Bulk Material Transport and Handling System
Prof. Khanindra Pathak
Department of Mining Engineering
Indian Institute of Technology, Kharagpur

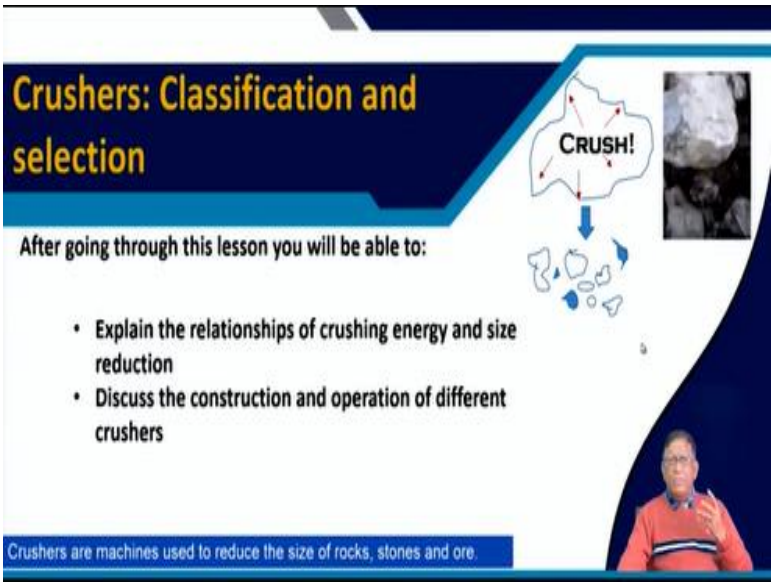
Lecture - 28
Crushers: Classification and Selection

So, you have been now studying a lot of things about mineral bulk solid handling and transportation. Today we are starting another section of this bulk material handling. You know that the maximum number of employment in the bulk material handling is in the mineral beneficiation plants and next to that is in our different ore dressing or you say coal washing and the coal preparation plant.

So, in that there are major operation which is going there with whatever you are getting as a run-off-mine. You can think that in the whole world there will be billion tons of minerals are being mined every year. So, all this run-off-mine they must go to the users either in the metallurgical plant, steel plant or different smelters or say if the lime stones they will have to go for cement making purposes. They all will undergo crushing that is exactly a size reduction.

Now this size reduction which is often said as a comminution technology. So, we will be discussing in today's class that how this crushing and screening is done. In the subsequent classes we will be discussing more about this screening. But today we will be introducing you what is this crushing. Already in our introduction to bulk material handling we have told that how different crushers are there and then what are they. Now today we will be discussing basically that what is the relationship with the crushing energy.

(Refer Slide Time: 02:17)



Because you know that when a rock is there that will have to be crushed to make small particles. So, that within that rock or the ore mineral whatever the valuable components are there that will have to be liberated. This liberation is the main purpose of this handling. Now what is done there? This rock will have to be crushed means you will have to have some energy to be applied over there. That is the crushing energy.

Now how that crushing energy is related to that what type of reduction of sizes you are going to take. And on this basis, this is a very old science right from the 19th century people have been studying and there are lot of different scientists have given many empirical equations. And then it is a crushing theory have been developed. But always there is an improvement you will see the history of these different models that they have developed for the crushing purposes.

And today also there is a scope of developing and modifying some of this. Because as you know that rock is a heterogeneous thing and it undergoes at different places, they will be having a different type of rock.

(Video starts: 03:49)

So, when you will be depending on that which type of rock how we are putting that will exactly require that how much energy to break this rock you might have seen how hard a rock is.

(Video Ends: 03:59)

Now then this if we know how much energy is required that energy in which way will be imparting to the rock. That is why that machine by which will be imparting this energy to rock is called crusher. Now the crusher which will crushed rock? How the rock will be received there? How the energy will be imparted to it? Depending on that the construction and operation of those crushers will be different.

So, as a beginner in this area you will have to know the basic science behind crushing and also, how those equipments are there at present existing. So, that you can think of what type of RND activities or how you will be using them? There are two things whatever the existing machines are there while you are deploying them in the field you will have to increase their productivity. Productivity means whatever input you will be giving for that you will be getting some output.

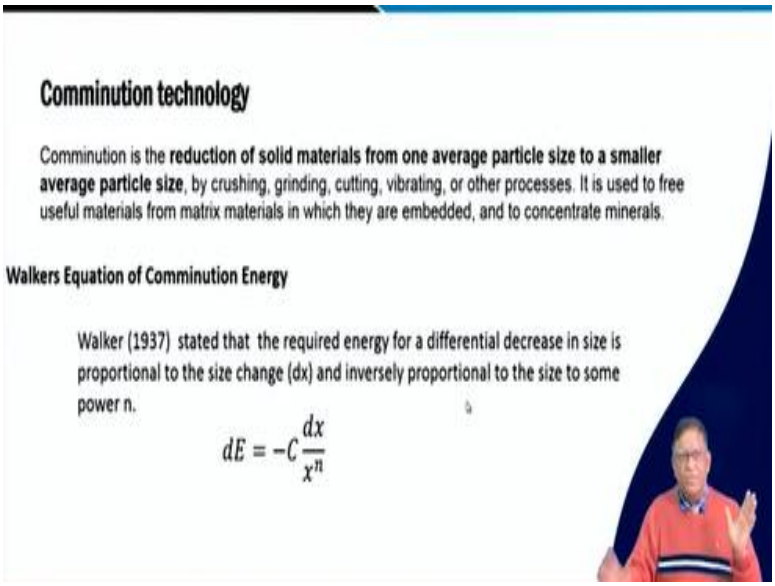
Now your output is this crushed rock. The crushed rock will be whether it is to be crushed to what size from what size to what size, this ratio of the sizes that is one important thing. And how much quantity you are getting per year or per shift? And then for that how much energy you have given? So, your input if it is energy that is your ton crushed or that amount of a particular size produced.

Maybe you want to get production of within the range of your 1 centimetre to 5 centimetre size. From say 1 meter boulders or to that is from a smaller to this size. Now if that size reduction in a 1 shift you do in this much quantity for that, how much kilowatt hour energy you have spent or how much rupee you have spent for it? So, that means that your rupee per ton of a particular size production that could be an indicator for your performance.

And then how you can do a re-engineering if required or you do your operational improvement. So, that the system can serve the industry better way. So, towards that you will have to know the construction and operation of the existing machines which are being deployed in our industry. So, this is the purpose of it. So, your competency in understanding the way it works and that understanding, what is the present level of technology?

And then how the recent advancements of say your information technology industry 4.0? All these terms are you are hearing. Now you need to study this. Where that mechatronics can be used for sensing some of the operations. So, that the sensors can collect certain data. From the data how can you give a decision support to the management for improving the productivity? So, that is the final applications when you will be learning all these things by doing some of the learning activities.

(Refer Slide Time: 07:43)



So, let us talk about what is this comminution technology? It is exactly the reduction of the solid materials from one average particle size to a smaller average particle size. So, this can be done by different way. It may be by crushing it maybe by grinding, it may be by cutting it may be by vibrating many things may be there. The size reduction you know that crushing means by applying an impact force or a high force.

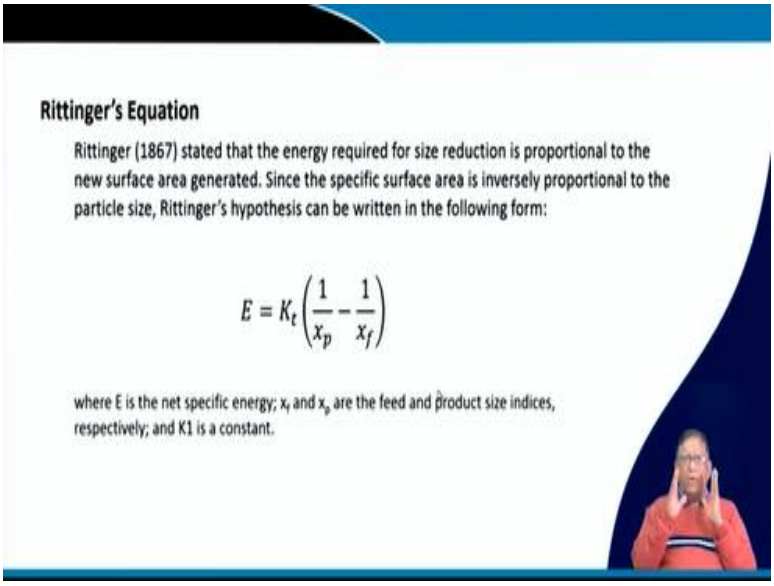
A grinding may be sometimes by giving a shearing that by that moving it over there. So, that your fine particles are there. Cutting may be small you have seen that woods are cut by different by showing they are also by it is reducing the size. The vibration sometimes if you keep the things in a shaking things then they will be started breaking down themselves. So, that vibration may also give an energy that is exactly what happens.

Maybe you will be seeing some milling like autogenous mill and all that particle to particle they themselves start striking each other and they break. So, there are different way this energy required for the crushing or size reduction can be imparted. Depending on how you are imparting the energy to the rock your machines will be different. And the purpose is known to you. Now it is only for liberating the valuable mineral from the rock.

Now these studies there were number of studies as I said. The Walker he studies in 1937, he founded this hypothesis. He proved it that the required energy for differential decrease in size is proportional to the size change. If your size change that is from x 2 - x 1 if that dx is the side change then whatever the original size was there that is raised to the power n that becomes that exactly he found out this is a hypothesis. Then he did a lot of testings.

And from there he found out what is that constant C and then they got an equation. So, that is why whenever you find an equation do not take the value of C from there. It is all such type of equations where the energy is estimated. You will have to determine the constants from your rock mask by doing the same experiment. That is why in all mineral processing laboratory or in anywhere wherever you are studying this energy you will have to do the experiments. That is an experimental study so far.

(Refer Slide Time: 10:30)



Now there is exactly the genesis of this what you have got over here as a Walker's equation it is exactly from the original studies of the Rittinger. Rittinger in 19th century 1867 at that time came out with this famous equation by stating that. The energy required for size reduction is proportional to the new surface area generated. This is a very important thing that means whenever you break a thing, what happens? Exactly your surface area becoming more.

You might have seen that you may take potato chips in a packet there what is there? Maybe if you take 3 or 4 potato their surface area and then if you take the chips that is your 3 potato that can give us so many number of chips and then more so having this you forget about the peri circumferential. You just take the both the sides how much the surfaces are there the total surface will be?

Then you can see even simply if you want to make a potato, 4 pieces how much energy or time required? But if you want to make number of pieces you can see how much time you are giving a cutting chips over there in the kitchen you can see. So, that means the energy it is proportional to the more the surface area you want to create more energy will have to be given. And that how Rittinger given this hypothesis and then he maintained that these 2 variables.

That is what is your feed size and the product size. When you are cutting or reducing the sizes of a potato by cutting the size of the potato which is there in that was the input size. And size of your chips small pieces that are there your products. Even if when a big rock is there say maybe your that is 1 feet diameter diagonal diameter rock sample is there. And you have crushed it by hammering and then you are getting that is your 0.5 centimetre 2.1 centimetre diameter small chips get this.

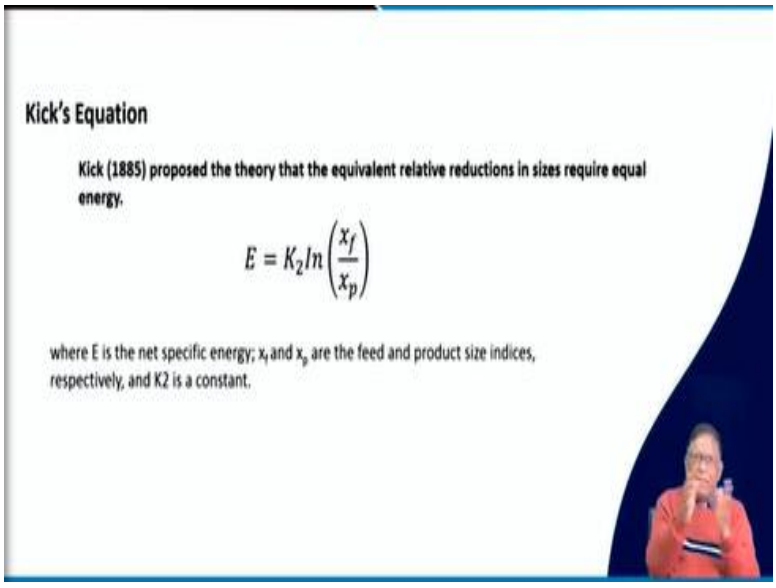
So, that means what this x p and x f that is your product size and the feed size. Feed size is always bigger. So, that is why it is minus. That you know that if the bigger it is in the denominator so that person is there. So, this value energy is always a positive energy. You can change that K t is the constant which you will be getting for different. So, it gives you I think you can yourself do a study you can take whatever if you are now doing online classes you take from some chalk pencils.

You can take some of this maybe a brick. Maybe you take some piece of coal somewhere over there in your house. You just take a platform from where you just measure the height. Let the things to fall and then that means that you can find out that how much you have raised the height that is the potential energy you have increased. Now you can apply that energy to the rock when it will be falling onto the floor. It will shatter into number of pieces.

Now you collect that you put it inside this. So, that you can properly collect it over there. See that what are the sizes ranges that coming. From there you can see that what is the smallest size you are getting you can measure if you are a Vernier. Otherwise, you can just take a small piece of rock. And then you assume suppose it is a circular you use a thread by measure it surrounding area over there measure the length with a scale.

Roughly you will find that your chalk might be breaking into some very small where you cannot measure with your scale. You can estimate it may be say 0.1 millimetre or may be like that estimations. But some estimation you will get. Then you can find out the energy required for dropping a coal, a brick or a rock which one is taking more energy do that experiment you will be able to verify this Rittinger's equation. At home wherever you are there you do a scientifically go to the study your study will be ok.

(Refer Slide Time: 14:42)

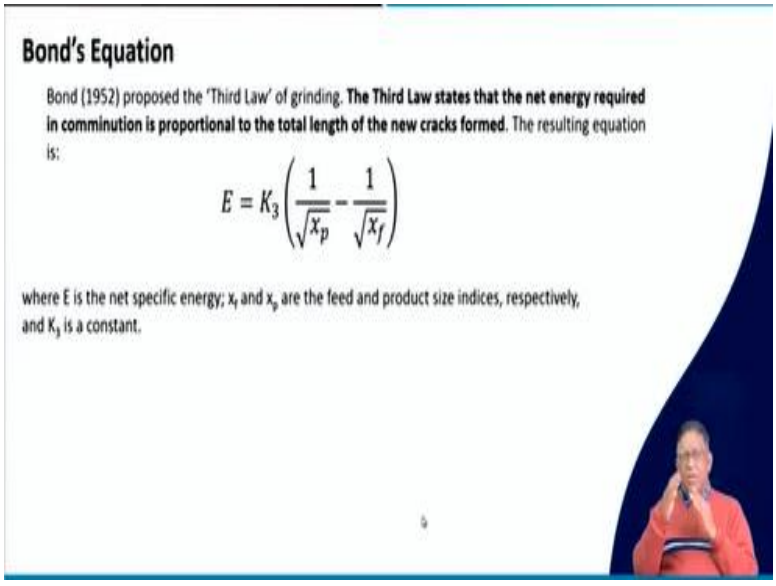


Then same thing in the letter after Rittinger did that same study when Kicks he did in 1885 and he proposed the theory that the equivalent relative reductions in sizes require equal energy. That means if you are having that is your feed size and the product size their ratio. If you are doing several separate that is go on breaking this ratio exactly that give equivalent reductions it is proportional to that.

So, this is also the same doing a little experiment you can verify how he found it roughly. I am not telling that very accurately that is exactly to do an accurate they will be telling a particular set of particular equipment, particular things. And they will ask that that somebody will be manufacturing that in a foreign country will be coming to us and then only will be knowing over there. But do not wait for that.

If in the laboratory no instrument is there do whatever there at your home and try to verify if it is there if you can see a trend yes, no need of exactly because here we require the knowledge part of it. So, that we can think of a better way of doing the things in future.

(Refer Slide Time: 15:56)

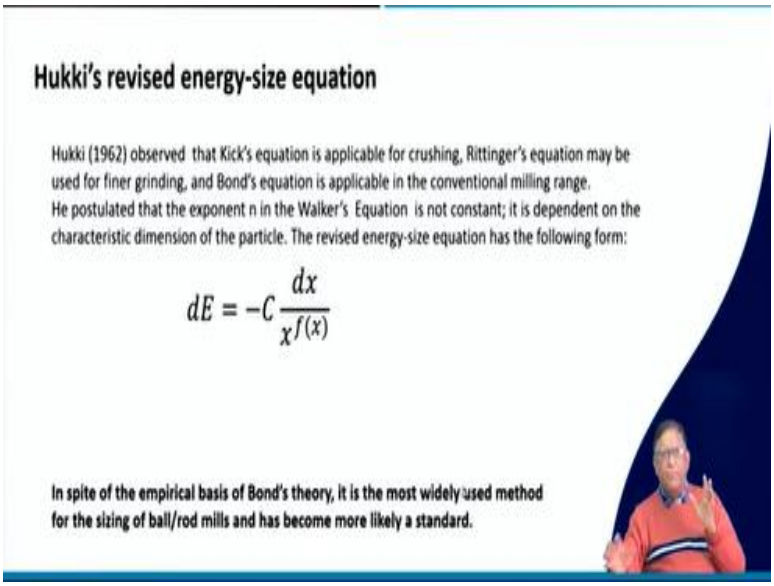


So, now after that what happens? This is a famous study after that about 50 years there were not much bigger study if you see the literature but the Bond's equation and then the Bond law that is they say it is a third law. But he did it for this grinding little bit for the producing finer sizes for

the mineral processing and overdressing purposes. And he gave this equation that is the net energy required in comminution is proportional to the total length of the new cracks formed.

Here we are giving that is because whenever you break there will be some crack is forming and from there it is breaking. So, from that crack propagations theory the fracture mechanics those things they applied over here and came out with this equation.

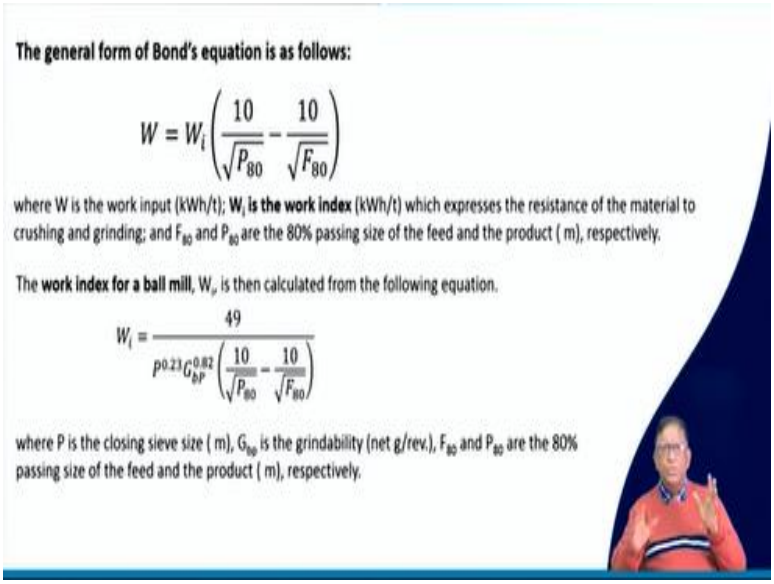
(Refer Slide Time: 16:54)



And then the Bond equations exactly were studied by again with Hukki. He gave this equation and then he observed from the earlier whatever the Kick did, Rittinger did and then he came out with this. After studying all the things that in a milling when you are making finer of these particles ultimately for the final your liberation purposes, he postulated that the exponent in that your Walker's equations whatever that external was there that is not only a constant like n.

It is a function of the size. This was his observations and again he did a lot of experiment and he proved that this is the equation. Now all these things are postulated and proved and then used by as an empirical. But this everybody ultimately, they agreed that this is the Bond's equation.

(Refer Slide Time: 17:57)



After that the Bond's equations gave what is called a work index. This work index that means that constant whatever they found they found that this different rock gives a different type of constant. Then they define that this particular constant for a particular rock can be defined as an indicator called your work index. So, that depending on the work index you can find out that which type of rock will be requiring more energy to break.

And that is why here what happens again this two denominator, P 80 and F 80 it is to be there. So, suppose you are taking a particular size you want say 10 micron size or you want that 2 centimetre size then you will be taking a screen. We will be discussing about the screening later on. But all of you know screen because whenever you purchase your atta for making your roti I think always in your home.

So, that you do not want some of the dust and that husk in that atta you always your mother might be screening with that. So, I think every household there is a screen or you know about your tea strainer also is a screen. So, they exactly allow some of the very powder type of tea you cannot strain with the screen. Those are some of the very different types of tea lovers. There are some these which we always take a lot of even a clothes a fine cloth.

For particularly (FL: From 19:35 to 19:38) you can use that for screening purposes where there is a very powdery components of the tea leaves are there. So, you can see that when you use a

screen there is a size of that how much is going. If a screen on that you gave a feed in the product you find 80%. That means 80% is passing through that hole that means it is having a P 80 size you are getting that whatever the size up to 80% goes that way.

Similarly, the feed is also screen and it is going through that. That means now what happens even you are crushing all the materials into less than 1 millimetre size. It may so happen in the screening that all the 100% will not go through that. Why? Because there will be different blending of the whole cell. So, the particles have got chances of the getting obstruction over there.

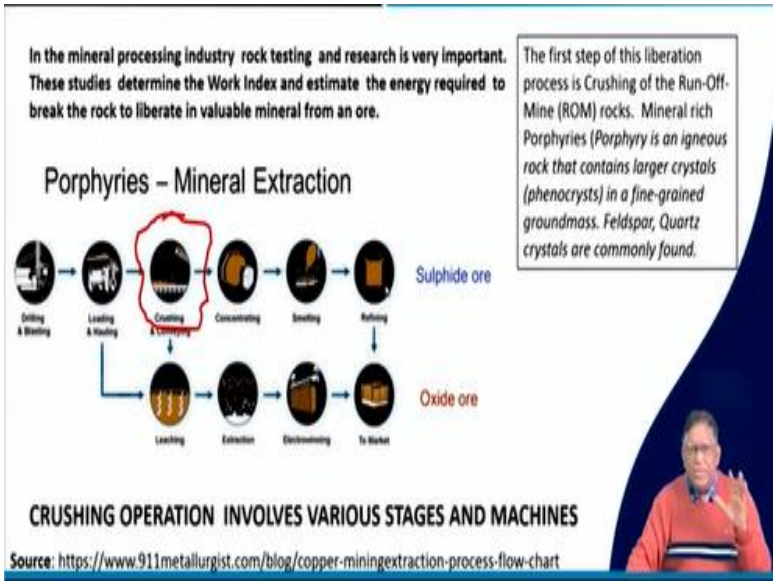
So, that is why your crushing and screening when it is together, we always say that ok 80% which has gone that size will be taking. Then they give that a work in this in a ball mill. Ball mill means where we will be having very spherical balls of a very hard material like your iron balls and then you are putting gold ore. So, whenever they say gold ore is put into a mill to crush it further very grind it for fine things you mix that ore with some of the very hard balls and then take it in a big trommel.

Trommel means a cylinder in which you are putting that thing from one side. Along with the ball and this your whole material together and you rotate it. When you rotate it at a particular thing that all the time it will go up to the top and then it will fall down and different way. They will be having lot of grinding actions in between and that mill there they have asked this work index for a ball mill it is given by these equations.

Again, here the figures and numbers which you are getting it is for the study how bound it. But in our mining industry in the mineral processing, you will find that these types of index studies are done. If you make a little bit of search that what is there in the Tata Steel, Noamundi iron ore mines how they have done or if you see that in Bhilai for the Dalli Rajhara mines iron ore when it is coming you are putting it to a mineral beneficiation plant.

What type of crushing energy will have to be given? This test may be there. But as Indian studies many of them are not published properly you may not find but still I know that there are a lot of studies have been done in a mineral processing departments of our country.

(Refer Slide Time: 22:40)



So, after these things the mineral processing industry and this rock testing research is very, very important. So, from all these things you have learned that there are the crushing energy is required. And then for different operation of crushing at a different stage of crushing we will have to put that, that means how our run-off-mine from the ore or that mines whatever we are getting we may get different type of rocks.

A coal is coming or many of that your copper or your gold and all that thing you will be finding for zinc mines. Those are uranium. They will be having a porphyry. I think in the rock what happens that igneous rock when they are coming that many a time you will be hearing this word that porphyric or porphyries. Porphyries are nothing but in that whole your igneous rock if you see on the roadside also in that stones there are lot of different grain that is your grain sizes are there.

When a rock this porphyries word is related to the texture, you may find there will be some greenish or there will be some very brownish colour of big particles you can see in a rock. So, those are exactly. And on the basis, there are very some fine grain particles a rocks a stone like

that a porphyry rock mostly the igneous rocks and all which exactly form our ore. There will be having this type of different grain sizes. So, they are very hard also.

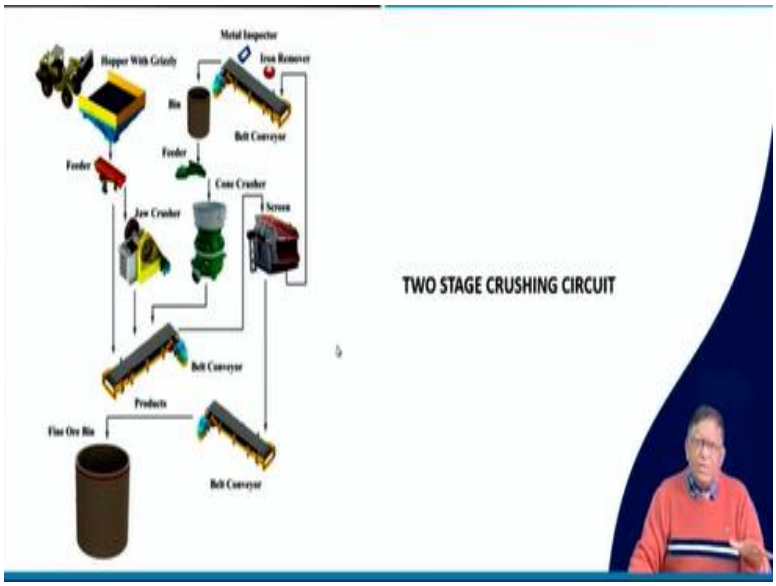
Now these rocks or stones when it is coming from the mine are producing them by blasting. You know that in the blasting they done the size reduction that is your in sheet rock mass where it was there that the first reduction has taken place. You put the hole by the drilling process. There is also different breaking. We are not talking about that. But when explosive was done, they are producing this blasting which is again affected by number of in situ conditions, uncontrollable parameter.

How well ever you design? But there could be accidentally big boulders and things. And then in the mine today it is exactly the blasting technology has improved. Your crushing load in the plant may be reduced a lot by doing a proper blasting over there. So, in that whenever you get these different porphyries rock you will find that what is the mineral extraction process exactly from the drilling and blasting that blasted rock is taken by truck to this crushing.

And then there could be different sulphide ore or oxide ore. Normally sometimes this oxide ores and all they do by leaching and extraction and all. But they also go to this process of collecting the ore for the minerals after crushing or if you are getting a sulphide ore there also it will be going that after crushing then you liberates the particles, they are going for the concentrate you make it and after that it will go to the smelter.

And from there you will be doing that refinery or that mineral beneficiation plan. You will do that thing and from there it will go to the metallurgical plan.

(Refer Slide Time: 26:14)

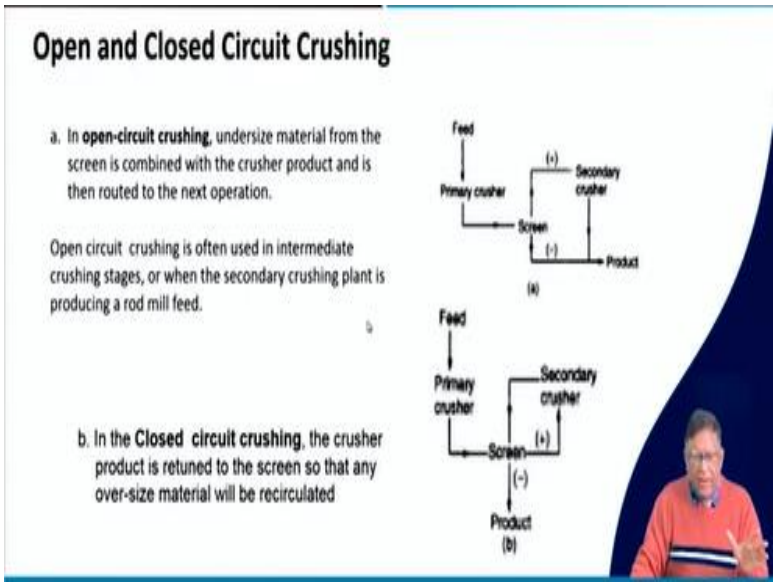


Now this crushing operation involves various types of machines now. So, here you have seen that energy is required and depending on the rock you will have to select the crushers. Now there are different stages of crushing when from the mines rock is coming you are putting on a grizzly. Grizzly is a type of screen we will be talking about it. It is just a hopper you have studied that hopper where it is coming over there.

There is a platform and that a whole the bigger size will be taken out. And the smaller size will go. And to a feeder you have studied already feeder. From that feeder it will fit to a jaw crusher and then this jaw crusher will be taking the material that whatever your undersides were there some of them they come directly to the conveyor belt. And then they go to another that is your another thing is whichever you are getting cone crusher that is your next stage of crusher.

So, when this material is given to the screen. This screen is separating to whatever the undersize is going for your giving as a product oversize is going and giving over here that remove the iron and all that thing. And then they will be keeping it over there. So, this is the way the mineral processing operations are done.

(Refer Slide Time: 27:29)

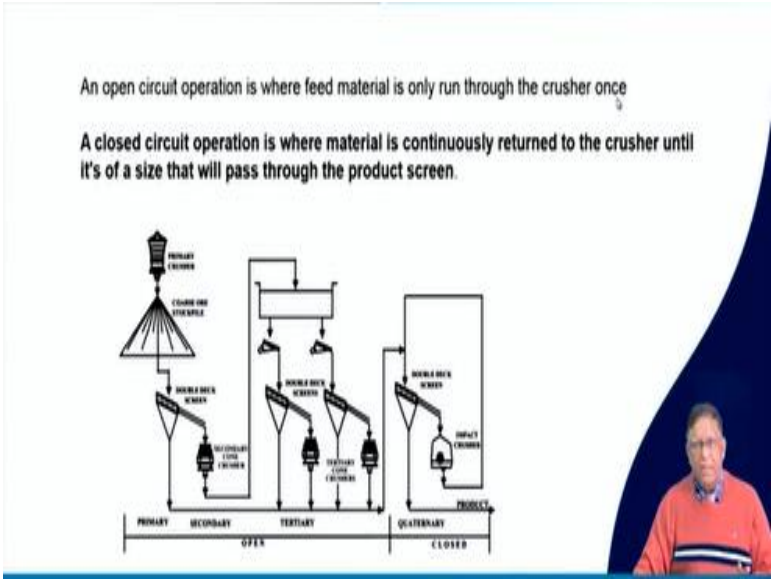


Now when we do this crushing in the field you have seen that there are different processes are there and different level of crushing. There two types of crushing comes; one is called your open circuit another your closed circuit. Now what is this open circuit crushing? You just try to see over here the differences what is done that bigger size which is coming the primary crusher is crushing it and then the screen.

And from that screen it is sending as a sum is going as a product and then the oversize is sent to a secondary crusher. Now once this material is fed to this crusher no material is coming back to this crusher again because there is a separate secondary crusher. So, this is open circuit. Now in this case what is happening? There after the screening some is going to the product. But this second part is again coming to the same crushers again and again.

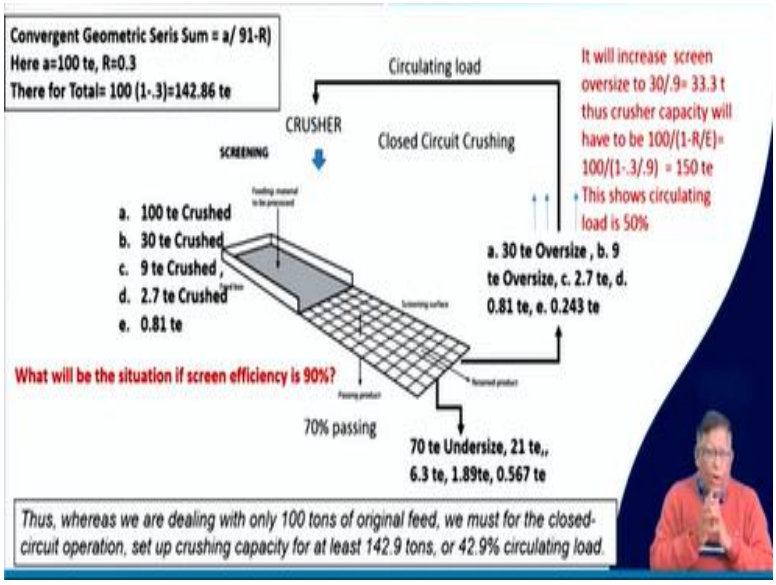
If the crusher that is in a closed circuit crushing the crusher product is returned to the screen you can see here better way.

(Refer Slide Time: 28:40)



That is an open circuit operation is where feed mineral is only run through the crusher once, but in a closed circuit operations they can come back. You can see here that is this crusher when it is impact crushed crushing it over here. And then the product is again going over here to this screen unless and until the whole thing is coming into this product that some portion is always going back again to this cursor. So, this is a closed circuit. And these are all open circuit because the crusher is not taking the feedback over here.

(Refer Slide Time: 29:22)



Now, these crushing operations, what is happening? If you are doing a crusher operation by a screening let us, think of here. This crusher has done and that 100 ton out of that 70% is passing through as under. So, it is a closed circuit crushing. There will be always some circulating load.

What is that circulating load? Suppose that 30% was not getting through that was not crushed. So, then what will happen?

That out of that 100 ton 30 ton will be going at the oversize and that will be again going back to circulated. Now when that 30 ton is coming out of that again 30% is going. So, that means your another 9 ton is again getting for a circulating load. Next time what is happening? That out of this 9 ton it is 6.3 ton is coming over here your 2.7 ton will be again circulating. This is the way it will go on circulating unless and until whole or whatever material came over here is going to the process.

Now in this what is happening over there? That means what happened to the how much load is circulating? So, that means this capacity we are telling as a 100 ton. But in fact, that circulating load another extra load it is taking. So, that is why if you see as a geometric series that is sum it is the geometric progression ratio is the percentage over here. Then if we are having a 100 ton that percentage ratio if you see this is not 9 sorry it is a bracket 9 was the bracket typo here.

So, that is why that you can find out the total 142.86 ton is going through this crusher. So, that means in a closed circuit there is a circulating load which will be telling that this capacity is not exactly 100 ton though it is a 100 ton crusher but there is certain amount is going more. So, that is a circulating load here about 42.9% extra circulating load is there. Now another question comes over here what will be the situation if screening efficiency is 90%.

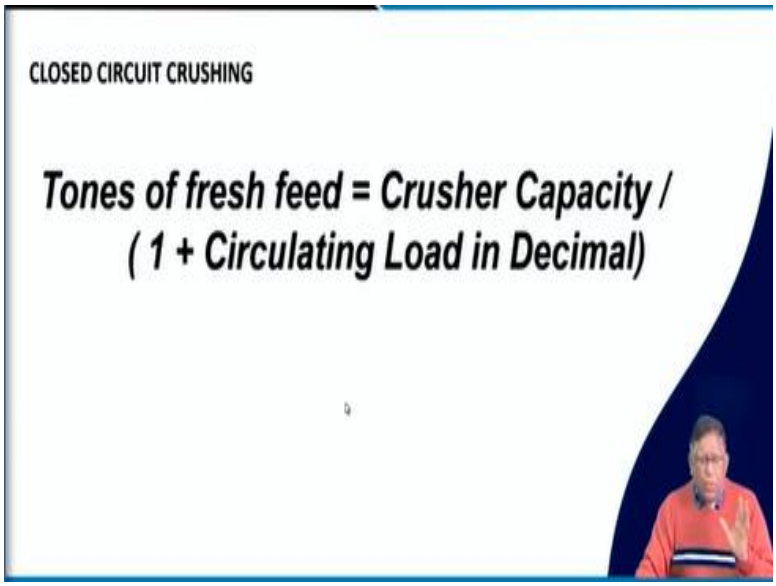
That means this screen which is designed for getting 70% to pass. But the screen has got an efficiency because as I said that screening is also different type of screen we will be discussing if it is a vibrating screen material is advancing through vibrations or that at that time what happens that whatever the particle is falling in between in the centre that will be passing. If the better under vibration one per particle is coming on the edge of these two holes it will get jumping but it will not pass through.

So, that is why does how the screen is designed that your 100% will never go. We are telling 90% go. So, in that case what will happen? If the 90% then it will not go 30%. That is 30 ton will

not be there because now that screen efficiency if we divide this one that means your 33.3 ton will be coming over here. That is that 10% extra will be added over there. So, like that if we see the overall that load without that when we considered as a 100% efficiency, we were taking this formula that is your 100 by 1-R that ratio.

But now we are dividing it by R minus this efficiency. So, this gives about 150 tons. So, almost 50% more capacity over there.

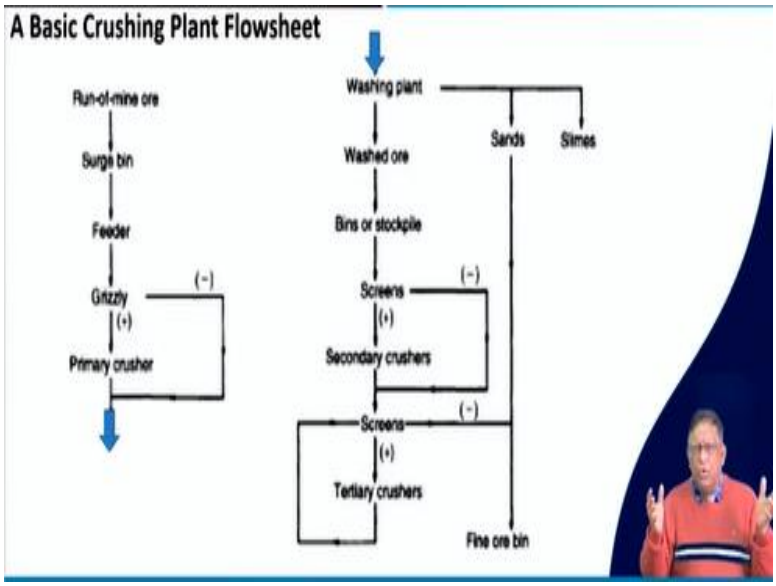
(Refer Slide Time: 33:17)



So, that means when we need to know about what fresh feed will be coming? Why you are telling here that the circulating loads because next time whatever if you are continuously feeding? What will be the load of feeding? Because if you are having a 100 ton capacity of this crusher in that 100 ton crusher but it is a closed circuit all the time this much stone is recirculating. So, next time once you have given 100 ton unless and until this whole thing is crushed.

If you put another 100 tone what will be there? There will be over spillage then the screen also will not be able to take care of things. So, that is why what is the circulating load? That will be determining how much fresh load you will be putting.

(Refer Slide Time: 34:06)



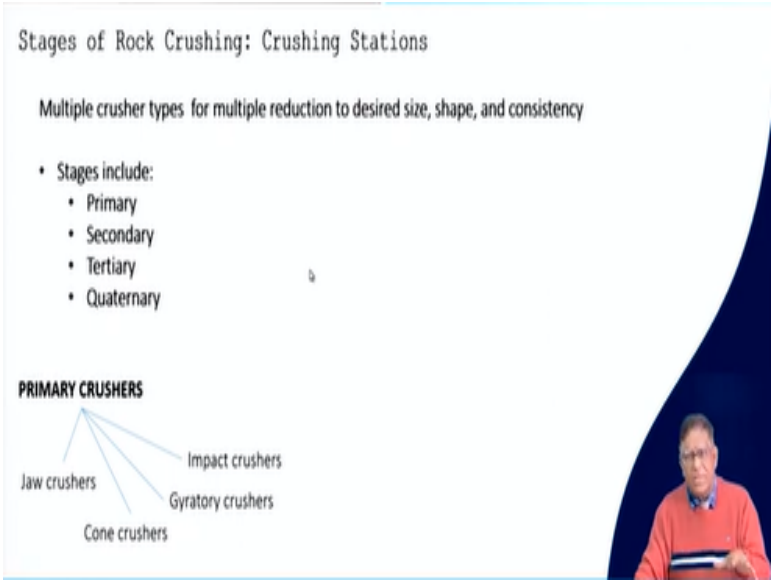
So, I think you have understood that when the crushing is there that depending on the closed circuit and open circuit your whole system design will be changing. You need to study a little bit on this, then the basic circuit of the different flowcharts how it goes? There will be in between storage. You can see the surge bin then the feeder then grizzly. So, now you will be able to when you study the book you have already studied about what is the feeder? What is a bin? What is a silo?

And how they are put in a crushing plant and or in a beneficial plan you will be understanding. So, start looking into some of the circuit you may find in the net. You try to find out what is the Harty gold mine? In the gold mine gold processing plan what is the circuit? You can study about in the uranium that the corporation of India limited that is in Jaduguda. They have got the uranium processing plant. In the uranium processing how this screening and crushing is carried out.

You can see at a Noamundi or at a Meghataburu, Kiriburu. They have got the iron ore beneficiation plant. You can also think of NALCO. They have got the aluminium bauxite mine. How the bauxite is processing over there? Number of things are there. Depending on wherever your home town? Near your hometown whatever the mineral industry is there if you are living in Dhanbad you go to any coal washery there you will find that how the coal is broken and sizing their circuits over there.

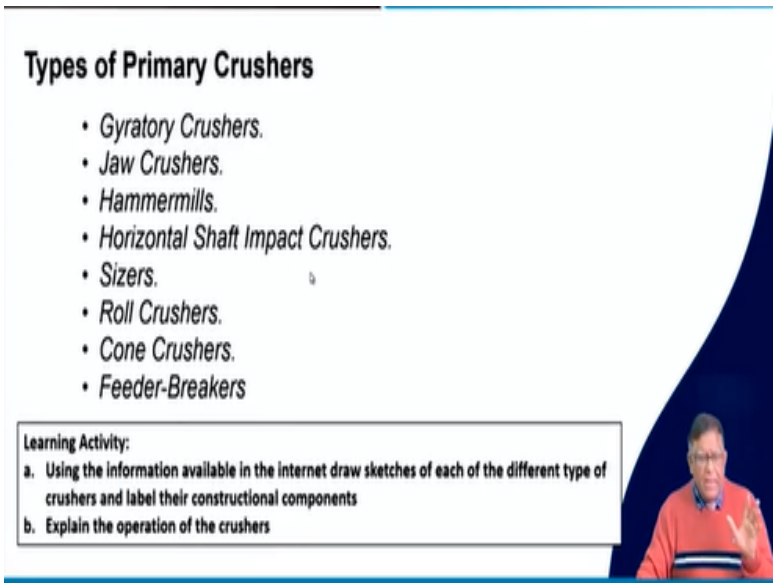
So, in our country in India you go to any state every state has got some or other mineral and there you can see the crushing circuit.

(Refer Slide Time: 35:44)



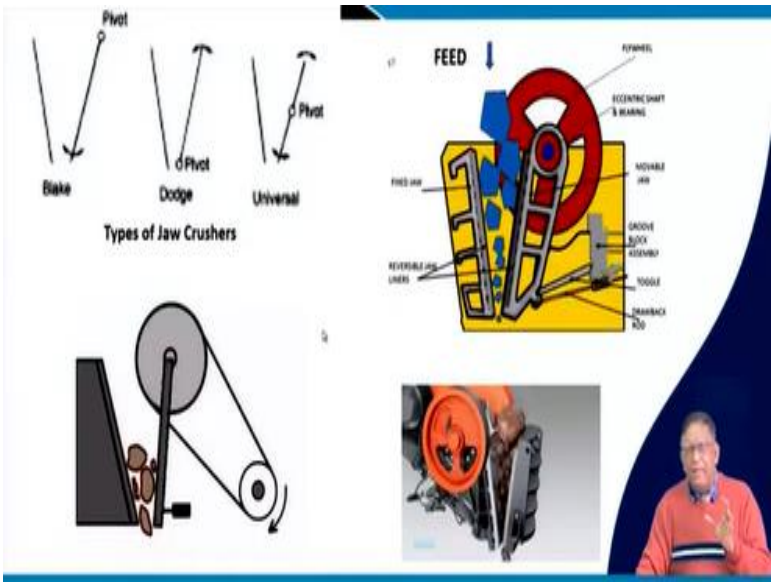
And then you collect the information from that and do it. So, when we do this crushing, we have to know that there are few stages that is primary, secondary, tertiary and quaternary different level of crushing. And that crushers are also primary crushers can be jaw crusher, cone crusher, gyratory crusher even impact crusher. Cone crusher in many places it is used as a secondary crusher.

(Refer Slide Time: 36:05)



Now there are different type of crushers are available. So, in a class everything may not be available to it may not be possible to discuss. So, this learning activity is very important for you and it is to be done in 3 days. That is using the information available in the internet draw sketches of each of the different types of crushers and label their constructional components explain the operation of the crusher.

(Refer Slide Time: 36:31)



This is a job you will have to do.

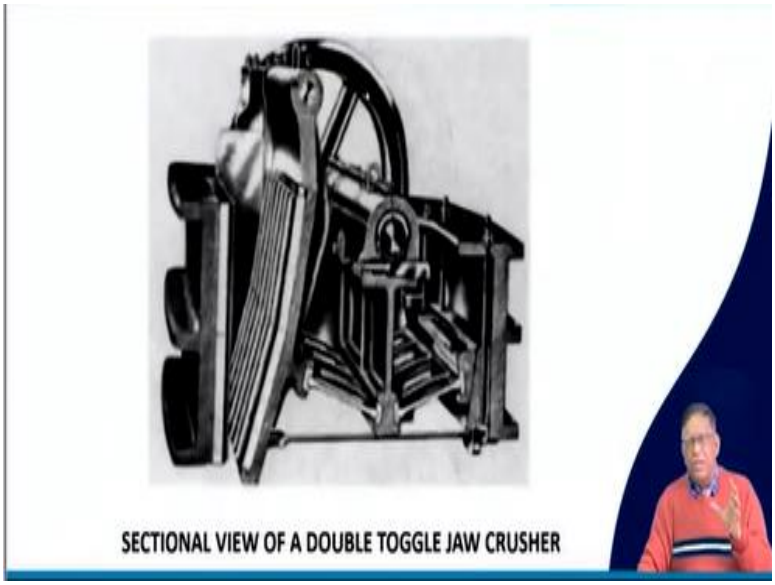
(Video Starts: 36:32)

And there you will find that how that is exactly a crusher as working you can see over there. This figure is not coming properly. But you can see that how a jaw crusher have got a fixed plate you can see that this is a fixed plate and this is a movable plate. When the movable plate is moving it is giving a just that crossing action and the rock is breaking. Similarity you can find out that this movable plate is having there must be a pivot point.

That pivot point can be at the top. Then it is called a Blake jaw crusher. If it is the pivot point is at the bottom it is called the dodge jaw crusher. If the pivot point is at the centre, then it is got a universal jaw crusher. Now that exactly the depending on the pivot point and then here you are just giving a rotations this is the energy basic principle of jaw crushing.

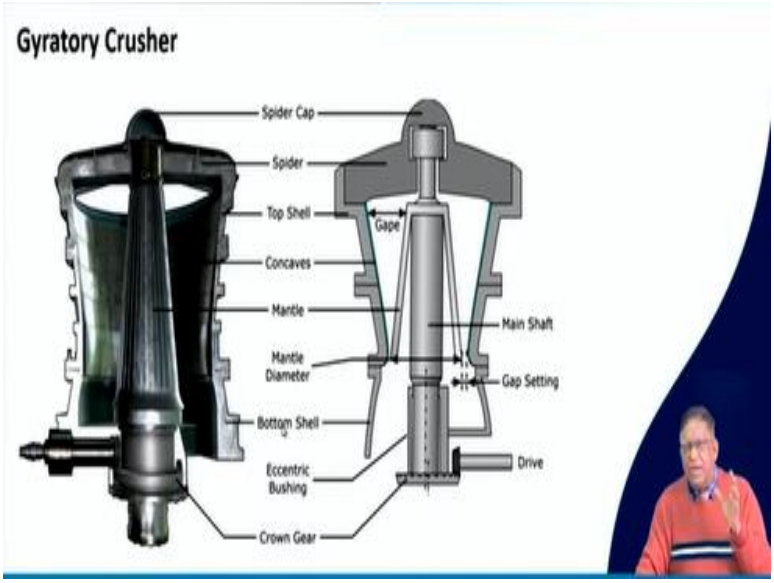
(Video Ends: 37:25)

(Refer Slide Time: 37:26)



And you can see that in the jaw crusher to give that motion here this is called a toggle. Here it is a double toggle this side and this side. So, you can see when there is a flywheel and then the rotations it will be giving and this portion it will go down and up by that exactly this open and close will be done. And then this crushing operation will take place.

(Refer Slide Time: 37:50)



So, there are very interesting and in a gyratory crusher you will find that there is an eccentric shaft. On which this whole thing can give a gyratory motion and then we will be going. And you can see you will be drawing such type of figures where this is called your spider cap and then the spider on which it is hang and the top cell is there. And the most important thing is this mantle which is there by outside you can see this is a very hard surface.

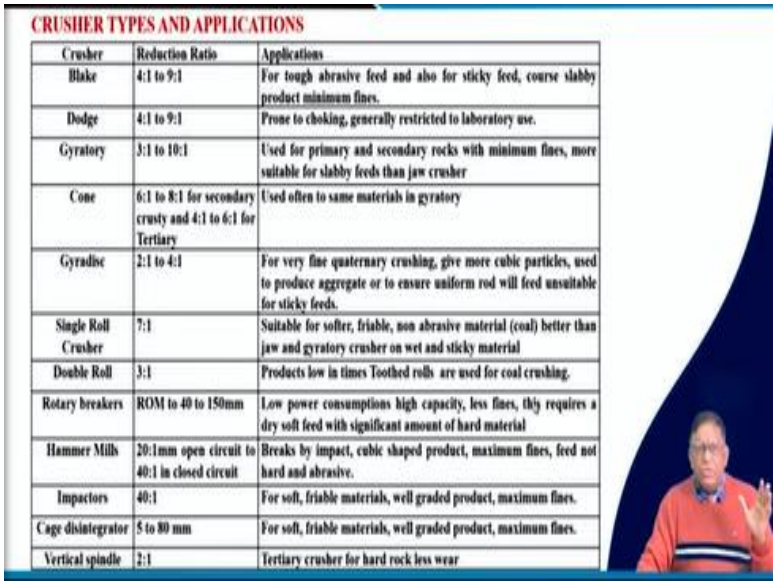
And the rock will be fed over here and that within this gap the rock will get crushed over there and then will be coming. And that this eccentric bush that is where it is there this bearing eccentric bearing is the main thing and you can give the drive with the help of a bevel gear. So, these structures you will have to see over here.

(Video Starts: 38:35)

There are some very good videos available in the net you can study. There you can see how at that mantle is getting rotated over here and then the whole thing is a gyratory crusher. It is one of the very good equipment and it is being used in most of our beneficiation plan and in the ore processing plan gyratory crushers. You can see how it operations and they try to look into some of the videos. So, that you understand how it works.

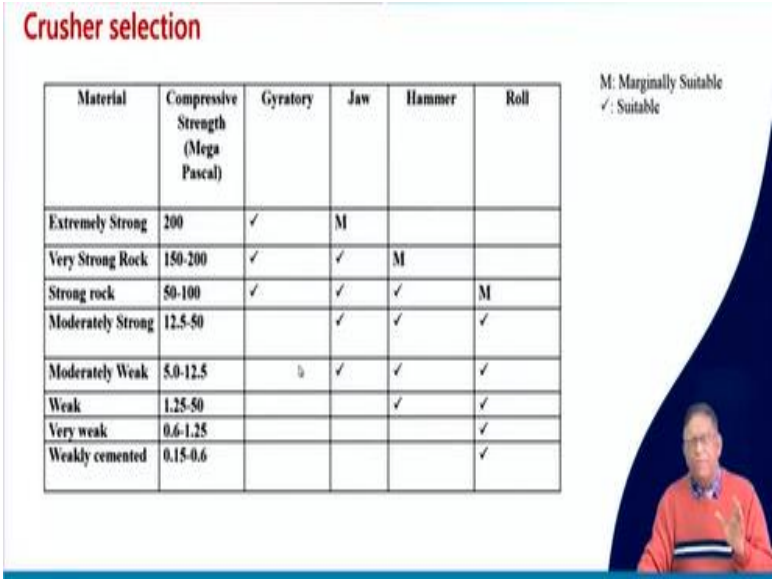
(Video Ends: 39:14)

(Refer Slide Time: 39:15)



And then once you do that there will be the different type of crushers and their applications. As when you will be doing your learning activity, try to develop a table like this. We will be discussing in our next class some of the crushers and their selection criteria but it is what are the different reduction ratio that can be achieved by different type of crusher and where they are applied. I wish that you please prepare a table do not depend on what the class will be giving it to you.

(Refer Slide Time: 39:50)



Material	Compressive Strength (Mega Pascal)	Gyratory	Jaw	Hammer	Roll
Extremely Strong	200	✓	M		
Very Strong Rock	150-200	✓	✓	M	
Strong rock	50-100	✓	✓	✓	M
Moderately Strong	12.5-50		✓	✓	✓
Moderately Weak	5.0-12.5		✓	✓	✓
Weak	1.25-50			✓	✓
Very weak	0.6-1.25				✓
Weakly cemented	0.15-0.6				✓

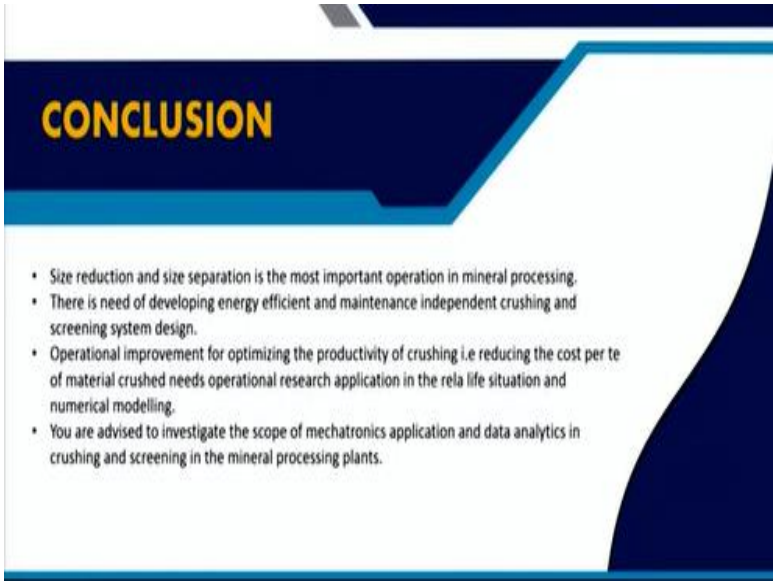
You will have to prepare by yourself for learning. And then you can find out that for what type of conditions what type of rock which type of crusher you will be selecting. Make this table that will make your knowledge clear that if given any situation and you will be able to tell to anybody ask that yes, I know how the different crushers work. And I know that for which type of rock what type of crusher to be selected. That is my competency level.

And you will be confidently appearing anywhere for a job. So, after doing this simple work your competency will be growing up. So, I request you please do the learning activity

(Refer Slide Time: 40:32)

And read some of the references given. There are lot of materials available. Do not get exactly involved in studying all those things do not study much, study a little bit make a table only for preparing the table and drawing one diagram whatever is required please study that do not study much.

(Refer Slide Time: 40:53)



So, I think by now you have got the idea about what is a crusher and then what is the crushing energy. Your size reduction and size separation is the most important operation in the mineral processing. And there is a need of developing energy efficient and maintenance independent crushing and screening system. So, that how you do it? It is depending on your knowledge acquisition and the knowledge applications.

And for that the operational improvement for optimizing the productivity of crushing that is reducing the cost per ton of material crust needs operational research application in real life situation and numerical modelling. So, you will have to do that, you are advised to investigate the scope of mechatronics application and data analytics in crushing and screening in the mineral processing plant.

These are those who want to go further for higher studies and higher educations want to get a specialized and different competency. You will have to do some additional work and if you wish you can contact us, we can do it. Thank you very much.