Mining Machinery
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Module - 06
Lecture - 30
Underground Mining Machinery Underground Drills and Roof Bolter

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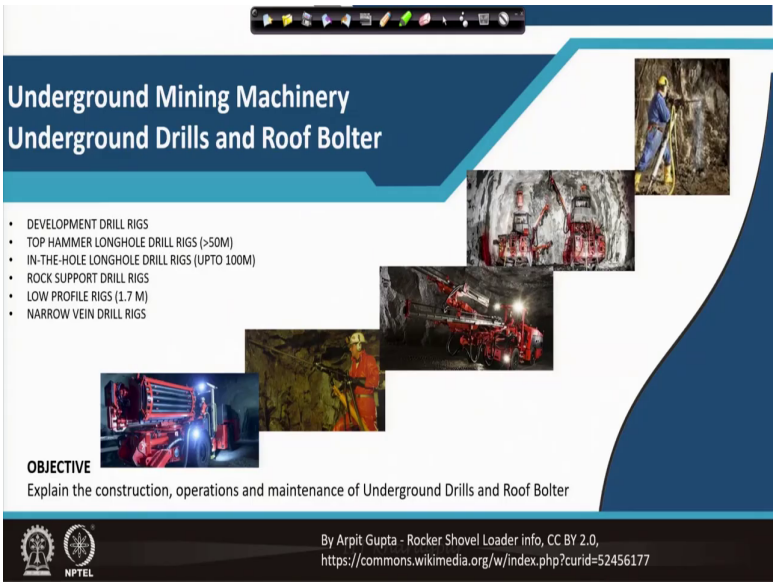

Welcome, today we will be discussing another type of Underground Mining Machinery. There is a underground drills and roof bolter. You know that basically the mining operation is a rock breaking operations in which we will have to make in a different way of rock breaking machineries are necessary.

So, today we will be discussing about how drilling machines and roof bolting machines are used in mines. So, our objective is to understand the construction operation of these

machines. So that we can think of how we will be maintaining such machines in a while doing a mine management.

Now, this purpose of this roof bolting or drilling machines, they are used for different operations like we have got some developmental drill rigs are there for doing the mine development activities. There are some long hole drilling that is they will be making for many exploration jobs over there.

Sometimes in metal mines and hard rock mining, we have got some in-hole long hole drilling rigs there are also that is supporting drilling rigs which are exactly for doing the cable bolting and for roof bolting operations how they will be making holes to make that. So, there are sometimes narrow vein drill rigs like that different type of underground drilling machines are manufactured by many companies.

In India we are having Atlas Copcos Farm as well as that is Sandvik has also got farm in India other than that some drilling machines were manufactured by other companies.

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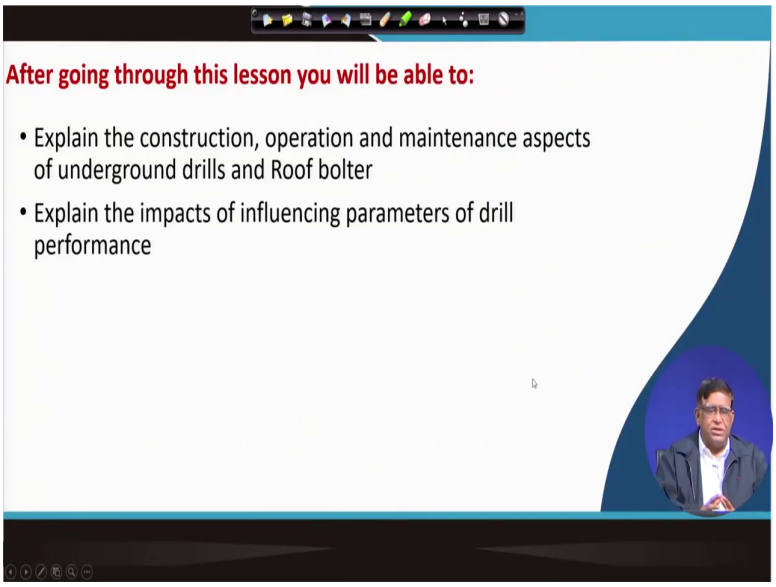

So, we need to know about how this machine is constructed. So, that after this class you should be able to explain how the construction, operation and maintenance aspects of this drilling machines. So, we will in general discuss what how these machines look like, and then how its performance will be there and the way we will be studying these machines.

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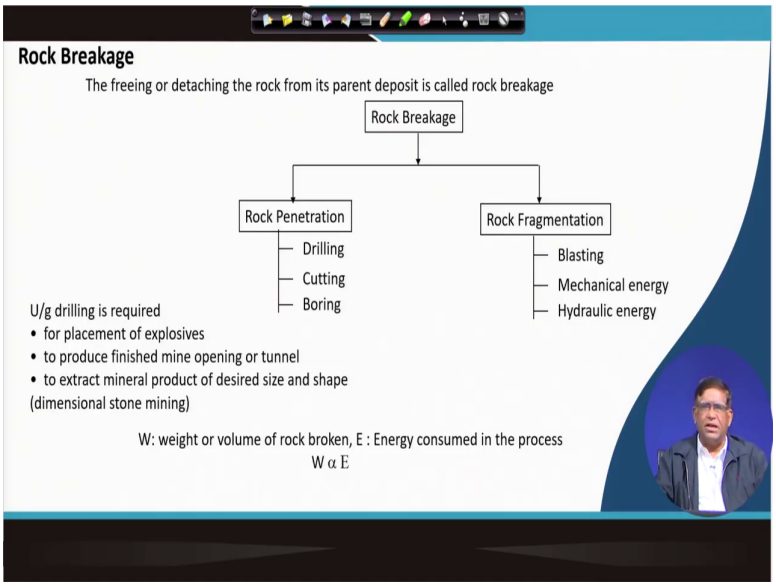

So, before that we know that rock breaking, it can be done by two basic things, one is you will have to do the penetration into the rock. Now, this penetration into the rock means we are making a small narrow space compared to the depth we are having the diameter is less and we are making a hole.

So that is a penetrating into the rock which is done by sometime by drilling and sometime by cutting or also the word terminology it is also boring. But an rock fragmentation which is all of you know in mining that blasting is done sometimes with the mechanical breakers are also there, hydraulic breaking also done. And other innovative methods are also there for fragmenting rocks by chemical fragmentations and all others.

But only thing is that this is how much volume of rock it will be broken and in how much fragmentations it will be done it is all related with the energy consumed that is. Now, when

we are considering about the underground drilling why we need this underground drilling for our production purposes, for the production purposes we will have to make some hole and there we to put the explosives. So, this is only for your placement of explosives we need to do the blast hole drill in underground.

And also sometimes we do the underground tunneling or this driving the galleries. There also we sometimes make a bigger way of drilling, but it is a tunnel boring or that boring is a bigger machines which are also used in civil constructions for tunnel constructions. Tunnel boring machines which is a different class of machines altogether.

And there is also we have this sometimes the mineral productions that extractions, we need make a desert size there is a different way of drilling operation is done in some of the dimensional stone extractions.

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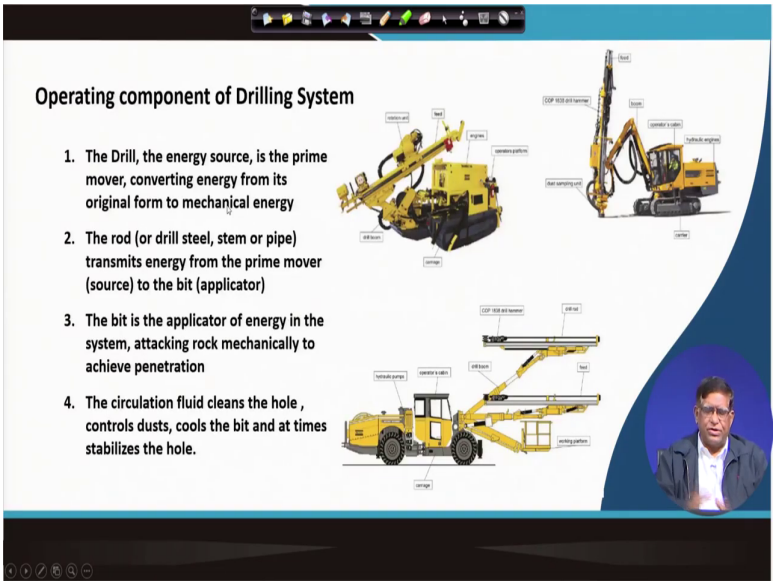

Now, let us see that how a drilling machines look like. In this particular figure, I am bringing some of the Atlas Copcos drilling machines. You can see over here that to become a system that is to drilling system, we need to get some energy, that energy will have to be transmitted to the rock first to break, and then we will have to get those broken rock masks, they will have to be removed from the hole. And then the rod at that the operations will have to go on inserting that is you will have to do the penetrations at a particular rate.

So, for that, you will find that the first component is your the drill that energy source where there will be the prime mover that energy will be converted from the original one by a mechanical, and then it will have to be transmitted. The prime mover it could be a diesel engine or it could be your electrical energy.

From there this whole energy will have to be transmitted to the rock mass via a drilling rod which is that is a it is a called a drill steel or sometimes it is called a drill pipe or drill stem. And then in some surface mining or in oil well mining, you might have heard that word called drill string where in the surface mine or particularly for oil or gas drilling you do a drilling of up to 5000 meter, 6000 meter drilling is also done over there that hole the drill string it is called.

But here in underground drill you will be doing some of the rods couple of rods can be coupled together, and then the operation is carried out. So, the drilling rod is basically your transmitting the energy from the prime mover to the under. Then there is the main tool by which it will be interacting with the rock is the bit. And this that is exactly the applicator of energy in the system.

And then it will be the bit will be attacking the rock mechanically, so that it will break, and then it will make its pathway towards inside the rock mass. And while doing that this way how the debris generated or that rock mass generated will be flushed out of the rod. So, that hole. So, while it is flushing out that all chips and dust which are produced it will be coming. So, that is why to get this operations, the circulation of the fluid for taking out this debris it would be associated with a their collections and disposal.

A lot of dust could be generated. So, the dust will have to be collected. So, there are different mechanisms will have to be provided for the safety of the people as well as safety of the environment. Now, you can see here in this machine basically it is to be moving, it can be a crawler mounted or it can be a tire mounted. And then the machine will be having that main engines unit where it will be, and then there will have to be a operator platform from where it will be controlling that machines.

Now, there will be a hydraulic system by which you will be having this your the hole drilling operations will be carried out through that your drilling feed is that is how the push will have to be given to the rod, so that it penetrates into that is called the feeding the rod. So, there will be a drilling rod system. And then this hole drilling rod is suspended on a drilling boom.

Now, that can be a different in a this type of this is another machine in which that your this boom drilling boom which is connecting this drilling rod, and then they will be just giving the feet from the top pressure will be given. And then whatever the dust will be coming that will be collected over here a dust collecting system is there.

And the other thing sometimes we are having this drilling machines underground where there will be a working platform and it will be getting this drilling boom. And there will be a feed mechanism to push the drilling rod inside, and that there will be the operator cabin and also the hydraulic systems over here.

So, from this figures what you understand is that the design of the machine is basically how you will make the rock to break. Now, as in the drilling systems in surface mining drilling we have discussed, there is a your percussive drilling, you have got rotary drilling, you have got rotary percussive drilling.

Now, in the this your most of this rock trails because it is a very hard rock when you are working on in a underground hard rock mining, you will have to have a percussive drillings in which the and also we will be having a rotary percussive drilling.

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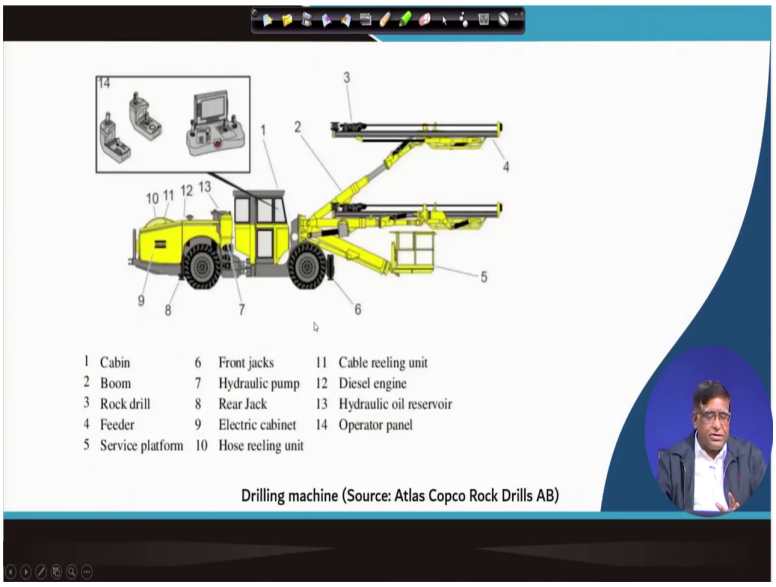

Now, you can see here that the components of the machine. So, you can see this is the operators cabin will be there. And there will be the boom – drilling boom on which the rock drill that is the main drill is that which is just transferring that energy for the drill rod that. And that exactly the feeder means this rod will be fed into the rock by giving a push which can be a.

If in a horizontal hole you are making you are giving a horizontal push, if you are making a vertical hole you are giving an axial thrust particularly that feeder will be giving an axial thrust on the this drilling rod. And then there is a service platform from which you can do the whole maintenance service jobs.

Then it has got a front jack that is while the drilling is going on these machines will have to be not standing on the tire, it will be this putting the jacks, so that the machine is in a horizontal level.

So, that this the because if the platform or the machine is not properly kept horizontally, then the angle which will be drilled will be getting an angle drill, so that is why the jacks are there. So, that the while operating the machine can be placed in stable, it can be made to remain stable and also maintaining that angle of the drilling.

Then there is a the in the machine will be having the hydraulic pump there is a rear jack that is on which this machine will be supporting. Then there are some electric cabinet for the control and the there is a so that all controls units are placed over here. Then the there you can see here there are two one big reel is there, that electric power cable or this your pneumatic pipes, they will be the pipe reel and the cable reel it will be there.

So, that if there is any loose cable or loose pipe, they get automatically wound up over here. So, that the machine can properly maneuver in that working area, that is why this your hose pipe reeling and the cable reeling these two units are there. Then there is the diesel engine; this is a diesel operated machines.

So, it is a having the diesel. And then hydraulic oil reservoir is there, and the operator panel that is how the operator will be controlling. Now, this is this hose drilling because you can you need to get pneumatic here, and also you need the this your sometimes if you are having a weight drilling, you may do even with water or mud can be brought depending on the situation. So, this is a machine manufactured by Atlas Copco, Atlas Copco has our their company in Pune.

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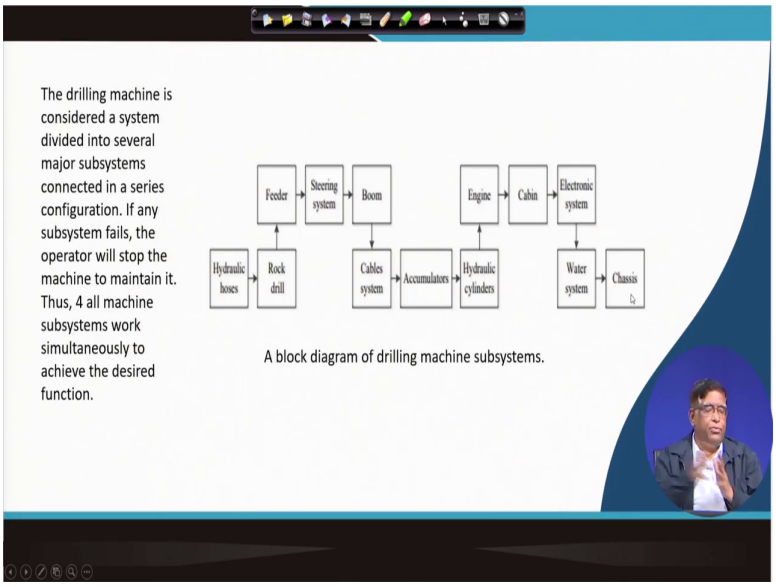

So, now, then what exactly a drilling system is so when you are studying any machines, we can think of that how the machines can be separated into different subsystems. Now, all these subsystems simultaneously work, then only the whole machines can be working. So, this is exactly it can see that hole drilling operations, it can be divided into some of the subsystems.

There is a hydraulic hoses and rock drill is giving to the feeder, there is a steering system, there is a boom system, a cable system, accumulator system and hydraulic cylinders are there. The engine is there, cabin is there, electrical system, water system which is given on to the chassis as a for supporting the machines like that.

So, whenever you want to analyze any machine, you can think of that what does the structurally what basic subsystems are there. They do there in all of this they will be exactly contributing to the main job that you will have to transfer the energy to the rock mass to make

the cutting, and then cleaning and separating it out. So that the cutting process continue and you get a particular penetration rate.

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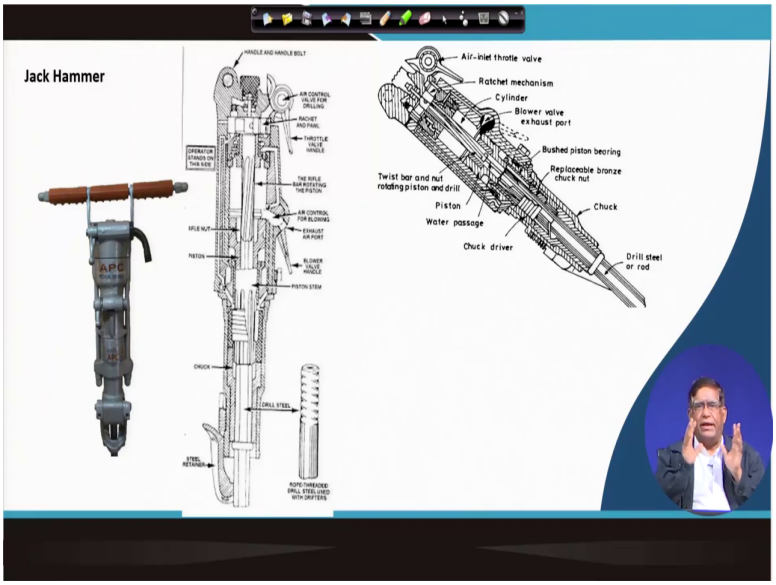

Now, this hole drilling can be done by different machines for different things. In underground mining, there were this machines jack hammer which is also used in surface mines. And this jack hammer is a very old drilling machines still being used and it is there. So, you can know that this is basically a pneumatically operated percussive drill.

So, here these two diagrams are of the same thing, of course, just only to for your understanding. It has got a machine will be looking like this. A simple there is a handle on that handle at the top there is a that through which a hose pipe is there your that is your with a lubricate, lubricant air.

There will be a compressed air will be moving. When the compressed air is entering into this pipe that compressed air, there will be an online lubricator from here this is exactly the atomized lubricant also will be fit together through inside this system. Now, when it is there, if you see the component wise that is the way the air will be going through a turtle valve and there on this we have got a mechanism called your pole and ratchet mechanism at the top that is your head.

And the head at this point there is a pawl and ratchet mechanism called I will be telling you what is the pawl and ratchet. And then below that there is a rifle bar. This you can see this is the rifle bar and this rifle bar is fitted with a rifle nut. You can see here this is persons this is the rifle nut.

And then this is there on a piston and this is that here you can also see that piston and that piston stem, it is exactly this portion is a anvil portions where it gives the hitting and you can see the drill rod is there. This rod is fitted with a chuck. Now, there is this your this piston stem, it goes with the chuck when this drill rod or the main drill steel it is called it is fitted over here.

So, when this air is entering through this, it goes through the valve and then it gives the reciprocating motion. Because this air will be going and through that there is a hole through it will be going out and then come out and then return air will be going out which will be also working with the flushing system.

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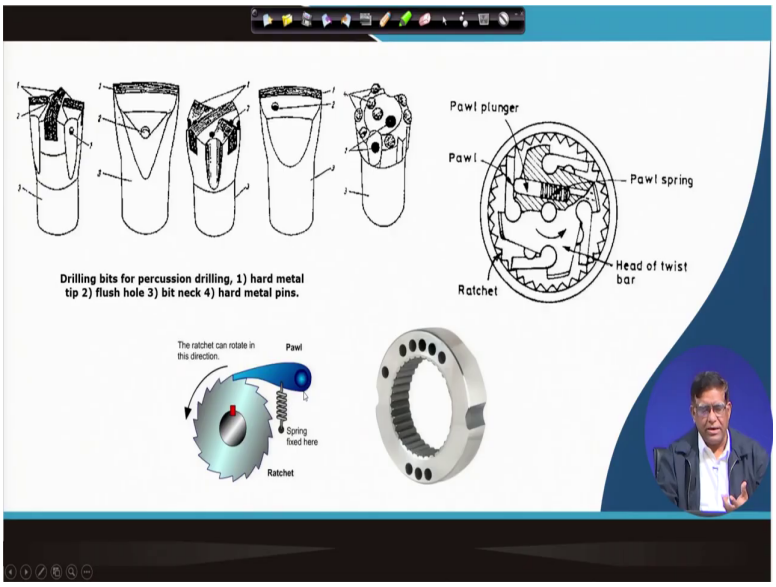

So, exactly that drill steel or that which we have said here this drill steel the end portion is the drill bit. So, here this bit can be of different type. Now, you can see here that we are having a cross bit this is a tungsten carbide which is inserted over here. At the end of it, there is this hole through which that air will be coming and then it will be going out of the hole, the material will be that is the debris will be clean from the hole.

So, that is there could be a different shape of it is a sizzle bit, you have got a cross bit or sometimes you can get a tungsten carbide button also put over here and you can do it. Now, when this your this drilled rod will be doing this percussive time, at that time there will be an indexing. That means, if you have a sizzle bit like this type of sizzle bit, then if you all the time hit it at one place you will not get a circular hole.

So, that means, when you are be hitting it over there, every time it will have to be given a rotation. Now, to give that rotation which is called your indexing, that means, after certain number of blow, it will make a one rotation that exactly that rate is called your indexing rate.

Now, to do that, we are having this pawl and ratchet mechanisms that is exactly this the inside this we are having a such type of my system here we are having this pawl and ratchet mechanism in set. In a pawl and ratchet mechanism basically a pawl is there which is fitted just like here you can see this pawl with a spring loaded thing, it is kept over here. Now, this can rotate in only one direction. If it rotates in the other directions, it will get obstructed by the pawl and it will not rotate.

Now, why this is required is you can see here that in this one when it will be going down, it will be because of the spiral group, it will go and write it. And then when it is coming back there will not be having a rotation. So, that means, by giving these rotations, every time when it is coming you are giving a turn. And then depending on the number of blows you are getting this turn.

And then you are making that bit is every blow attacking a new surface and the rock is getting broken. So, this pawl and ratchet mechanism is one of the way that is for doing in a jackhammer to give the indexing, so that our hole is made perfect. And also during this, when it comes, it will not rotate.

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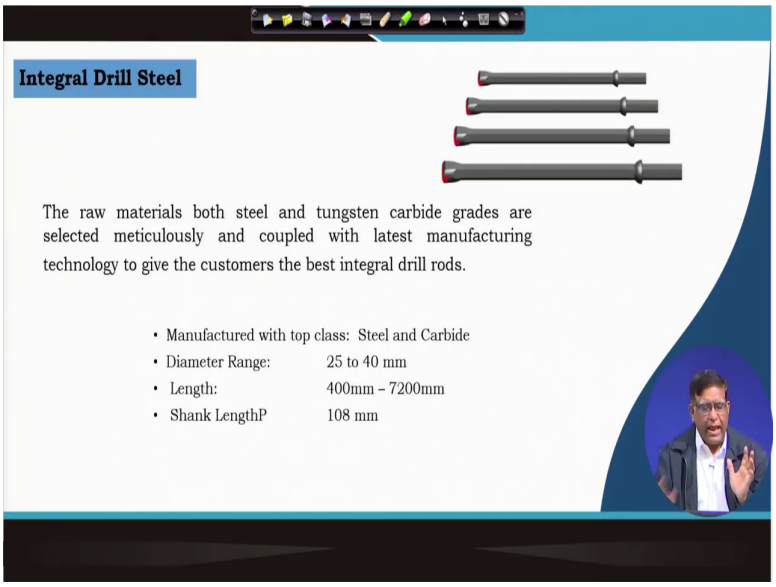

And you see that this drill steel which is there you have seen in the jack hammer, your this drill steel portion this is exactly here. This type of rods are there when this portion is connected with the chuck and here.

This could be of different length, sometimes it can go up to 7.2 meter also in that I have showed in the first slide that there could be a long hole drilling. Sometimes it is done for explorations and sometimes for testing purposes it is used in some underground mines.

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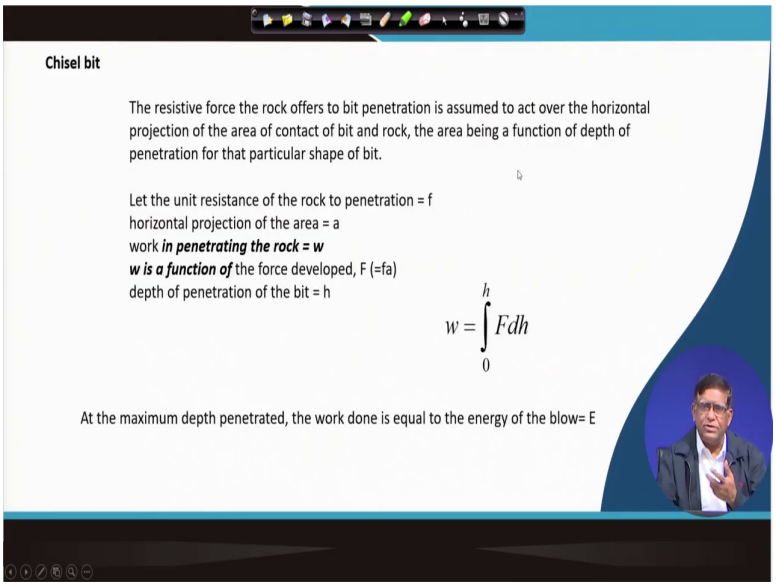

But in many of the coal mining you can find that this for the roof bolting earlier that jackhammers are used. So, this the material exactly it will have to be a tungsten carbide button inside here all are of sizzle bit type.

So, you can see here, this chisel bit how it will be exactly cutting, that will be depending on the rock properties that is our main thing in any drilling machine is to know that how much energy is available to break the rock that is depending on the type of rock.

You will have to find out that how many number of blows will have to be given and how much energy you will have to do. So, this there had been a lot of studies on this analysis. Now, that is basically the rock has got a resistance to break, and that resistive force it will be so that the penetration to make it you will have to put more energy over here.

Now, if your that unit resistance of the rock penetration suppose it is F, and if you know that the area it is A, then the your the force to be developed over this will be your F A. So, the work done in penetrations if you want to calculate it out, if your depth of penetration is h, that will be only integral of this F d h. Now, at this penetration, you will have to give that blows on a blow that energy how much you have to give.

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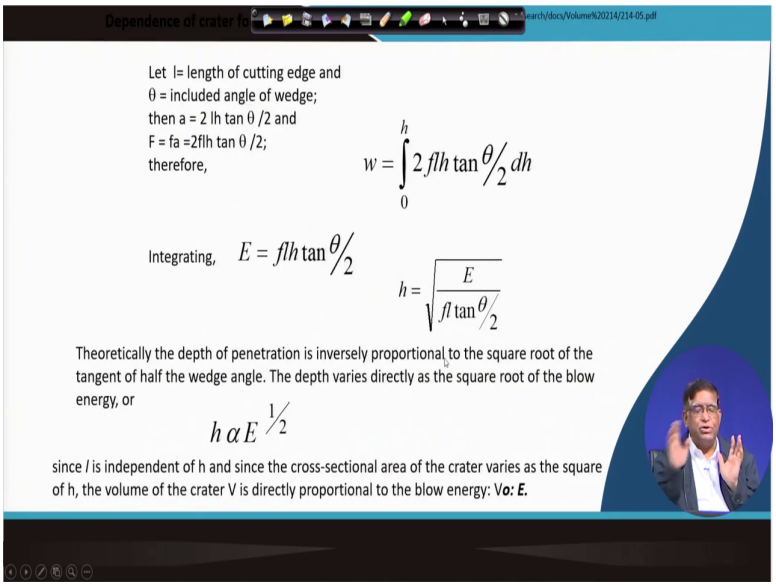

Now, if your l is your length of the cutting edge, and then your theta is a included angle of the wedge of the in the hole, then you will find that this total work can be calculated by this integration of this twice of this f l h tan theta by 2 d h. This if you integrate it, you can find out that is your how much exactly it is a going to give that penetrations you can find out from here.

And this gives that is your total the depth will be exactly that the penetration which it will get that is a function of the energy applied.

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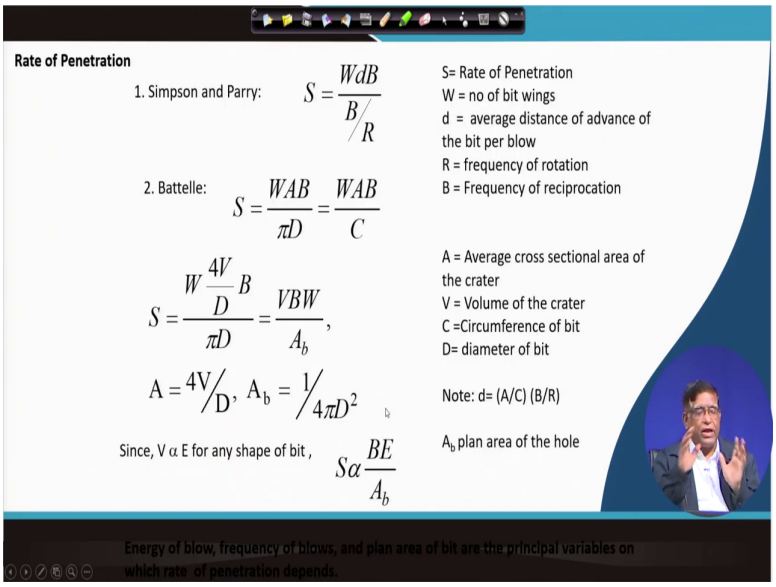

So, that is exactly this rate of penetrations will be how this energy is put into air. So, while designing the machine, they take care of that what will be the that your strength required to what will be the pressures of, then at what rate that your flushing air will have to be flowing there at what pressure those what type of compressor will have to be selected, those things are over there.

And then sometimes whether this blow per minute whether you will be doing it by pneumatically or by doing it electrically or by electro hydraulically, all these things are decided based on this the energy requirement. And the penetration rate how it will be coming? Different authors have studied you can study the literature that Simpson and Parry,

they gave these equations. Then the there is a Battelle theoretically this based on the energy consumed, there is the equations are derived.

The other than this there is a you many times you will find the study is done empirically, that means, rock you know is a heterogeneous substance heterogeneous material. The bonding between the particles are different. Same sandstone, if there is a quartz grain sandstone or if it is a your fine grain sandstone, you will find that it will be giving a different type of this is your that resistance to it.

Depending on that in your rock mechanics class, you might have studied what is called drillability. The drillability of a particular rock whether it is how it will be responding to a penetration by a to percussion or in rotary percussion, so that study is very, very important in selecting a drill.

So, we need to know about the penetration rate because that how many number of blast holes are required, and then because depending on that only you will be blasting and generating the fragmented rock mass. So, whole productivity of the mine will be depending on how you are exactly blasting the rock and that is why the if the penetration rate is not received properly. If while doing your bit is worn out because of the abrasivity of the rock is very high, then your production rate will be going down.

That is why they when you will be taking any practical example of having selecting a drill. We need to consider that how much penetration rate and how much bit life will be getting in that particular rock. And on the basis of that, you select the drilling system.

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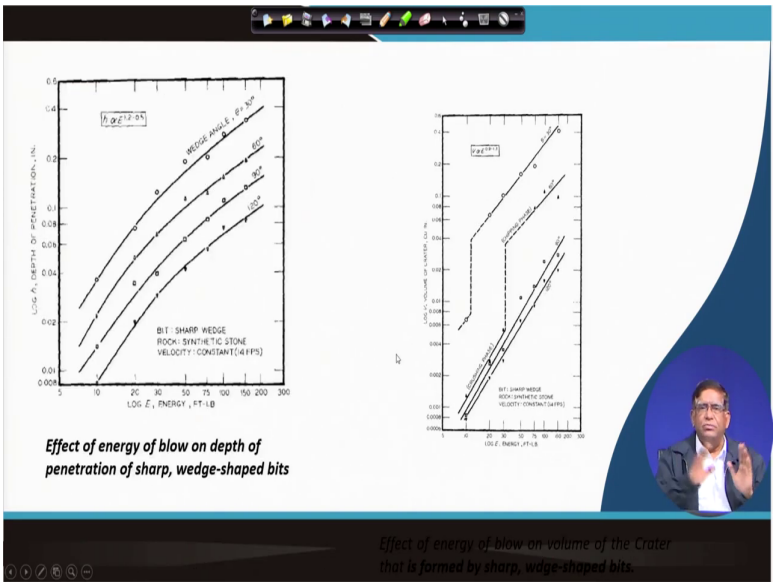

And exactly this your if you see that the depth of penetrations and then there is a energy required, they have got a relationship. So, before selecting any drill, we need to get this study.

And surface mining also you know that exactly the penetration rate will be depending on the blow per minute, how much it is coming, and at what rate you are flushing, or that exactly rotary speed at which the bit is attacking. And also that your the that how much exactly you are flushing.

If your penetration rate is very high, but your flushing media, that means, the air or water whatever you use for flushing out the debris's, if they are not proper then there will be jamming. So, this study is essential to do.

So, it is just for an example that you are getting this your how much volume of material will be coming and how much energy. This is of course just an example, but it will be varying depending on the type of rock depending of the type of machines individually for each will have to be studied. A lot of studies are in depth it is available.

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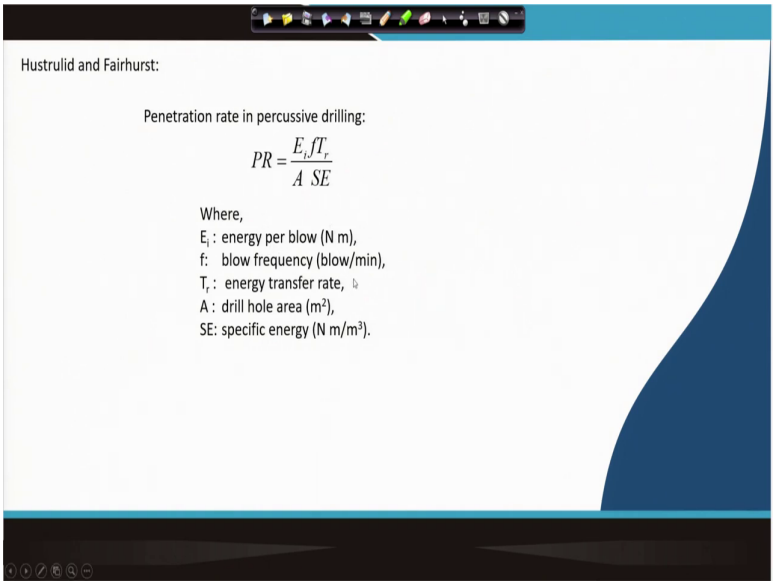

So, if we see that there is a that Hustrulid book I refer to you that in surface mining machinery than that surface mining that Hustrulid a book gives a how the penetration rate in percussive drilling is given other than that there are a number of studies. So, you please see that while selecting a drilling, you will have to get the penetration rate.

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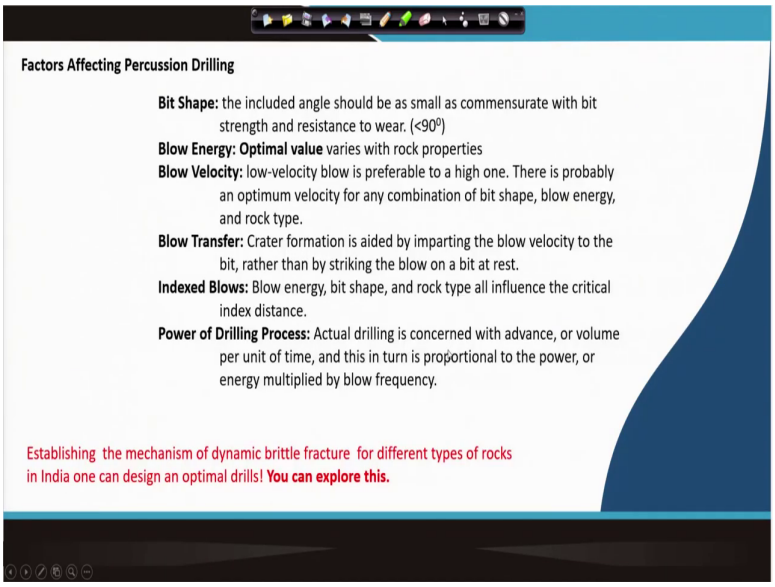

So, factor affecting this percussion drilling we have got the bit shape, blow energy, then blow velocity, blow transfer, indexed blows and power of drilling process. These are the factors which will have to be individually studied. So, that is your you will have to explore that how different type of rocks exactly respond to different type of drilling.

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Then this sometimes to improve that; that is your there are different advancement has taken place, there is a pusher leg drill. Because if your this drill leg will have to a jackhammer type of drilling machines to make a upward hole, so that we are having a pusher leg an air hose which is exactly making one persons to keep that hole drilling machines upward over there that is a air supported.

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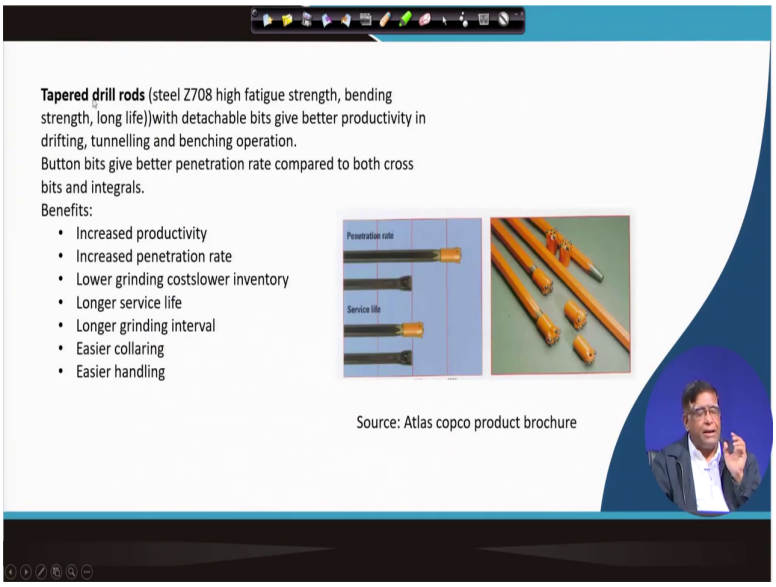

Then there is a tapered drill rods in which you can see here the drill bit is not an integral part of the drill rod, but there is the bit part is separately and then it is exactly fitted with that. So, that this part can be changed and a new bit can be brought, and the same drill still is used. Earlier, if it made an integral, if your bit is damaged their whole steel has to be removed. So, this type of advancement has taken place.

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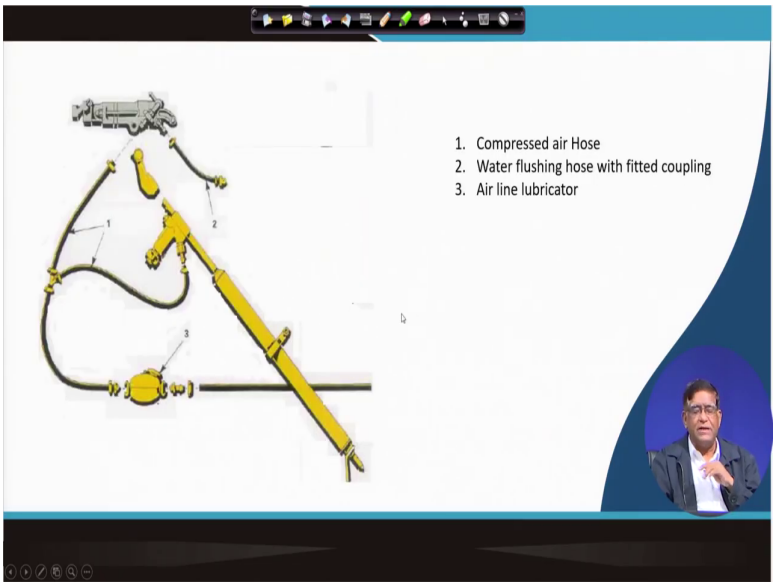

So, while doing an air leg drilling for as a for this type of drilling system that air leg drill, how it happens that these components are there, there could be a water hose also for cleaning. A air hose, in the air hose there is a airline lubricator which takes the lubrication and air through over there. This is the hole drilling system will be there this drill rod will be holding over here. So, this type of systems are available.

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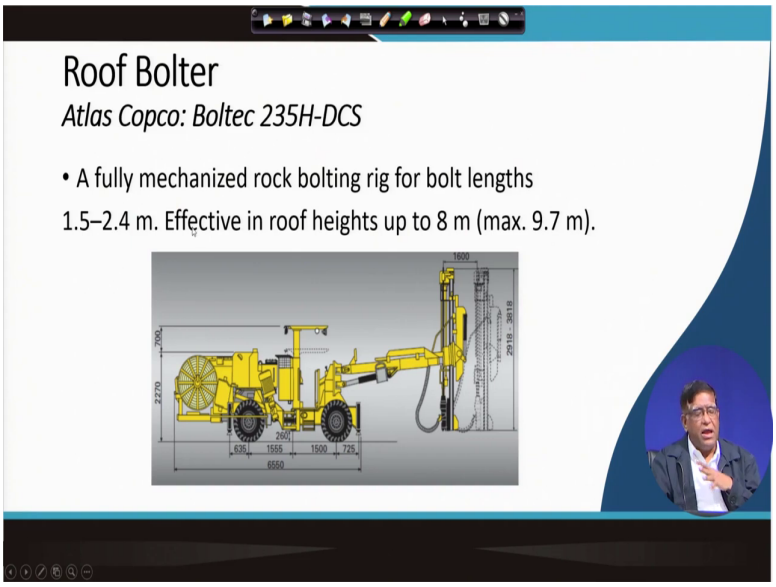

Now, the roof bolter is roof bolting is nothing but a making a hole on the roof of the gallery. So that you can put a bolt there and then anchor it by giving your resin or by cement.

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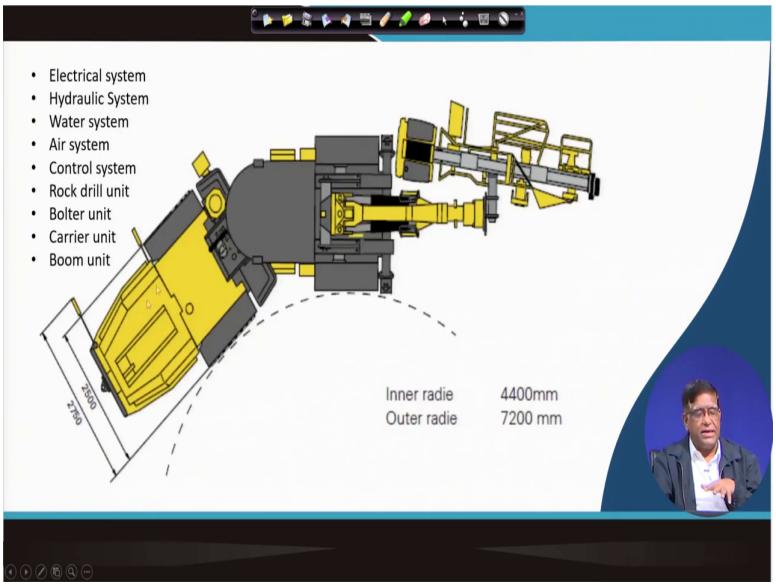

For that purposes, different type of machines are there. This Atlas Copcos machines you can study there, there exactly is an articulated vehicle which can be taking some turn in underground environment and they give. Such a machine also has got its electrical system, hydraulic system, water system, air system, control system, rock drill unit, bolter unit, carrier unit and boom unit.

So, these are there. Many times drilling machines for these bolting purposes there could be a platform, and it will have to carry the number of bolts to be there.

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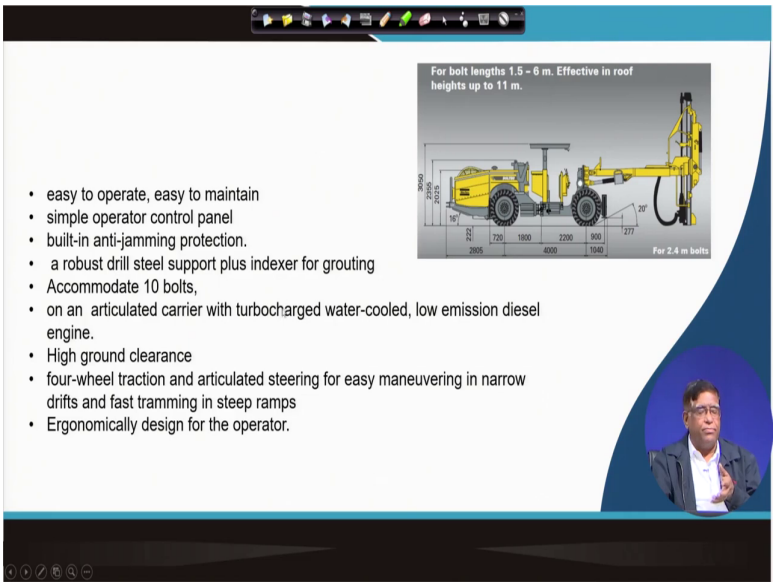

So, if you go through the operators manual, you will find out that what are the special features, they are given as a required. It should be easy to operate and easy to maintain. It should be simple operator control should be there; it should not be very difficult to work, so that you can easily train a person to a work with it. Then there should not be a jamming.

If jamming takes place, it should take out the material. Before the jamming, warning should be given. So, lot of instrumentations are available with this. So, there should be a good ground clearance. You can see here that machine will be moving in on an undulated part on the underground mine. So, that ground clearances should be there.

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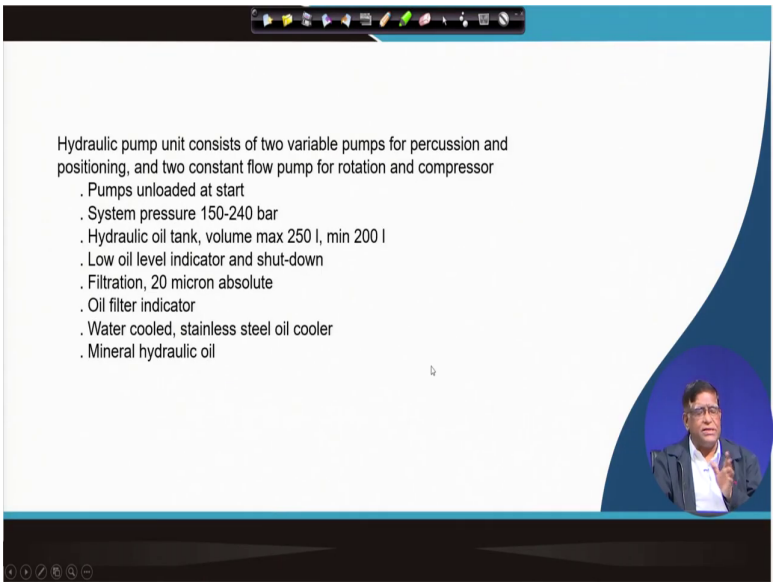

And the operator wherever it is working, it should be ergonomically sound. So, those things are taken over here. So, there is a the main system which are all hydraulically worked. So, that hydraulic systems when you are using, you are using an oil in an underground conditions, it should not catch fire, it should not get deteriorated by dust and all.

So, any adequate protective systems will have to be there. The pump will be up in adequate size then the hose pipes and all will have to be of a proper specifications.

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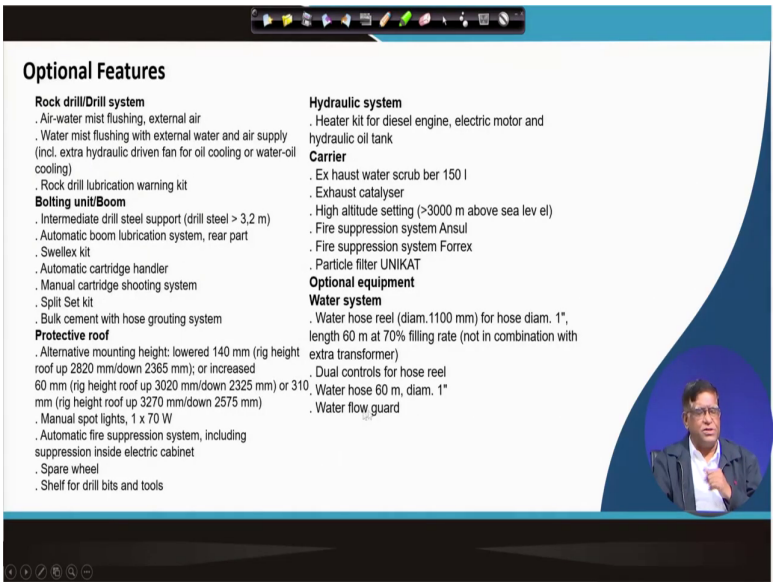

There could be many other features associated with these machines. So, as we will be studying you can find out that how different bolting units will be given, additional features so that depending on your working requirement you can have. Every company, when they manufactures a machine, they will be well they can make some add-ons over here.

So, when you make a habit of reading some of the this manufacturer leaflet, try to find out it and then take a special thing that for that what is the science behind such features.

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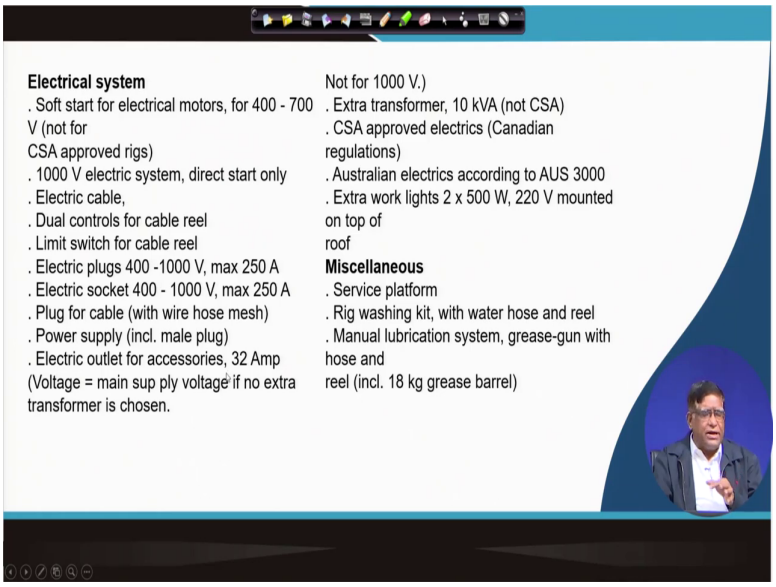

So, that you need to know the general operating range of this in electrical they will be working with a 400 to 700 volt this motor powers are used depending on the same or country wise, in our country will be having that 50 Hertz equipment.

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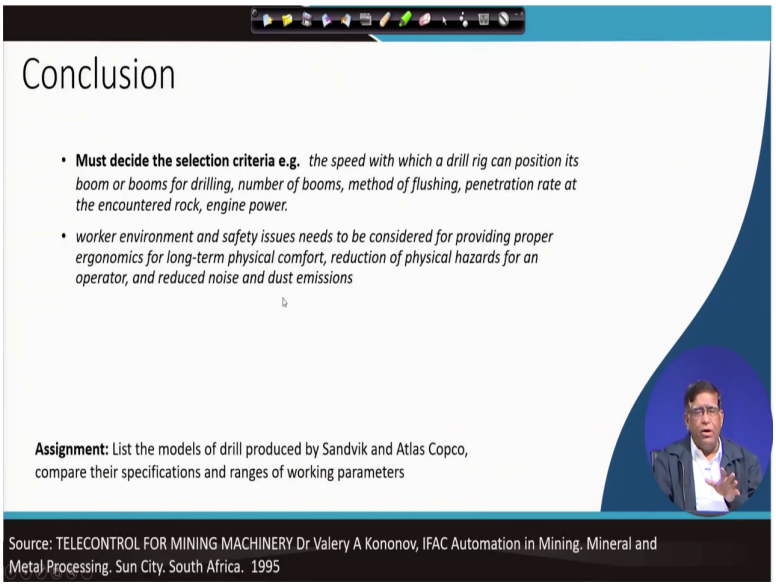

Then there the cable by which the power will be going to the machines that need to be exactly, there will be electrical supply system in underground mine. So, that there will be the hose pipe will be having a control cable also, so that you can operate from distance this machines is also a it can be remotely controlled.

There are only problem wise such machines when you will be using underground, there will be a lot of noise. Because the rock cutting at that time and that pneumatic machines is always noisy, when doing a drilling operation is noisy, when such a machine will be working underground, it will be very uncomfortable for the person. So, that is while working you will have to have this proper personal protective units and the safety of that must be looked into.

So, that is your while selecting you must see that what type of drilling boom or what type of drilling rig you will be using. How the method of flushing will be done, how the penetration

rate will be done that you must look into. And the environmental safety will have to be put, particularly this hazard is it should not make the persons to work more than 2 hours in this so such type of machines are used.

Say in Manganese Ore India limited also if you go to some of the underground mines say for example, near Nagpur that Goomba mine is there. When they are for race boring and other purposes, they are doing with jackhammer the drilling, but that noise which comes that is why they make the operator and the other people to work only for 1 hour or one and a half hour.

You can see that the standard specifications are given for a particular level of noise the operator can be working only for time. So that the operators will have to give the noise dosimeter they will put and depending on that how much time they should be working near such machines will be determined.

So, in a nutshell we have discussed that this type of drilling machines are there, quite a wide varieties of machines are available. And there is a study you need to know how to calculate the penetration rate and how to make it say operational safety over here. So, as an assignment, please list the models of the drill produced by Sandvik and Atlas Aopco in Indian. And then you make a comparative list and study their differences.

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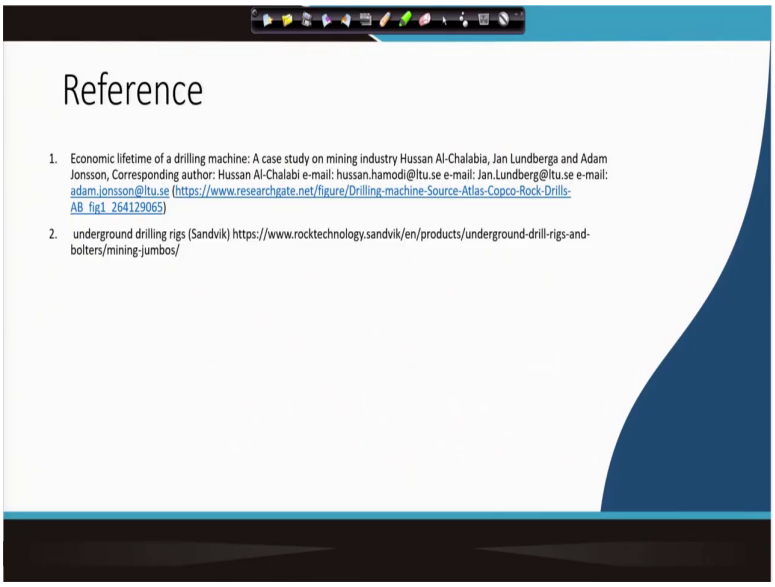

There are wide range of materials available, please go through it. Hope you will be learning and getting interesting in this subject.

Thank you very much.