Mining Machinery

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Module - 07
Lecture - 40
Fans of Mining

Welcome back to our discussion on turbo machinery. Today, we will be discussing about another very important turbo machinery for mining that is fans.

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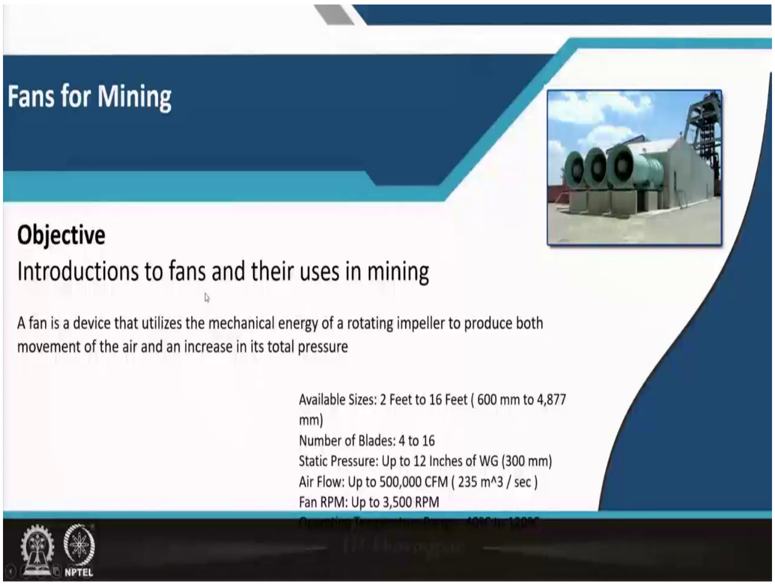

So, this is a fan, these are used in mining in a very big way and particularly, when we talk of underground mining, there our main this is a very critical item because you will have to supply air and oxygen to the underground operations. So, for that, there are a huge mine installations as you can see here next to the mine shaft in the figure, you can see a that mine ventilations installation in which we can see here three axial flow fans here.

So, there are different types of fans and they can be selected from different sizes, different designs. So, today, we will be discussing about this what are this mine fans are and you can see here, some specification is given that they can be a wide varieties say available sizes of the diameter up to 600 millimeter to 4877 millimeter, a particular mix value is given over here.

And then, this is a number of blades can be from 4 to 16 and then, the pressure it could go for 300-millimeter ok pressures over there and then, this flow rate that is air flow also it can go up to 235 meter cube per second and that going from at a 3500 RPM. So, this gives you a general range of the operating parameters of a mine fan.

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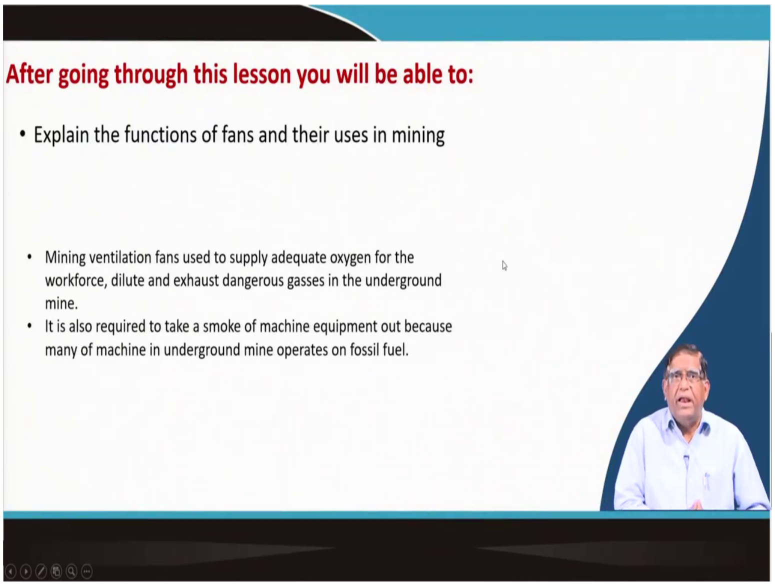

So, our this mine fans, they are using exactly for the ventilation purposes. We say that there is a other than that supplying air, there are other jobs of the fan is also to create a safe operational environment. You know particularly when there is a underground coal mining, you coal seam may be associated with different gases. You might have heard about that fire damp and also there is sometime toxic gases like carbon monoxides and all.

So, one of the most important way of handling these gases is to keep them diluted that means, whatever is inhaled by the persons operating there, it should be minimal. Second thing, you will be also whatever the dust is generated that will have to be exactly from that it will have to be made air bound to that get is again separated sometimes if you are not having proper ventilations in a very limited space, there will be a huge concentration of dust so that the miners who are working over there will be very difficult conditions.

So, that is why the dilution of the suspended particular matter in the underground mine atmosphere is also one of the job and also there is a different sometimes in the mines, you will be using diesel engine. Now, how the combustion of diesel will take place that will have to have also that is oxygen is required and that air also will have to be supplied from outside and there comes this need of mining fans.

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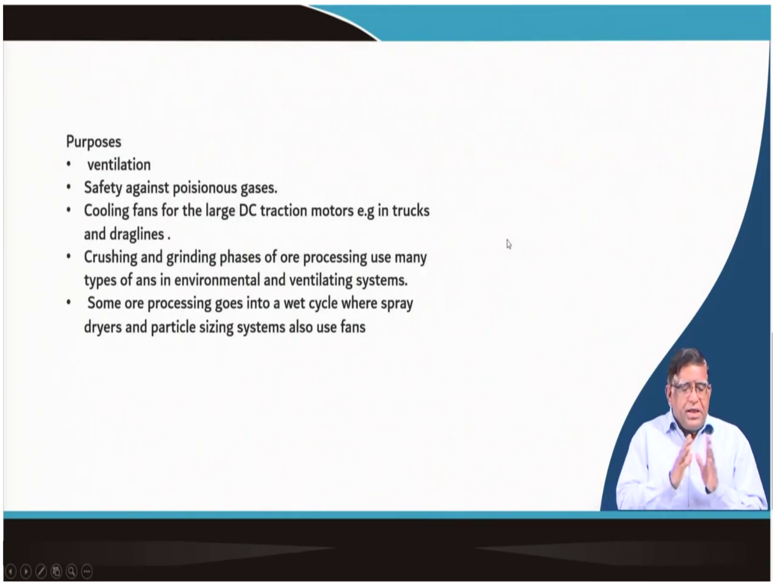

So, they to be very now summarily, you can tell that the purposes of mining fans are for ventilation, then this your safety against poisonous gases, cooling fans, cooling of motors that is your in the DC motors which are used in many machines used in underground mines as well as in opencast mines also, you will have to have fans for cooling these motors. Even in the surface mines, your if you talk of a drag line, a shovel or distracts everywhere there will be certain DC motors and there the cooling fan will be a fan is required for supplying air over there.

Then, similarly in the mineral processing plant, even that crushing and grinding jobs there also the requirement of fans are there. Now, they say for some processing where there is a wet cycles for there also you will have to have some fans for this. So, that means, the fans of different types and are used for different purposes in mining.

So, whether it is in opencast mine, whether it is an underground mine or it is in the related auxiliary operations like mineral processing, mineral beneficiations you will have to have some fans, other than that you know that fans are there in as a household item everywhere you need.

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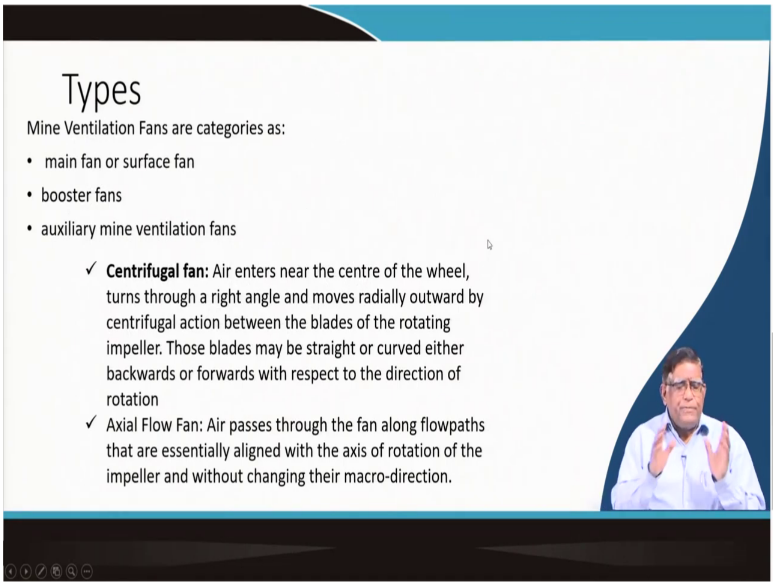

So, we would like to see that the that how, what are the different types of fans used in underground mining, you can have the three main types are there; one is that main fan or the surface fan. The main fan as you have shown in seen in the diagrams or the photographs I have put in the first slides that is exactly installed at the surface from the atmosphere, air is taken and then, it is put over there. So, that is a main fan purpose.

The type, the size, the capacity, this all depends on your ventilation design. The ventilation design is done based on what are the total resistances that will have to be overcome on the basis of that exactly fans are selected that you will be studying in your ventilation courses.

But there are also in the mine method and that ventilation, you will be learning about there are booster fan which are exactly that where your main fan cannot reach up to that capacity or in a there is a branching out in the mines, you will have to have this booster fan or auxiliary fan which also for the branching out from one is stream, one gallery to take it into two, three galleries separately, there could be an auxiliary fan.

So, those classification of these fans are on the basis of the purposes how they are being used in an underground mine. But in general, you will find there are two types of construction wise that fans are mainly centrifugal fan and axial flow fan. The basic operating principle is same as that is in your that centrifugal pump or this axial flow pump that is there because these are all the fluid is now instead of water or mud, it will be coming as a air or some other gases also.

But thing is that this is a basic type that is in a centrifugal fan what happens? The air will be entering near the centre of the that of the wheel that is exactly you have learned in a pump at the eye of the pump and then, it take right angle and moves radially outward by a centrifugal action between the blades and a rotating impeller.

So, these impeller, centrifugal impeller we should say that is exactly the main principle of the how much air flow will be coming out, what pressure will be generated that depends on the centrifugal actions of this impeller. We will be discussing little bit today.

And then, axial flow, you know that air passes through the fan along the flow part you see you know, you have studied in the axial flow pump that is your that same parallel directions that is it is entering and going out as a parallel to the main shaft or the main drum on which you are having this rotor and stator fixed on that part. So, same principle is followed in your axial flow fans.

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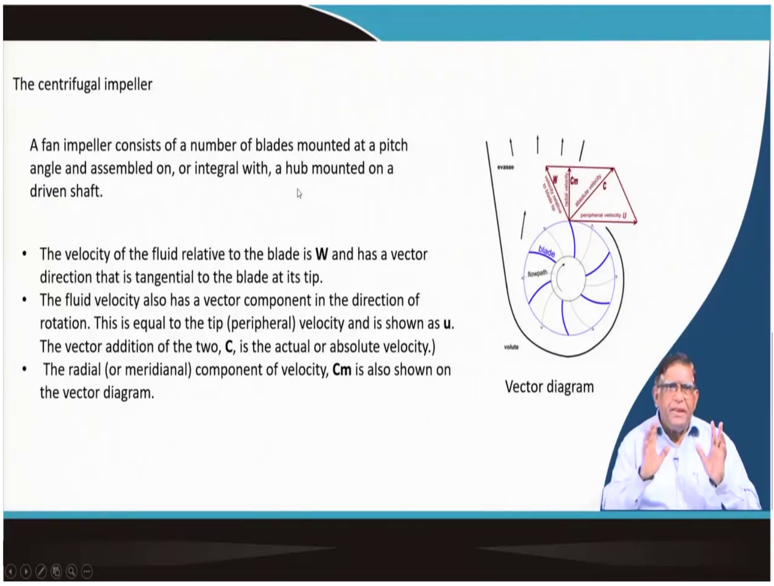

Now, coming to this centrifugal, let us little bit learn about this theory how exactly it goes. Now, as you say that is a vector diagram of you have already we have discussed about this impeller where we are having this the blades are as a forward curved, backward curved and radial blades in pump we have disguised.

Now, here, the velocity of the fluid relative to the blade is your this is W that is your velocity relative to the blade tip and there is a the velocity which is exactly peripherally, it is velocity is tangential over here. Now, this is a, as it is a rotating, then your this is a peripheral velocity it will be there is tangentially.

Now, the other thing is that there is a component; radial component will be there that absolute velocity is shown over here as a vector diagram of this and then as a perpendicular to this peripheral is their radial velocity. So, these vector diagram is very very important for our this study of this fan.

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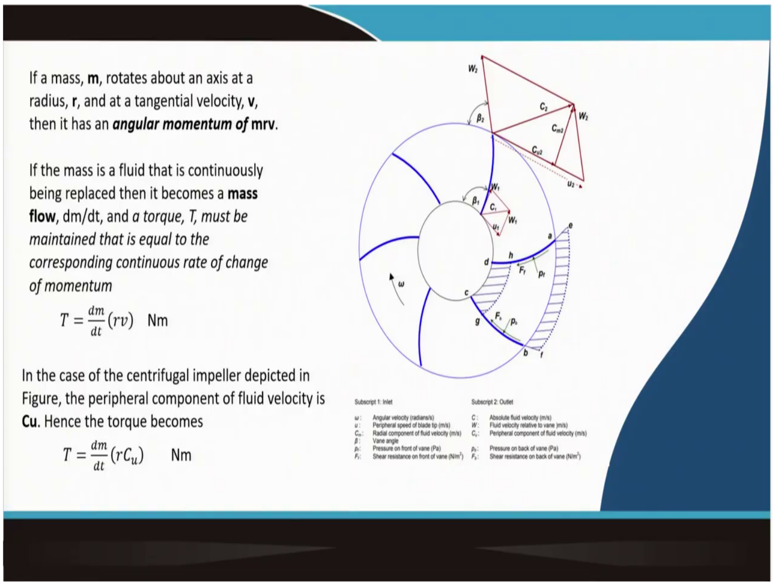

Now, what is here? Suppose your; your having this blade. Now, your if any mass are this is rotated and then that axis of this radius we are keeping that here say radius is r and then, what will be this tangential velocity which will be coming and then, we can know that if your the momentum that is you can follow the principle of momentum.

Now, here you understand that is your impeller, when it is rotating, what happen? This mass say for example, which is there in that c, d, h, g and then that in that same time, while particular time this will be moving to your b, f, e, this portions.

Now, this mass flow, if this mass is flowing at the rate of if this mass has gone to here in time dt, then this mass flow is your dm dt and this will be possible when a torque is applied over here, you can see that this shaft which is having an angular velocity of w

So that means, this these one your the torque which will be; the torque which will be coming over here that is exactly you can get it by this formula your dm dt by rv. Now, in case of this velocity that is there your velocity here is this C u at your inlet were telling it as a nu 1 and that outlet it is your u 2.

Now, in a this centrifugal impeller their the peripheral component of the fluid velocity is C u we can that fluid, how it is going over here? You first try to understand this diagram, what is there at the inlet? At the inlet, we have got an angular velocity this is your omega and that radian per second it is moving and the peripheral speed it is in u 1 which is tangential to this and then, there will be also a radial component over here that will be going on this that is exactly perpendicular to the peripheral one.

And then, this vane it is making an angle at the inlet it is B 1 and at the outlet, it is making an angle B 2 and then, there will be a pressure on this vane, there will be a pressure on the front vane, this is called the front side of the vane and this is the back side of the vane. When it is moving in these directions so, this is there is a shear of this is also taking place at these two vanes.

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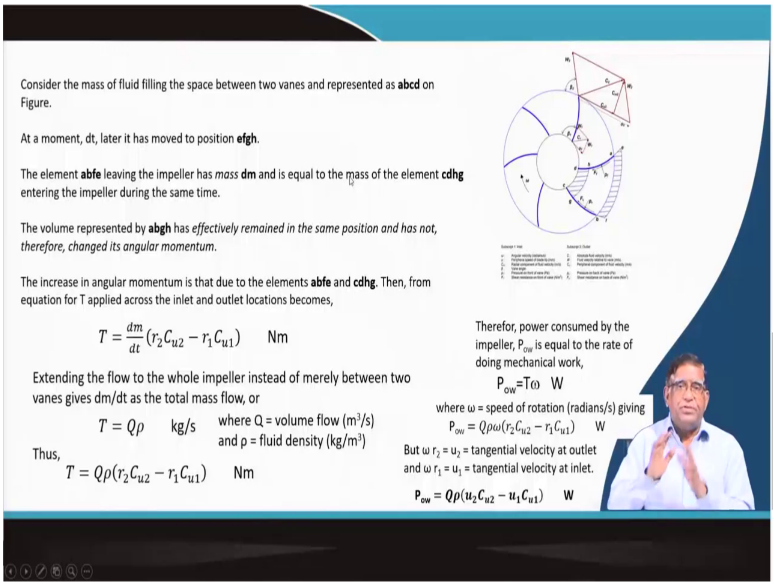

So, if you understand this vector diagram from here, we can derive this principle of your fan operations. Now, suppose here your consider a particular amount of mass is moving that is in your this a, b, c, d this is the part in which that your the particular amount of air is there ok. At a particular time dt, this has gone your e, f, b; e, f, g, h this is a that means, originally this part a, b, c, d after time dt has gone to here that means some air has been released from this that which are scrapped in this impeller.

Now, that if you see here, try to derive this equation for the torque, then this we have shown here that dm dt is rv and this particular one, you can see here, this will be the differences of there and here that means, whatever this this torque differences that will be only giving you the that is your that total mass which will be flowing across the fan.

Now, this one, if you the whole impeller when you are talking into in considerations, if your whole impeller will be giving an total amount that is your what is the volume flow that is your exactly that Q into rho. So, that means, that torque which is Q rho can be expressed in terms of the differences of this peripheral velocities at the outlet and the inlet.

So, this is exactly the basic principle from here, you can if you know the torque, you can also find out what will be the power consumed, power consume will be torque into omega that these ones if you put it now here these equations, the power can be expressed by this.

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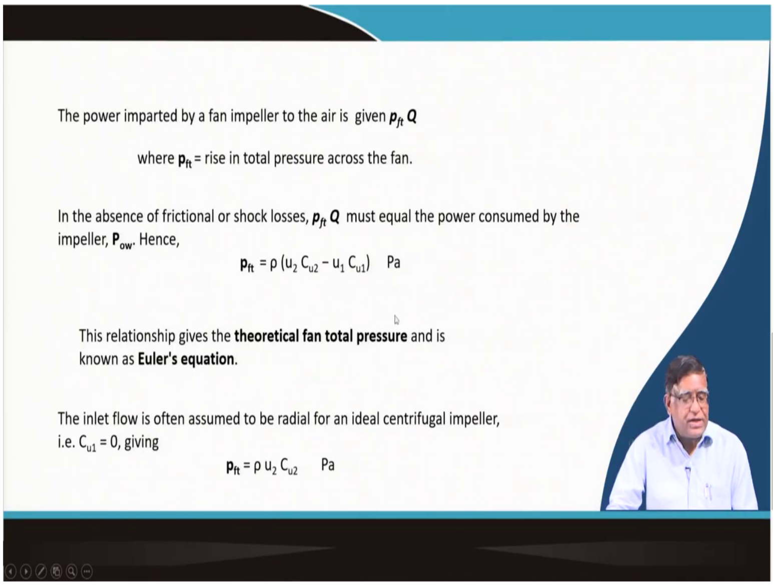

So, ultimately that total power which is exactly flowing, it is coming up this equation which is exactly coming up as a power imparted by a fan of an impeller to the air because exactly this power p ft, this is exactly the rise in the total pressure across the fan. If you put that equation, this equation is called your Euler's equation of that is your fan pressure.

And this pressure, if it is at a radial if you are telling at a radial conditions, this u 1 will be 0 at that time, our total pressures it will be coming only that is whatever velocity we are getting at the outlet velocity of the air.

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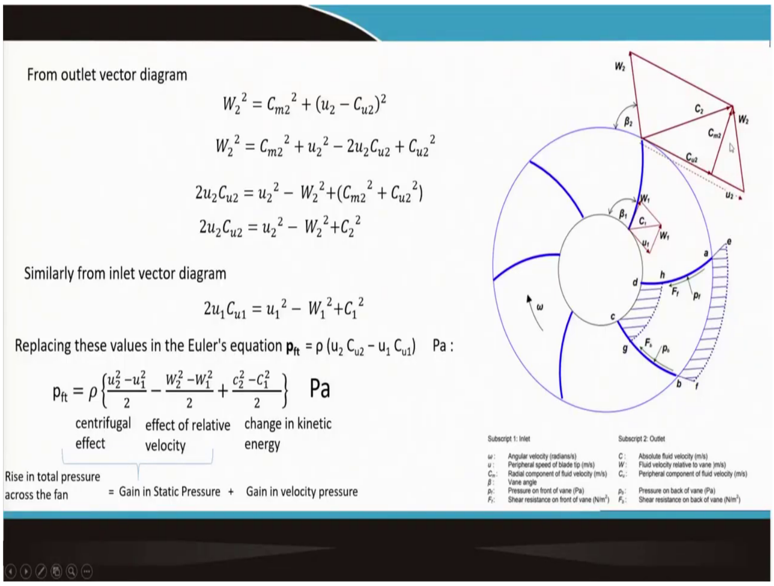

So, that is what if that outlet flow diagram if you see over here, this particular vector W 2, this is exactly nothing, but your the C m2 square plus this u 2 square and u that it is u 2 minus C u2, this by applying Pythagoras theorem.

Then, from that one, you can find out what is exactly this value of this u 2 C u2 which is there in your Euler's equations. In Euler's equations u 2 C u2 when you derive from here, then we can replace it to find out that exactly what is this a pressure which is across the fan, how it is happening and these comprises of three parts, you can see here that is that centrifugal effect part, effect of the relative velocity and the change in the kinetic energy.

So, this is what exactly the rise in the pressure across the fan it gain some static pressure and gain some that your velocity pressure. So, this is what is exactly happening in a centrifugal form fan or that same as a centrifugal impeller wherever it is there

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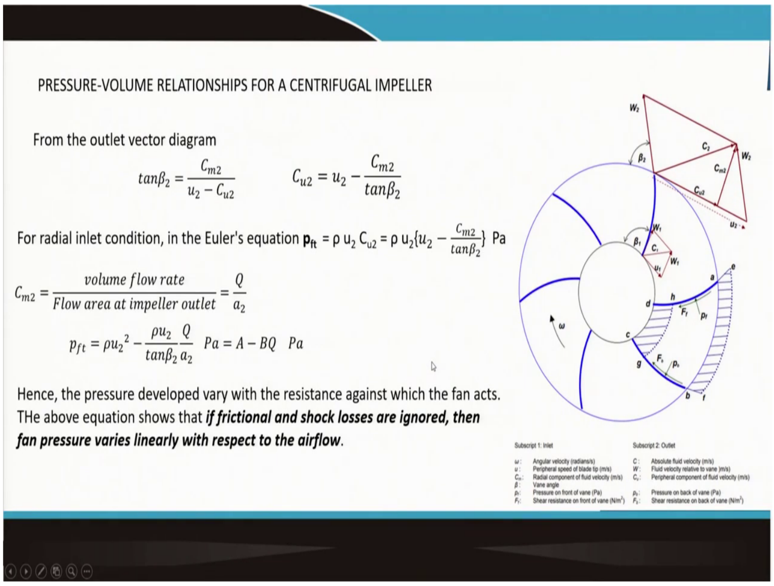

Now, from here, we can derive a very important relation that is your pressure volume relationship that is from this diagram, you can find out that tan beta it is nothing, but your that is C m2 by u 2 minus C m.

So, this is your tan beta 2. If you put that one, then you can find out that from this, what is the value of that C m2 and these gives your particularly, the pressure across the fan which is coming as a relationship, these two constant terms are there, you can put it as a A minus BQ.

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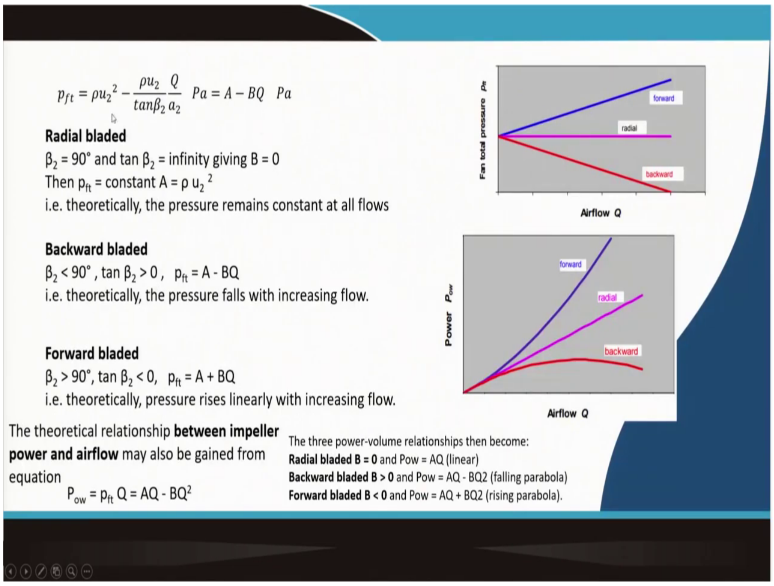

So, that means, this has got now some conditions that is your what will be the under different conditions if your frictional and shock losses are neglected, then you can find out under this particular equation, we will be giving you under radial bladed your beta 2 is 90 degree, then you can find out that B is equal to 0 so that your pressure will be constant, you will get like that.

So, under this your backward blade conditions as because this is your beta 2 is greater than 0 is minus BQ you will get the that is your air flow rate will be decreasing and in case of your forward bladed that will be increasing and these one in pump also we told about that there is a power requirement in different type of blade it goes like that exactly it is just on the basis of this the velocity diagrams how it happens in the pump, we can find out that is your how our power and fan processor is require is associated with your air flow.

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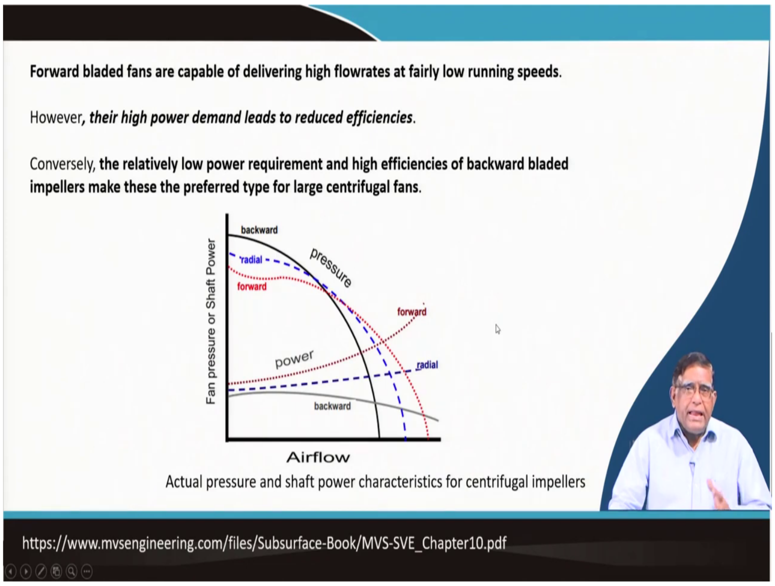

Now, this is a basic principle from the that our pump or fan or any turbo machinery and from there, when you see in actual conditions sometimes that will not be as it is, but you can see that is your fan pressure or the shaft power which will be coming it has got that pressure has got a in a forward blade, it will be going radial (Refer Time: 19:37) and coming like this.

In case of your radial, it is giving in this way that is your pressure decreases with the airflow and then, in case of backward, it goes like this and then the power requirement as you can see here in the forward. So, this is a main characteristics of the centrifugal impellers at which you will find.

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Now, question is that why it is required? Because our main ventilation fan if we are using it, but that is centrifugal type, it will behave like that and similarly, in many of the cases, you will be using our axial flow fan because that.

What are the basic requirement that the features your main fan requires is your it must be very robust design and constructions because there will be a heavy load and you need to withstand that is exactly under different conditions, your maintenance and all requirement should be minimum as minimum as possible. It should be properly monitored for that exactly, a robust design which will be requiring very less maintenance is expected.

Normally, mine fans will have to be a maintenance free operations and so far as because as mining is always done in a very remote areas and every time the excess may not be very convenient so, that is why a monitoring everything is required, a remote monitoring is very very essential.

Many of the old installations, therefore, is a it is a area of interest for you now, you can do a lot of mechatronics applications for sensors, for different parameters and then, giving a threshold values for different key performance indicators so that when what type of maintenance will be necessary and what type of conditions need to be monitored that must be specified that is why your a remote monitoring is another features which whenever you go for selecting a mine fan, you will have to think about that.

And then, there is some other characteristic is that it will have to be efficiency of this fan need to be high because efficiency is associated with your power consumption as because this is a cost factor that is your to run a mine, your you will have to have the fan whatever the cost it must be bond and that is why if you can reduce the costs, it is always good.

So, by for the reduction of cost, you will have to make its efficiency high that means, energy consumption required is less, but also that is your total amount of the manpower to be deployed for that and all these things also contribute to the costs. So, that is why if you can make it a higher operational efficient, it should have also a low operating costs.

Low operating costs maybe if you require little maintenance, if there is no more maintenance crew is required, no more operational crew is required, your operating cost will go down. So, that is why what you will have to see that this is a mine fan must be having a high efficient at low operating cost.

Similarly, you will have to this machines are running at a low speed and then, your expected condition is a low noised operations. Then, you can see that this can be installed at surface or sometimes you can install in the mines also.

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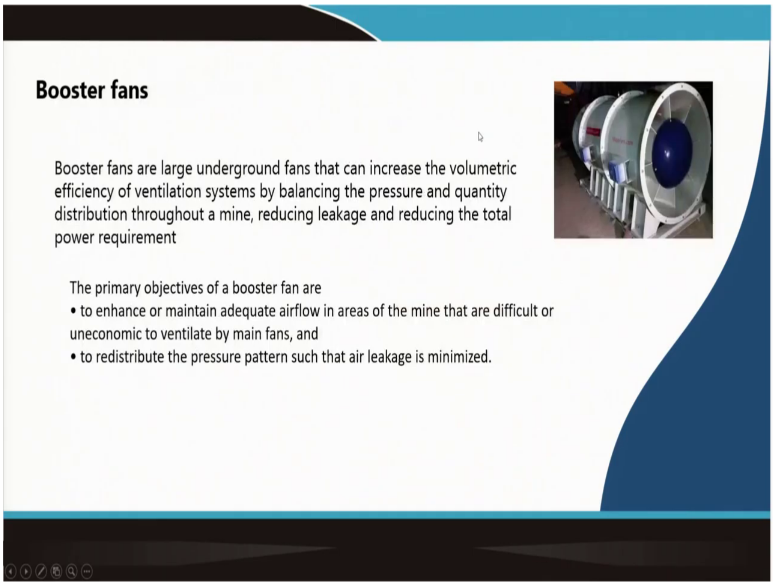

Now, when we talk about the booster fan, this booster fan many a times we use centrifugal fan also can be used, axial flow fan depending on the capacity size required. Now, what is a booster fans? These are exactly to increase the volumetric efficiency of the ventilation system. So, while studying your mine ventilations, you will be studying about their that how exactly your volumetric efficiency of a mine ventilation is determined.

Now, that means, your same here it will have to move to the different locations and that freshly expose the phases so, for that on the main part you will be having this booster fan.

Now, the main objectives of this exactly that is your in the mines there could be a leakage, there could be new more resistances may get introduced because of bringing of for introduction of new machinery or a different type of support system requirements come in in a mines so, under that conditions, there may be exactly the that requirement of booster fan may come in and enhance the main adequate airflow.

So, for example, in your main gallery, if a roof fall takes place at that time what will happen? There will be the total area will be increasing so, as a result that the flow velocity will decrease because now, you have got a more volume of air will be occupied in that space. Other than that when to support that one, you will be putting some additional support measurements so, that will be increasing more resistances to the airflow. As a result, what may happen? At the end where your people are working, there they can get a less amount of air and there is a specified as per mines act and regulations that you will have to have that much amount of air.

So, for that region, you will be having a booster fan and with the help of this booster fan, your the pressure that is whatever the ventilations air pressure should be there at different districts and different phases that you can maintain.

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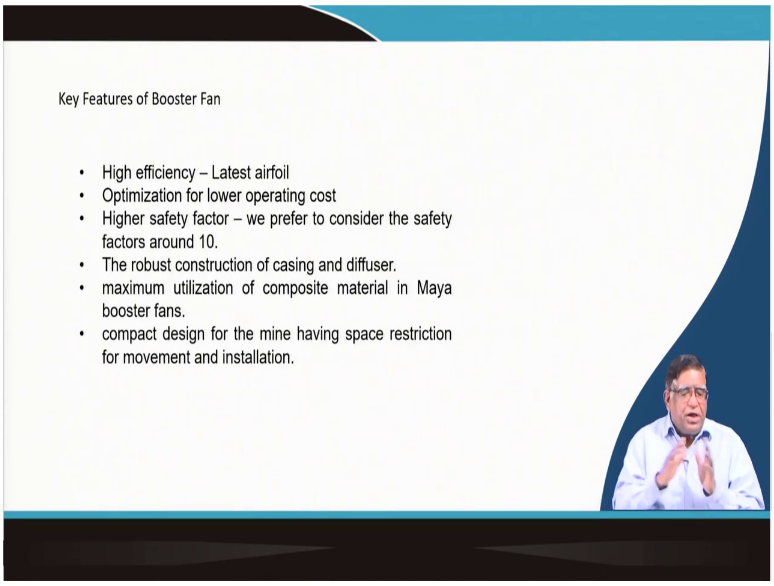

So, what type of features there that main key features here also that is your high efficiency, high efficiency of your booster fan can be accept by a proper airfoil that is if you are putting a latest air foil structures, there is a the design of the fan should take care of this higher efficiency. Then, as we said in the main fan, it is also you will have to optimize it for a low operating cost.

Then, it must have a high safety factor that is it should not get damaged and then under a work may be the conditions, it will have to be operating. Then, the robust constructions of the casing and diffuser that is important and a maximum utilization of the composite material a Maya booster fan is a company, Maya company's fans are very famous in the US and all. So, you can study that company's booklet. Similarly, we have got here also pulp fans and the number of Indian manufacturers are also there, you can see the specification of these fans.

Then, they need to be a compact design and having very space restrictions. In the mine, you will have to see that whether this fans are should be located inside the booster fan will have to be located inside in the gallery at the top and then, from there the booster fan your it is just entering into the mine.

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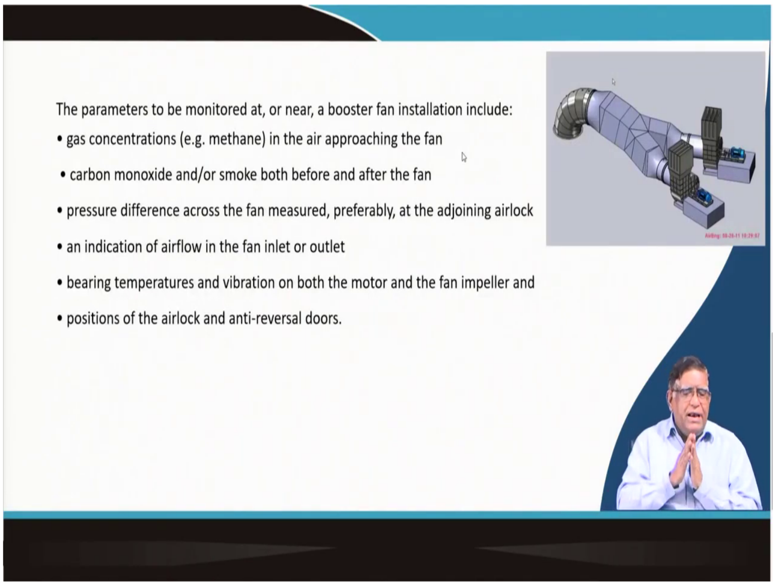

Similarly, your that is your booster fan you can see here that is the main fan it was coming over here, then you are having these booster fans going to the two different sections, now from there, you can have a temporary duct may be connected to this and then the fan may go like that.

So, that is the what you need to monitor for a booster fan it include you will have to see the concentration of gas if you methane particularly in a gassy mines say mines of that is a gassiness level degree 3 where parked on of coal exposed, you will be having a more amount of methane coming at that time, you will have to maintain a particular level of dilutions and then, so, that the inflammability of the gas mixture it is not there for that we will have to you can calculate out that how much air or will have to be send into a particular phase. So, in ventilation planar, they give that specifications and then, you will have to have that.

Similarly, if there is a carbon dioxide monoxide is coming that also will have to be reduced otherwise that is people will be having a problem with that their hemoglobin will get the exposure of carbon monoxide is dangerous you know about that and then, this is mainly what type of pressure differences will have to be maintained at the phase also that is your you will have to keep on monitoring.

So, that is the whole underground atmosphere your humidity, your temperatures, your air flow velocities and then, maximum and minimum temperatures all these things will have to be properly maintain and monitor and then, you will be designing in your ventilation systems where we will have to have the airlock, where we will be giving the stoppers and then how exactly people will be instructed to use this. So, this is how exactly done in a booster fan.

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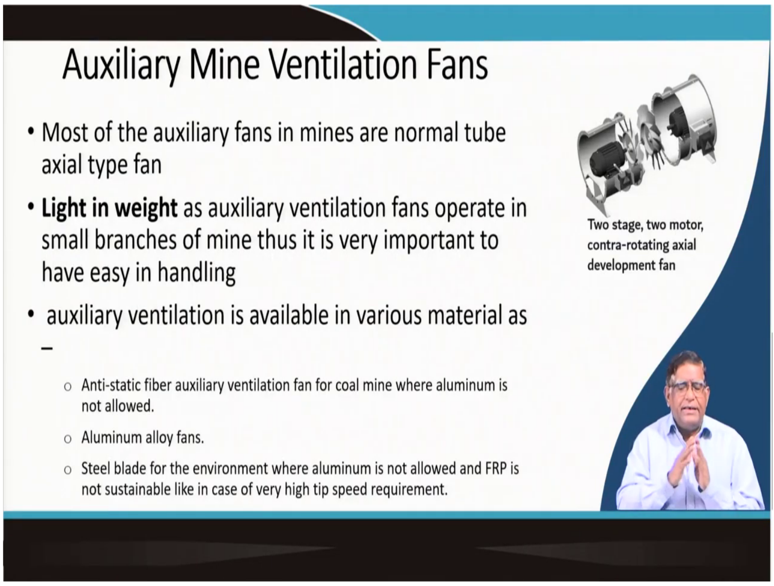

There is another type of fan which is your auxiliary fans. This is exactly normal tube shelf type of fans are used and their auxiliary fans are mainly used for just to give air where this it is not yet that say when the mine ventilation has not yet got to fully establish your that stopper door lock all these are not made you have connected say a gallery by a new phase is getting exposed at that time, at the working space you need to give.

So, you will be developing this auxiliary fan and that from the auxiliary fan, there will be a duct going and it will be supporting and providing to the phase. So, this basically, the mine fan is nothing, but in a ventilation system, how you will be selecting the machines and then, how it will be there.

Now, as because in underground, there is a the situations should there should not be much your what is called that are safety is of very important thing. So, how this fan will be powered that is very very important that to give the electric supply to the fan that your whole circuit will have to be intrinsically safe and that whole motors there it will have to be a flameproof enclosure.

And there another thing is there that is your the material which will be used there you need to take careful, be careful for coal mine that is your a for this purposes aluminum is not allowed so that is why you will have to antistatic fiber that will have to be used in those cases and then, some of the aluminum alloy, if it is a permitted type that is approved by the (Refer Time: 31:13) through their experimentations are only to be used.

And steel blades for the environment where aluminum is not allowed and your that is why you will have to see a flameproof operators at the flameproof enclosures will have to be used for this purpose.

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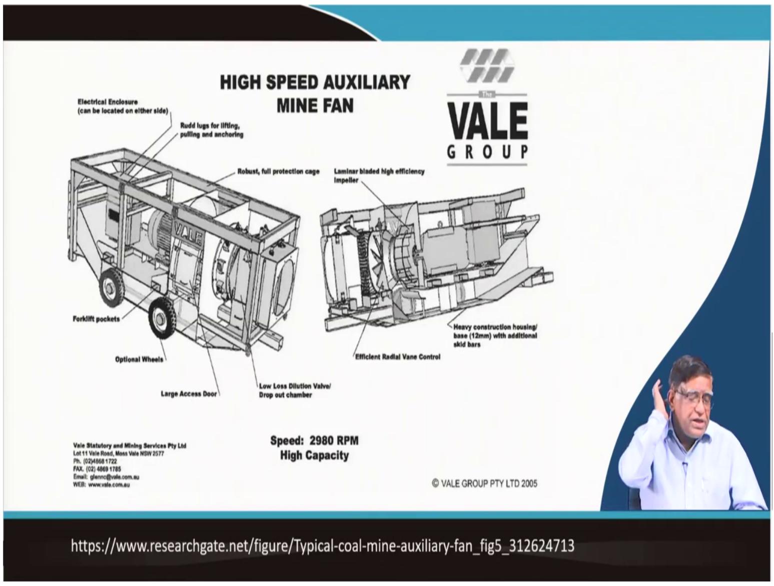

So, there are the different type of installations can be there that auxiliary fan can be a trolley mounted and it can be brought into the mines and then, you are having that exactly your motor and that all controls everything is given over here so that it is in a modular, it is a it should be a that is very easily handleable with in the dimensions of the gallery, these type of systems are there.

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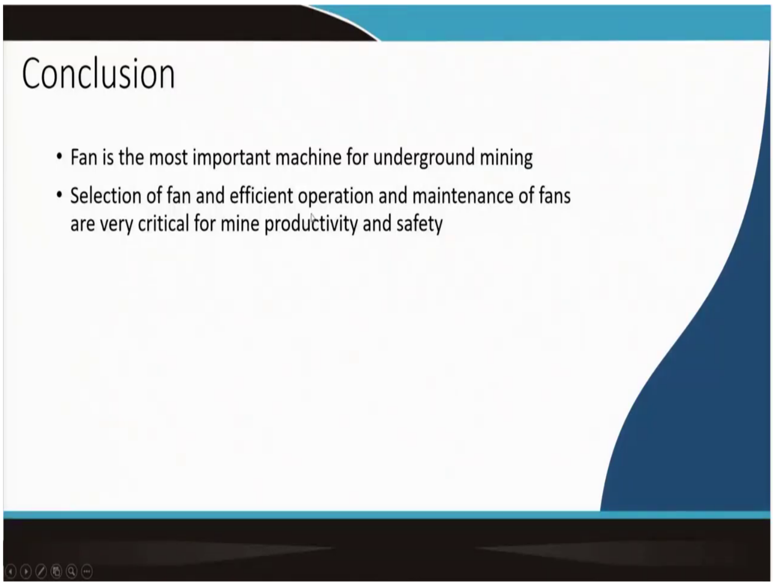

So, to conclude here, there is a fan is a very important machines for underground mining and we will have to select the fan based on the ventilation circuit which demands. Other than that in your machines like for cooling purposes, the fans are the normal fan.

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So, in this class, we have just given you in a nutshell the introductions of the fans of mine fans, but I hope that turbo machinery, it is an important piece of machinery we have discussed about the pump, fan and compressors. So, you please develop a interest in this subject so that you can do that as we have given some of the assignments and particularly, yourself study is very very important.

I hope after this discussions, it will give you the capability to study the relevant literature because here everything we have not covered, the theories we have not deducted, over here there are much more than what we have said. But for to become a best mine manager, you will have to have these basic information's and then, you can do a study.

Particularly, you will have to make a list of what are the main inspections to be carried out and how the operational data to be maintained so that it can help you in your decision making. To that extent, you can take in your mini projects or you can make a study.

That what are the main that is a parameters to be monitored for important decision making regarding how many manpower will have to be deployed in the mines for the management of the pump, fan and compressors, what type of trained manpower, skilled manpower at the worker or skilled worker will be required for running a mine in a trouble free manner because this pump, fan and compressors.

If they are not operating, if they are giving trouble as a mine manager, you will find a lot of troubles that is why you need to know about it how will you train and the workers for this to do certain job and how will you take decisions for selecting the best equipment for a reliable life.

So, with that, thank you very much. With this, we have completed this module on turbo machinery. Next, we will be starting discussing some of our transportation machinery in mining.

Thank you very much.