Bulk Material Transport and Handling System
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Lecture - 32
Concentration and Separation

Welcome dear students, so in our journey of learning bulk material transportation and handling system. We have been discussing about the mineral processing plant and equipment. Under this we have introduced you different type of machines used over there and also we talked yesterday about the type of maintenance systems you do it over there. Now few more processing operations are there in a mineral beneficiation plant.

Out of that there is a one important area is concentration and separation. Now as you know already in the bulk material handling or bulk material processing particularly when we are talking about extraction of ore that is your metal from ore in a metallurgical plant particularly in the extractive metallurgy there are some of the handling operations and processes where there is a different type of equipments are used.

I thought it will be good for you that to know about the overall dimensions of this material handling business.

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Briefly I will be telling you some of the concentration and separation work which after attending this lecture I hope you will be able to describe the various concentration and separation processes and discuss the functions of various equipment and devices used for concentration and separation. So, that you can take some analytic job or an investigation about the performance and maintenance of such type of machinery and processes.

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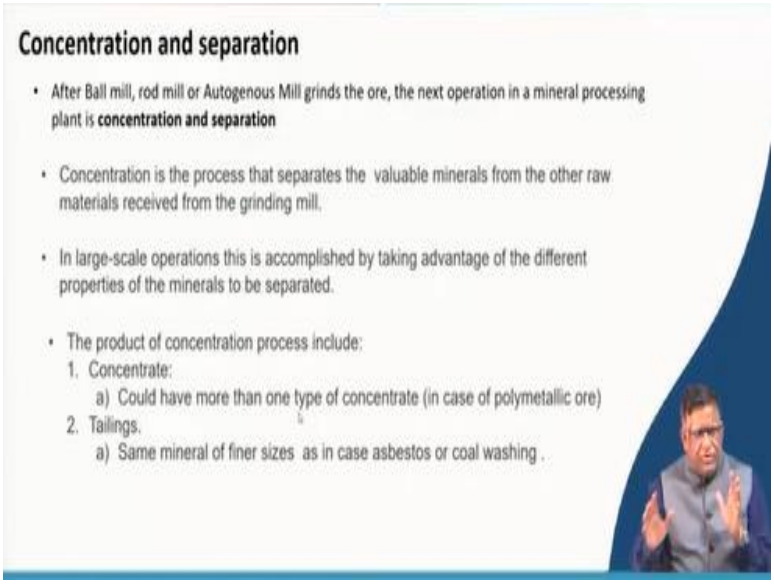

So, what is exactly the concentration and separation? You know that we have talked about the primary, secondary and tertiary crushing and then we said that exactly how you do the grinding in a ball mill or in a rod mill and then also you do it in autogenous mill when you grind it becomes powder. And from there exactly we separate the gangue material from the pores valuable minerals.

Say for example in gold processing when you have done this in autogenous mill from that the gold particles will have to be separated with the associated rock or the waste materials. Now while separating these very fines, it will not go as that screening which we were talking about screening at the early stage of beneficiation. Now we need to do it. But thing is that there whatever the things we want to collect from there after the grinding the concentration of the percentage of the available mineral will have to be increased.

Now that is what here it is that process by which you separate out that gangue material and then you improve this the concentrator that machine where it is done that machine is called the concentrator. Now this concentration job it will yield two things. One is the concentrate which will be used as the your valuable where from you will be extracting that the main metal maybe your gold or a nickel or they say your platinum.

Everywhere this will have to be the; from the concentrate only you will be taking. You may be hearing in the news and all that India imports a lot of copper concentrate that is those concentrate which are in a processing plate they do it say you are getting in from the octet copper mines India export imports those concentrate. And this concentrate is ready for other metallurgical extractive metallurgy for extracting the metal.

Other things also you may be hearing one word that tailing and tailing dams that some of the while you are separating these fines those final reject which is going to the tailings. But that does not mean the tailings do not have the valuable mineral, there are. Now sometimes this concentration and separation are also today will be coming with that at that time say 20 years ago 50 years ago that whatever has gone to the tailings.

Because at that time the technology for concentrating and separating were not that advanced. It may so happen that whatever is lying over there can be separated out by this matter. That is why I tell that why this subject is interesting for you because when you are no new minds are coming over there but you may find that in some of the tailing dams there may be more valuable minerals which can be extracted from them or it can be if we can concentrate and separate over there.

So, there comes the business. Also, you may be knowing that in a cold washery that the coal fines which cannot be recovered they are separated that have gun to the tailing dams. But these are all carbon there is a lot of calorific value is lying over there. So, that is how it will have to be utilized those things comes under handling of those materials which are lying in the tailing dams and also in the valuable you want to do from the mine run of mines you will be doing.

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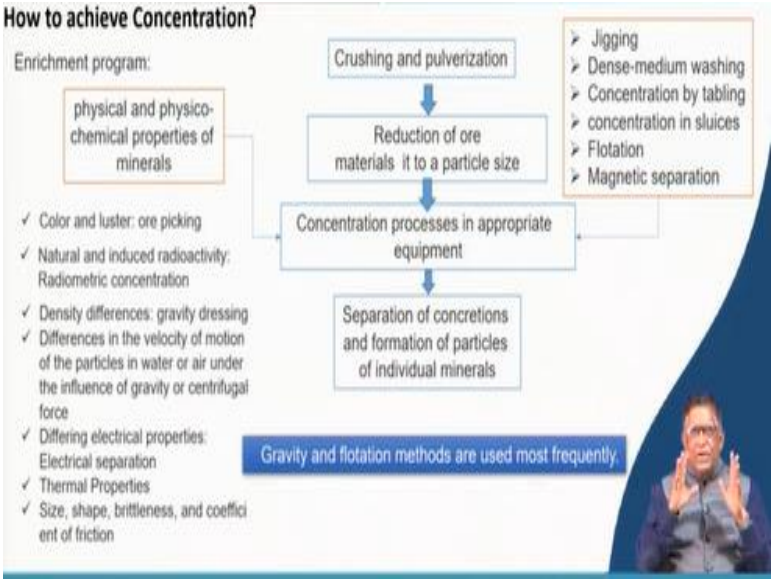

So, I think now you know that what is the concentration and separation business. Now basically they how to achieve this concentration that means the run of mine when it is coming you are crushing and then you are reducing that is your ore minerals to a very particle size has been reduction size reduction has been done. Now you are having those fines from there to develop the concentrate you will have to look into what are the physical and physical chemical properties of that mineral.

So, to select that in which we will handle it, it will be depending on what are the properties that can be used for this. And depending on the properties used you will be developing this different type of equipment which will do the job for you because anything you will have to do if think in your mind it will have to be designed and there the engineering required that how you will put the things over there.

Now that is exactly your separation and conclusions that job that is and the formation of the particle of individual mineral which will be using these properties. Now what could be those properties it can be colour and lustre by there would be the ore picking. It is sometimes done manually in the past say for example the near in (())(07:50) area or in jargon west Jharkhand district there are many tribal ladies who are sitting down on the roadside on a piles of manganese ore.

They are just picking up which in manganese and which is not there by seeing the colour by seeing the weight of that by hand these village ladies they can do this hand sorting over there. Today that thing has been done with the advancement of your amazing technique and advancement of your online weighing technique advancement of the how X-Rays and that your X-Rays can be done on the while the material is slowly moving on the conveyor belt.

They can be scanned and then they can be you can use you can make them in a monolayer to go and in between you can have an arm to push them and then sorting out only the valuable minerals will go that type of systems are coming and some of the things maybe you may also decide. But only thing what will have to know that whatever was done earlier by visual eye and that by observing and then by their experiences.

That is now with technology you are getting a that is your by ICT applications in this or sorting that handling is done. Then other thing is there natural and induced radioactivity sometimes some of the radioactive minerals and all you can have the radioactive detector by which you can separate them out. If you are separating you are improving the concentration. That is the philosophy. Then the most widely used system is the density differences.

This is a very important things you know all atomic that is all the elements depending on their atomic number and mass number how exactly their total molecules weight and that your particles weight will be varying density will be varying. That means every mineral everything has got its ace signature that is density. Now if you can use those density differences of the valuable mineral and gangue mineral.

So, if you have got a system which can take that the heavier things will be settling down lighter things will be going out when the lighter thing is going out you separate that out. That is how exactly your concentrations can be achieved. Now then another thing is there if you are putting them to move in water that is yours materials you are keeping over there they are flowing around things and then along with the water.

Then in that water that the particles will be having different velocity settling velocity will be different depending on the size of the particle and depending on the weight on the particle. So, that can be used that how they exactly settle in the water that can be also a property by which you can separate it out. Then there are some that is a electrical property may be changing with the electrical property also there could be a machine.

Then thermal properties some under heated conditions there will be the your target mineral may be behaving differently your non target mineral will be differing behaving differently identify the behaviour and separate it out that is the thing. Then size, shape, brittleness, coefficient of friction these are also some of the things you can separate it out. It is just like the particles will have to be separate.

It is not like that, that is you are in a class you can say all the tall students should go sit at the back and short students come in the front in our primary schools you have seen how our teacher used to shorten the class that then they will be separating out the students. So, that they can get the learning better. This is something same way that particles will have to be separated so that the same type of things put together means their concentration is increased.

So, this can be done by various methods that what exactly you will have to learn scientifically and then you will have to execute as an engineer's way. Now this could be done by some of the words you will be learning in this class is your jigging then there is a dense medium washing there is a concentration by tabling there is a tabling then concentration by sluices I will not be discussing here the sluices.

You may get that your all the alluvial mining you might be hearing in the river Subarnarekha or the (()) (12:35) or in those rivers in Arunachal they used to get this sand washing for getting the gold that how they were separating those things and then how the hand panning were done in the river Subarnarekha. Those things were also a concentration there they used to have a sluice those exactly in the alluvium mining.

Still, it is used in some places in Alaska or in some of the in the pacific south pacific oceans or ocean islands where this gold are there they do it like that but the other thing is the flotation or the magnetic separation these are the different methods. So, by now at least if you have noted down while you are listening to me make a practice of writing it down. Then what are the properties and what are these different methods?

Take an exercise write down this properties name and write down these methods match it which one is there. One at least by doing the same simple exercise you will be enhancing your level of knowledge over there. So, the gravity and rotation methods are used most frequently. In many of the things and you will be learning if those who are in mining or mineral engineering you will be doing that more.

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Now trends in development of this mineral concentration this trends of development I will not discuss much over here. But what is there they have been doing a lot of improvement in the individual concentration processes and there is a combined processes. Now whether that is your how you will be improving the quality. So, as I said that in the 20 year 25 years ago in the tailings lot of valuables were going out.

Now they are improving these processes by which that your the recovery is increasing that is your yield is increasing that is what is the trend. And that is your how you can do it by

intensification of the processes and the increase the equipment capacity. Their intensification means more energy can be given over there and they will do the work. So, there is a trend of development in that line.

Then integrated use of minerals that is your sometimes those tailings even if it is whatever it is going you do not bother about it because from there also you are using something. That trend is your waste to wealth whatever has been left as a waste mineral. Say for example after iron ore beneficiation in any mine iron ore mine the beneficiations they will be taking only up to say 62 or 65% hematite rest of the things which are going in the tailings there is always 30 to 50% of the iron is there.

Now this some of them are being used for briquetting some of them are used for some road making material and other but not that exactly your how you can integrate their use is an important thing then another trend is today automation has come. Now another thing is there the latest trend in last 5-10 years is your data analytics. That means you are getting your data-driven decision making in this.

It has got a very good that deployment and then almost all the mineral beneficiation plants and material handling they want to optimize their system and the optimization is identification of the effective variable and assigning their value. And there is a scope of lot of your tools utilizations and things are there. So, this is just only for getting your interest into this area so that you can work.

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But in the field if you go to any mineral beneficiation area you may be hearing these words that is your jig separator that even in some of the coal washers if you go to (()) (17:02) coal washery there is a you may find a bomb jig there the jigging operation is there very much. Then shaker table if you go to in the metal mining sector in there are number of places you will find this secure table. Then gold concentrator in your old gold mines they use this gold concentrator.

Spiral separator you can find in many of the coal washing also for removing this your (()) (17:30) materials that separated the spiral separators are used. Magnetic separator using say it was used in Kudremukh iron ore mines where they were having those beneficiations of the magnetite ore which has got this magnetic property magnetized or separated like this. Electrostatic separator of course you find it in your dust separation system and dust collection system handling the dust is also by electrostatics separator.

Flotation you may be hearing about that I think you have read in your intermediate science that how steel is made. You know that this iron ore is beneficiated by froth flotation process that froth flotation word is known by each and every engineer because they need to know about the materials. No engineer can be an engineer without the knowledge of materials like steel and that steel making where you need your iron ore.

And that iron or beneficiations still will be finding a lot of that froth flotation process and also there are in gold mine in copper mine in many way you will be finding out this froth flotation as a process.

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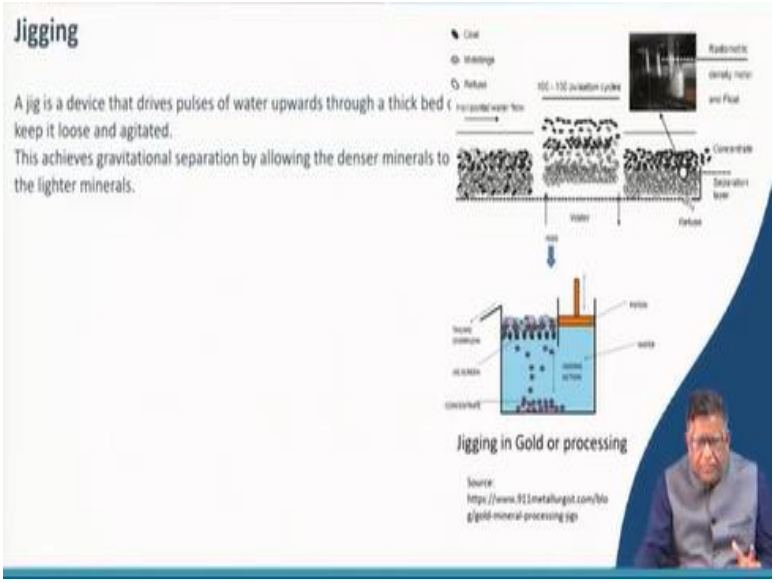

Now coming to this let us talk about what is this jigging means. A jig is a device that drives pulses of water upward and through a thick bed and then with that they will be making the things to separate it out. What happens? The denser material will be coming at the bottom and the lighter material will be going up. So, that is in a cold jig at a bounce egg basically they are getting these things when the water is putting over here.

And you are giving a pulse of water like that then your heavier materials are going at the down because in a you know the coal density is 0.921, 0.1. But the sandstone or shell whatever comes along with coal their density is 2.2 to 2.7, 2.4 like that. So, what happens sometimes in the cell carbonaceous cell sometimes they are 1.7 2.0 like the density. So, some of them will be falling over here and that when this whole pet particle will be moving in these directions.

Then your cold will be at the top and from there you can have a lander through which this at a line that your coal is coming out. So, whatever the material you are getting it back there they will be having that high calorific value per ton. But if all these were mixed together and one ton coal

of if you burnt you will be finding only very less calorific value. And you know that you have got a different grade of coal depending on that.

In sometimes when we get a 41% ash content coal like in your Mahanadi coal field. That coal if it is washed like that it will be coming and at 41% ash it maybe you are selling it say hardly or 1700 to 2000 rupees. But if you reduce this as to say for example up to or 15 20% bringing it to a high calorific value pool in that it will be selling as a 4000 to 5000 per ton. Now for whole process of washing you can just by spending some money.

You can increase your profit much more and that is why this coal washing business came up and whenever the business come there is other business matter also comes in there are a lot of issues related to this coal washing you may read the newspapers.

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Now this, what is happening here? The jigging is also done in here say in case of gold mines there also the what happens there the heavier materials are collected in that coal what was there the heavier material was the residue. Now in sometimes the jigging is done so that a particularly in the gold mines the gold processing your gold and that other sandstone gold's density is more. That is why when they will be giving this whole water the feed gold.

And ore mixed things after the your ball mill after the autogenous mill it is coming over here and then you are giving some water into this and then you are giving a pulsating things. So, that there is a screen over here through which the gold particles are getting deposited over here as a concentrate and then your this gangue materials will be going out and they take it out. So, this is the way how jigging is done.

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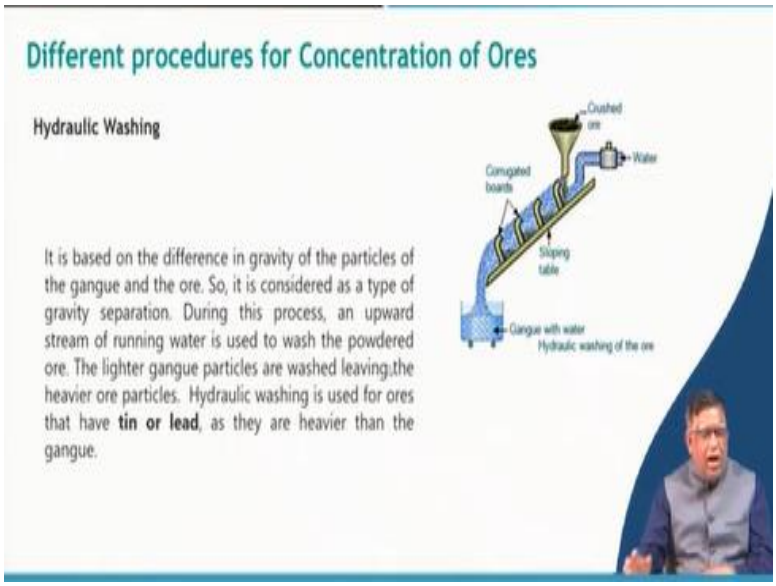

Now the next thing is your that hydraulic washing. Now what have is done? There also the same principle your gravity separation that is when you are having this your water and that the mixture they are coming over there. Then you will find that they in this table your the crust ore is placed over here the heavier material is going down and they are arrested by these corrugated boards and that lighter particles will be going and they will be collecting over here.

So, this is a hydraulic washing, you are just washing the things and getting the valuable collected over here.

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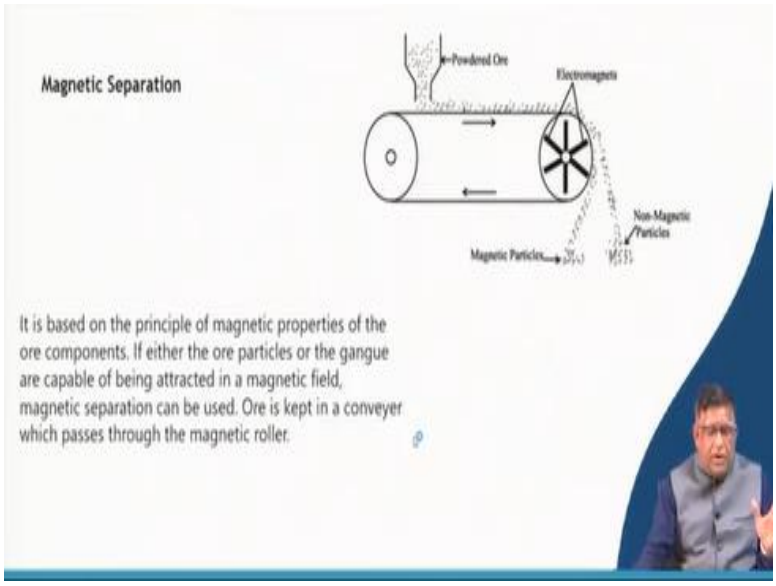

Now there are different type of that concentration processes like your magnetic separation. If your the material which you have got from the mines after crushing it has got the magnetic property just like I told you a magnetite. Then what it may there then you are having an electromagnet inside this pulley. So, as I told you in the magnetic separation your powdered ore which has got your magnetic property like magnetite which is attracted by magnets.

Then there is a non-magnetic and magnetic material it will be allowed to pass through a slow-moving conveyor belt. And that conveyable and pulley inside the pulley are we are having those electromagnets. That is why they will be connecting over here and then when it is coming into this position that electromagnetic effect is not there. This will be again your electromagnet this will be because the your magnetic field is there in one quarter.

After that it is again known magnet, so whatever sticking to this plate they will be now released. So, these magnetic particles are separated and non-magnetic particle will be projectile and if you can have a shoot over here and they will be separated out.

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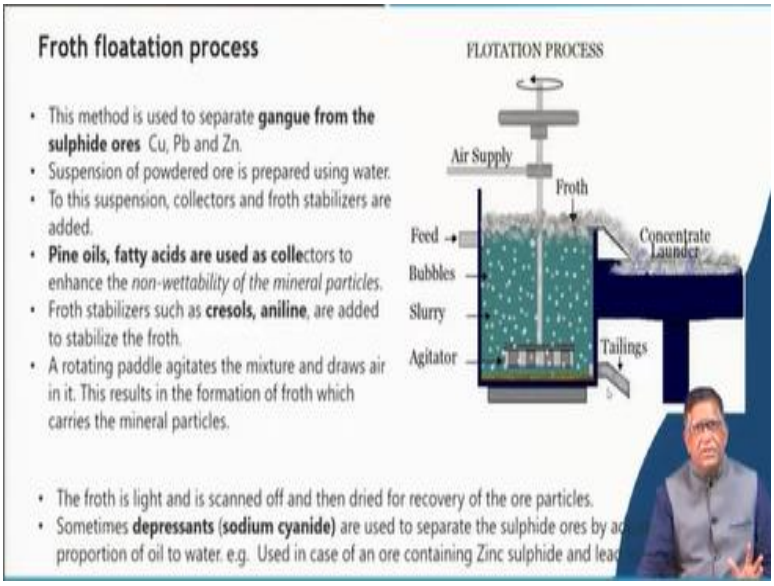

So, this is how the magnetic separation takes place. And the most widely used this froth floatation. Froth floatation is exactly used for your sulphide ores. That sulphide ore are for copper for lead for zinc and many others there we have got this sulphide ore which are exactly

very easy for separating by froth floatation. Now there exactly the powdered ore will be giving if they you are having in a water.

And then you will be having an agitator you can say this is an agitator that means the fine particles and the water they will be mixed and this should be agitating. You can see that in the flotation process they are just putting it over there. Sometimes you can send air also and then you add here stabilizers and collectors. Now the your when you are putting as a collector that pine oil or fatty acid they are used as collectors.

Now what they do they are exactly enhance the non-wettability of the mineral particles. So, that they will not getting it that is they will be not having the affinity to that water so that they will be having a tendency to go to the froth. And there are also sometimes some that organic oils like your cresols and aniline they are added to stabilize the froth. That whatever the foam is created at the top they should be remaining in foam position.

So, that this foam do not break because if the; foam break inside the foam this particles have been lifted and that is there. And that foam or the froth is allowed to pass over here so here in this lounger you get the concentrate. So, now this, what happens from here they will be this rotating plate it will be just pushing them over here. So, you know that this froth floatation system is we are having the main ore crust and powdered ore.

And gangue material they are coming as a slurry and then this is bubbles are getting formed. And that bubble it just make the bouncy increases they go to the top and then they remain as a froth in that froth that your valuable mineral particles are there. Now this they can be you can take here there are lot of advancements can be done how you sense it there whether this is exactly the proper froth whatever expected has come or not whether you have given the adequate quantity of the pineal or the fatty acids.

Or then sometimes you use this depression that is your to separate the sulphur sulphide ores that by adjusting the proportion of oil to the water and then using that sodium cyanide they can improve the function of this froth floatation process.

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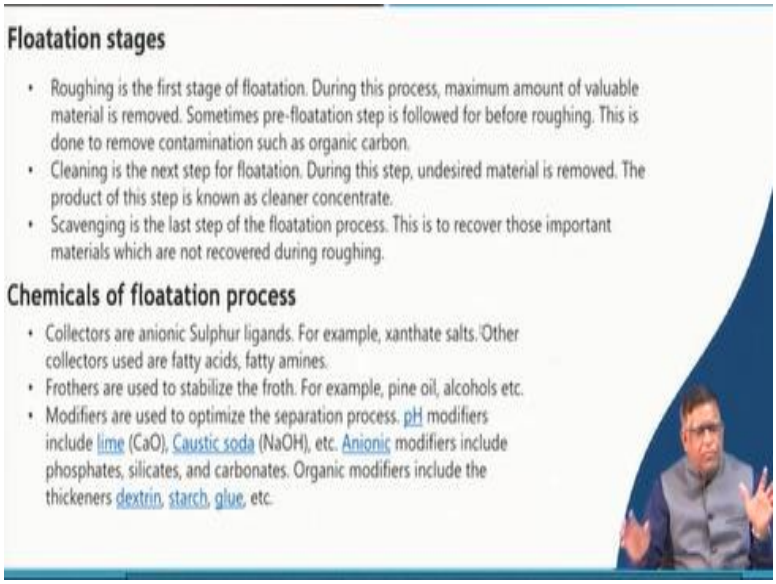

Now this in the froth floatation processes the some of the terminology you may be having that the first stage of the froth floatation is called your roughing. Now in roughing what is done your the material is coming out maximum that initial froth and then sometimes the pre floatation step is followed for being that is before roughing operations also you can separate out some of this. So, this is done to remove the contamination such as organic carbon etcetera.

If it is coming that roughing job is there the processing people will be doing this job. Then that you do the floatation that sometimes you clean the froth also during this step your the undeserved materials can be removed from there and then the scavenging that when the scavenging is when the froth has come your how you are separating it out. So, that as we said that is your sometimes different type of collectors and floaters and modifiers are used in the your froth flotation processes. So, those in the metallurgy you can do.

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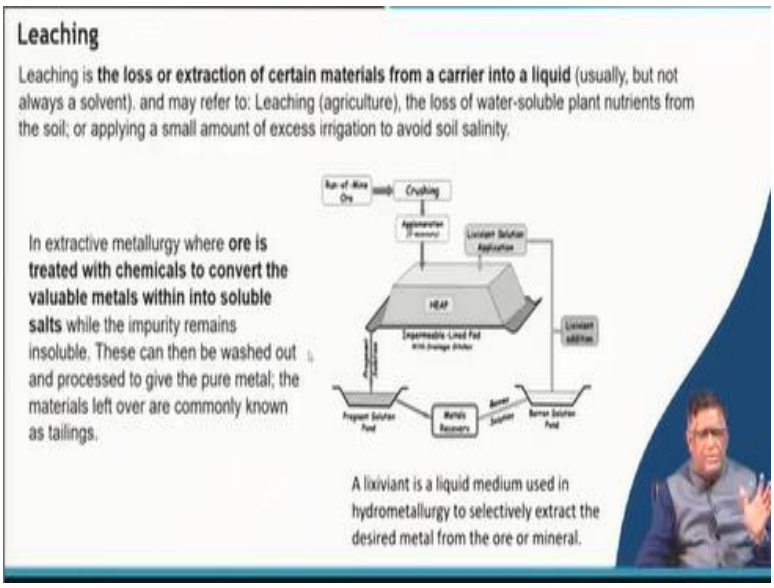

The another thing is call your leaching. Leaching is also a separating and concentration process in which the extractable mineral they are exactly that made to dissolve into a liquid. And then that liquid is taken out from there and then you come that dry it out and you separate these things. So, this is a leaching process sometimes you may be hearing this leaching that is your when you apply in a agricultural field a lot of fertilizers.

Then that fertilizer also leach out in the water and they do it but that is why you need to handle them in a different way that in the field how will you give it. Similarly, if some of the valuable minerals say for example sometimes even that there is another things terminology similar to it is their solution mining which is a different institute you can dissolve that thing in water. But if the valuable mineral which is there you can put them in a heap.

And then this class material it is there and you give it this the liquid the solvent that is called your lixiviant. That lixiviant solution is applied over here so that then they will be dissolving the valuable that mineral and then those because there is a impermeable layer is there and from that impermeable layer that whatever the water will be percolating and down you collect it over there. That is a pregnant solution.

That solution it has now brought all the valuable and then from there you can take it out and then when your material is taken then there will be the bearing solution. That your solvent is again

coming that solvent can be your as a lixiviant can be again pumped out their number of times the same thing can be doing going on. So, this is a method of leaching.

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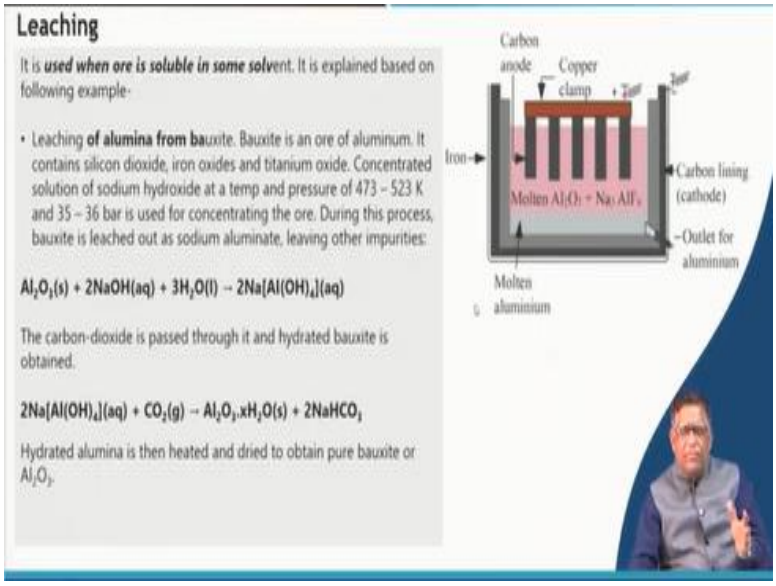

But that putting that extracting from the liquid media that leaching has got another type of leaching also which you might have heard about that how aluminium is extracted from the bauxite. There exactly you put this alumina from that oxide that you are as a is iron oxides and titanium oxides they are separated out from here. Now what is there that sodium hydroxide that is your that alkaline solutions at a high pressure and temperature kept in these ones and then you have got the high electrode.

Exactly this is a now in future or some of our carbon that from the coal you extract the carbon you made the electrode and it is export India has got a very good business also of exporting these electrodes for aluminium industry from I think near number of firms are there. They export this electrode that for doing this electrolytic the separations by the putting this aluminium oxide will be going to the solutions under the action of this electrical electricity first.

That is your in a dielectric it will happen. So, this is also putting the things into the solution when it has come into the solution then you take it out and there it is a concentrate of aluminium will be coming from the bauxite.

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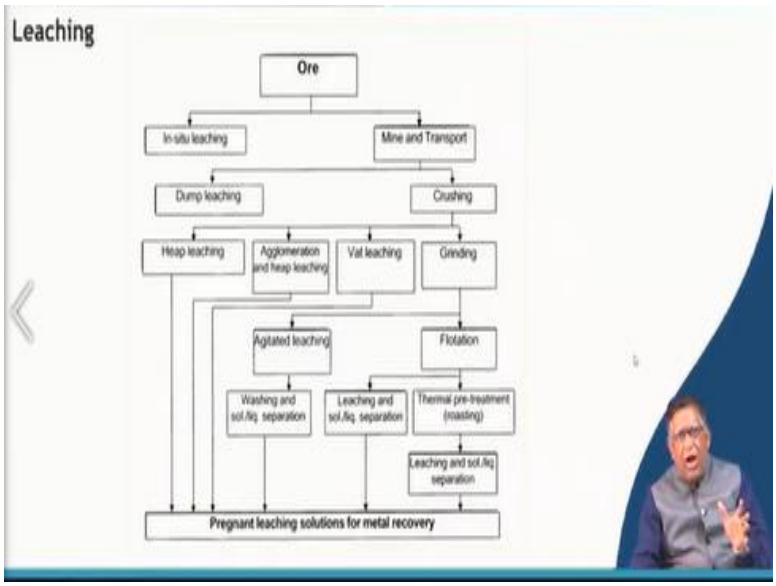

So, this is the way how you exactly from the ore by leaching you improve the concentrations that is your in-situ leaching which is done in some of this your I think it is Kazakhstan where that uranium mining is done by solution mining. You dissolve the solution and then take out the solution you do not remove any solid rock or mass or anything. You are just pumping in the water and after that ore is dissolved.

And from there you take it out and get the yellow cake for extracting uranium. So, that type of is a in situ leasing or solution mining is there. And then other thing is that from the ROM run of mine you can put it in the dump and from there you can leach and make it by heap leaching which will be giving you the pregnant leaching solution. Or by crushing with it your do a agglomerations and wet leaching and grinding after that you can do it as a by flotations.

Or you can do that leaching by you get a agitated leaching and from there you do the washings. Similarly, your that under the floatation they can do a leaching the solution and separating it out then thermal pre-treatment or roasting is also done there is another process. So, these are the processes for concentration and separation.

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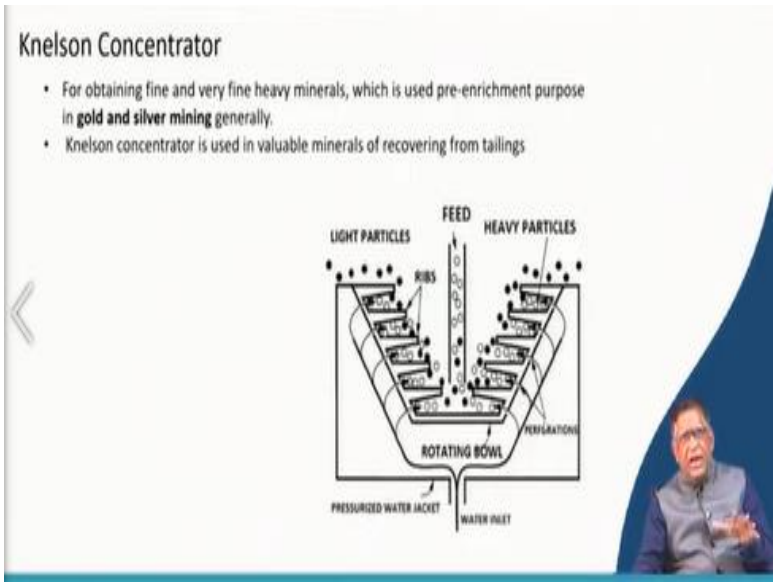

Now for that there are different type of concentrator that is for that your gravity concentration and that your by hydraulic washing. You can have a different trade name different company they have made it over there thinking in which engineered way you can separate the material in a better way there you improve your efficiency and all that. So, when you go to measure the performance and efficiency that will tell you what type of new solutions new engineering you can do it.

So, in a Knelson concentrator they have done in a very nice way that you are having a chamber in which these ribs or the blades type of things are there. Now the feed is coming from centrally you are pushing the water and this ball is rotated, when it is rotated you can see that your the light particles will be going up and this your heavy particles it will be going down and they will be getting collected. So, this is the way how Knelson concentrate work.

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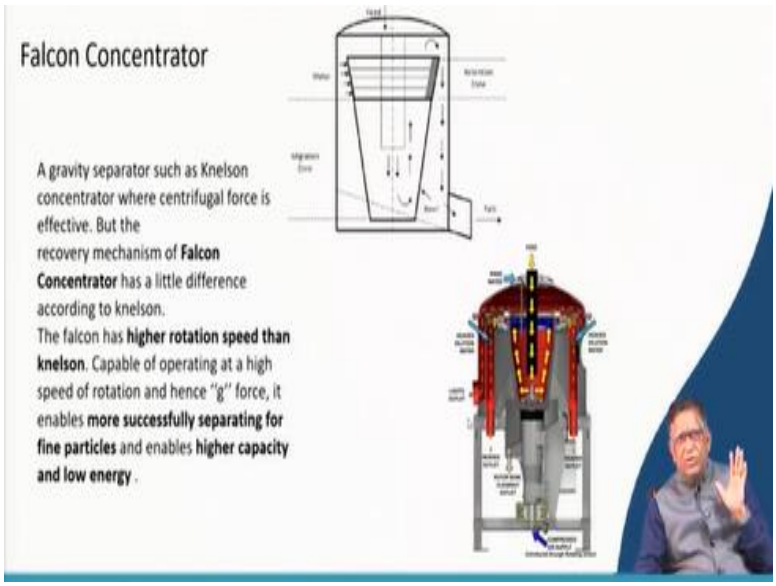

Similarly, there is a falcon concentrator depending on the company depending on the persons their engineering way they have done. Here the difference is that the mechanism of it has that is the difference is basically higher rotation speed than Knelson. So, they do it is at a very high speed they work and over there. So, as a result the feed depending on the feed size depending on your material properties you can find out that whether in your case that with the Knelson things concentrator will work or the falcon.

But here what is done the feed is coming over here and then your this when they are rotating over there then get it mixed and then your heavier dilution water it comes out over here and your heavier outlet heavier material will be coming over here and the lighter is going like this. So, that means there to layer wise separated depending on when you are giving a rotations at a speed and then your material is falling out that mainly it is a gravity separation.

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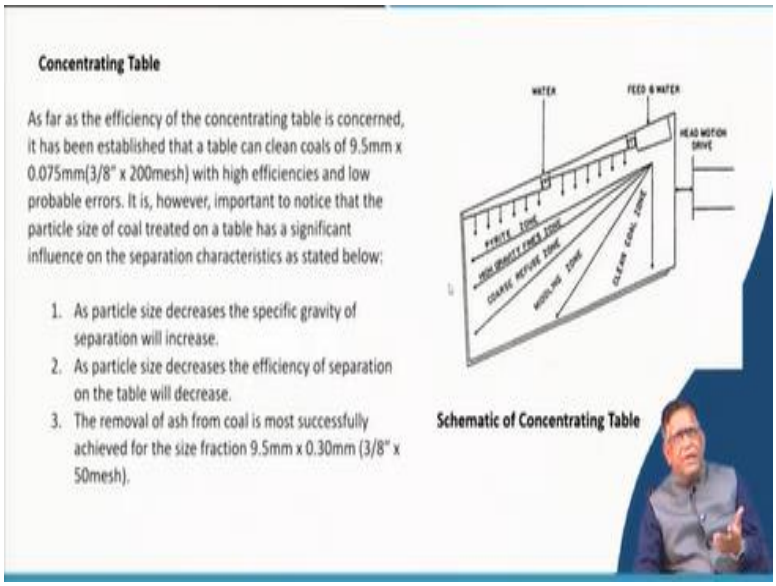

So, the same gravity separation is very simply done by the concentrating table. That is your tabling sometimes the word is as a tabling the feed or the material it will be coming over there then it is used for the coal washing with the coal and that inside the coal there will be dirt that is your maybe your sandstone or that your shell. They will be when allowed to move like this then the particles will becoming a heavier particle will be falling down.

That means that because sandstone and all are heavier, they will be ended from there the coal will be going at the top and they are separated. So, that at which stage what is separated these are studied.

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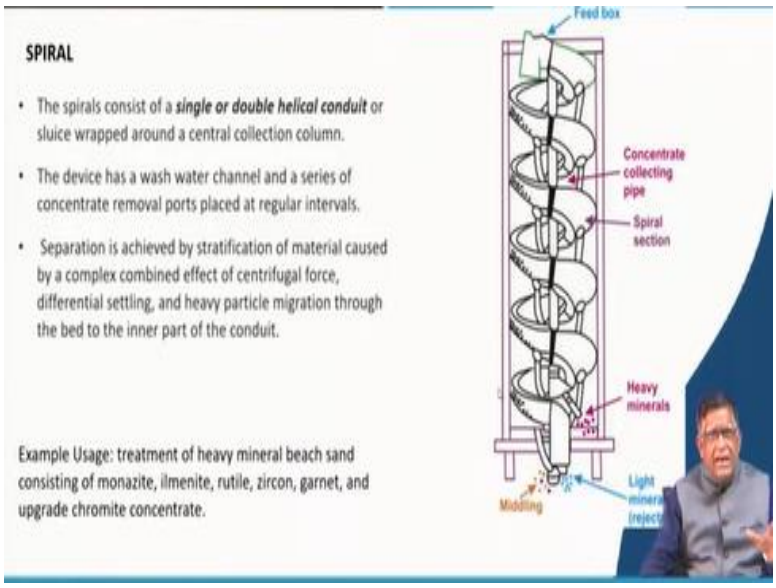

Then the spiral also that your whole feed will be going over here and then when they will be going through a spiral part. Then they will be started there the heavier material the dust particle and all they will be going to the centrally. Centrally you can collect them and they will be breathing that is and then the lighter particle which is there is a; this will be rejected over here that spiral classifier can be used in your just like as a gravity separations.

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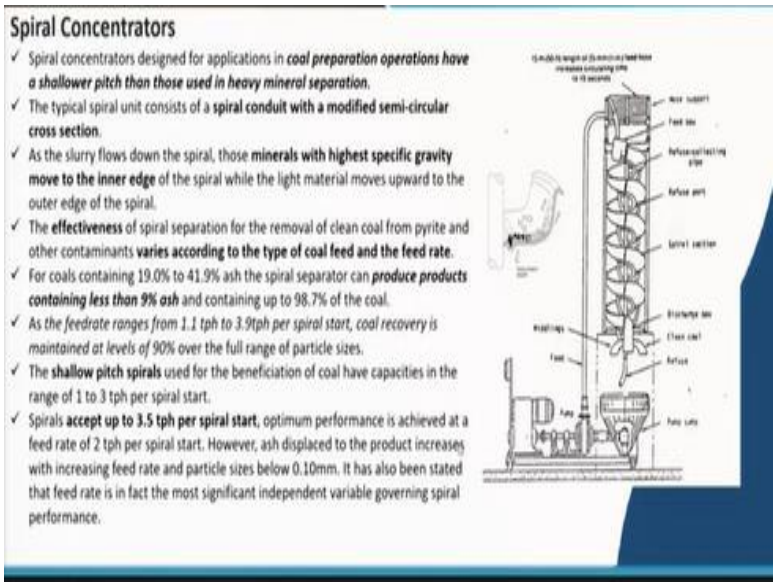

So, these are different type of concentrator. In a spiral container you can see that if you just take a cross section here it will look like that you can see here the heavy particle is coming towards the centre that lighter particles are going outside the things and from there they can be separated.

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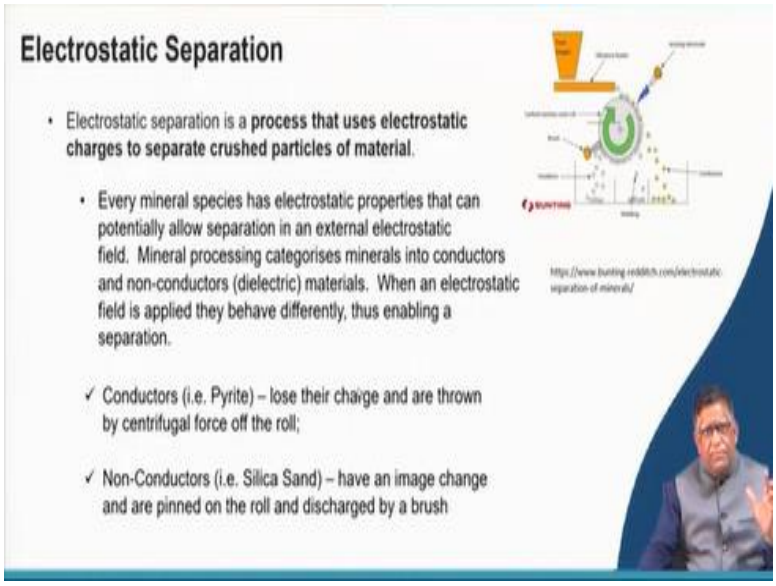

So, ultimately what you have just learned that there are different type of so this is an electrostatic separation your feed hopper that velocity and then your vibratory feeder is there. It is making this material to move they are magnetically getting connected over here and that non-magnetic particles are going over here then that you are having a brass by which your all the magnetic particle which are getting connected. They are just separated out. This is the way the your electrostatic separations can be carried out.

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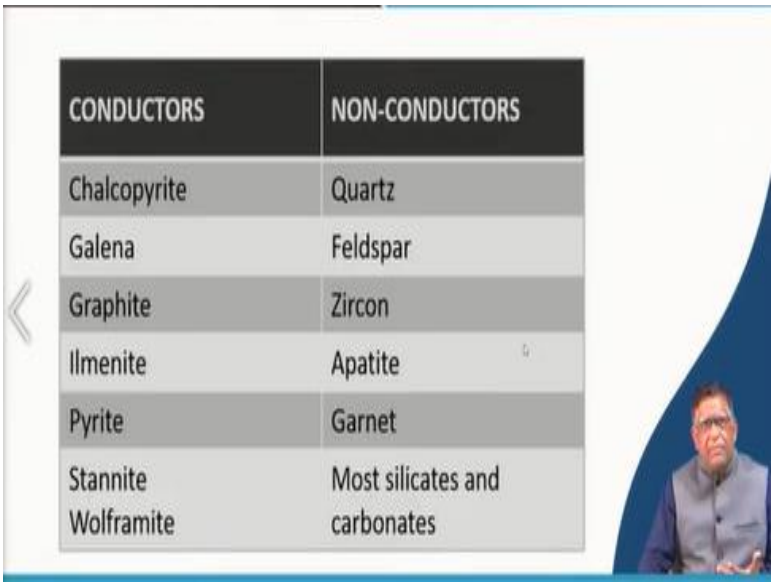

So, there are that is a what is a conducting type of mineral and what are the non-conducting type of mineral based on that electrical separations can be done. There are a number of minerals are there that is who are conductor like chalcopyrite for your copper Galena (()) (37:48) graphite your ilmenite, pyrites, stannite wolframite that tungsten these are exactly conductor that quartz, feldspar, zircon, apatite, garnet most silicates and carbonates these are non-conductor.

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But only thing is there different way they your concentration and separations can be carried out. But you will have to know the basic principle the properties of the material and the engineering how those different concentrations are made.

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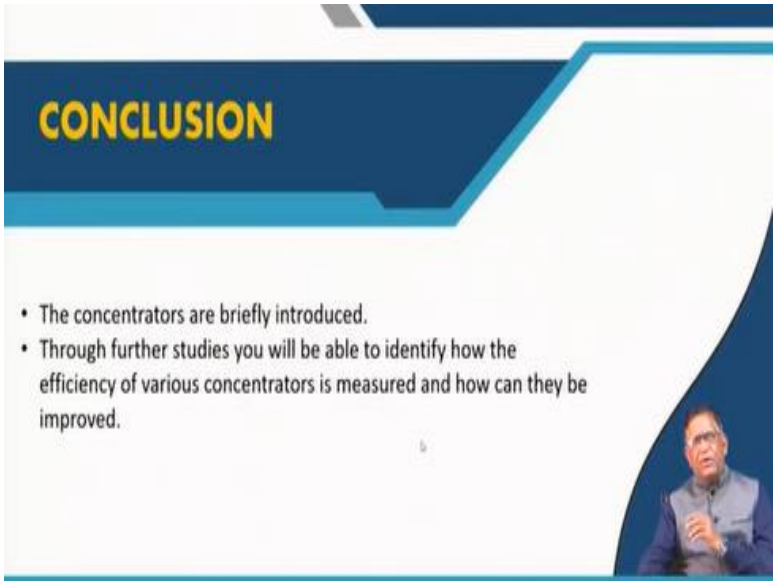

And then it is you that is your you can take more studies identify that how the efficiency and the performance of this concentrator will be there. If you are in charge of a processing plant how can you improve the recovery or how can you just analyse the tailings from there what could be there. Now in a near future there will be business that how to do this waste to weld and then the very fine particles will have to be separated out which there is a challenge.

And then say for example in Japan like technologically advanced they are purchasing the iron ore even having 39 45% of iron but because they have got an advanced technology, they can separate it out. And we are in our because we have got lot of iron ore, we are not doing in many times 60 to 65% if it is below 60 to 65% in the ore, we say its reject. Now of course by law we are staggered that your segregating and putting it in a whole mine area and in near future very soon many of the mines will get closed.

There are huge amount of bulk material which are lying in those dumps of the waste rocks which will have to be handled and from there the wealth generation will be there whether we make it a sand for construction we extract some aggregates for road building or the valuable minerals for other metallurgical purposes. So, there comes the business of your bulk material handling. Thank you very much.