Mining Machinery
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Module - 02
Lecture - 06
Fluid Power for Mining Machinery

Welcome back. Today, we are going to discuss about the Fluid Power for Mining Machinery. As already you have started studying about this mining machinery, now as a mining engineer to get the proper services from the machines, you need to know that how these machines work. Now, out of that one of the major component of any machines these days is the hydraulic system. All these machines are working by fluid power.

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So, in this lecture, we will be discussing basically the hydraulics part of mining machinery as we will be introducing you what is a hydraulic system and how it exactly work. You know that the fluid, fluid is we both the liquid and gas together it is said as fluid. Now, in the mining machinery we use oil, mineral oil as a fluid, and also as a compressed air as fluid.

There are number of machines which use compressed air, particularly in drilling machines we use compressed air for its powering it as a pneumatic motors are used. And in many conditions, in a hazardous conditions where there is a electricity use may give spark, and then there could be explosions in any underground coal mine, that pneumatic systems were used.

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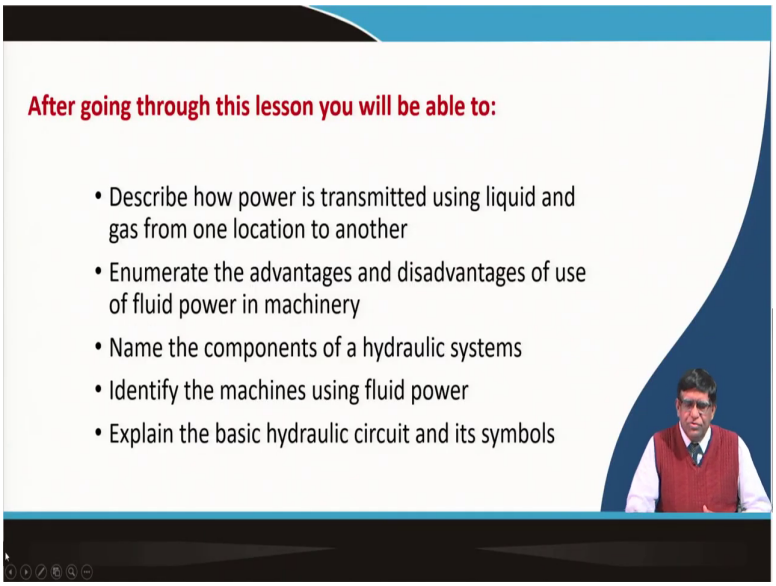

And hydraulics of course, is a one of the major utilizations in the machines. Now, in this class, particularly, we will try to describe how power is transmitted using liquid and gas from

one location to another. And we will try to enumerate the advantages and disadvantages of use of fluid power in machinery.

And you will be understanding or just what is an hydraulic system, and you will be able to name that what are the components of a hydraulic system, and how they work. And you will be able to identify that which are the machines in mining, they will be they use a fluid power.

And also you will be able to explain the basic circuits, and you will be able to read the circuit by identifying the symbols so that whenever any troubleshooting of this machinery are explained to you, you will be able to refer to these diagrams. So, we will be trying to concentrate on these areas that pneumatic part may not be included within the short period, but we will be introducing the general systems of this.

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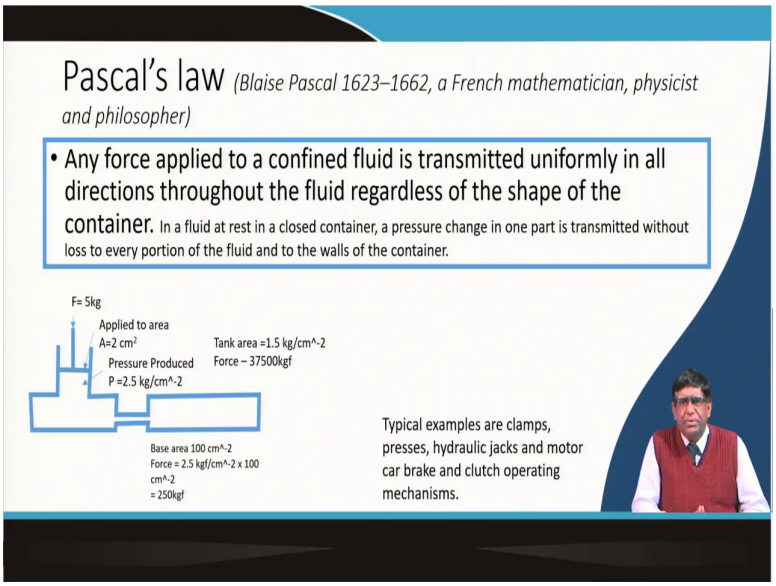

We know that the Pascal's law you have studied in your school days that is a when there is a fluid in a confined container, then there is a the pressure which get dissipated over there equally in all directions. There is any force applied to a confined fluid is transmitted uniformly in all directions throughout the fluid regardless of the shape of the container.

This you knew as a Pascal's law. And then all the development in fluid power transmissions were based on because of this particular properties of fluid. And you know that the basic equations if you are having a fluid or here in these two containers you can see. If we are applying a pressure that is force over here, that pressure which will be generated over here it will be distributed equally in all directions.

So, that means, here if we apply say for in this case in the if the cross sectional area, here is 2 centimeter square, then with that 5 kg force, it will be giving a pressure that is 5 kg f per centimeter square. Now, that same pressures will be coming over here. So, if your area on this portion is different, then your the force available will be different.

So, here in this base plate, if the area is 100 centimeter square, then you will be getting a force of 250 kg f, that means, from a 5 kg f, 5 which we applied over here that one will be coming over has a 250 kg f. So, that means, by this was the principle you have studied earlier in your Brahma's sprays and many other things. So, this type of system that is your a hydraulic system where that is from the place where you are applied the force and where you are utilizing it, and there you can get whatever the control you can get the mechanical advantage of it.

These are used in number of appliances some typical examples are clamps that is used you might have seen when you are doing in the your workshop practice in your basic class of when you went to a workshop you might have worked with lead machines, you have worked number of this tool holder. Now that holding the tools over there that you can use clamp. That clamp is operated by a hydraulic system.

You may seen some presses or you have if you have done to your that rock mechanics for different type of rock testing where you are using the pressure that is your compressive strength when you measure of a rock then that pressure is given hydraulically those press you have seen. You have seen hydraulic jack in while repairing your car or changing of your tire of a car, you might have seen those hydraulic jacks.

And also that you have seen your braking system of your car that is a all hydraulic brake is there in your car, and also that clutch that is also operated with your hydraulic systems. There are everywhere in a day-to-day life you might have seen how hydraulic fluid, hydraulic power is used.

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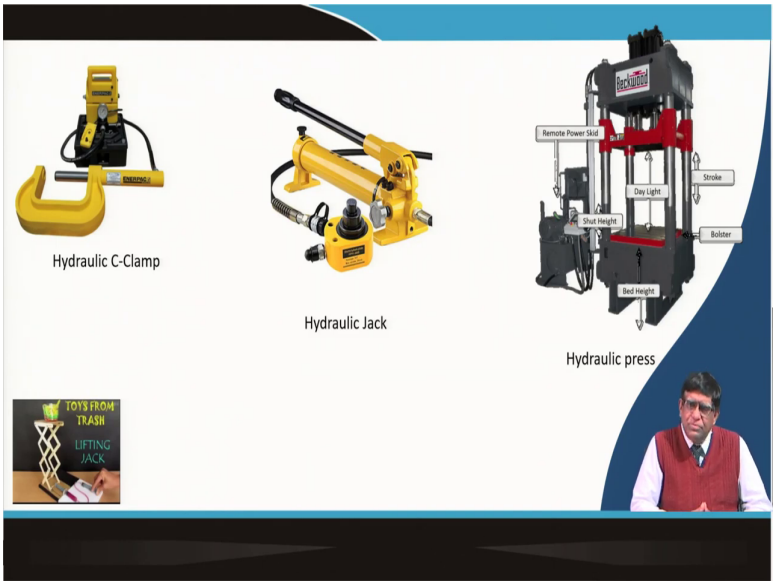

You may see here; this a hydraulic clamp. If you are to clamp certain things over here, you are having a hydraulic systems, you increase the pressure, the fluid will be coming, and you can

keep that thing tightly you hold it over there. A hydraulic jack you have seen; this once you can raise this piston and then you can take the load. A hydraulic press which is also there, you can keep the that is these are the different nomenclatures of a hydraulic press.

It is said that this big space is available. Then this is your lower bolster; this is a ram bolster. In between this you can lower it over there. You can keep a press over here and then you can give compressive pressures on some items. This, there are different uses of these type of machines. And also there is a this jack, many times the students make with their cylinder and things like that a jack for raising this type of toy.

Now, as I always tell you that for your mining for your machinery learning practical, you will have to start devising some toy. This is an example how some school boys they have done that is a jack hydraulic jack they have made with using this cylinder and some fluid they have operated like this. So, it is just in your free time you should think of developing some toys using these principles of hydraulics.

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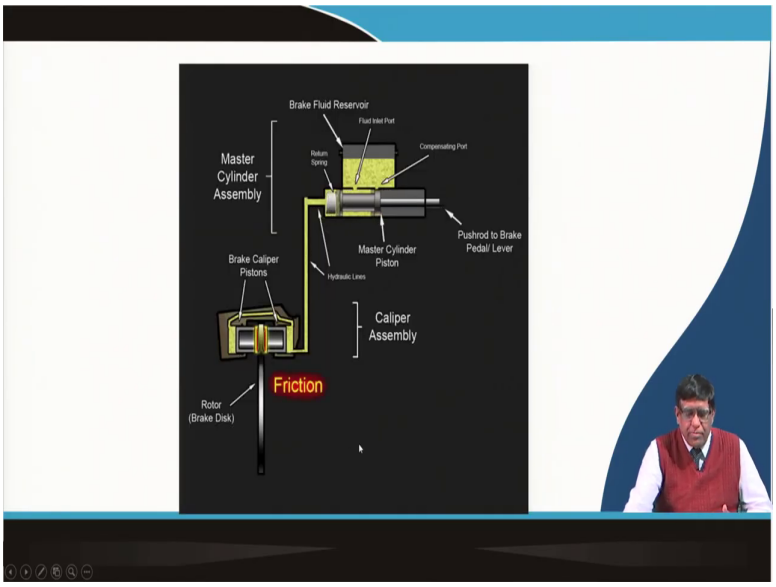

Now, here you can see that this how your braking systems work in your car, where you are having your when you apply your pedal that is brake paddle at that time you operate a master cylinder from which this hydraulic fluid that is your brake oil that goes and that gives the pressure. And where you are having the your brake calipers they keep if it is your rotary plate by which that exactly the wheel is getting power for rotations it is stopped over there and you apply the brake. So, these types of systems are available.

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And these are used in most of our mining machinery that you might have seen, we say this excavator as a hydraulic excavator that here the whole operation that is the propelling operations of the crawler, then your steering operations here for taking directions of it, then the swinging operation this whole superstructure of the machine can be revolving around that motion is also given hydraulically.

Then we have got this you can see these pistons where you are having this for the linear motions, you can this your gooseneck type of that boom, and this bucket connecting rod, all these can be moved over here. And then we can operate the bucket to excavate this is a backhoe where it is buckets the trouble is going in a backward direction. So, these types of excavators are used.

You can see here another equipment which is used in underground metal mines also very quite often called a drilling jumbo, that means, while you are to do a blasting in underground mine, you will have to do number of blast holes there to drill simultaneously four-five holes can be done by this type of hydraulic drilling tools attached over here.

So, this is a similarly in the surface mines, you can see here is a rock breaker that is we are giving by this big boulders are being broken to pieces by means of this rock breaker. Sometimes this is a rock breaker they use vibro reaper where there is a ripping blade is here. So, it is also to cut this rock.

And this is a vibrator this can be attached in the front attachment of this hydraulic excavator. You remove these portions and you can add it up another device, and you can do another operations over here. Similarly, in underground mines you will be having this is a roof bolter that is also they are doing a horizontal drilling over here, and also they can do vertical that is a hole, so that they can make a bolt, so that the roof do not collapse. So, this is also a machine.

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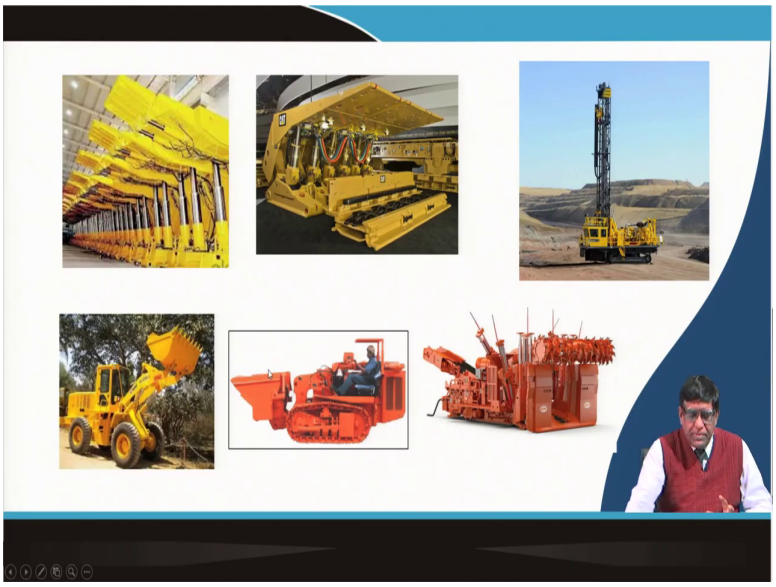

So, there are number of machines in underground mines also you can see this is a hydraulic power support. This when you do in a coal mining, you might have read about this long wall coal mining. When you will be doing that the gallery mine gallery must not get collapsed, so that upper strata will have to given a pressure, so that it do not collapse, and that is done by this hydraulic power support.

This there are wide range of the supports depending on the situations. We can have a very compact one as well as very high for depending on the thickness of the coal seam we can design this. But that also you can see here there is a which is a part of a armored phase conveyor where in a long wall mining that coal will be cutting a shearer will be sitting over here. Now, these face conveyor to move along with that when the mining advances the whole operation is done by hydraulic power.

So, similarly you have seen this is a side discharge loader which is used in underground. Also a front load front and loader which is used in open cast or a continuous miner with a roof bolting arrangements. This is a Joy company they make it that this type of machines or a drilling machines, blast hole drilling machines in surface mines, there the main drive is from hydraulic power.

So, as a mining engineer you must know that how the mechanical engineering has developed and these are included in these machines. So, you will have to have a basic understanding of hydraulic system.

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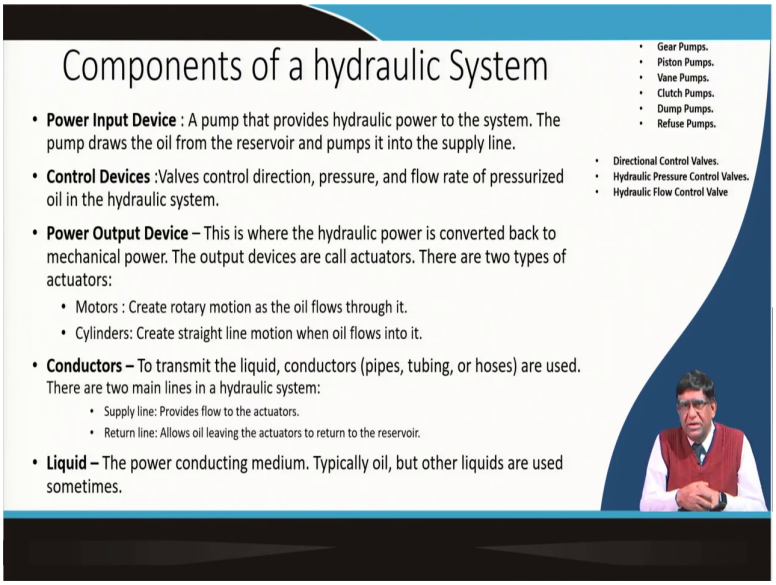

Now, if you talk of a hydraulic system in a machine basically these five main components are there. What are they? The power input device; that means, the fluid will have to take get the power, and so that this can operate the particular your this functional element of the machine.

Every machine has got a functional element. Say your bucket is a functional element, your drill bit is a functional element, and the functional element they required the torque to be given or the power to be given. And that one can be given through this fluid as we have said in case of this by hydraulic that oil or it can be in water in some cases.

Now, here, for that, it will have to get that power from a source and that is exactly the pump. So, that is in any hydraulic system, there will be the pump as the main power input device. And that pumps can be of different type for using in hydraulic systems. As you can see here there could be a gear pump.

This, there are a number of, this mainly the gear pump, piston pump and vane pump. These three types of pumps which give you the hydraulic that that main power input device for a hydraulic system; other than that, there are also some different type of pump we can say is a clutch pump, dump pump or refuse pump.

What is this clutch pump? It is in your clutch also how it is operated that is else wherever you are giving the energy from a source and then you are driving the fluid that is the pumping. You may have seen that even your that the tube oil there is also pumping operations. So, where that fluid is getting the power from your manual that tube will operations, fluid is getting power that is a pumping.

Similarly, your dump pump you might have seen on the roadside that sometime some of the trucks there that body is lifted up that is exactly to dumping the material whichever is there. There is a pump operating over there. You have this refuse pump sometimes in your waste generation system in wastewater and all where lot of debris is and all will be coming and accumulating over there that type of a mixing of study how it will be taken over there, those type of pumps are called also refuse pump.

Different type of pumps are there, but the mainly that we use in your hydraulic systems in your machines gear pump, piston pump and vane pump. So, we will be discussing in our later classes about the different type of pumps. But the other thing is that there are different control devices in a hydraulic system, you need to control the fluid.

Because whether that your operating device or the functional element will have to get that when it is required to work, when how much force is to be given, and then when it will have to do a smooth control all these things is done by this the fluid. And there are three different type of valves are there which exactly does this control.

These valves are directional control valve, hydraulic pressure control valve and hydraulic flow control valve. Similarly, there is a power output device. As I said that is a functional element how it will be working. In most of the work, there is exactly either it will have to rotate or it will have to give a linear motion.

So, depending on that, we have got a hydraulic motor or we are having this actuator whether piston and cylinder, these are the main output device. And then the fluid must go through certain distance, you will have to have some conductors. That conductors are nothing but you might be hearing that word called hose pipe.

Now, this the fluid will be under high pressure. So, that if you use an ordinary pipe that it will be bursting and if the oil bursts, it will be may creating a unsafe condition because it will become slippery. So, for that reason, what you need to do is you will have to have a proper design of those pipe or that through which this fluid will go.

These are there could be a different type of depending on where the machine is working if it is working in an open cast mines where the temperature may go up to 50 degree centigrade or sometimes if it is working in Alaska where it will be going about minus 20 degree centigrade. So, with a wide range that what type of pipe will be carrying out that fluid, that is depending on that we have got different type of hose pipes.

And then the main thing is that liquid that which will be working as we say this could be oil, water or air, and sometimes we have got systems in which nitrogen or other inert gases are used. So, then these are the basic components of a hydraulic system.

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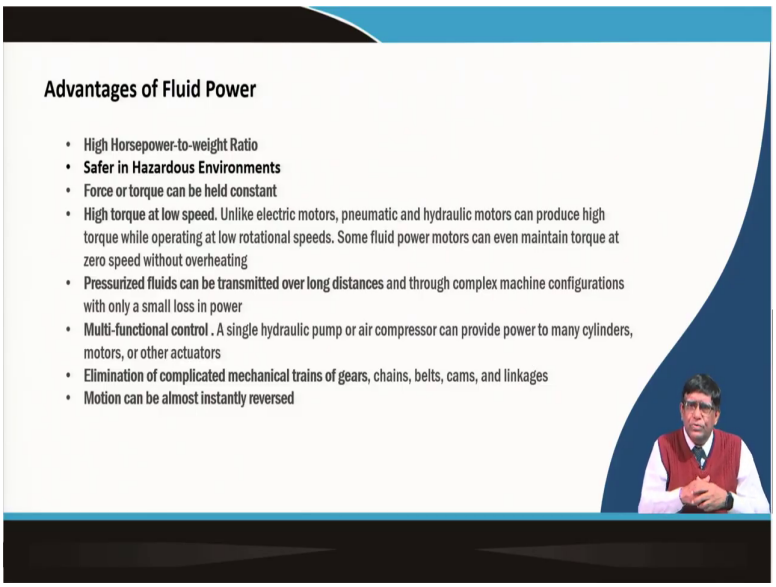

Now, a question comes that why we go for a hydraulic system? You have seen that in machines basically there were the originally everything are mechanical systems with your gears, your chains, you have studied already. Now, this when you use fluid for bringing in power, it has got the basic advantages high horsepower to weight ratio.

That is if you want to transmit power by a gearbox for a very applying for a very high torque, your this gear size and also will have to be robust, and its weight will be more. But in a

hydraulic systems your pump and other things there will be having a very less weight, but it can give a very high power output could be possible.

Then it is a safer in hazardous environment. In say as I already told that in an underground coal mine where there is fire damp which may get that if there is any spark because of the gear frictions if it gives a heat that gas may get burnt or if there is a when you make a electric switching, at that time whatever that for a momentary spark comes that can exactly ignite an explosive gas.

So, under that places if you are using the power is going by that is a in a not inflammable fluid or by air, then there will not be any such accidents.

So, then force to torque can be held constant that is your whatever is required at your working functional element can get a constant force or a constant torque. Then high torque at low speed, this is another things you can achieve through hydraulic fluid. So, normally you will find that for some of this that; another is pressurized which can be transmitted over a long distance.

Because this fluid pipe if you make a longer pipeline you can get the things to be done at the other point. Then there could be multifunctional control. As you have seen that from a one hydraulic pump in a drilling jumbo, four drills can be operated with the same compressors or same hydraulic motor.

Similarly, it can the that your power transmission in a gear or in a chain that is your in a belt, there will be the cams different links, all those components are not necessary, so that motion can be almost instantly you can reverse. Reversing the system is just fluid can easily get in the flow in the opposite directions if you can manipulate it away.

But in case of your gears and all you might have seen in your car also while you are driving to go in the backward directions, you need to put your that is your you operate your clutch

engaged reverse gear, then only it will do. So, in a hydraulic system this becomes much easier.

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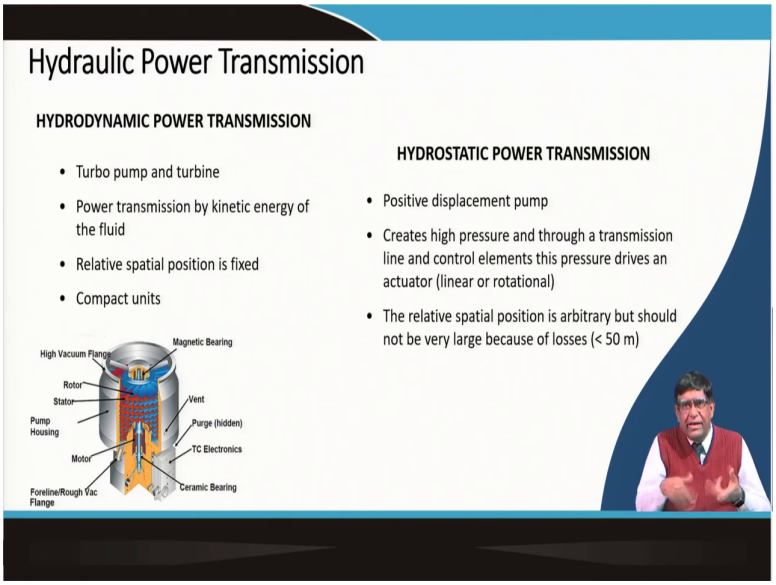

Now, hydraulic power transmission this, there are two basic system, one is called hydrodynamic power transmission and another is your hydrostatic power transmission. In a hydrodynamic exactly that all things in a motion; so, you this turbo pump and turbine this exactly you have heard earlier that I think that when you got the Leonardo Da Vinci's name is taken it is not only for the painting of Monalisa, you know that he was that exactly water wheel.

That water wheel was nothing but a it is a turbine when the water is coming over here, and then it started rotating, and it can do the necessary work. In your the basic fluid mechanics class, you might have studied about what is called your Pelton wheel, that Kaplan wheel and

different type of turbines and in the hydraulic sector it is there. But this basically a turbo pump is what? There will be a some of these there are blades or vanes, and then a fluid will be there which will get that rotations.

So, it can be working for that is for as a creating vacuum, you might have heard about the turbo molecular pump is there where you can exactly create a very good vacuum, or the turbines you have seen in case of your all hydraul term power stations and what that exactly the water is allowing to run the turbines rotates.

And then you do in case of your wind mill also in that wind power generations you have seen the blades move exactly it is making the turbine to rotate, and then you are generating electricity from that is exactly the basic things of our turbo rotary systems over there. Here exactly they when wind is moving there is a kinetic energy, or when water is flowing that kinetic energy is there. And from there this exactly from that plate you are getting the power.

Similarly, there is a relative spectral position is fixed, that is a there will be the turbine and then which is a rotor and the stator inside that will be the relative positions remain fixed. And then we are having a compact unit that is what is in a hydrodynamic power transmission. In hydrostatic power transmissions, we are exactly using a positive displacement pump where the fluid is exactly moved by the rotating member of it.

So, this exactly they can in a hydrostatic system, they generate a high pressure through the transmission line and the control elements of these pressures can drive the actuator, your whether the piston is getting that fluid. So, fluid is moved towards that, and then we are getting the translatory motion. So, the relative spatial position is arbitrary, but should not be very large because of the losses that is what is in your hydrostatic transmissions.

If you see in this diagram of a your high turbo pump, you can see here that is the main thing is there is a rotor, and there is a stator. Now, this rotor is rotating and then this exactly the fluid is getting over there.

So, as a this type of pumps that for a turbo molecular pump that where the gas is getting, your this the your when this rotor will be moving, and your that against a stator your the fluid will be getting that your the main operation is given from this motor. As a result you are able to suck the that is your ear, and you can create the vacuum that in a turbo molecular pump.

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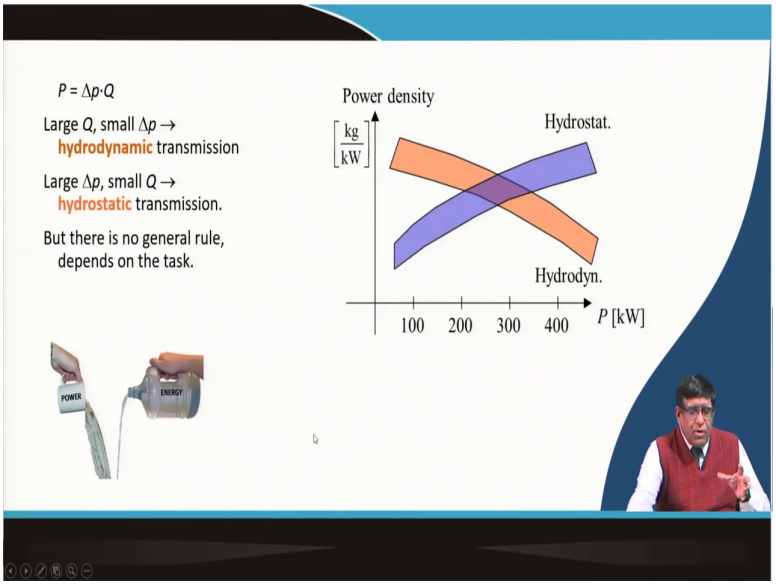

So, similarly, your exactly what is happening in case of your the in hydraulic systems that is basically your two things the power and energy. Sometimes, you can get more power because of the more fluid is flowing over here, and that more energy the kinetic energy coming over here. That basically the total pressure whatever you are getting that is your quantity and that pressure difference their product is coming over there.

In hydrodynamic transmissions, you are having the large quantity, but small pressure; and in case of hydrostatic, you are having more quantity and that your large pressure. And there you

can see here that how your pressures density power density in case of your hydrostatic less than 300 kilo Watt, you are having that is a lower power density. So, this is the way how you can see the differences of these two systems.

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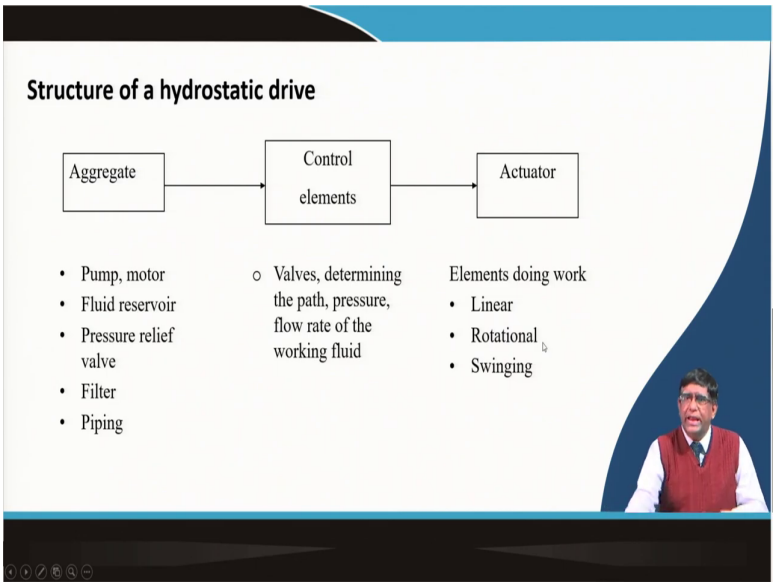

Exactly in a hydrostatic drive, your main components that is which are used the pump, motor, fluid reservoir, the pressure relief valve, filter and piping, this is what exactly used. And the control elements are valves that determine the paths, pressure at the pressure flow rate of the working fluid is controlled. And then the actuator whether we are getting a linear, rotational or swinging. So, this is the how in a system works.

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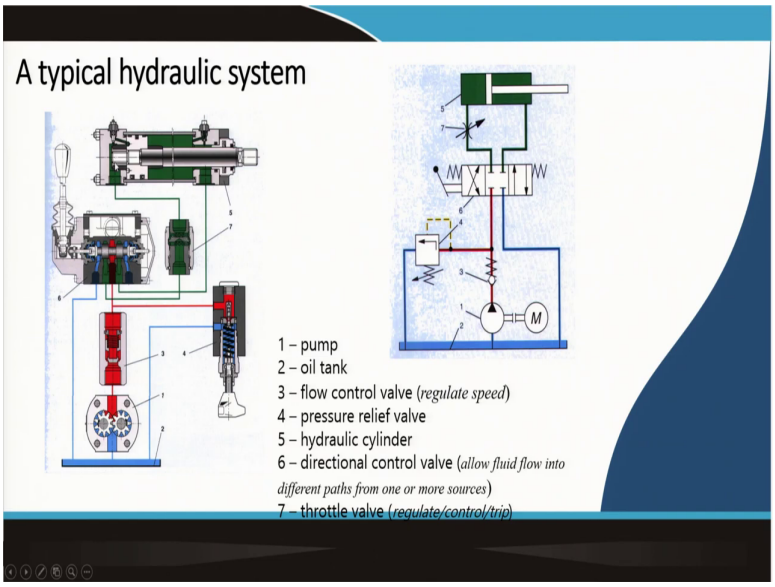

So, if you see that to work these hydraulic systems when you are going to use in a machines, then they will have to create a circuit, that means, the fluid will have to go from a reservoir. And then from that reservoir or tank, and then it will have to do the work, and that again will have to come back to the reservoir. So, that is why your in any hydraulically operated equipment we tell about a circuit hydraulic circuit is there.

So, here you can see a basic typical system what is there. You are having a oil tank here. From that oil tank, you can see this is a symbol of a pump that is it is a gear pump. There exactly this fluid is pressurized. This pressurized fluid you can see over here. And this will be going through a flow control valve. This will be that flow it will regulate the speed of it, and then there will be also always a pressure relief valve if to control that the fluid flow.

And then there will be a that your main directional control valve which will be changing that which directions the fluid will have to go. And then we are having this our a throttle valve that will be basically to regulate or sometimes you need to trip or control that operations will be looked into. And it is going to the main hydraulic cylinder or actuator.

Now, the same things when it is expressed, there are certain symbols. Here you can see that this is a symbol of a pump. And then this is a symbol of a motor that is driving this pump. You have got this is a non-return valve this symbol is here. Then you can see as a pressure relief valve, this is a symbol. And then there is a directional control valve in where which direction which flow will be going is controlled by this valve.

And then there is a piston, this is a symbol. So, in any hydraulic circuit these symbols are to be known and then you can tell that how it will be work. Now, there is a total valve which control and regulates, this is a symbol of that.

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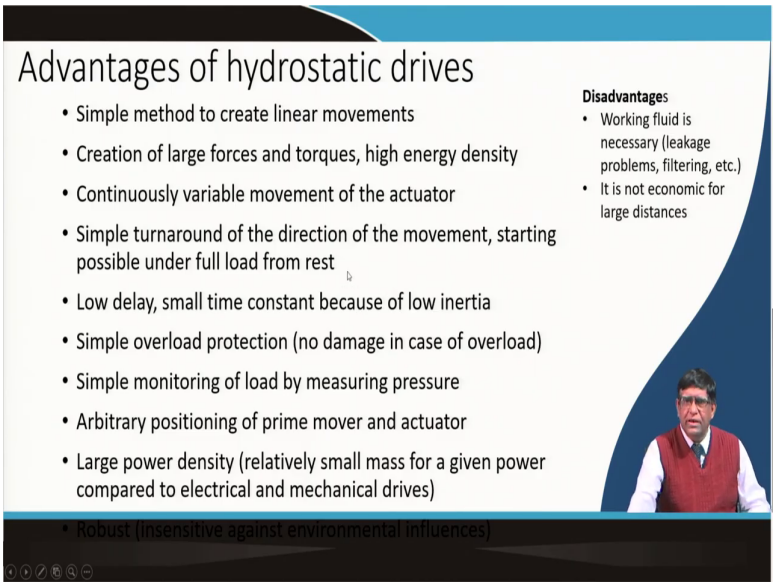

So, this type of systems when used there are different advantages on that hydraulic drives. That is a very simple and create linear movements; creation of large forces and torques, at high energy density; it is possible continuously variable movement of the actuator; simple turn around that we can easily make it reverse; low delay, small time constant because of low inertia; simple overload protections, you can easily get it there will not be any damage.

But in case of your electric motor and all in overload sometimes it may get the motor may burnt, and then it will be very big problem. Similarly, a arbitrary positioning of the prime mover and actuator wherever you want to stop it is possible, then large power density that is the advantage of the hydraulic system. Disadvantage is there is a fluid. So, if there is a leakage, then there will be a problem.

And then also it is not economic for a large distance. Electric motor from your having a source somewhere you lay down the wire and you can do anywhere that type of testing is not there. It is for a compact within an equipment or within a smaller area it can work over here.

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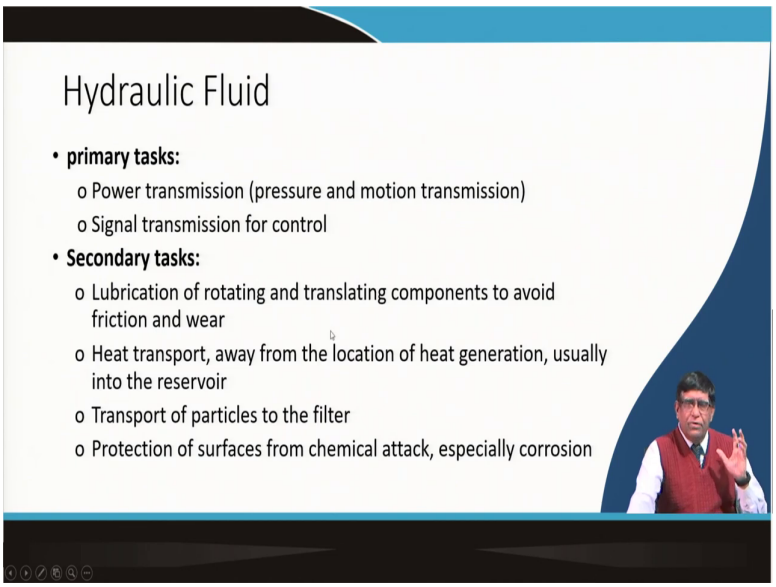

Now, this fluids as we said that the task mainly the fluid will have to do the power transmission. And for that, it will also do the lubrication of it then your heat transport away that is heat will have to be taken away.

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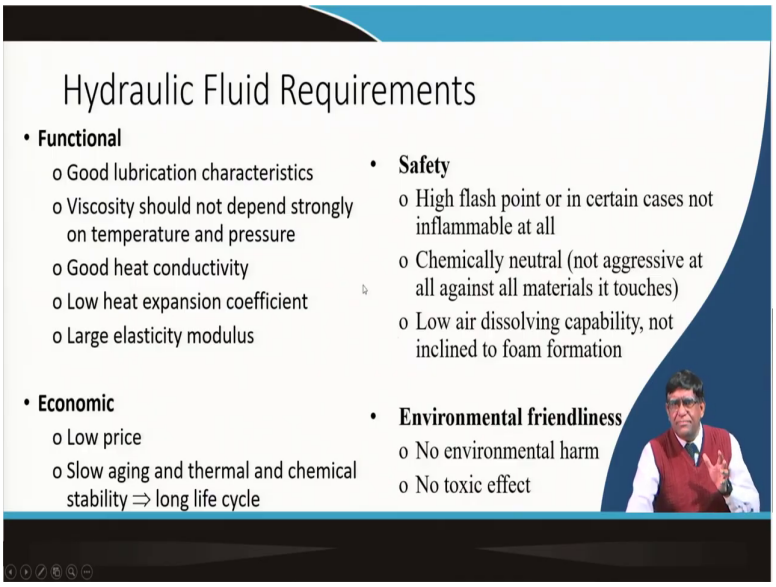

And then if there is any debris and all that particle also will be transported to this, and it will have to be protect from the corrosion and other things. Then other functional requirements for this fluid should be good lubrication characteristics should be there, viscosity should not depend strongly on the temperature and pressure, good heat conductivity, low heat expansion coefficient, large elastic modulus, then it should be low price.

So, that it should have be safer it flash point that means it should not get heated up under the operating condition whatever by the temperature there that temperature should not ignite it to make it too inflammable. So, that is a, that if the high flash point, then it will be always safe, then it should be environmentally friendly.

So, these are the some of the conditions on the basis of which the hydraulic fluids are generated which are sometimes an emulsions or that motorized fluids that we can have a oil

in water emulsion, or water in oil emulsions sometimes used as a fluid. And sometimes these mineral fluids depending on the type of work, you may have some additives to make it non-inflammable, you can make it a corrosion resistance, all these things are done.

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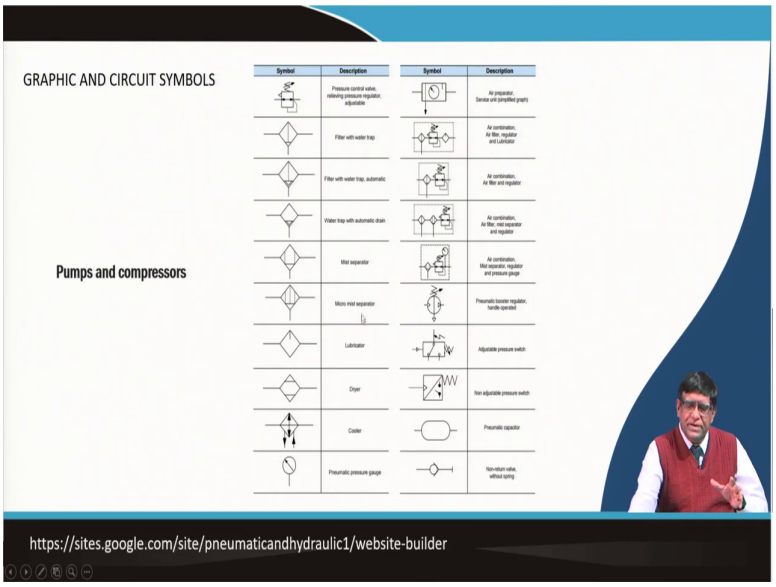

Now, that as a symbol if you refer to any books on hydraulics and pneumatics, you will be able to see that these different symbols are used for the pumps and compressors, different type of pumps different type of compressors are used in different circuits.

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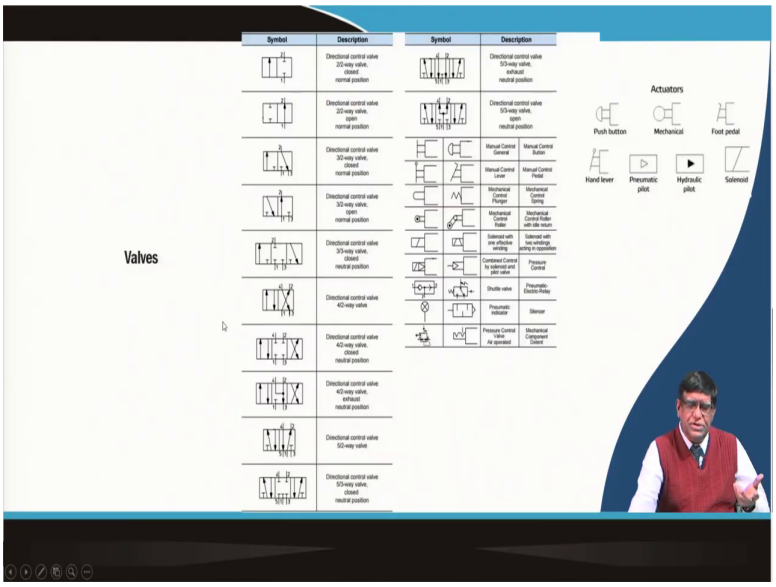

Similarly, there are different types of valves for which will be controlling the whole circuit. And then there are different type of actuators, they are all symbolically represented that you and these are to make the particular circuit.

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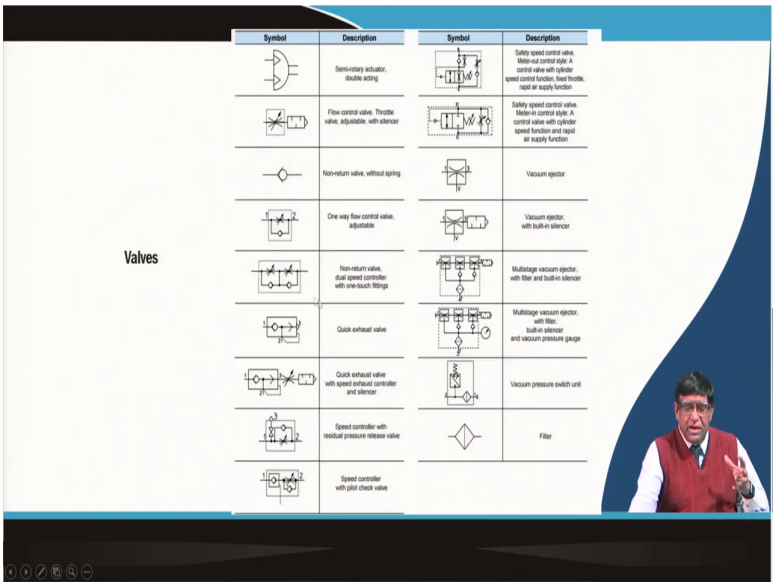

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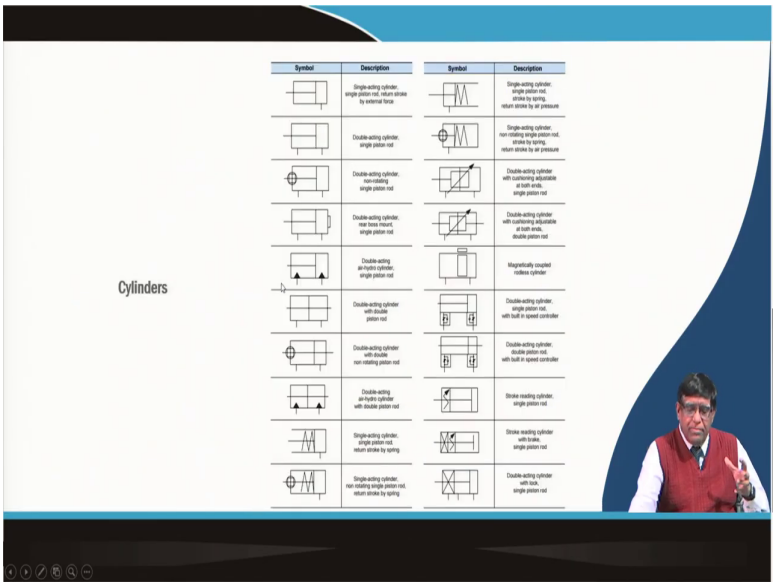

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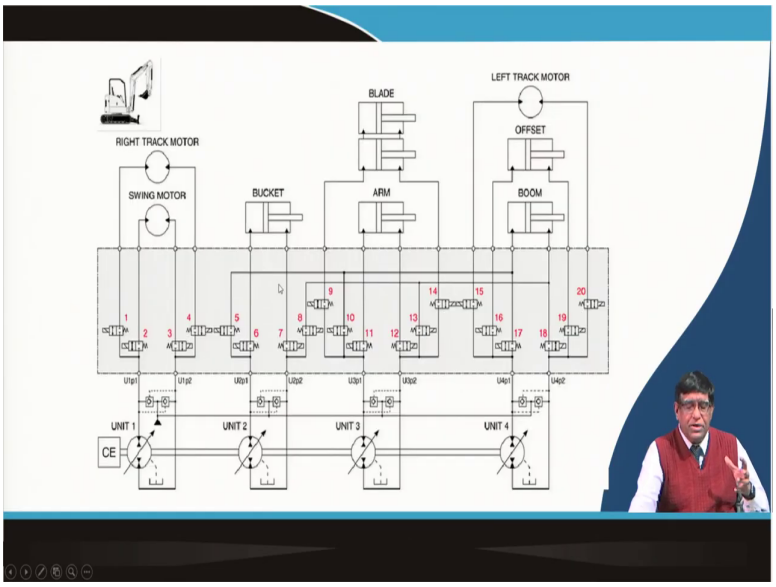

Say for example, in a hydraulic excavator for your which track motor, and then how they will be getting the fluid from the that your motor, and the pump unit that your fluids will be flowing through different valves and these valves will be controlling over here.

So, that means, the operators cabin when he is using the joysticks, by doing the joysticks he is exactly giving commands or he is controlling the different valves. And from that valves the fluid power is going, and that operation is working. So, basically this is how the machines work.

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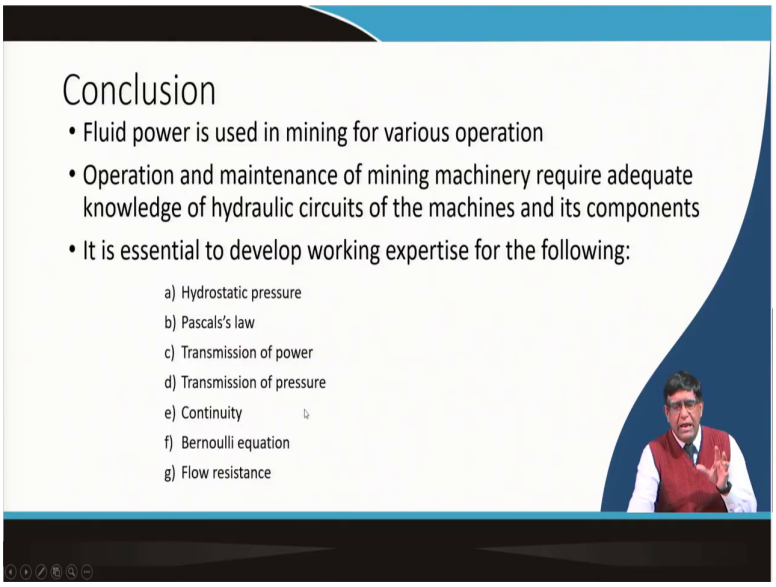

So, you will have to learn that the basic principles of it. So, for this the essential you need to know about that what is the hydrostatic pressures, you will have to know what is a Pascal's law that is a transmission of power how it takes place, transmission of pressures how it takes, the continuity equations which you have studied in your basic fluid mechanics that Bernoulli's equations you know, and the flow resistance in a pipe.

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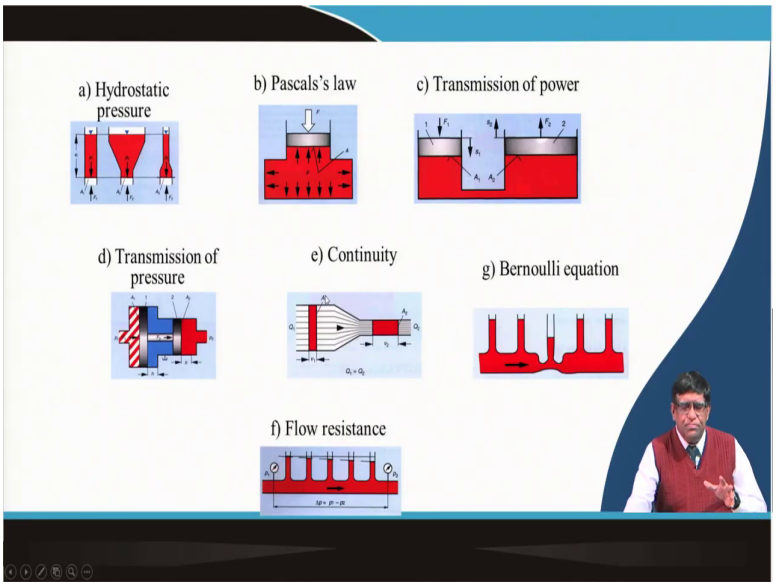

If you know the basic calculation of these parameters, then the oil hydraulics and that basic fundamental required for a learning about the machines will be clear. So, we will be discussing the machines at that time we may be referring to it.

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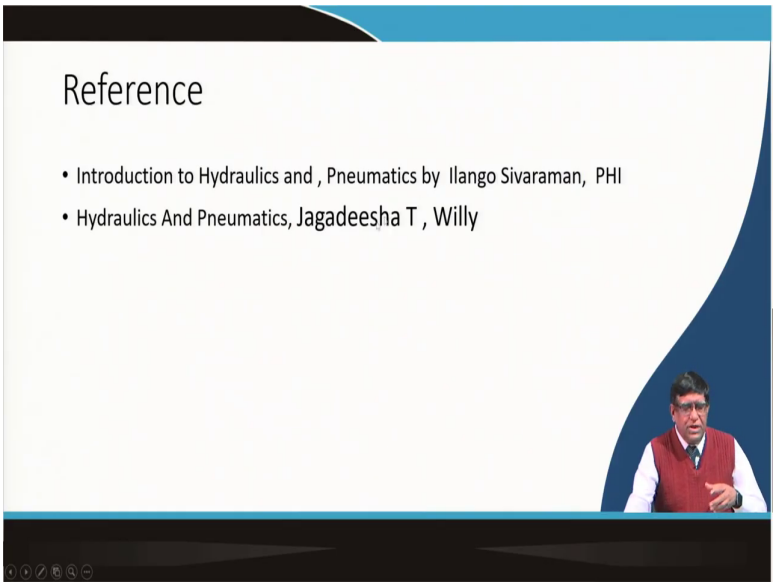

But I request that you please go through some of these books on Introduction of Hydraulics and Pneumatics, so that you can understand this basic your few things are there, this very basic concepts which are required to know more about the machinery. So, with this, I hope that you will be preparing yourself to study Mining Machinery.

Thank you very much.