

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

Lecture - 37
Classification and Selection

So, welcome back dear students. So, today we are going to start a new module. In this we will be discussing about the In-Pit Crushing and Conveying system. It is also called IPCC system. Now this in-pit crushing and conveying system it is introduced in the surface mining. It is not a very new one. It is in the 60s itself these systems were introduced. However, in many countries this has got recently little bit more interesting days because the environmental constraints.

The life cycle cost aspects these are being considered more rigorously. As a result, there is where earlier it was not thought of a best technology for that mines today it is coming up to be more useful. So, we will be discussing about this system.

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In-pit Crushing and Conveying System
Classification and Selection

The In Pit Crushing and Conveying (IPCC) System consists of crushing of the Run-Of-Mine ore/coal/mineral with mobile crushing plants right at the face, or with semi-mobile crushing plants placed at a strategic position within the mine for adopting the continuous transport of the material with belt conveyors.

After going through this lesson you will be able to:

- Explain the components of an IPCC system and their functions
- Classify the different types of IPCC
- Discuss the selection criteria of IPCC for specific geo-mining conditions

The first utilization of IPCC systems goes back to the 60s in a limestone quarry in Höver, Germany

But what it is? Exactly we know that belt conveying system is more economic. Because it eliminates the truck fleet which has got a diesel exhaust as well as more diesel consumption. And the electricity is cheaper than the diesel cost. So, because of that, if you can take out evacuate the run-of-mine that coal or produced in the mines by conveyor system it is always good. Now the

problem is the blasted rock mass that is the mineral or coal produced in surface mining by blasting.

Often, they will be having very large size of boulders. Such type of boulders cannot be loaded onto the conveyor belt and then the transportation becomes problematic. So, what it was done in that case they say inside the mines if you have a crushing plant this crushing plant will size this large size boulders will be crushed into a smaller one and will be carried. At the same time, it is to be also ensured that there more fines do not get generated.

So, these things in an in-pit crushing system basically it consists of that crushing plant which is placed inside the mine and then the produced crushed size material. The crushing plant will be also having a screening facility by which the sized material will be taken out from the mine by conveyor belt. As you can see over here there is a crushing plant. The materials are coming by truck and giving over here and there is a crushing plant.

From that crushed material it is loaded into this outgoing conveyor belt by this feeder here. So, this type of system is in-pit crushing conveying system. So, in this module we will be learning about that how you should be able to explain the components of an IPCC system. And also, you should be able to classify different types of such system which are available now. And then you should be able to discuss the selection criteria for what geo-mining conditions.

In what type of coal or what type of rock you will be using these things. And later on, once you know these basic things you can take up any other problems depending on your interest. So, let us start with this. As I told you that the first utilization it was there in the 60s and this technology is from Germany. Germany first introduced this technology.

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Components of IPCC

A typical IPCC system comprises of:

- Fully-mobile, semi-mobile or fixed in pit crushing stations
- A network of conveyors
- Spreaders (for waste) or stackers (for ore)



Takaraf's Relocatable Crushing Plant at Cliffe Hill Quarry, UK



Now as we said that what is the component of an in-pit crushing system? We will have to have a crusher that crushing plant which can be fully mobile or that means it can be a crawler mounted crusher which can move it or it can be a tire mounted crushing plant. It will be just following where the shovel is excavating. It will be just going and crushing over there. So, it can move or as the shovel is moving it can also follow at the back side of it. That is fully mobile.

Sometimes it is a semi mobile which is exactly relocated for some time. As you can see over here this is the crushing plant which is now on the top of a transporter. This transporter is transporting from one location to another location. Because up to that location the material may be brought inside the mine by truck and then load it over there. So, that is a semi mobile it is not a mobile but it can be. And there are certain as a fixed type.

That is fixed type means it will not be dismantled during the life of the mine. Maybe at a corner of the pit or at some strategic location it will be placed. Now depending on that we will have to have a network of conveyors also. From that wherever the crushing plant is located from there it will have to be taken out by conveyor belt. If it is a mobile conveyor that means from the crusher crushers will be having its discharge.

And from there it will have to be received by another conveyor belt. And then it will be feeding into the main conveyor belt. So, there could be a network of conveyor which can start near to the

crusher. Maybe a mobile transfer conveyor which will be transferring the material to a shiftable conveyor belt which will be having a proper feeder. And then that shiftable conveyor belt can give to a number of conveyors so that the material can be going into a place.

Alternatively, this could be also associated with either a high angle conveyor or a pipe belt conveyor. So, there are different combinations possible. At the end from the conveyor that material will have to be taken out by a machine called spreader. If you are taking the overburden rock mass that overburden rock from the conveyor belt will be taken out by a spreader and you will be forming the overburdened dumps.

If you are transporting the coal or the iron ore from the mines through this your in-pit crusher, from the in-pit crushers to the conveyor belt and from the conveyor belt to take it to the stock piles it will be done by stacker. So, we have discussed about these stackers and reclaimers and all that how the stock piles are from there? So, now you have understood that what are the main components of an in-pit crushing and conveying system.

You have got the crusher unit which could be a fixed type or a semi mobile type or a fully mobile type. And then there will be a network of conveyors and there will be spreader or stackers. So, one thing is clear from here when this is a system, this system has got more number of the components which are interconnected. When we tell about the shovel and dumper this combination of systems we do not have many components.

But there are many numbers of dumpers a fleet of dumpers will be there. Here we do not have many fleets but they are interconnected. But by that when you will be analysing if you want to analyse as a system, it will be coming under as a complex system that is there.

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What situations may demand IPCC?

- New technical aspects in mining projects such as *higher production demand, deepening the mine, increasing the stripping ratio, lower grade, unplanned delays and unavailability of Truck-Shovel systems* etc.
- Changing in the economic conditions in case of operating costs in the last decades such as *increasing fuel price, spare parts* etc.
- Environmental restrictions, which are needed to be followed by miners such as *reducing emissions, dust, noise*, etc.
- Safety and social circumstances that can affect the mining project such as *lowering the quantity of labor force, considering public health, safety, training the employees*, etc



But now we have said that there is an in-pit crushing conveying system. Briefly I have told also that why it is required because of it is going to make some cost benefit or environmental benefit or safety benefit. These three things are very important. Now under what situations you may have to have? Now this is if your high production demand and as you are going deeper and deeper in the mines then your production demand that will be increasing your fleet size.

If your stripping ratio is very high in a mine then what will happen? You will have to remove a large quantity of overburden. Now at that time if your quality of the coal or ore which you are being mining if it is not a very high grade then the price which you will be getting by selling that will not be sufficient to run a very high cost by deploying a number of trucks. Because if as you are going deeper into the mines you will have to remove more overburden and a longer distance.

As a result, more number of trucks. And if the more number of trucks for each truck at least three persons will be required for three strips and then some for that additional about 10% people for managing the human resources. So, a large number of persons need to be deployed. And another thing is this in the mines under the geo-mining conditions if you are having say hard rock on which the tire will be moving. The tire will be also damaging faster.

So, that means large number of dumpers means large number of tire will be also getting quickly damaged and that means your operating cost also will be increasing. So, in that situations you

need to think of an alternative where a large fleet is not to be managed to maintain and then most inventory of trucks, the trucks parts or the tires that will not be necessary. So, now another thing is that is the fuel price is another important part.

That is if you are having large fleet that diesel price is also going high and that cost of energy for evacuation will become more. So, that is why if you can transfer or if you can transport the material by conveyor belt which will be driven by electric power is always better. Then another problem is if you are having a large number of fleets there the tire and the whole roads are not metallic road whole roads are just in the mine as that non-metallic roads.

On that when a heavy-duty truck will be interacting lot of dust will be generated. Now they will easily get airborne and the whole around it will get dispersed by wind. And that is to a large extent the people will be suffering from that is your particulate matter 2.5 in particular matter 10 that is suspended particulate matter in the air will be more. Also, the diesel consumptions in the diesel trucks they will be giving that exhaust gases which are having lot of greenhouse gas also.

So, that means it will be contributing to the climate change. So, thinking all that now we want to do environmentally friendly mining we want to damage as less as possible to the environment. And for that a technology required and IPCC has got the promise for doing it because it will eliminate truck. Another aspect is if you look into some statistics in the whole mining industry the maximum number of accidents that come from the transportation sector.

Wherever there is the dumpers are running and the running stocks are always a source of accidents in the mines. So, if you are using your conveyor belt then you will not be having many rolling stocks. That is your many number of trucks on the whole road there will not be any traffic congestions. Then there will not be any conflict of the truck and the other small cars travelling on the same road. As a result, your safety will be improved.

Also, as because the; people who are working in the mines will not be exposed to more diesel exhaust and solid particular matter environmental problem. Their health-related problem also will be reduced. So, for these situations we are telling that there are lot of benefits of using IPCC.

But at the same time there may be because this system will not be flexible your trucks, they are very flexible wherever you want and you can go and collect it from there.

So, trucks will not be completely eliminated. If you are using a fixed locations at least by truck material will have to be taken over there. But as it may be working only at 1 or 2 levels and there will be short distance. So, number of trucks will be reduced so that is. So, there are some small problems but that can be eliminated.

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The slide is titled "Features of IPCC System" and lists four key features. On the right side, there is a blue box with the text "Ideas for mini projects: How to prove these claims?" and a yellow thinking face emoji. In the bottom right corner, there is a small video inset showing a man in a suit speaking into a microphone.

Features of IPCC System

- Capability of moving **high volume of material** (ore or waste) because of the continuous system of hauling and higher availability
- **Lower operating cost** mainly because of lower electricity price.
- **Lower production of emissions and dust** in comparison with Truck-Shovel system.
- Providing a **safer working environment** because of not using trucks as a moving object inside the mining area and lower need to the labor force.

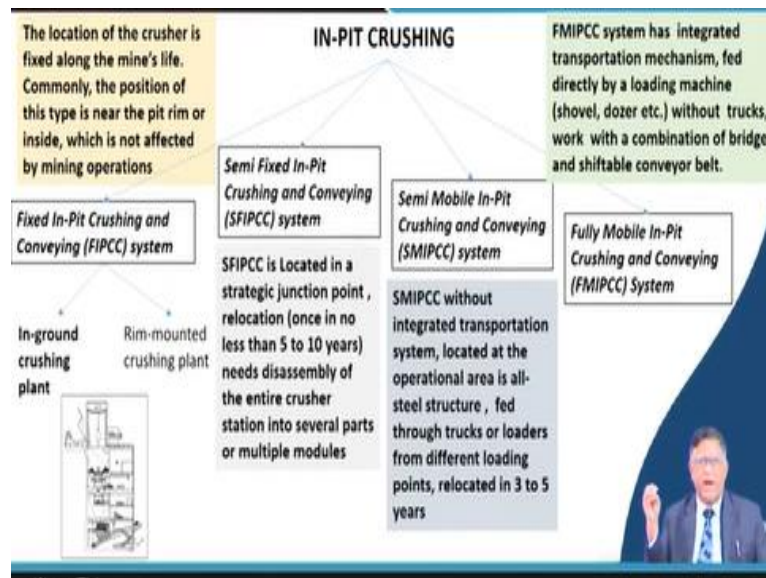
Ideas for mini projects:
How to prove these claims?

Now what are the main features then? If we say this system, it has got a capability of moving high volume of material it can that whether ore or the waste that over burden it is a continuous system. So, it can transport only thing is that if you can make your blasting and the loading system your excavation system if you can improve your continuously transporting will be very easier. And then of course there may be the same conveyor belt can be of higher capacity.

If your crushing takes longer time 2, 3 crushing plants also can be put over there and by that way you can achieve the high capacity. And as I already told it has got the lower operating cost and then lower dust emission and the safer working. So, you know now what are the benefits and what are that exactly that is the features and that will have to be there. Now when we have said this that exactly lower operating cost, low emission dust, a better safety I think this can give you an idea that you can take up some mini project to prove this.

How analytically you can prove that a lower operating cost? So, those who are serious student you can take up a simple case if there what will be the total energy consumption? What will be its operating cost? What are the other thing? You can develop a cost estimation model and you can prove that whatever statement is given over here is correct or not.

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Now we have said that this is a good system it is there. And how we can say that it is a good and it is accepting because now a good number of such types of in-pit crushing and conveying systems are there. Every year nowadays before corona this in-pit crushing and conveying systems international conference used to be there. And there all the world case studies are discussed over there.

So, that means there is at present also people are thinking about of this technology. And they are studying about this technology and you can see that this in-pit crushing systems can be of different type. One is that is fixed in-pit crushing and conveying system you say it is a FIPCC that is fixed. That means the crushing plant on a fixed location. There is a semi fixed in-pit crushing and conveying system which is you can say in 4 or 5 years you can dismantle it and then you can place it in any way.

That is a modular type of things can be there or semi mobile. Semi fixed is that you can dismantle and take it and semi mobile you can make it to move. It can be lifted on a transporter and the transporter it can move that is a semi mobile or it can be exactly a fully mobile in-pit crushing and conveying system. Now these four systems they have got their own merits and demerits.

This fixed type it can be in ground crushing plant that is if the crushing plant is located fixed on a particular location or on a rim mounted. That means it is at the end of the pit or quarry or the mines they will be mounted over there. So, it can be either on a side of your high wall you can make the crushing plant or you can make on the floor of the mines. Now the location of the crusher is fixed along the mine's life.

That means you select the location in such a way that as you make the calendar plan of the mine or that how the mine will be exactly expanding in x y and z direction over time. But then this particular location will not get disturbed and you will be keeping the crushing plant through for the whole life of it. Only thing you will have to select that location of the crushing plant in such a way that towards the end of the mine from the face how much distance it will be coming.

If you can locate it properly and expand the; mine or progress the mine in such a way that this distance always remain optimal. That is throughout the life your cost can be minimized. So, this is the part where we do the analysis of your total life cycle costing analysis to find out where this should be located if we are thinking of a fixed location because if you are taking a far you are having a strike length of 5 kilometre.

And then you start the mining at a place, say at the end of it, then towards the end of your mine it will be 3 to 4 kilometre that material will have to come up to the crushing plant. So, that means that is going to be a costly affair. So, that is why initially where you will be giving the initial mine cut there the locations will have to be taught and then the fixed location of your crusher will be placed in such a way that where your mining has started initial box cut.

They say that near the box cut is also chosen in such a way that mine can be expanding these directions or in these directions or in a forward. So, that throughout the life of the mine the distance to be travelled from your face to the crusher it does not go and exorbitant and that your cost remains as a constant. If your operating cost you can keep it at a constantly throughout your life then it will be good for planning your economic planning of the mine.

So, these are the things which they looked into it and there this type of locations it can be there we will be discussing about how the crusher is there. On a rim they are having that is sure at two levels the crushing is taking place. And then giving it to a conveyor belt and from that conveyor belt the material will go. Similarly, in case of your semi fixed type what it is done? It is located in a strategic junction point relocation less than 5 to 10 years.

So, if you are having 25 to 30 years of that your mines then you are not bothering about initially locations you keep it. That is, you have done and then after 5, 10 years you shift it. So, that again the transportation distance from the face to the mine it can be kept controlled. So, at least you consider the economics for 5 to 10 years and after that it may happen that the crushing plants their life is also some of the components life also will be over there they will require replacement.

So, you plan in such a way that when some of the parts are going to be replaced and the measure overhauling is required. At the time of that your mines also will be progressing in such a way that your this overhauling time you will be doing a major overhauling and replacement. And you will relocate into a nick new position. That is how exactly that your mine the whole bulk material handling is planned over there.

So, similarly in case of your semi mobile exactly it can be transported. You can whole material whole things can be taken into the next positions by without dismantling you will make them to move. And then that can be done say within 3 years or 5 years also you can keep changing the locations. And then the fully mobile one this fully mobile unit means it will be just crawler mounted or rail mounted.

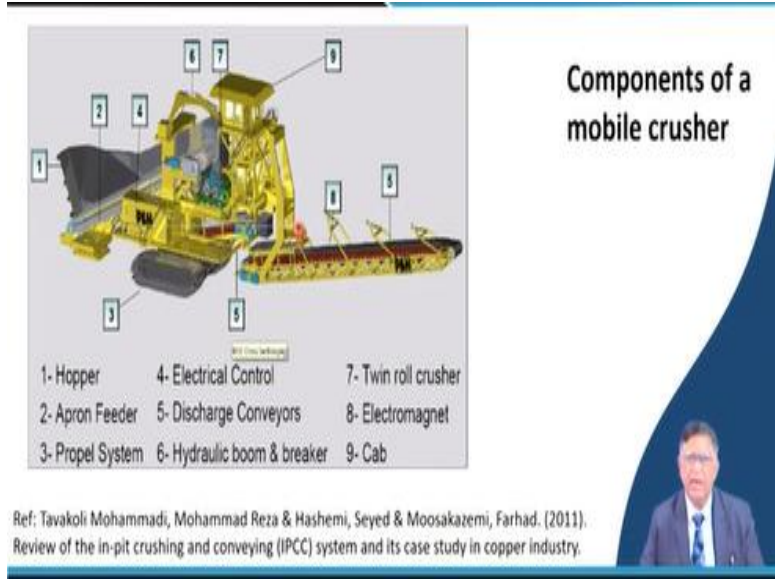
And it will be going over there that is it will follow the main your excavating machinery. So, and there you need not have the truck. That is the crushing plant it will be having a hopper and then your shovel will be loading on to the hopper of the crusher. So, by that you are eliminating the truck inside the mine also. So, this is a system normally that in some of the quarries small quarries and this has stone quarries some of this even in iron ore or some of the hard rock mines they use this type of system.

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So, these are some of the system which is there you can see that how a fully mobile unit looks like. You can see over here that is the hopper and then you can have this part the crushing part is there that it get crushed. The crushed material getting loaded over here and then from there it is going to conveyor belt.

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So, that is how a component of such a crusher you can see here this end the hopper is you are having this is the hopper part. This hopper and then it is giving on to this apron feeder and there we are having a propel mechanism, the travelling mechanism you can see it is a crawler mounted whole crushing plant is movable on this crawler. And then it has got all these electrical control systems for the drives of the motors.

That is for the crawler, for the feeder, for the conveyor belt for the crusher all are there. That electric box and that electric power can be taken over there or in some cases that is you may have the trailing cable connected to this so that the power can be taken over up to here and then it will be following into this. And then we are having the discharge conveyor. This is the discharge conveyor from the crusher it is giving over there.

And then there is a hydraulic boom by which it is if any big things are there which is to be removed like that for that a hydraulic boom breaker it could be a rock breaker. If the feed size is very big then that cannot be fed to the crusher over here. Then it can be broken by this hydraulic boom breaker and then there is a twin roll crusher we will be discussing later there are different type of crusher. For coal this twin roll crushers are there.

I think in our crushing discussions we have told about it. And then there is an electromagnet for if any electromagnetic is kept. If any magnetic that is scrap iron is coming over here that will be

removed by this. We discussed also in some other class and then we can have an operator cabin. So, this is the way how the components are there in case of your in-pit crushing systems.

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Benefits

- Reduction and elimination of Dump Trucks
- Optimal Life Cycle Cost

Drawbacks

- High capital cost, orebody characteristics, mine planning and operational reliability

WITH PROPER MAINTENANCE AND PLANNING, IPCC IS BY NO MEANS ANY LESS RELIABLE

There could be you can see here also this is the system that the whole crusher unit is there. And then from the surroundings it is feeding to the evacuation conveyor belt. So, the benefits we have already said you know now that is it is exactly the elimination of the dump trucks at that optimum life cycle cost. But the drawback is the capital investment will be very high. Though the operating cost may be less but the capital investment is more.

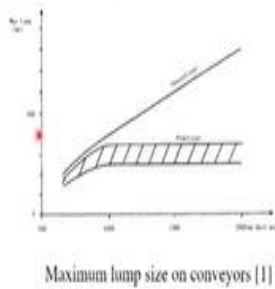
So, when you do the financial analysis, you can find out how it will be? What is the optimal? What is the turning point? Then all type of ore cannot be done over there. That is also an issue in this. Then depending on the mine planning and the operational reliability that sometimes it affect. And those drawbacks can be removed with proper maintenance planning. So, this is that you can make it reliable to work.

And because their systems should not if any breakdown in that or any choking takes place in the feeding or any type of maintenance problem will stop your evacuation part. So, that is why the whole system reliability or the system capacity utilization may be brought down if you do not take proper care. So, that is where the question line is.

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INCC system improves feasibility of belt Conveyors

- Sizing of the material to be transported is a pre-requisite with a belt conveyor transport system.
- Factors such as belt width, speed, troughing angle and conveyor inclination control the maximum lump size that can be transported on conveyors.
- Figure illustrates the relationship between maximum lump size and belt width.



An important factor on conveyor design is the frequency of large lumps. As fluctuations are usually beyond the control of the conveyor operator, a cut-off limit between 250 mm and 350 mm maximum lump size for belts of 1000 mm width and above is usually adhered to



Now you can see that this in-pit crushing systems that is it improves feasibility of the belt conveyor. Because as I said its main purpose is normally for there is a maximum lump size of the conveyor belt that can carry. But thing is that though if you keep the maximum lump size say 51 it is 500 millimetre if you are having a 0.5 meter it should be a belt of your 1300-millimetre belt which will have to be here. In this horizontal axis is the width of the belt.

And then this vertical axis is your lump size. Normally if you are having say this is your 2000-millimetre point. In a 2000-millimetre point theoretically you should be able to use your lump size about 800 millimetre easily you can do it. This is a theoretical capability. But in practical it is seen that if you put that 1 there will be problem either in siding way or that built may sway. Then practically it is only less than 500 can be conveyed over here.

So, that is why when you use a crusher you are keeping the bulk material size within less than 300 less than 400 millimetre. And that is why it becomes more economic.

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Expected Features of Mobile Crushers

1. Mobile equipment should be reasonably compact and spatial distribution of the components should save time during construction at site .
2. It should have improved flexibility
3. It should demand minimal infrastructure for construction and operation.
4. Bottom head of the truck-mounted coarse mobile crushing station is normally high. The width and turning radius should be compatible with the travel-roads and working face design. Travelling speed and maneuverability is designed considering the working constraints.



Now these different features that a mobile crushing unit you will have to have you can study. There are number of things that where what are the main features your mobile equipment should be reasonably compact. So, that it can move and then it will have to have a small turning radius depending on it in the face it will have to be manoeuvrable it will have to be flexible. And it should not demand many a lot of infrastructure for construction and operation.

It should be easily erectable at your mine site and then where the material from there when you will be giving it to the next phase. So, that phase where the blasting will be taking place. So, that this; how the fly rocks and all will not have to disturb it over there. So, your system will have to have the adequate protection. So, these are the expected features in your mobile crusher.


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5. Depending on the size requirements crushers are selected. Cone crusher is used for fine crushing. It can produce fine grained final products of stones and sands.

6. The crushed product should be easily transferred to the transporting units and the transporting machine should be compatibly designed and deployed.

7. The installation of the crushing units on the mobile plant should be easy for installation, operation and maintenance.

8. The crushing efficiency should be high and should save time in various operations.



<https://strikercrushing.com/mobile-crushers-screens/mobile-cone-crushers-available-now/>

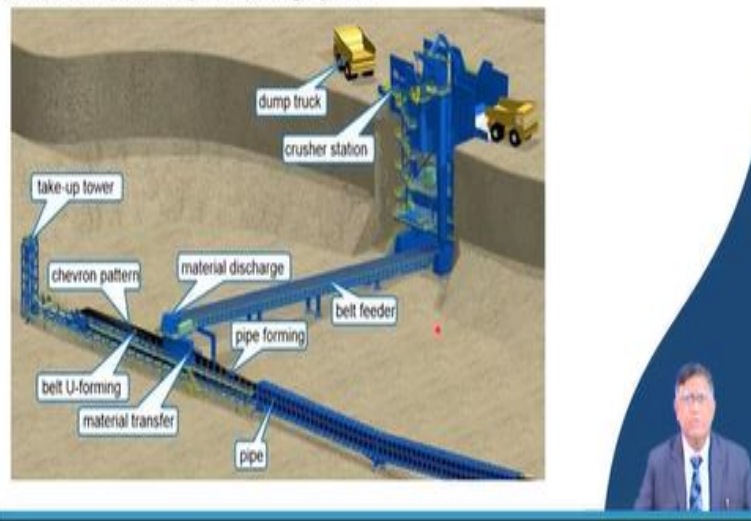
Now there are different manufacturers. They are giving these machines. And you can see the designs depending on the innovations and the considerations of the manufacturer. You may find out different type of them. Now what will be the type of crusher? It can have a cone crusher, gyratory crusher, jaw crusher, roller breaker any type of can be. But depending on for the rock you will have to make that compatibility.

The crushed product should be easily transferred to the transporting units. That is how you will be evacuating feeding it? It can give a directly or you can have your conveyor belt is a discharge boom. In this particular model you can see here is a small discharge boom where you are having a 1200 millimetre belt width is there. So, depending on the size of the crusher and the material that the throughput rate how much ton per hour it is giving you can have the size and dimensions decided.

So, these are once you know that in your operation your characteristics that is your requirements are specified. Then accordingly it could be designed and there are lot of companies they have done over here. So, like Takaraf then you can think of this Sandwik then number of companies number of national companies. They have also started making it.

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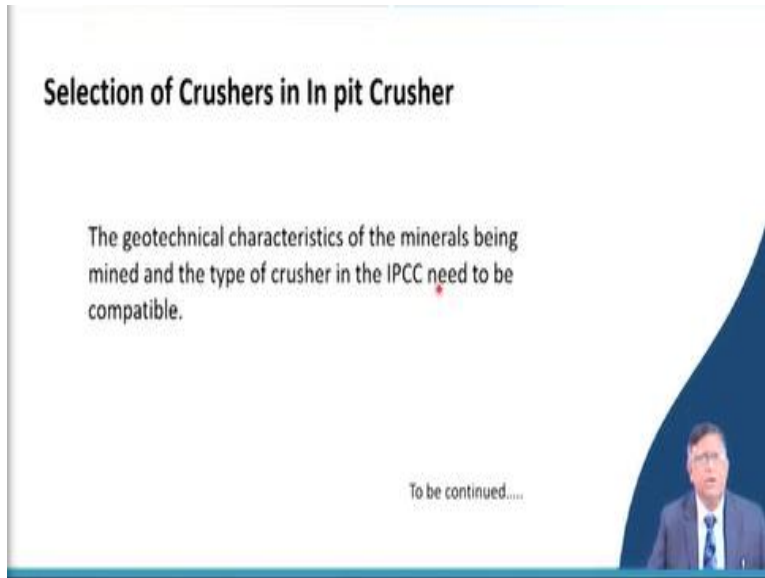
An Illustration of In pit Crushing System



And as an illustration of that whole system when it is used you can see here that it is the rim mounted or fixed type of your mobile crushers here or a semi fixed type trucks are coming and giving on to the hopper here. They will be giving the material. There will be 2, 3 stage of crushing as a vertically and then they are going to give in this to the feeder. And the material is coming by this belt feeder to that hopper and then from that hopper it is going to this is a pipe belt conveyor.

Here this conveyor belt is getting opened over here. And then at the end we are having a take up arrangements and this whole belt is turned so that the lower portions will be going also making a pipe here. And this is I showed you earlier in the conveyor discussions how the pipe belt conveyor is used. So, this is one of the schematic diagrams of a system how it can be used in the mines.

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Now you will have to select the crusher in the in-pit crusher. So, we will be coming and will be discussing those things in our next class. I hope you have understood the importance of in-pit crushing system and how it will do.

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There are the references given over here and you can search them in the internet. Now from the lectures find out the main keywords and do a Google search and find out some study material.

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CONCLUSION

- IPCC system is introduced and their classification is discussed
- Takaraf, Sandwik, and many other companies produce IPC of different features. Students must watch the operating videos of these machines in the utube before undertaking any analytic study



<https://www.youtube.com/watch?v=doNcVs-APvY>



So, this IPCC system is introduced and their classification is discussed today. Takaraf, Sandwik and many other companies produce this in-pit crusher of different features. So, students must watch the operating videos of these machines in the YouTube before undertaking any analytics study. So, please acquaint yourself with this system. There are many good videos available in YouTube.

You will know that how exactly the combination of different components can be made to work as a system as which is called in-pit crushing and conveying system.