Bulk Material Transport and Handling System
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Lecture - 33
Fine Size Classification: Desliming and Cycloning

Welcome back students, we are discussing about this size classifications and separation. In our last class, we discussed about how we do this size reduction and then size screening. And then, we were also telling about introduced you the different type of size classifications and fine size separation. So, in this context today we will be talking about desliming and cycloning, that how these two operations are done for bulk material handling.

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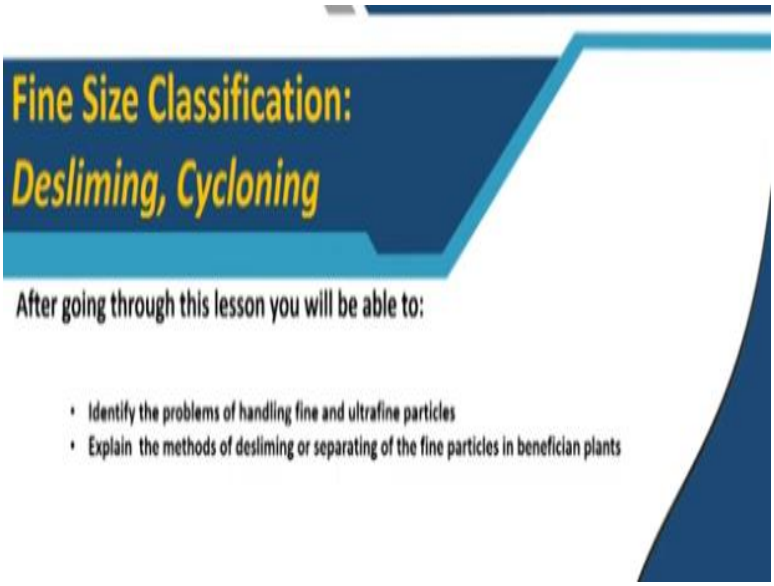

So, you know that after going through this lecture, you should be able to identify the problems of handling fine and ultra-fine. And then, what is exactly the scope of handling operations for classifying and separating these fines and ultra-fines. Where you need to do that? Where you need to apply that? What is the economics of it? Explain the methods of desliming and or separating of the fine particles in a beneficiation plant.

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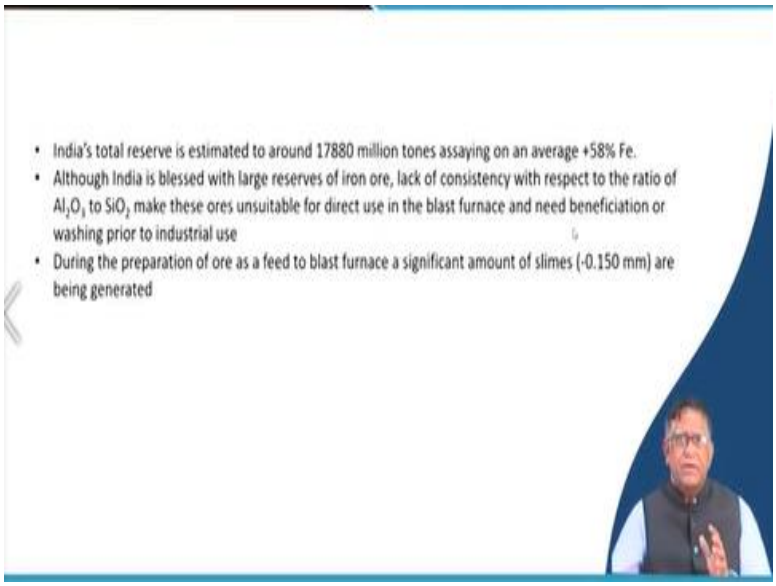

So, we just start discussing here, our why we require this fine size handling. There you might be hearing a lot of thing about the dust collecting system for the environmental concerns. There we get different types of fine dusts; we talk about the particles even up to 2.5 micron and 10 micron like that. But there is a huge area where we have got to, we will need to handle large quantity of this fines.

The reason is you know in our India's mineral production scenario, we have got our gold mine, we have our copper mine, we have our aluminium bauxite mining, iron ore mining. Out of that, iron ore is one of the things where we are very strong in that say our reserves are up to 17880 million that such a 17 billion ton of iron ore is there; our tier concentration average is only 58% of iron.

There are certain iron ores, which are having less than even 39-40% of iron, as it was there you know about the Kudremuk iron ore mines. So, along with this there are also alumina and silica. Now, that is why that to maintain the ratio of alumina and silica that should be your less than one ratio, it should be there when you are giving a feed to the blast furnace. So, what is necessary that you need to beneficiate or you have to improve the quality of the ore.

In that process, we have already talked about that lot of fines get generated. Now, if the fines are there, then it has got lot of problems, environmental problem because if they are going to your

tailing ponds, then it will be a lot of when it dries, lot of airborne dust will be generated. If fines are coming into your froth flotation cell, there the froth forming that process may get affected and then you may get more that is valuable mineral may get lost.

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Other than that, there is also one scenario that, we are producing this lot of palings and there are more than 8 to 10 11 12 million ton of this source of iron is lying in that in the form of those fines. If you can take out those fines for and then extract the iron from there, it can add to our economy. So, then what is going on in this handling in the iron ore beneficiation plant. You know that, their first the comminution process that crushing process.

They get that is your below 70 millimetre, that go out of the crusher and then, they go to the directory that secondary crushers, cone crushers they give up to 30 millimetre. And then, this exactly that after the screening they are washed, while this crushing lot of fines also get generated, because, in the crushing process that material to metal attrition is there, wherever the attrition is their lot of this your dust get generated.

So, then, when you are getting that after that -30, this is again crushed you are getting your that is your below 10 millimetre, it goes to the next process. And then, there going to the very smaller particles now they go for the classifier. And then, the classifier they retained as your plus 22 plus

that is 0.75 millimetre, that is a high-grade fine sand type of materials. Now, after that below your 0.075 millimetre less than one millimetre, this your fraction.

There are these fines, which have got about 45% iron, that is by 20% of its weight it can be iron, but those are going to the tailings. So, that is why in the tailing ponds across the country, there are lot of this iron ore is there. Now, if that can be beneficiated and if you can extract iron, we will get good business. So, for this purpose what is necessary? There are two, three things are required; first is, in that processing system, whatever the fines and all are coming out, you need to take it separate it.

And, when you separate it, you can put it that whatever the fine mixing slurry, that slurry need be treated and from there the solid parts can be separated out. And then, it can be thickened in a thickener and that product whatever is coming out you can dry and you can get it and from there you can put it, if your system allows that, you can process it for preparing a feed for the steel plant. So, then this is one part.

Second part is whatever there in the tailings, if you excavate that is a re mining of the tailing ponds, it will be a very easy because it is a non-consolidated material. If you adopt proper methodology and proper machines you can collect that. From there, if you can separate it out and those very fine slimes, from there also you can produce. So, this is the scenario because of which we need to know about this fine separation.

Because, you may be knowing about that or number of our mines have been closed, as I talk about this Goa mines. In Goa, there are many mines were closed, but those mines whoever had the beneficiation planned their tailing dams will be having some possibility. Similarly, that in the existing dams of steel authority of India, Jindal and all everywhere there is a huge quantity of this fine slime.

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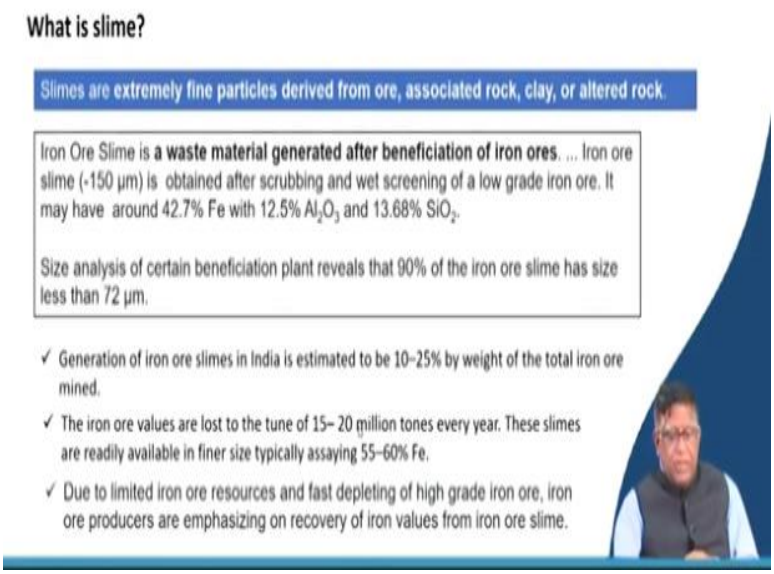

So, now this we know about what is that slime? As we have said that, these are the very fine particles derived from ore, associated rock, clay or altered rock. The slime is produced not only in the mining field; they are also in the agricultural field. That sometimes, very fine particles are there in the different medicine manufacturing process also. Where they will have to crush and very fine things need to be separated sometime.

Then say for example, and if in a cattle farm there that cow dung, that can be also mixed and then they can be some the main organic particles can be separated it out, that is also fine separation, because in a suspended liquid form if you taking it over there, they may having a lot of slime, because only by filtering it will not come out. So, there may be a different field, where the slimes are there.

But as we have said in our iron ore mining, there is this is of our industrial requirement of handling slimes in a industrial manner. And, there mostly the iron ore slime, it will be coming in the range of your 100 and that is below 150-micron size. Now, this is exactly there are about say, that is your 90% of the iron ore slime has size even less than 72 micron. So, now you know about that such type of that is your fine sizes then they need to be treated, which the fine size could be about 10 to 25% of the ore mine.

You have got if some your 300, 400 million ton coming, then 10-25% is a considerable amount. So, that means from the ore which we have estimated in a mining as a field, it is the reserve estimated is this much, then when you will be doing the mining, because of the losses line, our exactly the deposits what we have planned for that we will be selling out this much of iron ore and ultimately, we may find a very, that is your 20 to 25% less.

So, that means that is a lot of money. So, in these cases the technology can assist that how you will be improving that scenario, that slimes can be recovered, slimes can be separated, slimes can be used.

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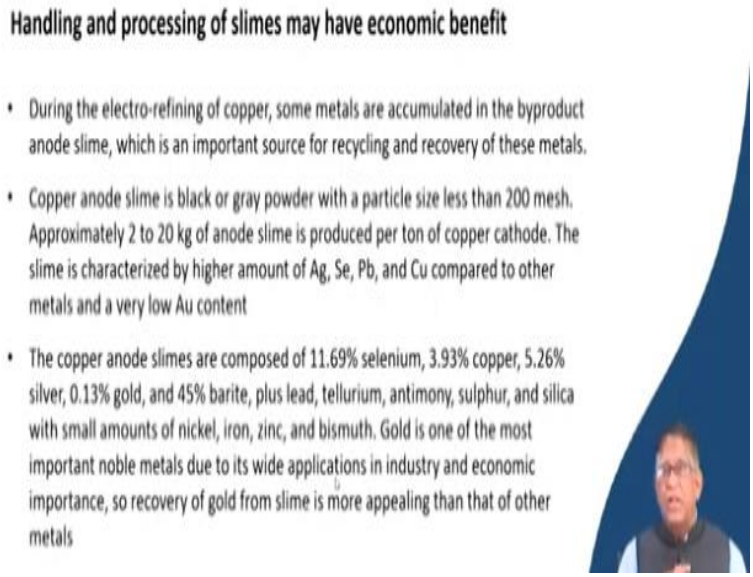

Now, of course that mineral processing engineers they know about there are various methods by which those will be recovered. But, as a handling engineer you need to see now, how it can be at least taken it out and given for, so that the metallurgist can extract the iron part from there. Now, it is not the story of iron ore alone, there is a valuable extraction from fines and ultra-fine particles is also a story of in the copper mining.

In copper, you know that is refining of copper that is copper ore concentrate we import. India does not have that much of copper deposit, though we do have copper mining and we have copper beneficiation, but that is not but we are using this bring the concentrate and then do the

electro refining of the copper if you do, then there is a product called anode slime. They are the anode this grey particle size they get deposited over there.

Now, this copper anode slime, those black grape powder it is a variable. There of about 200 mesh size that is in 200 meshes, you know that in one square inch there are 200 holes are there. So, that is this amount is a considerable amount can get, that is your 1 ton of copper production may give this 2 to 20 kg of this anode slime. This may have some very valuable product. What are those? That can be always that copper ore is associated with other minerals as well.

So, they are gold, selenium, led, copper. These are often find and also to certain extent there are gold also. You know that, all the mines there are many mines which are exactly both copper and gold they find together. For example, that Ok-Tedi mines in Papua New Guinea, there the Ok-Tedi mines were, who is supplying even India imports that concentrate from there. Now, they had exactly a gold mine.

It started while doing the mining that they are also getting extracting gold from there. Similarly, many of the cases the very (()) (13:46) ore, they have got number of different. While this zinc, many a zinc along with zinc also you may get gold. So, like that but we are talking about this copper anode slime. Anode slime will be having about 11.69% of that slime could be selenium. And then, from the anode even 3 to 4% of copper can be extracted from there, silver up to 5 to 5.26% and where if 0.13% is gold.

And then, there also there could be barite, now this barite can be used in the drilling mud for the waiting purposes. So, it is also a sellable good product. Like, we have got lead and tellurium, antimony sulphur and silica with small amounts of nickel, iron, zinc, bismuth depending on the ore which you have used, depending on the type of which deposit you have got.

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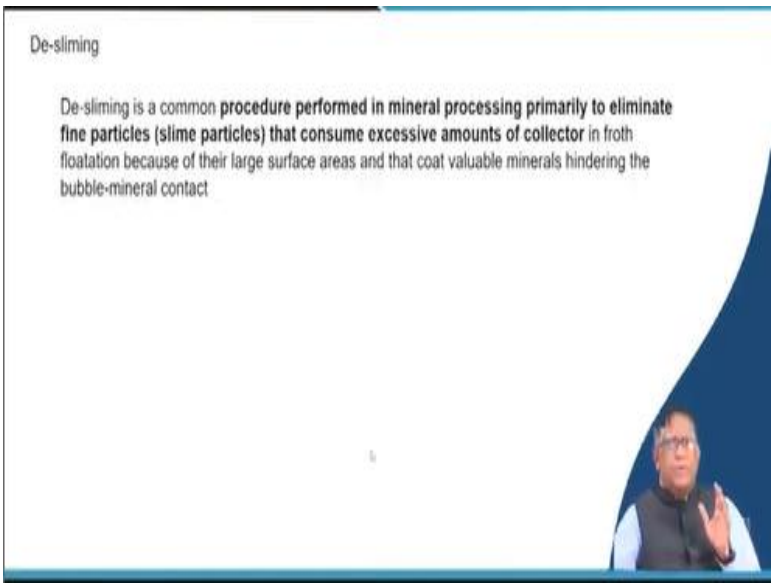

So, that means if you know the technology for recovering the slime and you can get lot of other benefits of it. So, what we need to know about this these sliming? This sliming whether it is a copper anode, that slime you are desliming or you are desliming means separating out, all those that your eliminate the fine particles, that consume excessive amounts of collector. Means, if you are having some fines coming and you are putting it to the froth floatation cell.

There you will be adding these floating agents the chemicals, which will be telling you are giving these collectors. Then, these chemicals consumptions will go more. That is why, that is you do not want that slime should go into your flotation cell.

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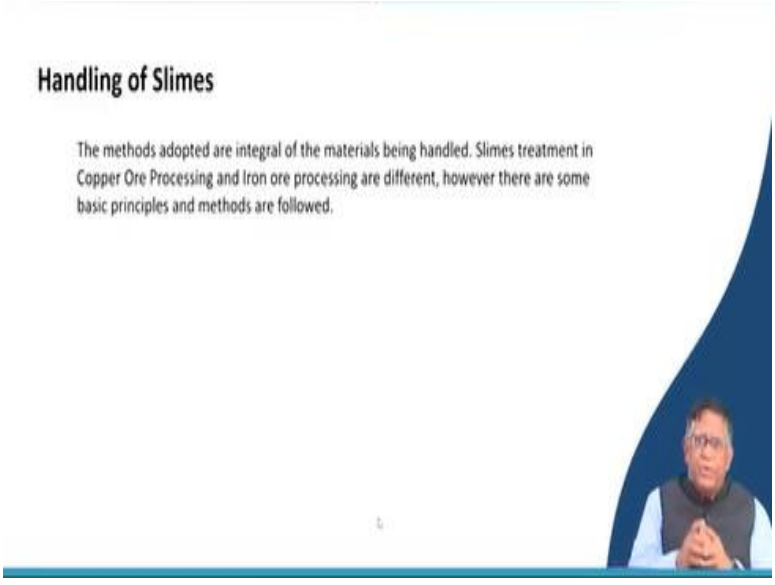

So, before that how you can de-slime it? So, this handling of the slimes, that it is exactly an integral part of the material being handled, that whenever for the processing plant it will have to do this. Now, the slime treatment and copper ore processing, iron ore processing they may be different. But there are some basic principles are followed, that your generic principles are there, but that appliance and applications that will be made differently.

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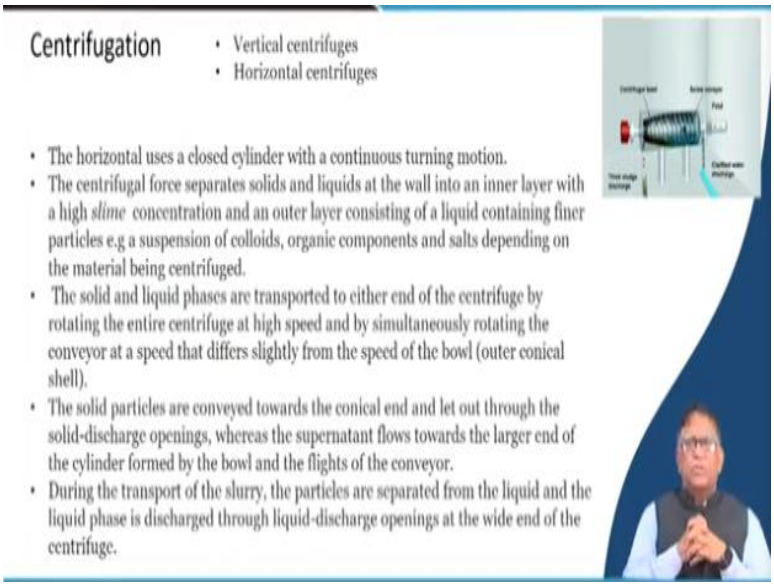

One method of this step as a principle is a centrifugation. Centrifugation or what is you are using centrifuges? This word may be known to you some of you may knowing it. There are two types of centrifuges; there are vertical centrifuge and horizontal centrifuge. Out of that this horizontal centrifuge, they are often used for. This is exactly the rotation centrifugal force is exactly used for separating the fines.

You know that in the old technology, exactly by churning or by rotating and all you take from the milk you are taking the butter that is how the butter is made, that is also a part of your exactly using a centrifugal force for separating the solid from the liquid. That colloid, milk is a colloid that collect particles are that separated out. Now, this centrifugal force separates the solid and the liquid, then they when you (()) (17:23) them, that exactly will lead to separation of it.

So, there in a centrifuge basically there will be a screw conveyor type of a spiral that your central part, which will be there inside your cylindrical hub, now both are rotated. Normally, you will be

rotating that screw as well as you are rotating the ball outside that the barrel boot. And, then you will be inserting from one side the slurry and then in that process whatever the solid particle they will be thrown.

And, then they will be getting collected and carried by the spiral and they will be adding and getting accumulated in the conical one and the liquid will be going to the other end.

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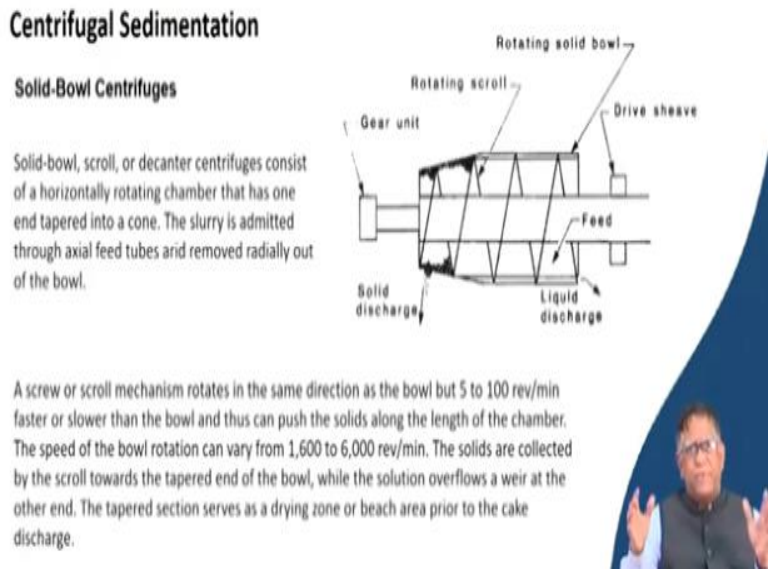

So, that is exactly the process which can be done and from that, there are wide range of different made and different type of this centrifuge you can find in the fill. That is, one is you can say that solid ball centrifuge. In this, we are having a rotating solid bowl outside and then we are having this your that screw conveyor that, with a spiral part, this is the inner part and then it is driven over here.

When the feed material is putting into this, the solid particles get accumulated in the end, where there is a conical part and the liquid will be going out. This is how a solid bowl centrifuge work.

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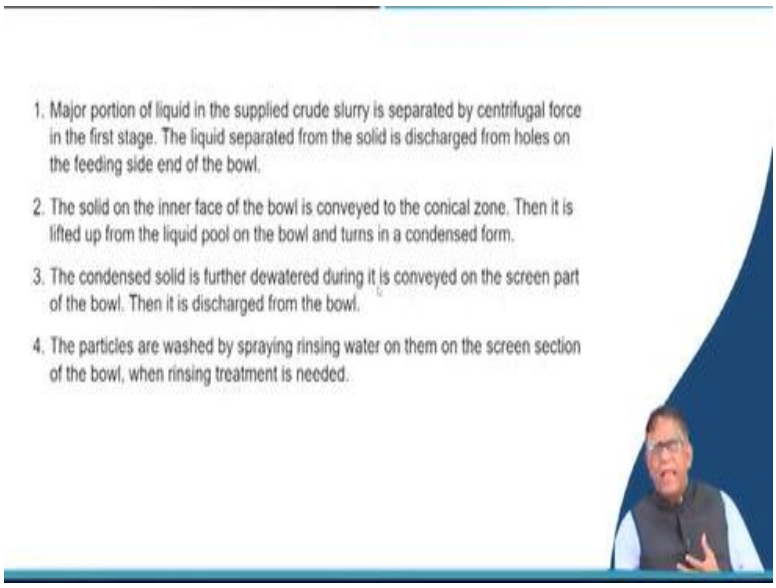

And, then the major portion of the liquid that is supplied in the crude slurry is separated by the centrifugal force in a first stage. And the liquid separated from the solid is discharged from the holes in that.

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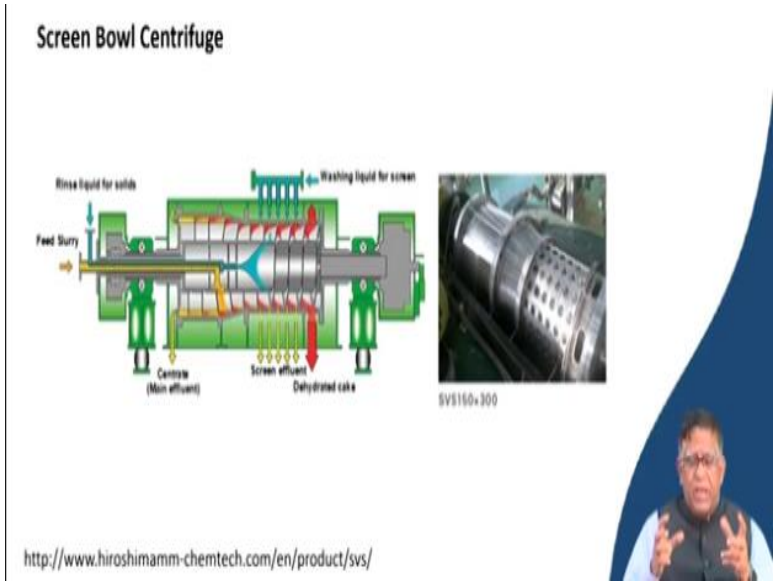

That is also another type of screen bowl centrifuge. In a screen bowl centrifuge, we are having that you can see here, that outside there are some holes are there. So, this is for the screening purposes, as we are telling over here. This feed which is coming over here it get rotated and then the concentrate material they get accumulated over here and the liquid is going over here. Now, here because this liquid is going through these holes out, there is also some rinsing.

That means, you put some good rinse liquid or for the solid particles, it is coming this water will come over here, it will give a rinse to this and then concentrate will be coming over here, the water will be separated out again from the holes. Similarly, there is a washing liquid for the screen, the screen otherwise what will happen they will get blocked with the particles. So, that is why your pressurized liquid is given over here and then this.

Now, when the feed slurry is put inside things starts rotating and then the solid particles, they get collected at the one end and the liquids are going out of this. That is how exactly your from that slurry, where this your fines were being carried out they can be separated.

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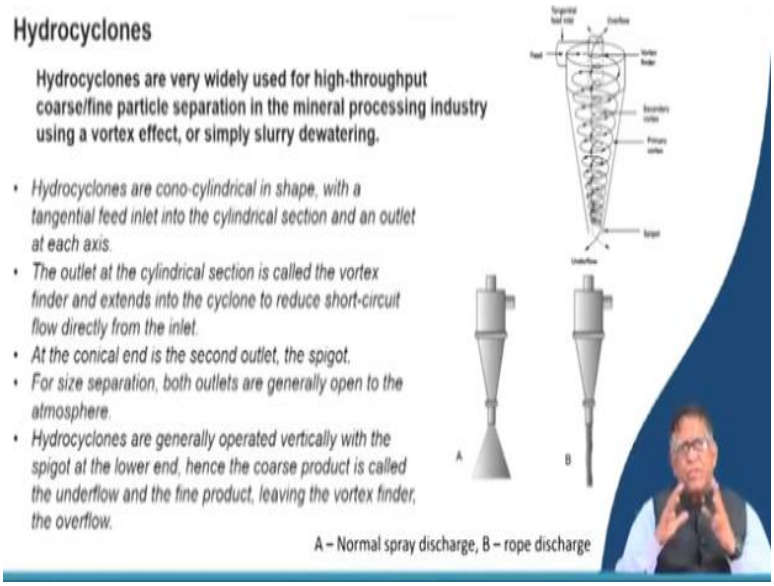

So, then the next, that this is the centrifuge, but another thing is their item is with a power you are rotating. Sometimes, there is a device which the device do not rotate, but the liquid is introduced in such a way that because of its that at the inlet, it will be having sufficient speed and then they go through a cylinder-conical apparatus called cyclone. In the cyclone what happens? This feed that slurry which is coming over here they get introduced either tangentially or spirally.

Then this met that liquid starts exactly rotating and going down. When it is there, slowly every time speed will go on increasing and the vortex will get created over here in the opposite direction. Now, that separation will take place over there. Now, here when this is going that solid

particles will get detached. Because, when it is rotating over here in a one part, when it strikes with that your wall, at that time the velocity will momentarily decrease.

At that time the particle will get released and the water will be going separately, particle will be started going down. This is the way the two material gets separated out and then this upward moving vortex, this there is a vertex finder that liquid particles and the fine particles will go away from here. So, this is hydro cyclone, if that you are maintaining the feed pressure then its velocity and its concentration and they are exactly matching with the diameter of the feed.

And the diameter and size geometry of the cyclone, at that time we can get that what will be the efficiency of separation. Sometimes, they do not get properly separated and we can get a rope formation that all the things are coming like this. But sometimes they get very nice separation, that particles will be going as a normal spray discharge, it will be coming out with a speed and then you can get a good separation.

Now, that is where exactly the separation is taking place, this portion is called the spigot over here. Each and every point what is this angle, what is this height and what is this velocity, what is all these parameters, their relationship it affects the performance. This has been, this is a device with more than 100 years old it was discovered, but still the improvement is going on, because it absolutely nobody can tell that and predict that this much will be the separation.

And this is the efficiency of this device. It is a very interesting piece of equipment, where people do a lot of research.

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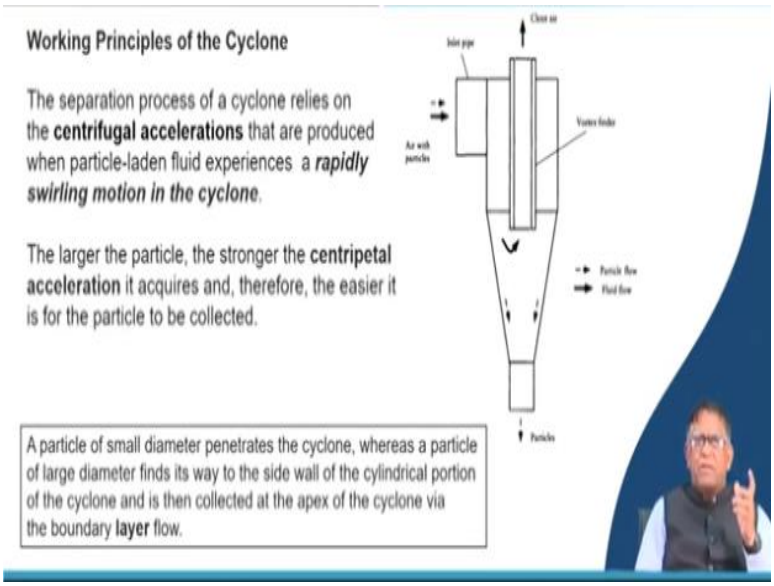

Now, that as a working principle is now it should be clear that it is the centrifugal acceleration that produced when the particle laden fluid experiences rapidly swirling motion in the cyclone. Exactly, that rapidly swirling motion which will be here that is very important. And that the centripetal force that is if the particles are little bit higher size to separate it out you will be requiring a more forced centripetal forces and how they will do.

That is your two different particles are sometimes this is working as a cyclone, where no liquid. Here, it is only air and the dust particles are coming, as you see in some of the drilling cases. In the drilling you will find, that this drilling when you are doing drilling by that is your flushing media is air, at that time the drill cuttings and the air they are coming out of the hole and at that time they can exactly get collected and blowed to and then given with a velocity introduce over here.

And when it goes inside it starts that wheeling and then your dust particles bigger particles will be going to the side and it will get accumulated over here and that fine air only pure air it will be going over as a clean air. So, in the drilling site you can manage a good, that is you are not releasing the SPM 2.5 or 10 micron dust will not be going to the air and that is the way how by cyclone you separate those fines and then you get a better job.

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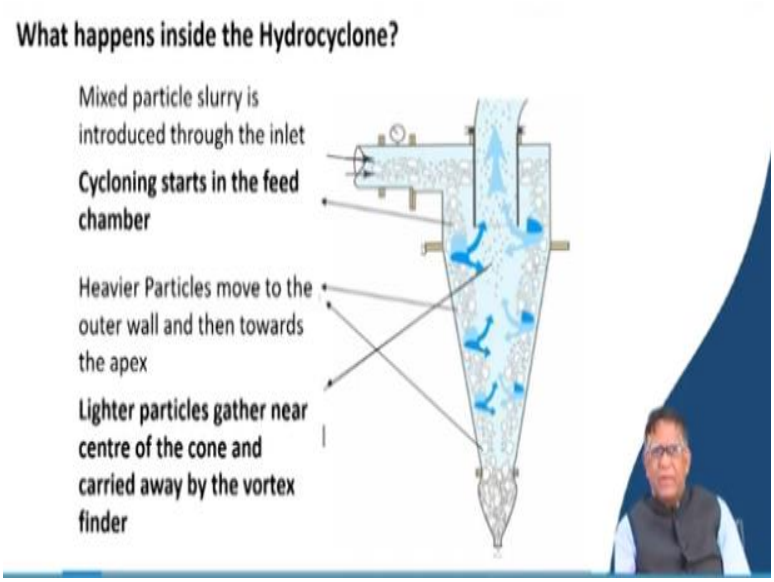

So, now that is hot exactly shown over there, what is happening inside the cyclone, you can see that these particles of different sizes and all with a velocity when it is coming in whether air laden or water laden. Then, they starts this wheeling and at that time the separation takes place, the solid particles that bigger particles they get attached to the near to the wall. And in the centrally only that vortex upward moving vortex and it will take out some of the fine particles.

And, they will get released to the air. So, lighter particles gather near the centre of the cone and carried away by the vertex finder. This vertex finder, these portions will be take it out.

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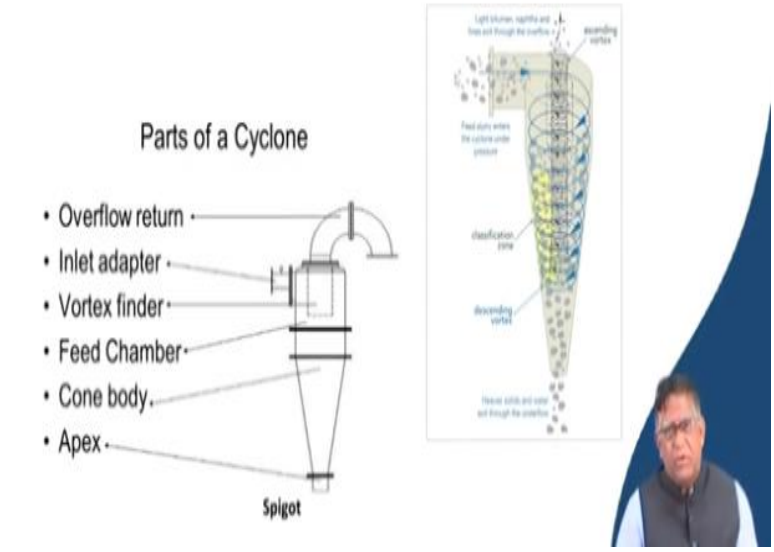

So, now you know that this, if you see that what are the main parts of the cyclone as we have seen over here. Sometimes in a cyclone you can use in the for coal slurry separations, you can use in iron study separations, you have got cyclone in many fields. But only thing is that the fine size and the liquid which go is the overflow and then the main things which is connected at the apex or spigot is the concentrate over there.

And there is a cone body and there is a feed chamber and then there is a vortex finder and there is an inlet adapter where the inlet comes. So, now you know what is a cyclone, what is the hydro cyclone and then how it works, how the wheeling takes place you are having here the tangentially entering and then when they are separating a upward moving vortex is generated. You might have seen sometimes you can do that vortex generations.

You can see how the vortex comes centrally when you are just putting your even while entering, filling a bucket by tap also you can see how a vortex get generated when it is wheeling over here, there you may have some of the experiences.

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But this how they separate the particles? The separation of the particles it is exactly, you can see that there are fines and then coarse particles are mixed over there. Then that in the fines will go the upper overflow and then this your the other part, that which is going the coarse particle will

be going to the downward, that is your under flow. But what will be the partition level, in the ideally it should be separated both but such things will never happen.

That is your, if ideal case the sharpness of separations like that vertically you do not get these two. What you may get? That some coarse particle may go and mix with the fine and some fine particles will be mixing with the coarse. So, now how best this curve can be made so that it will remain with the fines that is exactly is how you control the different parameter.

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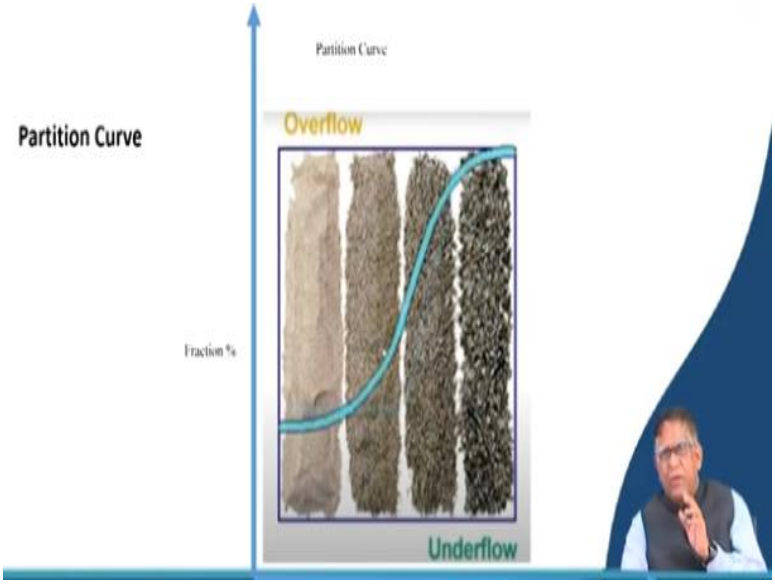

So, if you can have this type of partition curve, that means you are having most of the things you are taking over here, only little coarse particle has gone over here. So, then your overflow is ok. Now, this cut off point could be where it is a 50% over here, now what is the maximum you can get this range that will be determining the efficiency of your system.

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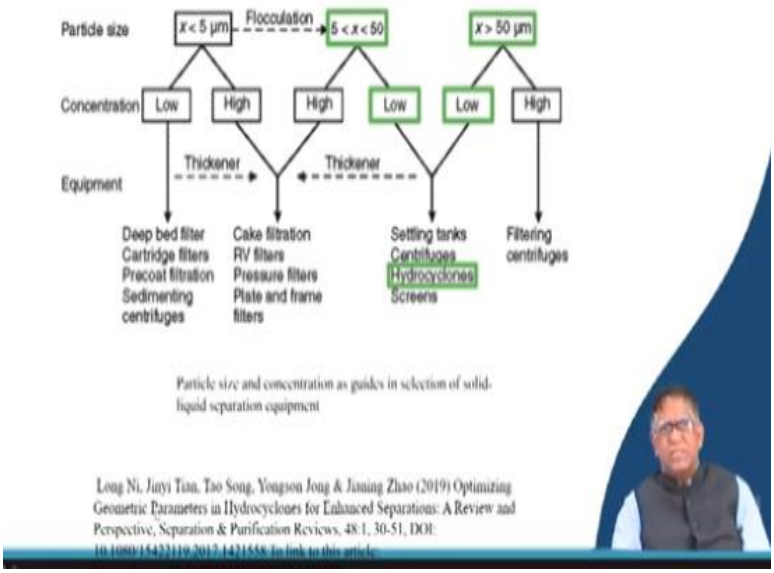

So, this partition curve are very-very important and this particular fine particle size separation desliming operations can be done by these concentrating devices, they can do it in thickener and then they can do it with the hydro cyclone. There are different way different size say in your particle size in between 5 to 50 micron, you are greater than 50 micron, they are exactly the concentration.

If the concentration is low, at that time they can do with the settling tank, centrifuge, hydro cyclone or by the screen. Now, if the concentration is high, they can do by filtering by the centrifuge. If there is a high concentration of this less than 5 micron and more than this range, they can be do it by cake filtration, then you have got RV filters, pressure filters and then there are plate and frame filters, different type of filters are there.

And then you have got this deep bed filter, cartridge filters so many things are there. So, here the filters that bed filters, they are taking out the water part separately and you are doing it. Sometimes, you can do with the vacuum and all there are many devices are there and after that the particles are getting you can do it.

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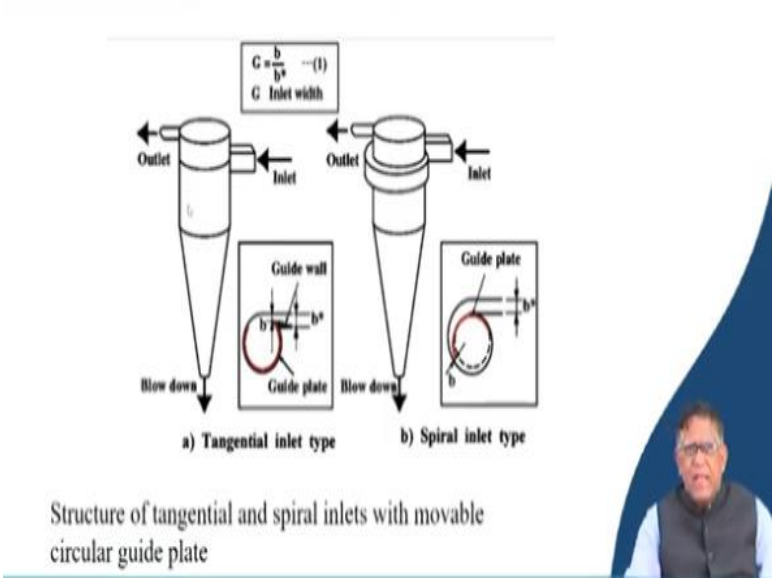

So, this your cyclone or hydro cyclone, as I have said that it can be a tangential entry or it can be a spiral entry, it can move over there. So, you can see that the spiralling down and the speed is increasing you are getting separate.

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So, designs can vary but another thing is sometimes you may use a bank, cyclone bank or it can be your cluster, cyclone cluster in which you can see such type of applications are there in many of the plants in India, even you can go to sometimes Joda, iron ore mines their beneficiation plant, you can find when at the time of installations they had a lot of problem here, the separation was not taking place.

Because, that how the design is made, it is very-very important, if you do not precisely design it properly, then the separation will not take place. So, that is why and these are that like where minerals (()) (31:43) India they make this type of cyclones, which can be made of different materials, it could metallic, it could be a rubber, but at the end of the day the thing is it requires a very good study and those who are interested in the hydrodynamics.

It is exactly how that slurry is introducing, how through the pipe it is flowing if you know the science of it. It will be a very interesting that exactly you will have to understand that how particle gets separated from there. But of course, here I am just introducing it what is a hydro cyclone, what is a centrifuge and how exactly slimes can be separated. And this type of technology can one day make the material which are lying in the tailings can be used.

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Lot of research is there, if you are interested in Richards, this is a very good area to study that fine separation, where there are lot of unanswered questions still there.

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And, so our desliming as an important operations and could enhance operational economics and environmental management associated with our mineral beneficiation and mineral uses. And, handling of slimes will be a major operation in extracting valuable minerals lying in the tailing dams. So, how this equipment; how these processes will be brought into designing a system called your bulk material handling system.

And then their economics is the things where we will have to work and your competency and skill in this field will be very-very welcome. Thank you very much.