Bulk Material Transport and Handling Systems
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Lecture – 4
Bulk material handling in Processing Plants Crushing and Screening Flow Charts

In our discussion of bulk material handling and transportation we are discussing on the bulk solid handling and as we told earlier that one of the major bulk handling operations that take place are in the mineral beneficiation and processing plants. As we know that all the metallurgical plants they depend on the raw materials which are coming from the mineral beneficiation plant.

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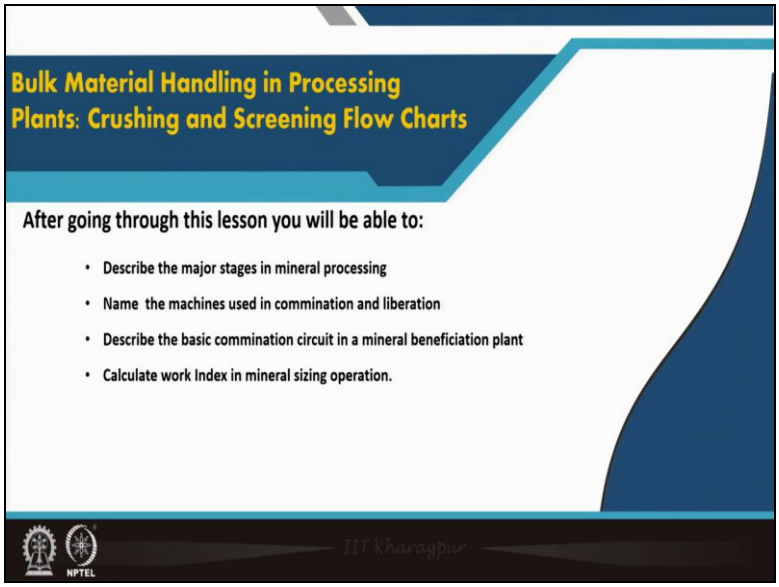

In today's class we will be discussing about the how the material handling operations take place in a processing plans and here after this class you should be able to describe the measured stages of operation which are taking place in a mineral processing plants. Then there are different type of operations are there different unit operations in a mineral beneficiation and processing will not go to the detail of that but what we will be discussing.

Basically what are the main machines which are used in your communication and liberations and also you should we will be introduced some of the this flow charts by which exactly the basic operations are carried out these are called a combination that circuits that.

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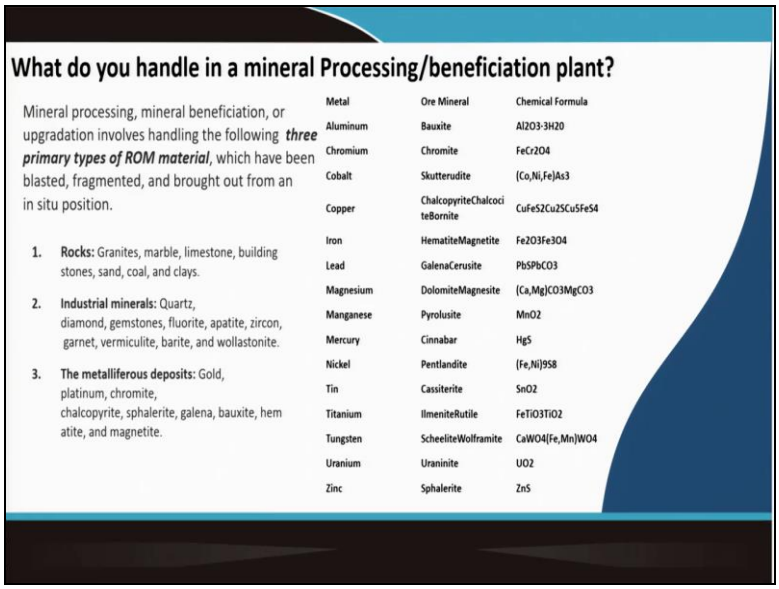

And then we will be also calculating some of this mineral that processing energy consumptions methodology. So, then you will be discussing about that how this whole operations are taking place. So, mineral processing or the mineral beneficiation this particularly involves three types of run of mine material that is exactly from the mines whatever is coming out that we call it as a runoff mine material.

Which are exactly in the mines in situ deserve as a solid that intact material which we call which we often tell it as an in situ position of the material from there they are exactly blasted when it is a blasted we get some fragmented rock mass. Now when we do the mining particularly three major types of rocks are coming that is your in a rock which we can say that granite your marble your limestone building stone sand coal and clay these are exactly as a rock.

And then there are certain industrial minerals which are used in different purposes like your quartz diamond gemstone fluoride apatite zircon garnet your vermiculite barite and the olastrom sternite these are different type of minerals like and they have different purposes. So, in your that basic geology or basic of the fundamentals of our mining engineering you have studied this things and in metallurgical students you might have studied this industrial minerals how they are processed and beneficiated.

Now there are also the source of our metals those are called metalliferous minerals which exactly that gold ore it can be your platinum or chromite ore chalcopoidet that is

your copper ore sphalerite or zinc or galena then bauxite that hematite or iron ore and then magnetite that source of iron ore these are the different types of rocks which are cut. And then as you can see in the tables given here different type of metals are derived from different type of mineral.

And that minerals are exactly their quality is dependent on what type of composition is there and along with this mineral there will be lot of associated mineral say in your when we are talking about hematite it is not that only the iron oxide will be coming that hydrated along with the iron oxide there will be many other things there may be blended quartzite may be there may be some other rock material where there is no iron content at all.

And you know that in a mineral those which are exactly not having the basic target element they are called gang material.

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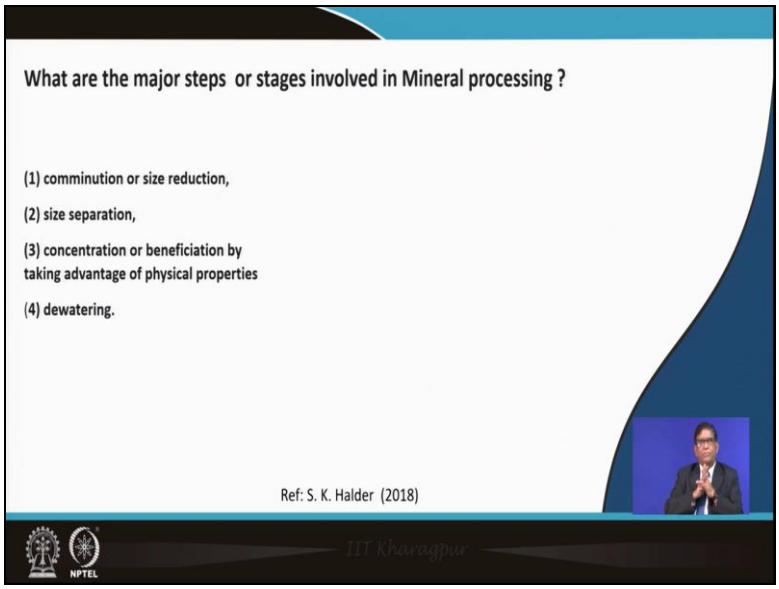

Now the whole process that is exactly what is going on in our mineral processing basically this four categories you can think of that is you have got a combination that communication is exactly breaking them and then that is exactly into small sizes that after that it is a size prepared separation because when you break it it will be having fines to big particles.

Now there how they will be screening it or they will be separating in sizes then there will be this is your concentration or beneficiation means those that is your unwanted material

gang material they will have to taken out and then whatever will be there you are exactly concentrating the valuable mineral. And after that because you will be processing in the process you will be mixing with water and then that those fine particles of the ore which you are getting that will have to be dewatered in a dried form you will have to go to the plant.

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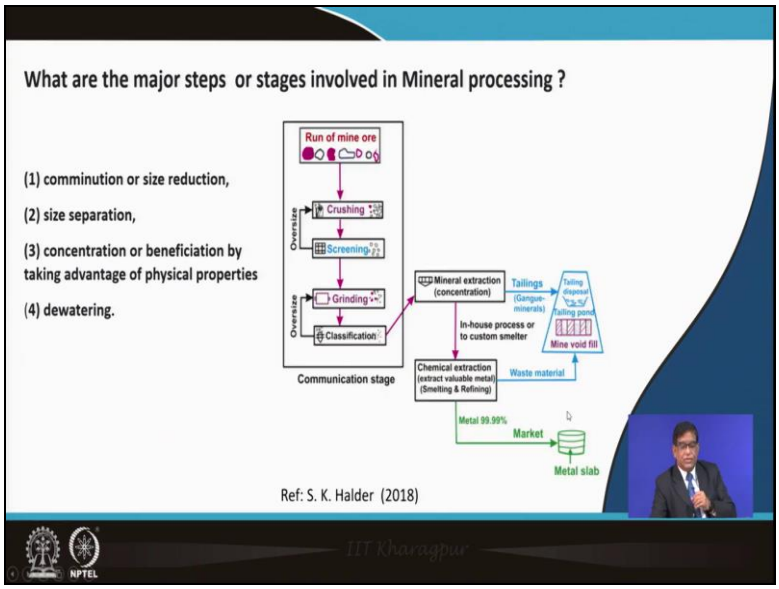

So, that is exactly if you see this is a circuit in which you can think of what happens in our mineral beneficiation plan. As you can see here the run of minor they are coming by different machines different transportation machinery we will be talking about those in our transportation discussions then there will be a crushing. Whenever there will be crust will be getting the product which will be sand for screening.

The oversize will be again recrust and the final smaller size material this crushing can be in different stages primary secondary tertiary and by that ultimately they will be going for grinding. So, that very fine that main mineral can be taken it out. Now once this your whole thing is ground at that time they will be going for the classifications that is exactly separating the valuable contents.

And there this concentrations concentrated ore when it is taken those fines particles which are not having the available mineral they will be discarded as a tailings. So, they are the tailings handling in a tailing pond or they can go for the underground mines for filling the voids or in open cast minds also sometimes in the that your excavated area pit you can fill them up and then there will be the main chemical extractions can go there

also different way of concentrating and extracting and from there it will go to the metallurgical plant in the steel plants or in their copper smelter or where and from there the metal will be extracted which will be going to the market.

So, this is in general a circuit. So, there is a book on mineral explorations and then mineral processing as a chapter by S K Holders book this is also it is you are referred too.

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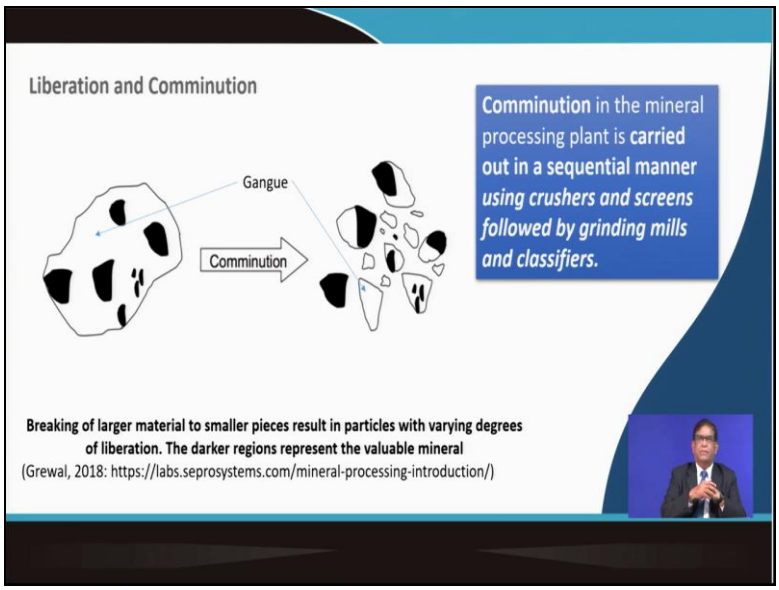

Then as we said in our discussions today we know about the liberation means freeing when a particular rock is there you can see that there are some valuable mineral that mean that your species specific chemical compositions minerals are at some places but it is Bond by all associated other mineral that white portion that is a gang material. Now when we do this communication that is a breaking you are breaking it out then there could be some of the purely gang material or some could be a purely your valuable mineral.

But there will be many places where there will be mixed up. So, in our first crushing systems we will have to take out this how you can liberate these portions also. From here at that time you will have to break them further and then making it to the fines and from there you can have in a processings we have got different type of methodology by which may be by gravity separations.

We can do you have heard about the floor floatation like a different type of methodologies are there where it goes in your handling for that you know handling during the processing is different. So, now if you see here that communication in a mineral processing plant is carried out in a sequential manner and for that you have got num different machines which are mainly crushers and screens.

As we have seen in the previous circuit diagram that you are crushing and screening that means separating the oversize and undersize and then finally doing for grinding and then after the grinding it will be classified. So, these are the operations which are taking place in a plant.

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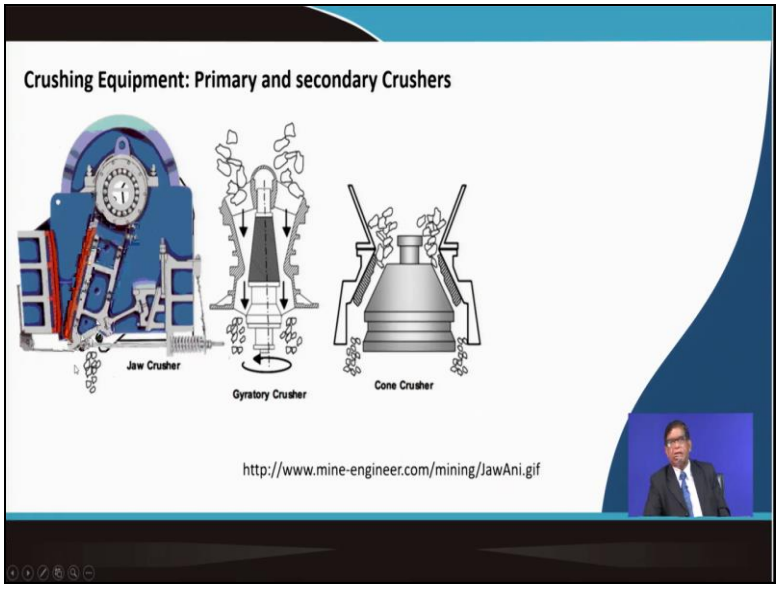

Now when we talk about this crushing that rock you know that in our discussion of the material properties we have discussed about the different types of rocks that is and their properties are different. Particularly if the rock is having a very high uniaxial compressive strength that is it is very difficult to break them very high strength some of the rocks may be very hard some of the rocks may be very tough some of the rock may be very abrasive.

So, then the type of machines in which they will be there that is a lot of things. So, basic crushing it is exactly we are having a primary crusher that is the run of mine directly put into it the first stage of crushing it can be done either by jaw crusher or gyratory crusher in this figure you can see a jaw crusher means you have got a fixed jaw type of things over here and there is a movable jaw. So, now this particular one which is pivoted at this

point and here there is a toggle by which exactly the drive is given. So, that this will be going front and there is a two and four like that.

So, when it is heating over here the rock which will be coming on to this position they will get broken and then the broken will be depending on the maximum size of this gap that material will flow. So, that is a jaw crusher, in a cone crusher there is a that eccentric shaft here this one is giving a this your that spindle on which a mantle is fixed over here this is the rock is exactly passing through this the mantle and then this your conical part of it.

Now here because of this is given an eccentric motion this gap also goes on increasing and decreasing while it is decreasing at that time the pressure is coming on to this rock and then that when that pressure that applied is more than its compressive strength then it will break over there and then the material will be going. And then there is another type of crushers then after getting it crushed by the primary crusher these undersize is put into another that will be the feeding into here this is a cone crusher.

In cone crusher this portion it is exactly giving a rotations over here in such a way with a eccentric movement this rock get pressed over here to get it broken. So, these are the different type of crushers you can see over here. So, now you can see here how in a jaw crusher that exactly the movable jaw is moving and then this get cut over there. So, this is the way you will have to study about this machines their construction their the functions.

Now here these particular red color persons you can see they will get wear out. So, the maintenance is you will have to time and on remove this part and fix it. So, that this can withstand because this other main structural part otherwise will get damaged. So, then the total energy how much it will be required that is very very important here. Now that exactly that for the sizing purposes how much energy is required that is called the specific energy for that rock mass.

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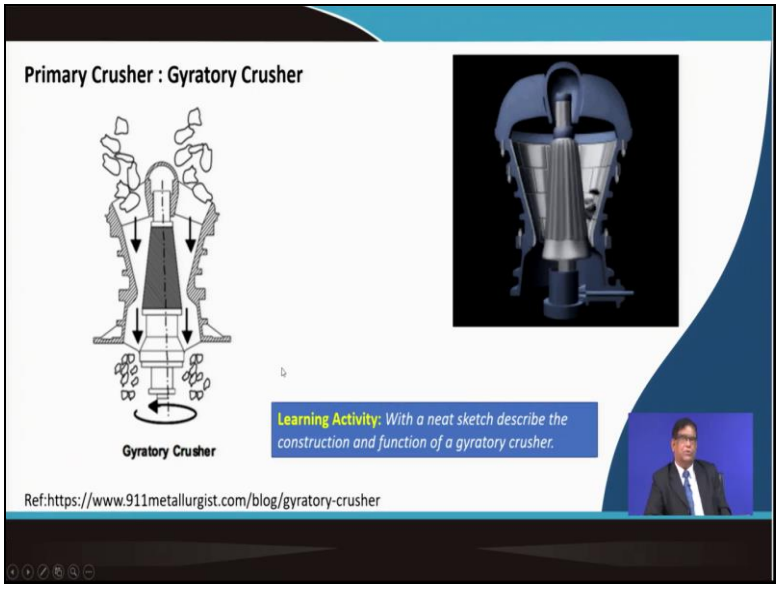

So, now when we talk about this gyratory crusher you can see that in a gyratory crusher that spindle on which that metal this one is having an eccentric motions. So, from here you can understand that means the drive is given over here at the bottom you can see that drive giving to a true a that is your bevel arrangements and then this particular bearing on which it is moving this is making them to put.

So, what as a learning activity you should draw any sketch of this and then try to find out that what are the main components in this and then describe their functions for that you will have to refer to any mineral beneficiation book or it is a lot of materials are available in the net also. So, you will have to prepare one document describing the construction and function.

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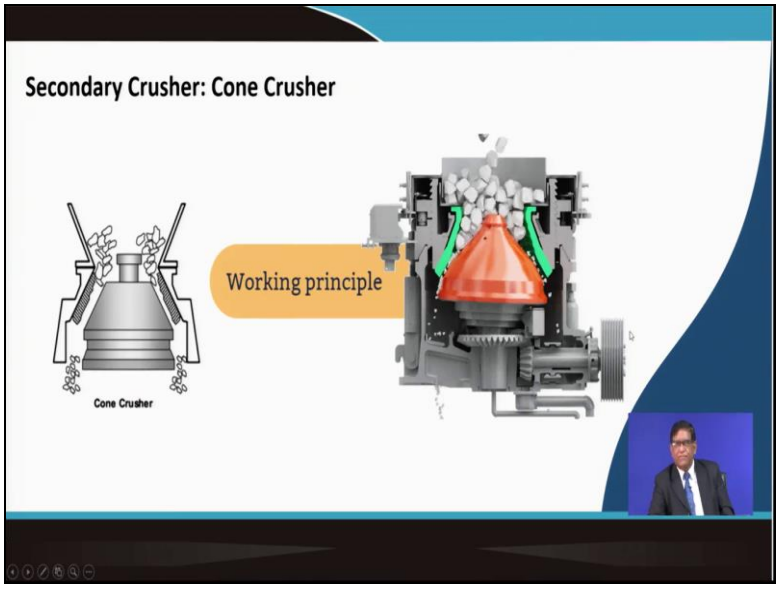

Similarly the in a cone crusher there you can see this cone it is also having here the drive is coming over here that main energy which is being supplied through this drive system there being available on this cone when it is moving you can see that it is getting pressed over here and the material is getting finer. Finer size of breaking is taking place this is in the secondary stage of crushing operations.

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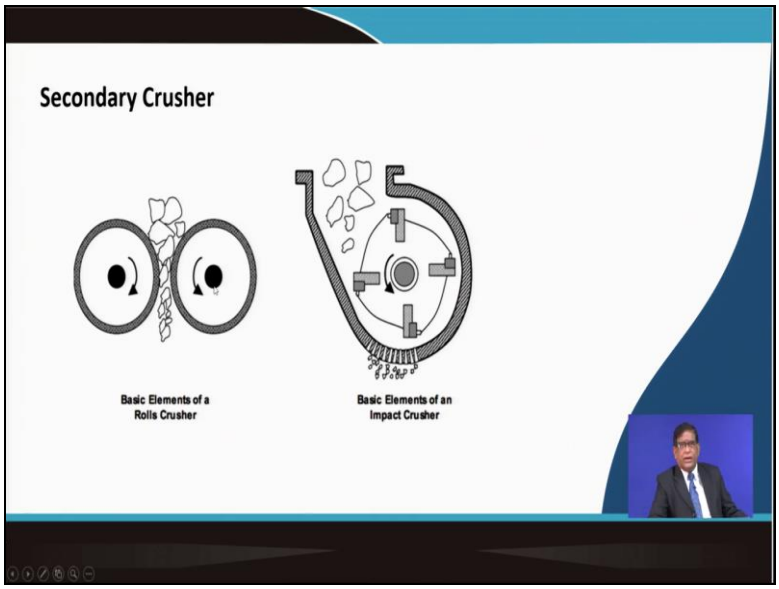

Then there are other type of secondary crushers also one is exactly we have got some that in a roll crushers. What is happening here these two cylindrical drum that is with a the top surface is a very hard still and then they will be rotating both in the opposite direction. When the rock is coming over here they are exactly getting an impact and then they get pressed over here they are getting broken over here.

Many a time some that material which are comparatively less hard say cool it can be very easily broken by this type of roll crushers. There is also an impact crushers or sometimes called hammer crushers here you have got the spring loaded hema when it rotates like this at this point it coming this one will be giving a hammering action on the falling rock and then when they will be breaking and you have got the gate here.

So, that the small broken mass will be coming over here. So, this is the way and then some of the unbroken things that will be again getting carried again putting it over here. So, like that it will be going on crushing. So, there are different types of crushers that selection will be again discussing down in our main discussion on crushing how you select different type of crushers for different operations.

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Now after the crashing as we said in the circuit that the next is for the grinding. Grinding means making into a finer. Now what happens after the crushing you have liberated some of the particles that but there are still some material which are exactly having associated with the grind material? So, for that there are different types of meals are used that grinding meals nowadays one is called your auto generous meal in an auto generous meal exactly there is a cylindrical or trommel or barrel type of things where the length is very short but the diameter is very big and in that the rock is fed over here.

Now when it is rotated this rock mass it will be getting lifted over here and then again it will be falling by that it will get crushed and also they will be having a friction amongst themselves that is your autogenuos mill that is the rock them that there will be a attrition because of their own rubbing while they are looking getting rotated within this type of a mill or a trommel that is your auto generous melt.

But sometimes that some of the rock they do not get grinded by itself. So, there they add some other hard material steel balls or iron or iron bowl balls. So, by that what happens they get further that is called a semi-autogenous that means when you are adding some additional material by which that exactly breaking process will be accelerated that is called your semi-autogenous mill.

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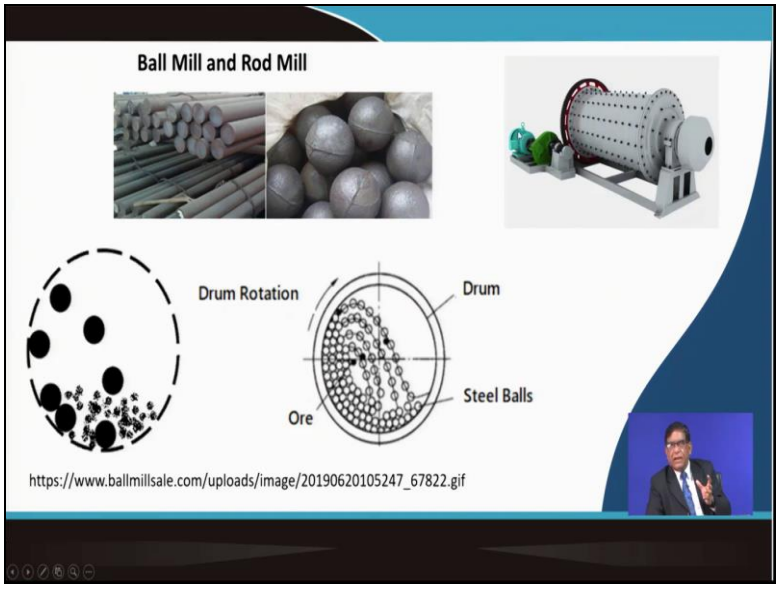

So, this grinding there are also your ball mill and rod mill. Now that trommel which we have seen it says that in an autogenous mill the diameter was very high the width of the barrel was very small. Now here it will be little bit longer width and the material along with that this type of your iron balls or that some rods will be placed over there. Now what will happen the material will get in between that hit by this ball and the rods as a result there will be further grinding.

But we have the materials which you have done the primary crushing and secondary crushing. Now when it will be coming into this trommel in which this balls are there and you can see that ore material which are exactly the black spots. Now they will get heated by these rods and as a result there will be further breaking of the things. So, this is what is happening in the mills in a ball mill or in a rod mill.

You can see that that exactly we are having a drive systems a power source is there through a gearbox it is given over here we are having a that your just like a sun gear we are giving the drive pinion is here. Now whatever energy you are giving into this pinion that exactly getting translated into that your crushing energy and ultimately the material will be crossed over here.

So, that you can see the rods here how the rods are moving and then all the material in between the rods getting trapped and by that exactly they are getting broken. So, this is a that your grinding process.

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After this grinding and you have seen in the liberation process we had to do a number of screening arrangements there are again a different type of screening machines. So, normally when the run of mine material is coming by a truck they are given on a hopper. Now the hopper that well that is your the funnel shape it is made by a thing called what is called as a grizzly.

Grizzly is nothing but it is just some very hard this your eye bar or sometimes this grizzly can be given instead of I bar they can give a t bar also that is your you can have say for example in your if you are having this your you can have the just you can have the rod instead of having a section you can have section like this. Now if you are having like this two that instead of that you are having this type of arrangements of the rods.

Now when the rock will be coming over here that because of the falling they will be breaking over here and then that whatever can come through this it will go and it will fall down. Normally that where the hopper is like this your; in that hopper when your; the truck will be discharging the material over here this whole material then through this that exactly this is the grizzlier fitted over here.

Now that smaller particles will be falling down directly over here and that the bigger particle which will be coming here we can have a guided gyratory crusher that crusher material will crush and then both this material it can come to a conveyor belt and then they can carry over the things. So, that means in case of your screening just iron material

is coming you are not applying any other energy you are keeping some of this type of grizzly which is a that is a just like you might have seen.

The cow catcher in your gate where some rods are placed over there with some that is your gap in between. So, the when the rock is falling over or it is discharged over here the underside stream will be going and that can be collected to a conveyor belt over here. So, this is a very primary screening which is done in most of the receiving section of the that your processing plant.

Now the other type of screens that is once we are having in that circuit also we have shown that after the gyratory crusher or jaw crusher they crush the material they fall onto a a there could be a feeder by which it could be there or it can directly on a vibratory screen. Now vibratory screen means it can have a number of deck. So, this is your single deck this is a double deck.

Now when the material is falling over here the material will be coming on to the top of this then there is a drive given over here which will make this screen vibrating it can vibrate to and fro or it can vibrate vertically up and down. Now there are different mechanism by which you can impart the vibration may be the shaft can be an eccentric stuff may be different type of your mask can be given.

And then there are different design depending on the applications where you will be there but the basic principle is when you are giving a vibration then the material will start falling down. And this is something like that shaving even in your you might have seen in your home when your atta is brought floor is brought for making your chapatis your mother might have put that screening.

So, that the husk is taken out that is a vibrating screen and then that whatever the undersize is coming. So, this screen below there they can be having a smaller hole. So, that that after that from the bigger hole here we are separating into two sizes our say if it is your that is called your mass how many number of holes are there in per square meter that will be giving you the mesh size of it.

Now if it is a bigger hole say maybe your 25 millimeter above will be your plus 25 will be getting separated minus 25 millimeter will be coming over here may be having the only the minus 10 millimeter will be collected at the bottom and then between the 25 and 10 millimeter material will be collected. So, like that a screen separates the material out. So, then there is also just to give a energy.

So, that the particle get a suns then vibration sometimes you are giving a vibrations up and down the particle will be jumping and there will be the chances of falling into the that is your hole because thus particle size shape will be different and there we are having a circular hole on the screen. So, that this there is a sense of getting it obstructed will be reduced when you give the vibration.

Similarly there is a directory screen in the generator screen this is have given a gyratory motions when you are giving a giant emotions exactly that materials which are of the smaller size they are getting a that is chances of fully falling into the hole through which it can pass will be increased. So, here is a lot of statistically you can find out it there are a lot of experiments lot of research are carried out how exactly the efficiency of this screen will be increased.

So, similarly there is another type of screen which is called a trommel screen or revolving screen a drum and then the outsides there are lot of holes here and then you do. You might be seeing somewhere if you go to say municipality west side where there are the organic matter and inorganic matter all are dumped in the municipally waste dump. Now that from there how will you separate the organic material from the inorganic one.

The organic materials are normally softer and then if you are having a such type of trommel and then if you give a rotation over here you feed the municipality waste into this and then you make in a very high speed rotations then the organic material whichever is there they will be getting broken and then they will be coming out this hole and then the inorganic material rod irons and plastics some of the things which are there which will not break over here they will be getting richer from the other end. So, this is the way how the bulk material are getting separated.

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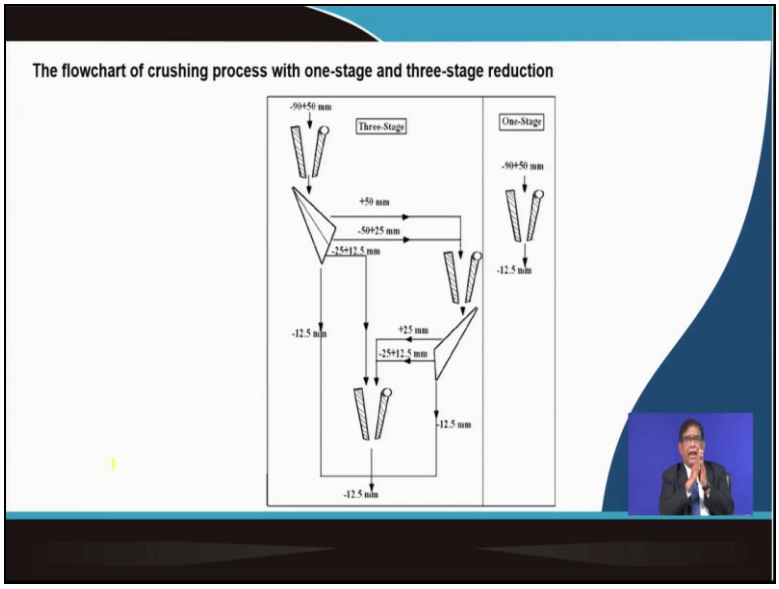

So, similarly you can have a number of other arrangements are also there but as a crushing you are doing whether your single stage or multi stage of crushings it is shown over here say for example here the feed material is having minus 90 millimeter that is a if it will pass through 90 millimeter mass to the plus 50 millimeter. So, those that whatever is the undersize it will be coming and it will be separated over here the two stage you can see that plus 55 millimeter on the plus 25 millimeter it is coming over here they are again given to this.

So, like that ultimately you are getting that whatever is less than 12.5 millimeter will be collected over here. So, this is how exactly a three stage crushing is taking place here or sometimes there could be only one stage crashing. So, if you are doing giving this feed and in one stage you want to get an only 12.5 millimeter then there will be a number of time you will have to go on spending energy to keep them breaking the your rate of getting the final product will be reduced because the bigger size will have to be crushed several times over here.

So, that is why the material will be having a that is your waiting that storage time there will be increase. So, in a principle of that material handling we have said that we should not retain the material at one place for longer time. Now if you are giving a single stage crushing that whole material unless and until the whole material is getting 12 less than 12.5 it will have to be going on operation in the same location.

So, that is why in the same location storage time is increased that is against the principle of handling better material handling. So, if you use a bigger size is coming over there you are introducing you are giving a capital investment here instead of one you are giving two. But by that what will be getting you know per day how much material will be bringing into the required size will be increased and there comes the economic decisions.

So, whenever you want to do a this bulk material handling overall holistic things must be seen.

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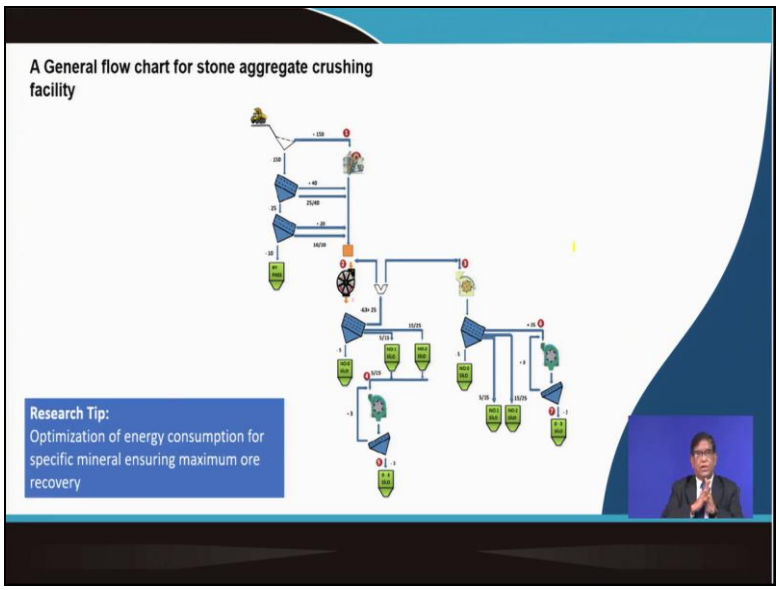

Similarly it is a general flow set you can see over here these are exactly the storage ultimately the material will be coming say here you have got it at the different stage of material. So, that is exactly you have seen here that if you if you see this the truck is giving the material over here it is getting that grizzly after the grizzly that is above 150 millimeter size will be going to this primary crusher.

And then the primary crushers will be bringing the material for a secondary that is your hammer crushers over here and there that whatever the under size which came that has been separated by the screens two screens. And then whatever at the first stage itself from the grizzly whatever came of that which does not require any further crushing is collecting by this bypass and they have kept in this particular silo.

And then all these things under different screening they are going and getting overcrossed over here. So, similarly this material is we going and they will be stored over here. Now whatever the things which you are not getting it will be going into the next stage. So, this is the way how step by step the work is carried out. Now optimization of energy in consumption for that is your specific mineral ensuring maximum or recovery is our main target.

So, here some of you can take up that investigating how energy efficiency is achieved in such type of plants.

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Now if you need to do some of the research from the net to find out how this different circuits are used in different processing plant you can take as say Normandy iron ore mines how it is being done or that if you say any of the NMDC processing plant if they have got how they are doing or in the our sale Kiriburu and Meghatoburu circuits how they are doing that you need to see.

And you can find out what type of crushers and whatever this type of drawing call you the flow diagram need to be calculated out.

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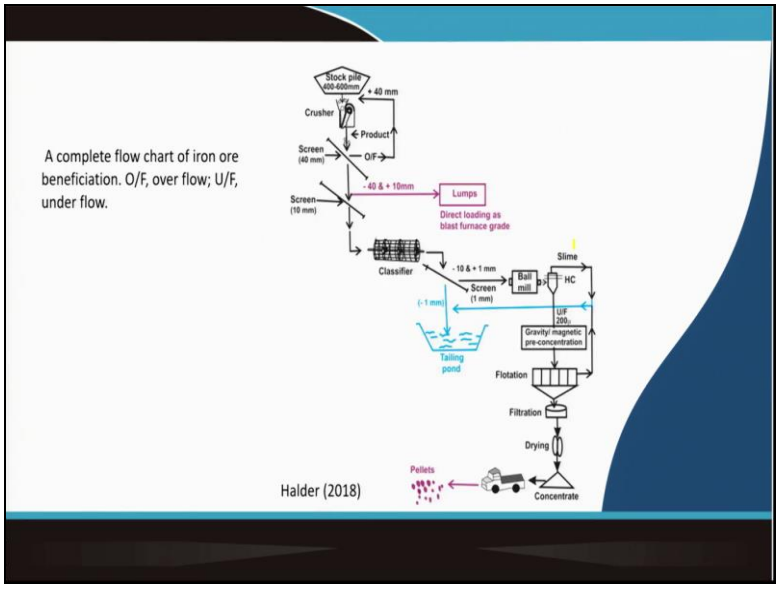

So, similarly you can a total out what is the sizes and then what are their quantity that also you can find out for finding out you can refer to different books for doing it.

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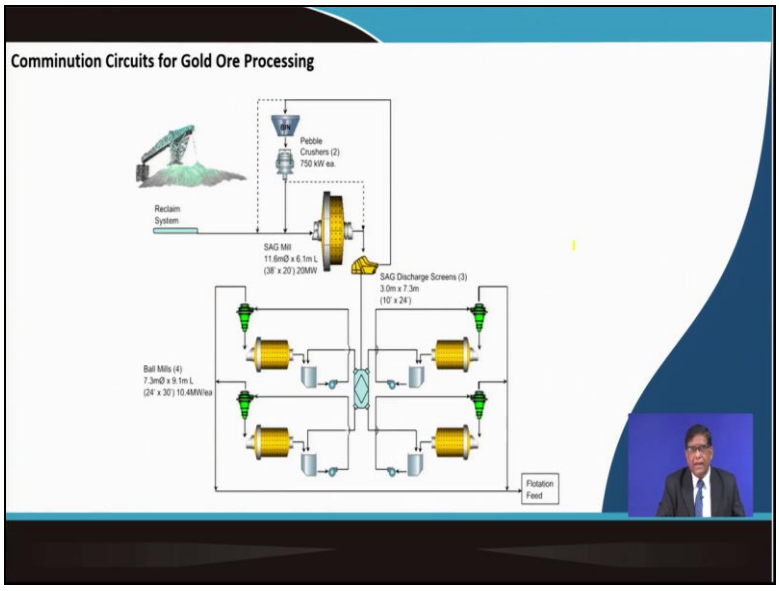

So, that in a gold mining as because you need to get a very fines to be generated you will be getting lot of autozonus and semi autogenous meals are used in a gold circuit you can find out in a hearty gold mines processing plant or that earlier Kohler gold fields their processing plants or you can get some of the international my the famous mine like Lahiri gold mines their processing plants these are available in the net you can study over there.

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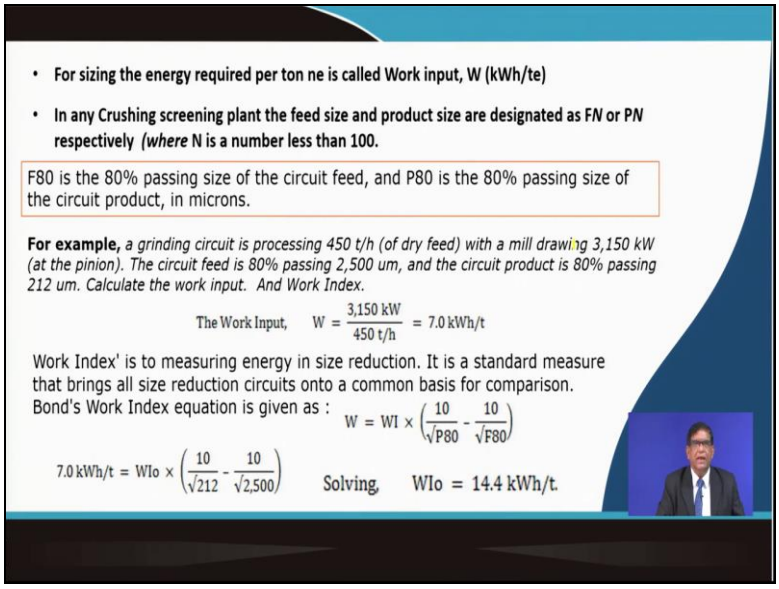

Now one thing is what is important that is your how you measure in any studies you should see that how exactly the efficiently you are doing the sizing. There are number of resources were there but still the most important things which is being used is a called Bond equation Bond which is a work of nineteen fifty 1950s they derived some formula based on some of the work which was done in the 19th century that from there the Rittingers equations.

You may find they gave exactly from the experimental observations certain formula. Now that what is a work input that is exactly called that that energy how much is spent that is your kilowatt hour per ton that is called as a work input for measuring that efficiency of a crushing purposes. Now in a crushing plant the feed size that is what size is given and the product size what exactly you are producing they are expressed in a as a how much percent exactly passing through.

Say you can say F80 it is a feed size where 80% of them will be passing through that size. Similarly when you say as a P80 that means 80% of that size will be passing through that size. So, this is how their example. So, you can take a small example if a processing plant they are getting 450 ton per hour dry feed with a mill drawing which is giving that that first that you can see that bevel gear and all that the animations you have seen that is your if the total energy given is your 3150 kilowatt.

And then the circuit is getting your 80% as passing as a 2500 micron and the whole circuit is giving your the product size it is coming out of 212 micron. So, now you know

the total energy given is 3150 for a feed rate of 450 ton. So, what is the work input this is exactly 7.0 kilowatt per ton this is the way how you calculate the work input. Now from there work input you get this work index which is a measure of the your crushing energy consumptions is given by this Bond equation where that you can find out that work in this by your that products percentage the square root of that it is giving.

Now the basic principle of deriving this is when you make a sizing more number of crushing means more surface area generated then there is a more energy is required to create more surface area. So, that gives exactly that is why the work index for crushing a coal will be different than crushing a iron ore because there that creating more surface area will be requiring more energy.

So, now if you have got these things that you work once you calculate the work input from there you can find.

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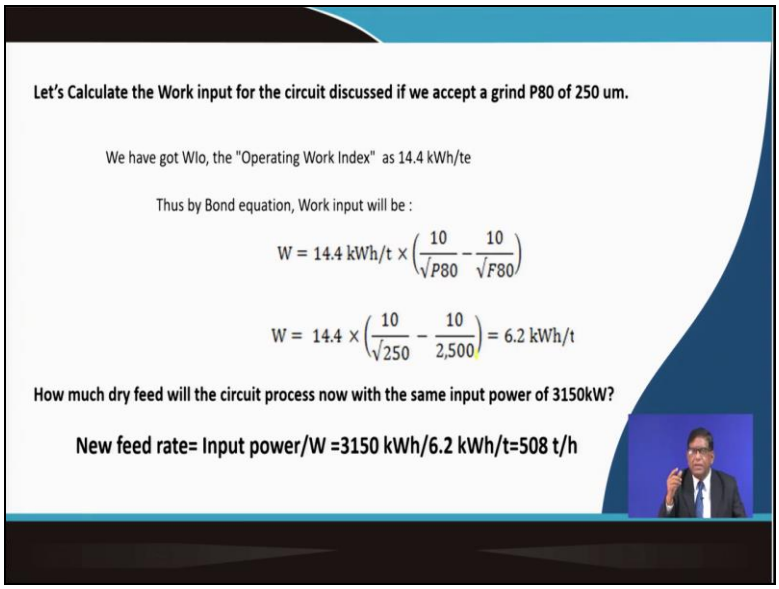

Say let us say one thing that if we calculate the work input in that given circuit how you can do it if it is a sizes your 250 micron then the operating input has been calculated earlier. Now giving that working input now this F80 and P80 it is given 250 millimeter and then 2500 you can get this 6.2 kilo watt that means when the your that fine size changing that is your product size changing your work input is also changing.

So, that is what if we now look into instead of that initially that power consumptions were at 3150. Now if you the power requirement also can be calculated. So, from that

equations by changing the value of different variables you can find out so and from there you can find out what will be the feed rate that means if your product size is different then your you can handle the same plant if you are giving adjusting the gap to get a particular product size.

Now if you change the gap to get a particular product size you will find the total handling capacity within that particular that hour in our will be changing. So, here by changing the that your the energy input or changing the size you can get the throughput of the plant can be changed.

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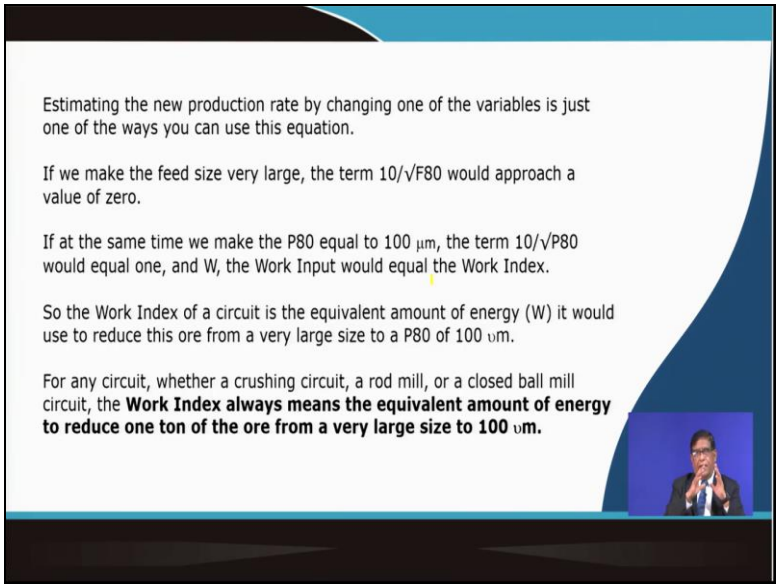

So, this type of studies will be helping you in future we will be discussing crushing again in a in a different way and when we will be going detail into this subject but the estimating the new production rate by changing one of the variable is just one of the ways you can use these equations. So, there are lot of studies have been done lot of research have been done on Rittingers equations and Bond equations that you will have to do it.

But particularly this work index it means that equivalent amount of energy to reduce one ton of ore that will be and it will be varying from that is your if you are if you in the equation if you put that size input size is very big then that your 10 by that square root of the size that will become negligible and it will become nearing to the zero and then that is why if you are taking that this that is your if we make the P80 equal to 100 micron at that time the 10 by that square root of 100 will be 1 and in that exactly the your equal to 1.

That means this equations if you put here if this is 10 by this becomes almost negligible that is because if your F feed size is very big this is almost near to the zero and the product size is 100 micron means this is equal to 1. So, that means what will happen your that main equations what you have seen over here that is your this work index it will be equal to this part is 1.

So, your work input and the work index will become same and that is what exactly as a principle it is said that definition of work index is that equal that work input which is required for the large size for getting it to the 100 micron size.

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So, there are number of articles are there in the net I request you to kindly make a little bit of habit of writing down and preparing your own notes and then the activities as a learning activity you please take it.

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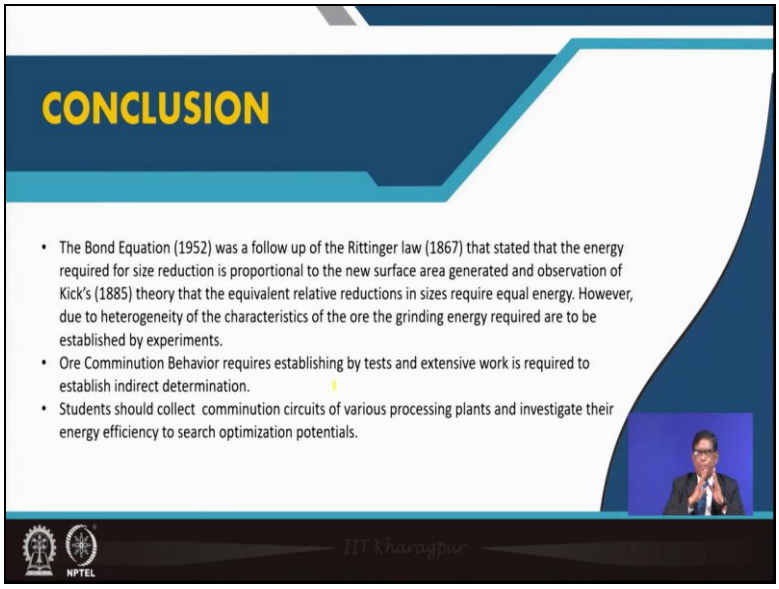

So, as I said that is your Rittingers law and the bond equations these are very very old but that even say you can see from 1867 and 1885 at that time the works were carried out in that way today lot of advancement has taken place and there is a that is a need and also a scope of optimizing this operations of. So, that nowadays one thing is very important because you will have to do the work in an environmentally friendly manner.

So, that the energy will have to produce less and that your fine generations and that waste generation will have to be also looked into. So, that is why there is a lot of research scopes are there in this particular field. Then the ore combination behaviour that is how exactly that it will respond to the crushing energy how you are giving the crushing energy whether it is responding better in case of jaw or it is better in case of gyrations or better in case of roll mill or that is which one will have to be selecting that will depend on the combination behaviour.

And that need to be done a lot of laboratory experiment can be carried out for a particular mineral and can be achieved over here. So, you should collect combination circuits of different plants and try to find out and then study the basic principles. So, that you can contribute something in this field where there is a scope of energy efficient operations and environmental field friendly operations and economic operations.

So, basic things your environment safety economics that will be related to this that is why there is a more need to study this communication that is crushing and screening in the plants how it is carried out, thank you very much.