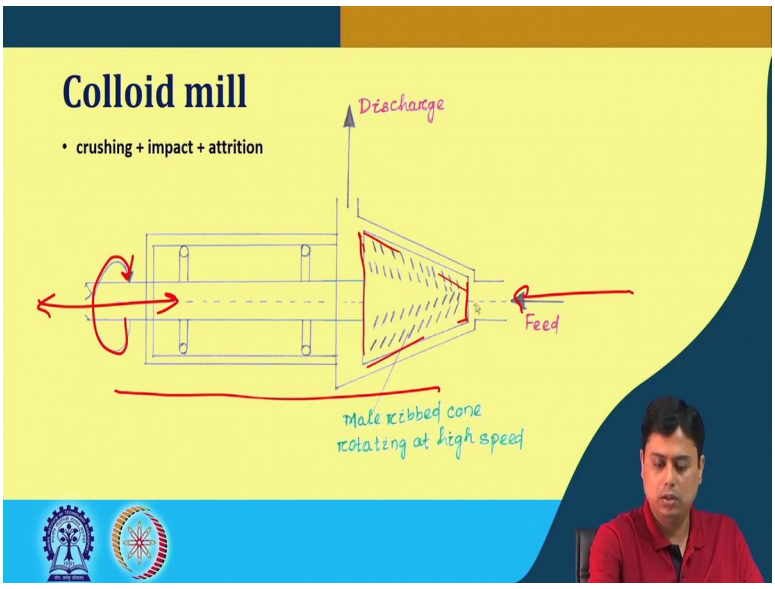

And until it reaches that fine enough value or equivalent to thus or equivalent to this screen size so, that it can escape from the bed. So, here we see that there are all the mechanism or the stress mechanism that we have to known that is the crushing, impact, attrition; everything is involved in one equipment or one such operation. The other such example is the colloid mill. Now, in such equipment what happens is that when we have this kind of a setup; that means, we have a spindle that has a conical head inside a static chamber which can rotate, this spindle can rotate as well as it can have a movement like this horizontal movement.

So, here what happens? The feed comes in from this side, goes into this chamber through this gap between the static wall or the chamber that has been created by the solid wall and this head of the spindle. Now, by movement horizontal movement of this axis of this spindle body, we can basically adjust this gap between this solid wall and the spindle head and so, the product size or its distribution is influenced. So, kind of a male female body we have here; so, this side we have this revved section. So, that it can if just our friction coefficient is higher, it can creates a higher resistance to the flow of this field.

So, that it can have a higher residence time of the feed and within that time, it crushes the particles and this gap between this static chamber of the static wall and the spindle head dictates the size. So, we can easily identify the crashing mechanism between the two solid parts. High velocity impact due to the very high-speed rotation of this spindle and the attrition between the particles.

So, by such colloid mill, the name actually says this colloid mill because we can have very finer particles from this equipment because, colloid particles are very very a fine or very small dimension in nature. So, that name attributes the fact, but by this kind of milling operation we can have ultrafine particles.

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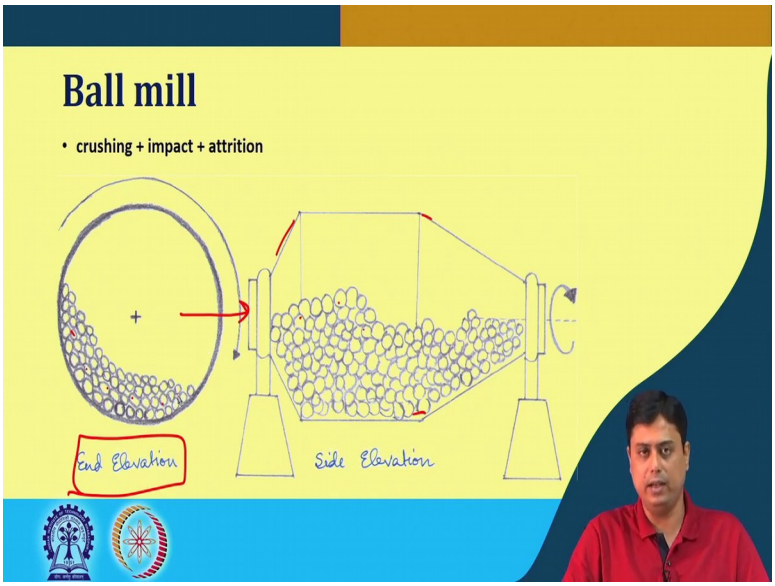

The other or I would say one of the very popular milling equipment or the grinding equipment is the ball mill that also uses this three stress mechanism that is crushing, impact and attrition. So, this is a schematic of the ball mill, here it is the end elevation that is if we look it from this side and this is a side view of a three dimensional ball mill, a cutaway view of ball mill. So, it basically consists of a cylindrical portion and conical portion attached. So, this is also one of the conical section, another conical section and we have a cylindrical section in between.

It is filled with several balls, this balls can be made of different materials say steel walls ok; that that material of construction can be of different types of material. So, these balls also are of different sizes why that is so, we will discuss that in detail. But, what happens here that we have say the half filled portion of this whole void space that is there in the equipment is filled with the balls of different sizes. The feed comes in and it goes out from this side and this whole body is basically rotating around its horizontal axis. So, what happens? At a critical velocity of this periphery or the solid say cylindrical section, the balls will also be attached to the solid wall.

So, it is the critical speed will be such that that the balls do not just slip back to the bottom portion, it attaches to the surface and goes to the upmost position and then falls on the feed that is coming. So, basically in ideal scenario what happens? This ball as the rotation is happening, we can see this movement of the ball and the ball goes here and at

this position there would be no resulting force and the ball drops on the feed that is the course particle solids particle and with this impact the size will be reduced. So, we will look into this ball mill in into a far greater details in the next class because this is what is one of the most popular milling operation because it can handle a wide range of feed part feed sizes, also different types of feed and that is why it is very popular in industrial application.

So, we will have a detailed look into this particular ball; ball mill in the next class and until then have a look of the all the equipments that I have mentioned; the mentioned equipments was basically categorized based on the stress mechanism but that is not only the way of categorizing these equipments, there are few things that we will discuss in the next lecture.

Thank you for your attention.