Mining Machinery
Prof. Khanindra Pathak
Department of Mininig Engineering
Indian Institute of Technology, Kharagpur

Module - 02
Lecture - 05
Shafts, Pulleys, Gears and Geartrains Bearing and Brakes

Welcome back to our discussions on Mining Machinery. So, today we will be discussing about some more machine elements which are available to study this machinery, we must have the acquaintance with different components and parts. So, today's class, we will be discussing about Shafts, Pulleys, Gears, Geartrains Bearing and Brake.

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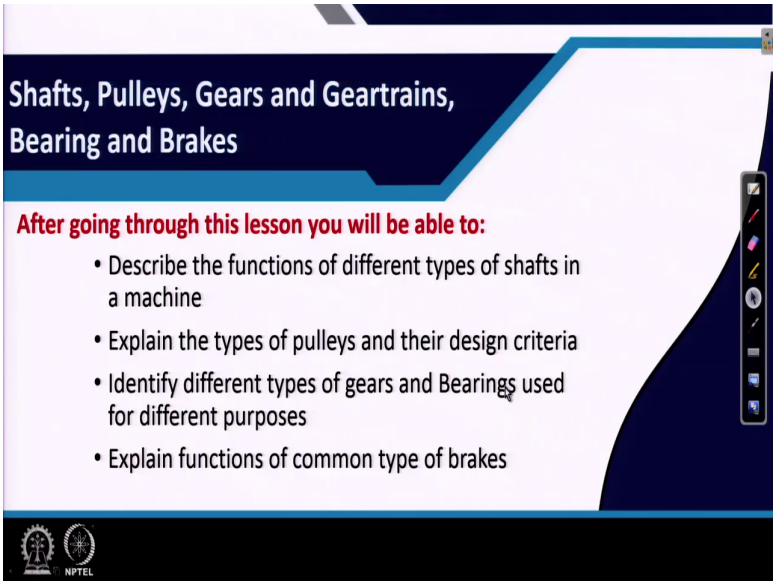

Number of items we will be just introducing our objective of today's class is that after going through this lesson, you will be able to describe the functions of different types of shafts in a

machine; explain the types of pulleys and their design criteria; identify different types of gears and bearings used for different purposes; also explain functions of common type of brakes which are there in different vehicles, different types of machines used in for mining purposes.

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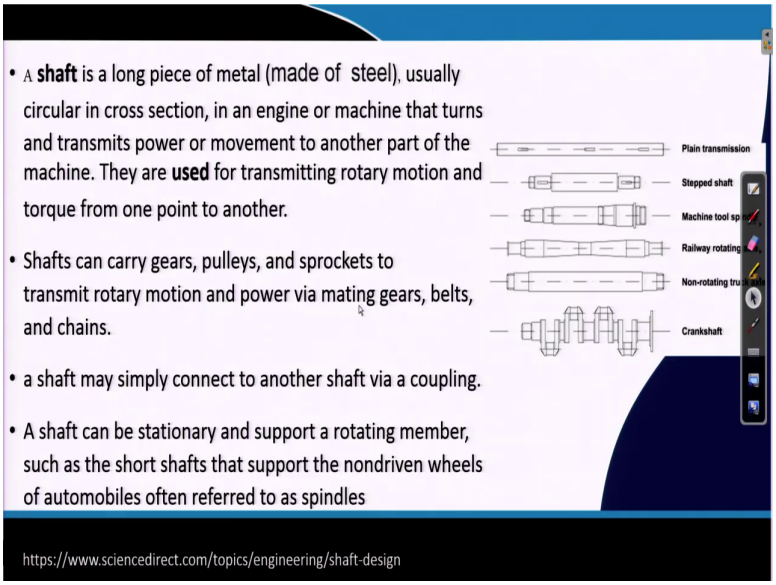

So, as we know shafts this word is exactly known to mining engineers in a different way; normally the when we understand that shaft is the vertical opening to the terminal deposit. But in a mechanical engineering, our shaft is a long piece of metal made of steel normally, usually circular in cross sections and it is a it turns and transmits power or movement of another part to this machine.

So, you might have seen the shafts of your even in a say bicycle, you sometime use this shaft where you are pedaling over there is also a shafts and axles, these two are very common

terminology you use. But this is a any part in a machine where you are mounting the gears, pulleys or sprockets, and so that the power from the prime mover or the main source of power; then it is transmitted to the driven objects by means of this shaft. And it is a sometimes one shaft is connected to the another shaft; it may not be carrying another element, another parts on it, it is just only transmitting power from one shaft to another shaft.

And sometimes these shafts can be in same in the same line or it can be at different angle. And it can be also a stationary to support some member, rotary members are being supported. So, it is therefore, a different purposes they are used. Now, you can see here in this figure, there are different types of shafts are being shown. You can see this is a plain transmission shaft, where it is a total cylindrical this shaft; you can see here these are the key holes by which that exactly it is connected to the bearing.

Now, here we have got a stepped shaft, in which a different part of the shaft; they have got a different diameter depending on the particular load and particular applications, such type of shafts are designed. You have got the machine tool spindles; there also you can see that number of the diameters are different sections are different.

You can see the railway rotating axle, where the two wheels of the railway are mounted at the end and this is an axle of the railway. You can see non rotating truck axle, where exactly this member will not be rotating; but the wheel which is connected over here they will be rotating, as you can see in the trucks or trailer tractors and all there.

And you can see this is a crankshaft that is an engine crankshaft, where your cylinder engine, cylinder blocks are mounted over here; so where the translatory motion is getting converted to a rotary motion in this. So, there are different types of shafts are available.

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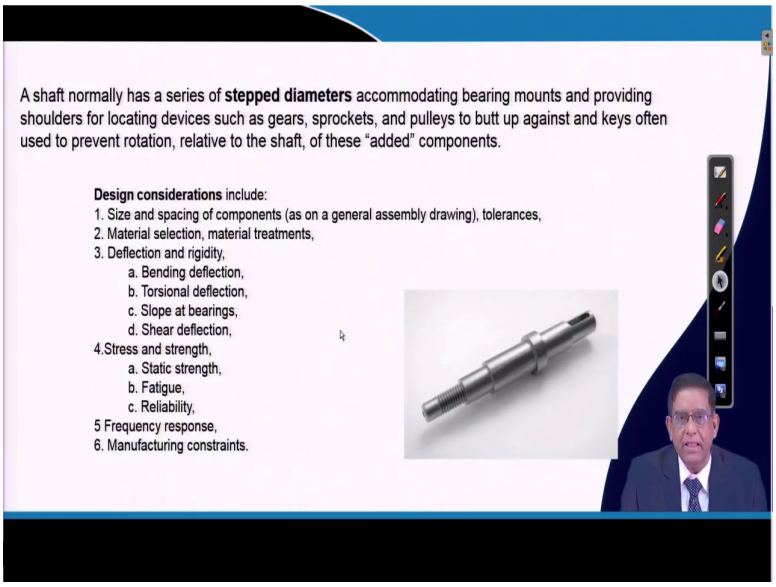

Now, they have, as you can see here; this is a picture photograph of a shaft which is used. So, it is normally you can find like that a stepped diameters are there. So, and there on these you will be mounting the gears, sprockets or pulleys, so that the different purposes in the machines can be done.

Now, while designing this shafts, the number of points are to be taken into considerations; particularly the size and spacing of the components and then what will be the tolerances, exactly how much vibration load, how much displacement will be there.

Then material selections, because it will be transmitting the torque; so it will be subjected to the torsional load and also it is taking this the load, there may be compressive load, there may be tensile load also, there are different types of loading can be done depending on that. It

should be strong enough to withstand that, that is why the material should be selected properly.

Many of the shafts will be finding still; then that some special purpose applications you will be using, some alloy steels also. Now, there is a deflection and rigidity; these two are the most important parameter to be considered, so that it should withstand the bending deflection, torsional deflection, slope at the bearing and shear deflections that need to be withstand. Similarly, the stress and strength; that static strength, fatigue and reliability that is considered.

And then the frequency response how exactly the load will be transmitting, stresses will be coming over there and then to manufacture that; if you design a very complicated type of things, if it is difficult to manufacture. And there another thing you need to see, where the stress concentrations will be there; whether these stress concentrations may lead to weakening of the shaft and that machine may get premature failure.

So, in a nutshell, that is shaft design is an important job for whenever the machinery manufacturing company they do it; that design need to take a very careful decisions over there. The basic things as a mining engineer, you will not be studying the design of the shafts and all; but you must know that, when you are selecting this, how you will be working with it.

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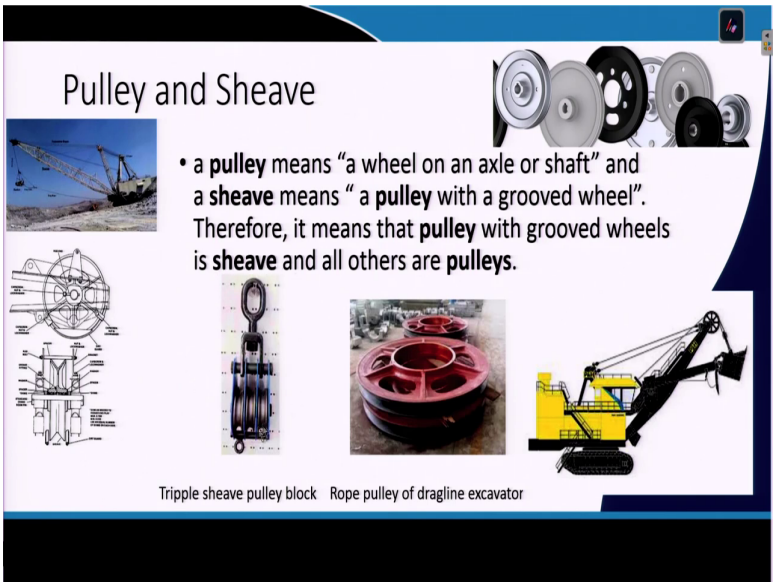

So, you should be able to identify in your machine that, whether that which are the shaft and when it were any proper machine, procurement machine, maintenance and other jobs are there; as a mine manager, you will have to have this information. So, please try to have the basic idea of what is a shaft and what are the main stresses coming on it and what are the basic considerations required for designing a shaft?

But the other important things you will find in mining machinery, the pulley and sheave; you can see here in this figure, this is a picture of a dragline, now and here is a picture of a shovel. So, now, the next important component in a mining machinery is the pulley and sheave. In this particular slide, you can see the two machines are shown here; one is your this dragline and the other one here a electric rope shovel.

Now, these machines are whole operating member, that is the bucket by which you are collecting the broken material; these bucket are handled in both these machines by wire ropes. Now, while doing that, that rope must be given a drive that there on a rope drum and when this is the rope is moving over this sheave. So, that sheave is a very very important to be designed to withstand that heavy load; exactly the depending on the type of rock and depending on the size of this bucket, there will be a heavy load coming on to this sheave or that on the boom point sheave it is said.

So, they need to be very carefully designed. So, you can see here that, a sheave is basically it is a wheel on an axle or shaft and it is a pulley with a grooved wheel. So, that is there is a grooves; you can see different types of pulleys are there, on which this sheave has been made by making a groove over here. Now, sometimes pulley that is where you are used for pulling the ropes and that many of the blocks you can see; that is a triple sheave pulley block, this type of arrangements are there in your oil drilling rig that, oil drill rig that where ropes are being handled in the crown block, we can have this type of arrangements are also there.

This is a showing a rope pulley of this dragline, here they have this type of arrangements are there. Now, the most important thing in case of this designing or selecting the pulley is, the materials must be proper and then the what type of liner is given; because this will be subjected to high friction with the wire rope. So, this must not get worn out; because that will damage the wire rope. And if the rope is damaged, then there will be a big problem; even in that because such type of pulleys are also there in the head gear, in the mining shafts.

So, that means, if the whole case is being lowered and taken up with the help of such type of sheaves and pulley that is called your head gear shaft.

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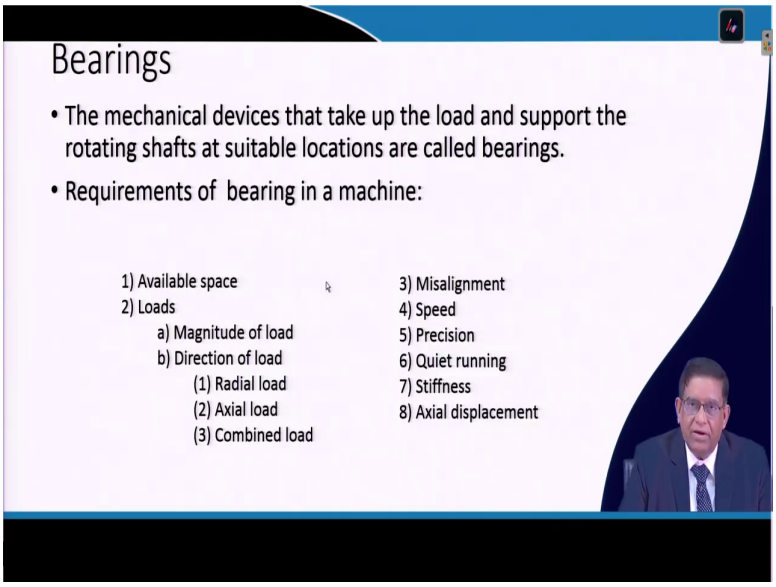

So, this pulleys are, this type of sheaves are that; the next important things you will be knowing about in the mining machinery is the bearings. Most of the machines they sometimes under brake down, because of the problem with bearings. If the say for example, in a drilling machines, when your drill bit is cutting at a depth; at that time a lot of heat is generated and also there is a your the bit is rotating against a bearing.

If the high heat which is generated there is not properly distributed by proper lubrication system provided to the bearing; then there are the bearing material is not properly selected, then they may melt and then they can just sheave and then you cannot do the whole drilling operations will get problem. We will be discussing that those aspects when drill machines will be discussed. Similarly, the you have got the big machines that, your shovel and this dragline which you have seen; these heavy machineries, they are revolving.

Now, when they are revolving that such a with a high load; the whole thing is resting on a bearing and revolving at that time to take the load as well as, so that this your the frictional and other resistances are in a properly dissipated. So, that bearing design is a very very important in mining machinery. So, we will be discussing some special type of bearings which are used for our revolving structures as in case of your crane, as in case of your dragline, bucket wheel excavator all machines have got a very large number of bearings for serving different purposes.

Now, while selecting this bearing; they do available space loads, their magnitude of the load, direction of the load, whether it is going radially, axially or in a combined type of loads are there. And then the most important thing is there; the load which is coming over there, it should be equally distributed any misalignment can lead to a problem. The in the bearing, if there is a differential wire or anything takes place; then the whole shaft get misaligned with the driven and driving shafts.

Then what may happen? The whole vibrations will be coming, a lot of noise will be coming, lot of energy will be dissipated; you will be consuming more that your fuel or more power and then ultimately that your total productivity will get affected, the by premature failure you will be incurring more cost on maintenance.

So, that is why you will have to take a proper care of this bearing. While telling it is a proper care of the bearing means that, what type of maintenance will have to be done. The in the maintenance of bearing is basically, how you are lubricating it; that is lubrication is a very very important job in mining machinery maintenance.

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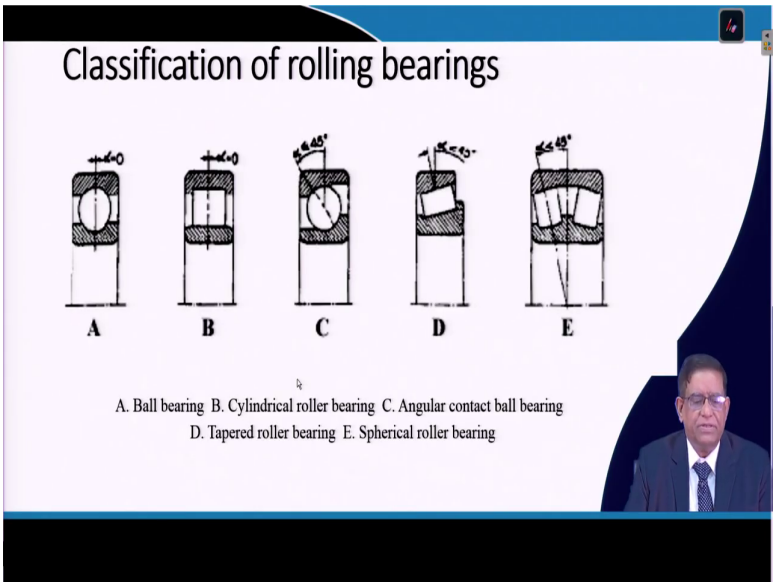

And there the bearings are of different types, that is your you may be hearing about that ball bearing, you might have seen in your bicycle also; in bicycle try to find out that how many places there are bearing.

You can find out whether it they handle, whether it is in your near the pedal or whether at the wheels; and then you try to understand that, why that locations are exactly having bearing. You can describe the functions of your bicycle and then you can easily find out at what are the basic job being done by the bearing.

Now, there is also cylindrical roller bearing; this depending on exactly it is a rolling contact bearing, that is your the two surfaces, there is a no sliding, friction is not there when there will be a rolling, because rolling friction is less, by that exactly you are reducing the metal wire. So those depending on that part which is the shape of that part which is rolling that makes

this name. Like that it is here a roller bearing, there is angular contact ball bearing; you can see that the contact is a not parallel.

Similarly, there could be a tapered roller bearing, there will be a spherical roller bearing and there are many combination of different type of shapes are also available.

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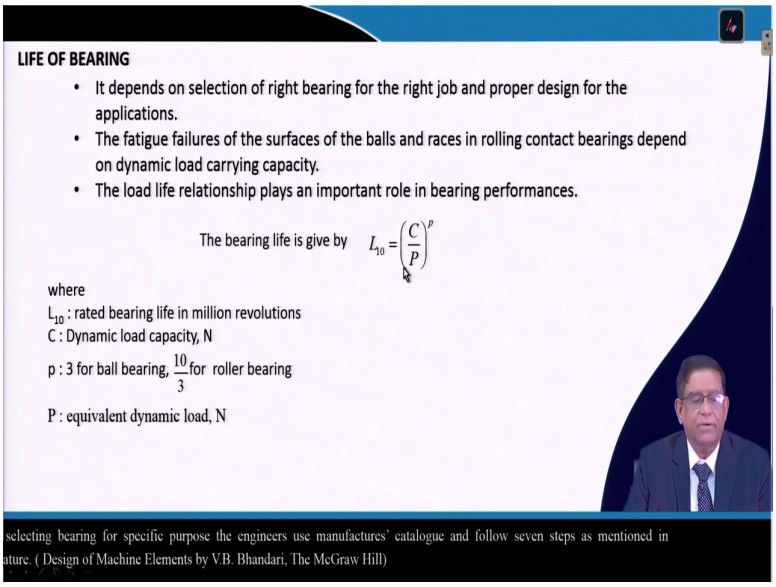

Now, there is a in machines life, the life of bearing is a very very important issue. Now, the bearing manufacturers, they do number of tests and they give prescribe a particular life. And while selecting the machinery manufacturers, they do it; exactly well as an user and as a mining engineer, you do not need to worry much about that exactly which machine will have to be there what bearing, because the original equipment manufacturer, they prescribe that what type of bearing and also.

In that bearing they specify what type of lubrication must be there, what should be the frequency of lubricating all this comes under prescribed decision in the manual. So, what you must understand; the importance of this bearing design and their components, so that you strictly follow whatever the instructions there and also try to evaluate and see whether the instructions given in the that is the manual is a adequate or not.

So, that is why, but as a life of bearing, this normally given in million revolutions; that is your in throughout that life that, bearing is making how much, how much revolutions and there. And the life of bearing is affected by the dynamic load capacity; that is dynamic load capacity and which is exactly different for that, your life will be different for your the ball bearing and roller bearing.

So, normally you can see the life of roller bearing is slightly higher; because this p is given 10 by 3 here. So, the equivalent dynamic load, so that is there the ratio of the dynamic load capacity and the equivalent dynamic load that is related to your life of ball bearing. Now, there are in a advanced mechanical engineering departments, you can see the test rig, where exactly the life of bearings are tested and then do finalize.

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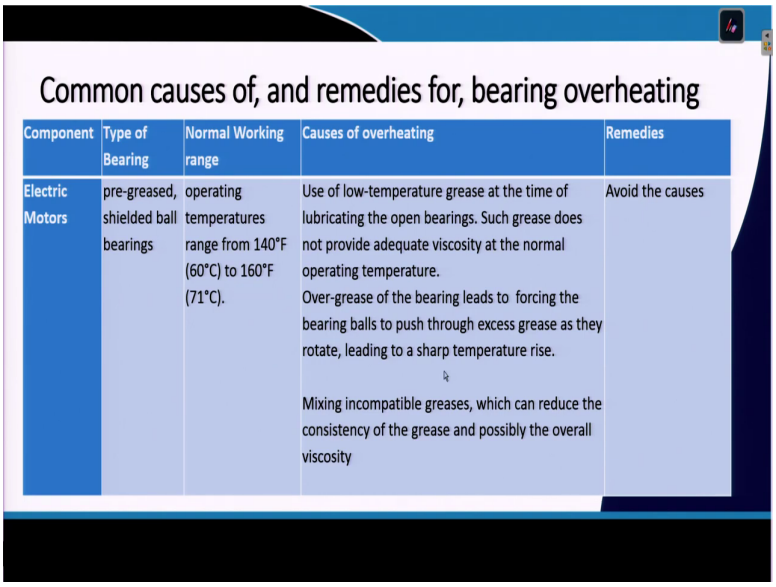

So, in the operations, particularly when you are in a mind; you will find that bearing they fail. So, you will have to make a note of that, what type of bearing, under what type of working range and what may be cause of their overheating; because most of the bearing failure is due to the overheating. And then the, that exactly under that heating conditions, either it is metallurgical conditions or it is a the other that the lubrication conditions, they get changed.

So, in an electric motors, there are also your bearing and then they the motor shaft which is running over there; the normal working range of this the temperature is 60 degree to 71 degree centigrade it will be working.

Now, if use of low temperature grease at time of lubricating of open bearing if you use; then it may lead to your overheating. Then grease does not provide the adequate viscosity; because the main cooling operations which is being taken or which is being performed by the

lubricants, unless and until the lubricants property is matching with the working condition, then you may lead to the, you may have the problem of overheating.

Now, over greasing also sometimes lead to a problem; exactly if you put excess grease at that time you are that (Refer Time: 18:57). So, that is why while doing the lubrication practice, you must see that the prescribed norms are used; do not give additional that extra lubricants or you do not give a low quality lubricant, under the both conditions it will be affecting adversely.

Nowadays there are the if you are, but you may see for every machine, they prescribe a particular type of the lubricant, the grease or whatever it is there. We will be discussing this in our maintenance lectures also, how exactly the; what type of properties of grease need to be selected.

But one thing we should be careful about that, never mix a different type of lubrication together; because every lubricants they have got the specific quality regarding its performing that is whether what type of viscosity, what temperature range and all. Now, if we mix it up; then they may behave totally differently and your machine may get damaged.

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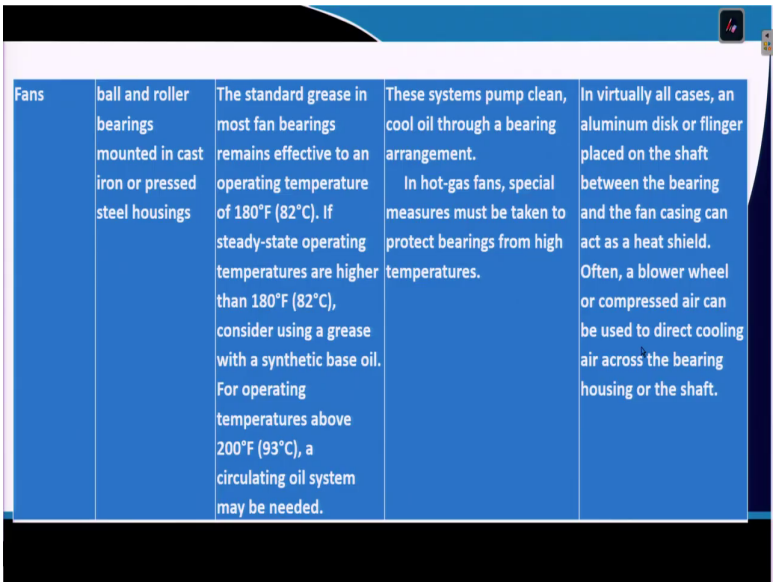

Fans	ball and roller bearings mounted in cast iron or pressed steel housings	The standard grease in most fan bearings remains effective to an operating temperature of 180°F (82°C). If steady-state operating temperatures are higher than 180°F (82°C), consider using a grease with a synthetic base oil. For operating temperatures above 200°F (93°C), a circulating oil system may be needed.	These systems pump clean, cool oil through a bearing arrangement. In hot-gas fans, special measures must be taken to protect bearings from high temperatures.	In virtually all cases, an aluminum disk or flinger placed on the shaft between the bearing and the fan casing can act as a heat shield. Often, a blower wheel or compressed air can be used to direct cooling air across the bearing housing or the shaft.

So, similarly for the fans, you have got in the mine number of exactly; most important is the mine fan, where we are having a big axial flow fan, there the bearings are very very important for doing it.

So, you can see there mostly ball and roller type of bearings are used and then they used standard grease for most of the fan bearings. Even in our this domestic fans you can see, they have got that; they sometimes go up to the temperature, if you touch a fans bearing zone, you can find out it very hot, sometimes it can go up to 80 degree 82 degree like that.

So, now that is what we will have to properly maintain the lubrications and then you will have to see that, there is no obstructions; that is your if there is a the ventilation channel should be proper. In any the any type of equipment wherever the bearings are there, that area should not be very constrained; if the heat dissipation should be proper. So, in all cases, an

aluminium disc and flinger placed on the shaft between the bearings and the fan, fan casing, so that it can be acting as a heat shield. So, that your overheating does not takes place.

So, sometimes you use a blower or a compressed air can be used for directly cooling air, that will go from here. You might be seeing that, in many of the fan driving motors; on the motors there will be certain fins. So, through that fins also that, exactly air goes the; you increase the surface area, when you increase the surface area, more heat dissipations are there and ultimately the bearing zone remain cool, so that is how a different.

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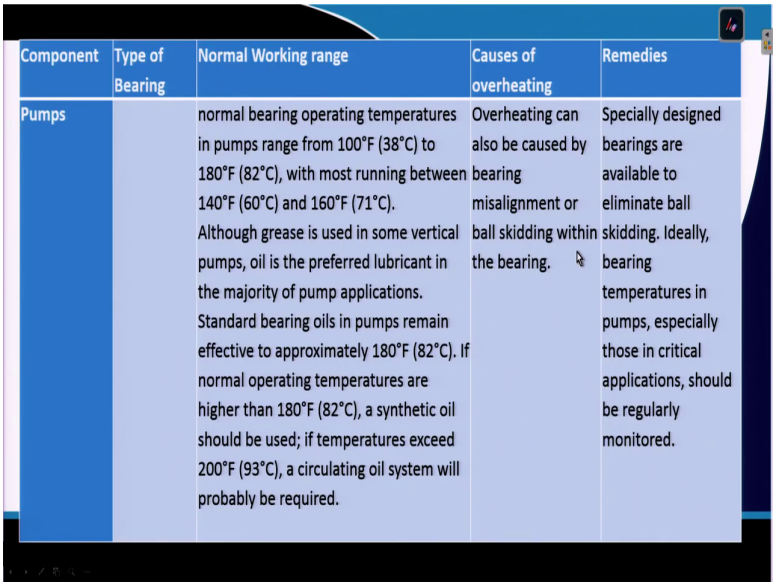

Similarly, in the pumps also they have got a different types of bearings; our there the operating temperatures that also while during normal operations, it goes to higher temperature. So, this mainly in sometimes the pumps, they get a misalignment; if you get a

misalignment of the shafts, then it will be exactly giving more frictions and more noise and as a result there can be more heat generations.

So, the you will have to see that during the designing, you give a proper type of bearing and that your you will have to very regularly observe that temperature should be monitored.

Nowadays all the advanced sensors technologies are there; wherever these pumps or fans which are remotely located in the mines, they can be having the proper sensors and then the data will be transmitted from the machines locations to a centrally to be monitored. So, this advanced computerized maintenance management systems, they exactly monitor these things.

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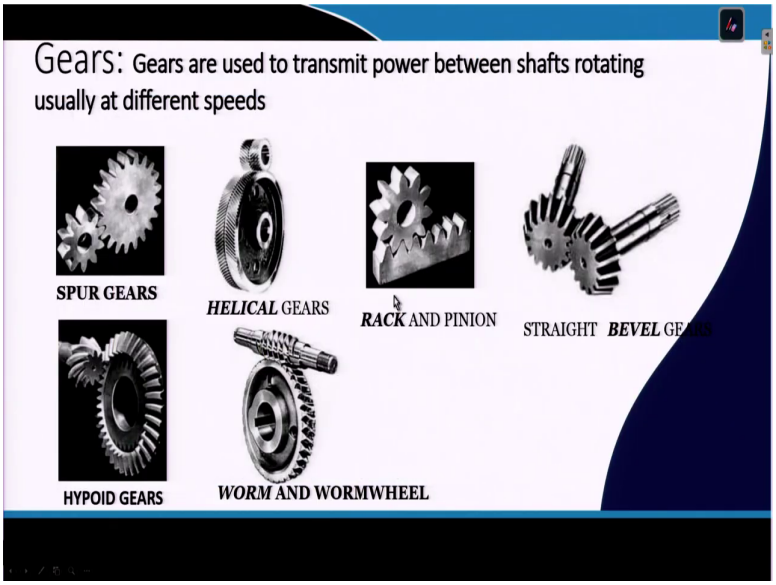

So, like that the other than the bearing, you know the life of that is the main component of any machine at the these gears. In a machine you may have a different types of gears, you

know about that the spur gear, where you can see that teeth are parallel to each other; the smaller one is called pinion and then this is your gear and they can be, if they are straight or they can be at an angle. You can see here these two had a pinion and the gear, they have got an and this type of gears are called helical gear.

Now, there is a rack and pinion, you can have one pinion is moving and this is a straight line as a called rack. Now, rack and pinion systems are used in shovel, where your that that shovel bucket is connected to a handle that is called your stick; then the or you can say bucket is called dipper, the dipper stick is moving forward and backward to give a push to the material to be cut and collected onto the bucket.

So, that type of linear motion is brought to the bucket by means of rack and pinion in any electric rope shovel. Similarly, there is a bevel gears, where your these two shafts are at angle. So, then we can use this bevel gear.

Now, we have got some hypoid gear; this is also, this type of gears are used with a the special type of profile, when we need to get the shafts at a different some critical angles. Then when we require a very high reduction ratio, you can go for this worm and worm wheel which are.

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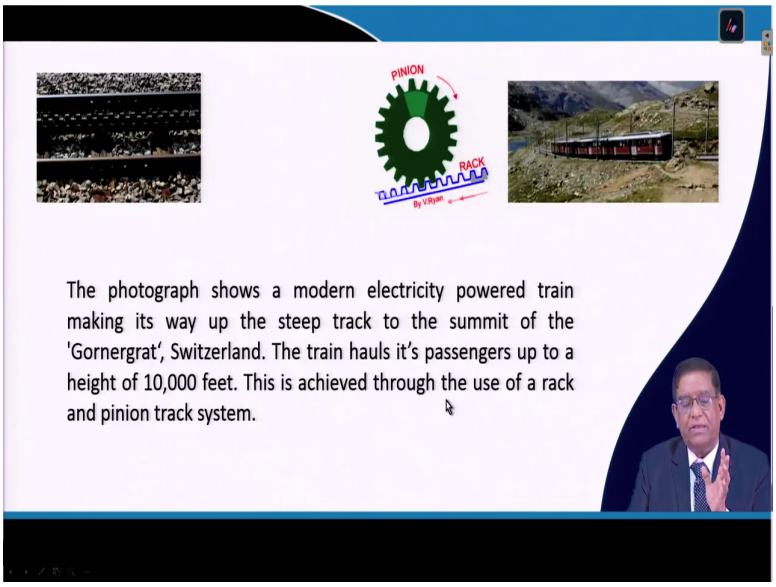

So, like that, you have got the different types of gear used in a of this; as we are seeing here, this is a rack and pinion systems. This it is it in Switzerland there is a place called Gornergrat; there the railway lines are because it is in a very steep slope, the train moves and for that the whole drive systems, it is exactly they are having a rack and pinion type of arrangements over there.

So, these are the different applications that mechanical engineering applications are there; you should see sometimes some of these in the Google and in Net you can find a lot of study materials to just have and improve your general knowledge about that, so that your mining machinery you can understand better way.

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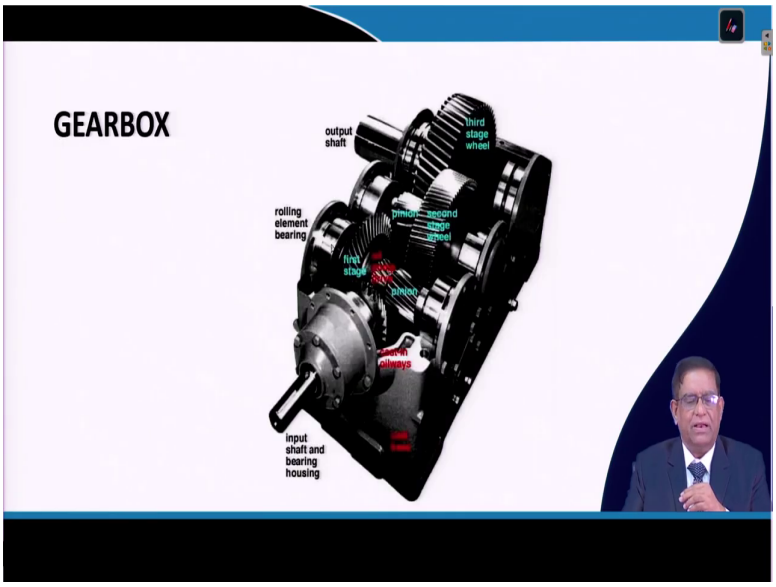

And then when we tell about the gearbox, many of you in our of course in your practical class; there you will be do you do the geartrain practical's, where you calculate and do it over there.

And here in a gearbox you can see that, number of different arrangements are there, so that is your input shaft which is connected to the main prime mover that your engine, that is electric or that diesel engines and then we can have this output shaft; depending on that which gear ratio you are using, you can get a different that speeds and also, that is a there are quite range of gearboxes are there.

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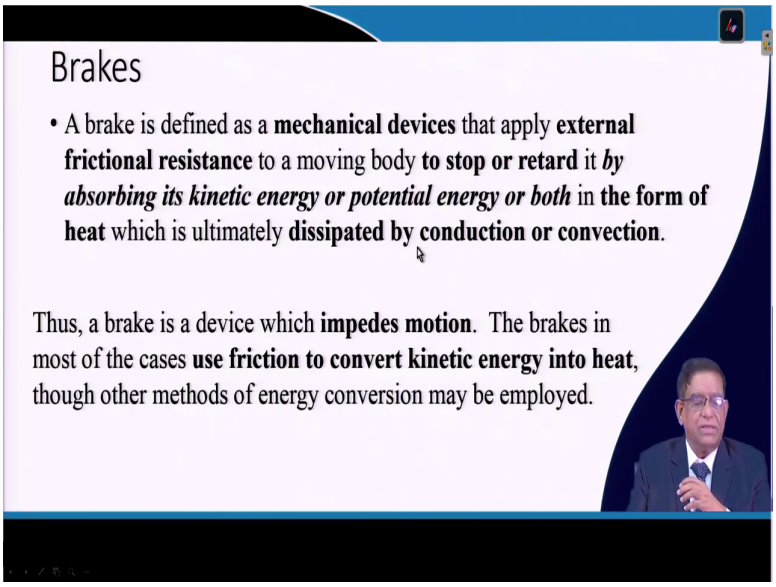

Similarly, next important component is the brakes. So, brake is a mechanical device, that apply external frictional resistance to a moving body to stop or retard it by absorbing its kinetic energy or potential energy or both.

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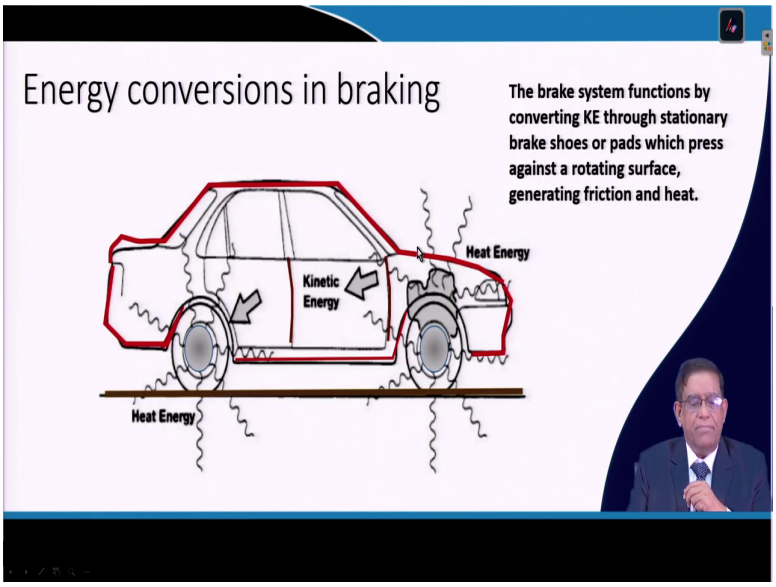

So, these brakes are very important component; you can see what is happening in a energy conversion takes place in a brake. So, when a car is moving, when this is having a lot of kinetic energy; then you apply the brake, then this kinetic energy is dissipated as a heat energy and then ultimately you are stopping the car.

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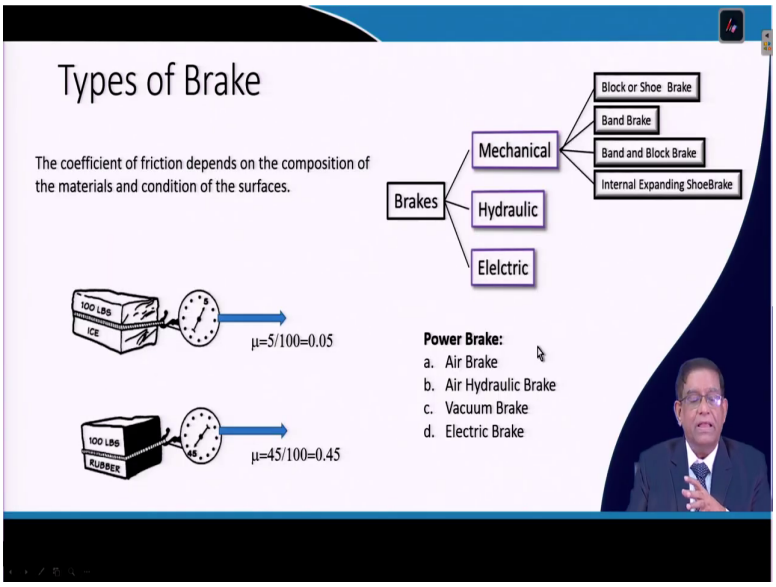

So, this there are different types of brakes exactly; you know that whole braking system it is a matter of principle is there friction. As you know that this here that coefficient of friction, that is exactly if you are taking a ice slab and then if you are pulling that thing to that on a rubber pad; if your ice slab is there, it will be just by giving only five that unit of your force is giving.

So, you can find out the coefficient of friction of that 100 pound they are keeping over here. So, that is the normal load coming over there, but to move that thing is required only five. So, that is a because this coefficient of friction is very less. But if it is a rubber and this on ice it was moving very smoothly; but on a rubber it is requiring up to 45 units. So, you can see that the coefficient of friction, but this friction exactly work in different type of brake, so that the wheel is arrested over there.

There are quite a number of different types of brake, mainly the mechanical brake and we can say power brake; that power brakes, hydraulics as well as this electric brakes it can be air brake, air hydraulic brake, vacuum brake, electric brake.

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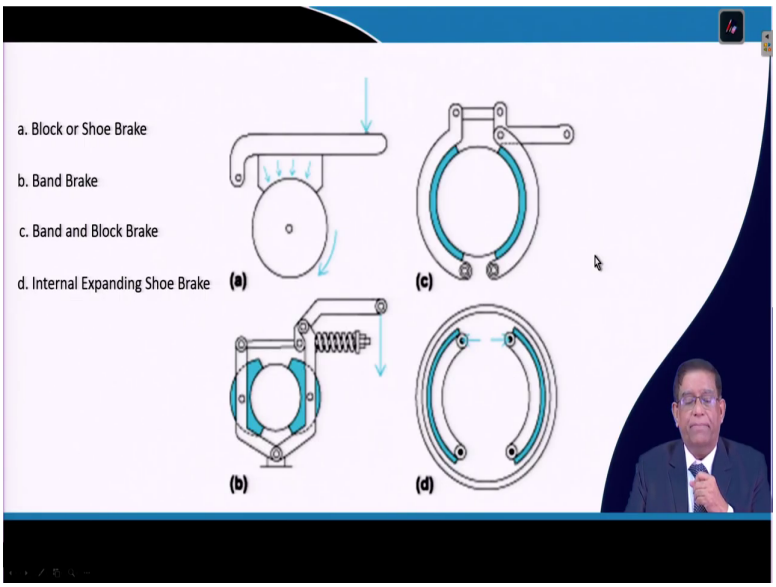

Now, mostly your the mechanical brakes which are used here mainly block and shoe brake; you use this your band brakes, you are using band and block brake and also you are using internal expansion type of brakes. These type of brakes are very common.

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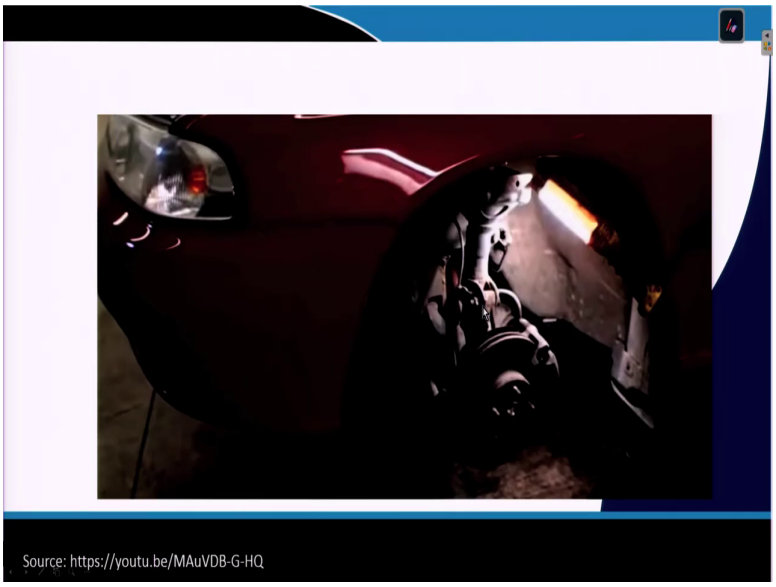

And you can see that in any car, if you open up the that take out the wheel; you can see this is that on that your this axial how this block; here we are having this brake shoes are over here. Now, we can see that in a wheel the mainly there is a that, your main brake caliper assembly, this is fitted over here and outside that disc brake that part is there and then the wheel hub assembly.

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That this wheel hub assembly and then this your main, main disc brake rotor this is working over there.

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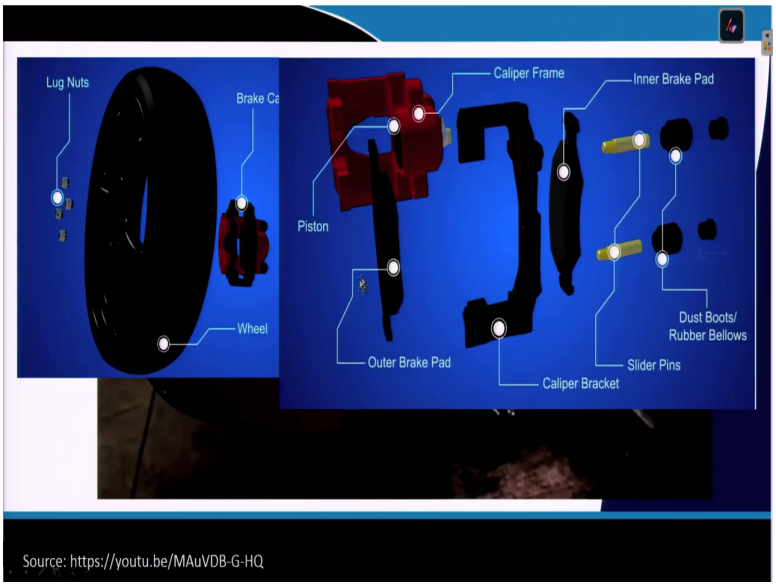

You can see the different components which are there, exactly that outer brake pad on which there is a caliper frame on within this we are having this caliper bracket.

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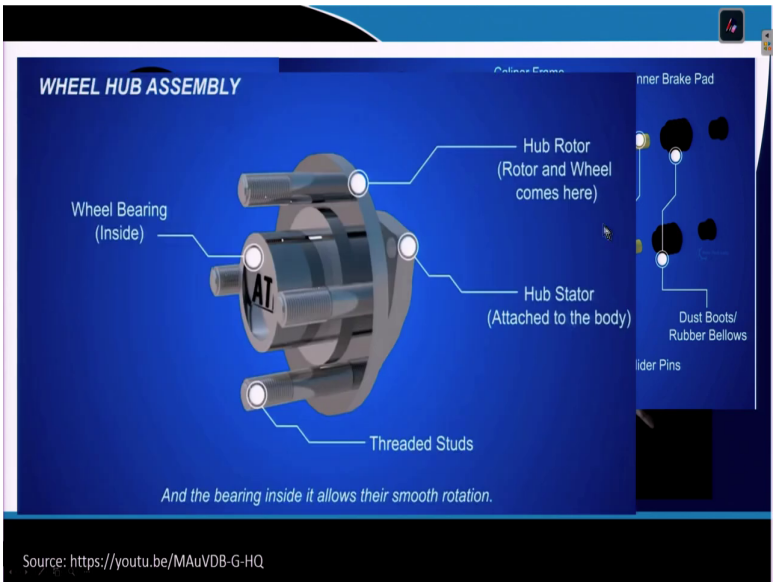

Now, these components are how they work exactly you can see here in a particular wheel hub assembly, your disk can be operated hydraulically.

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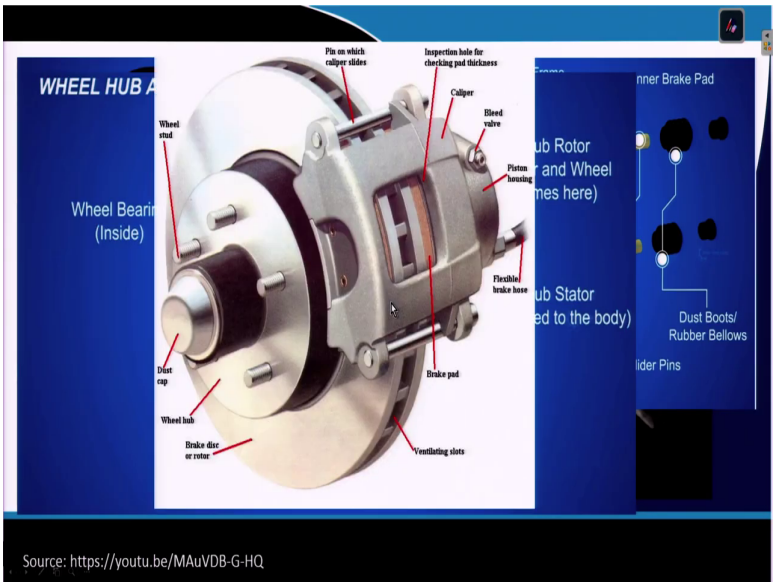

And then your that in a particular brake, you can see this is the block, where you are having this brake pad inside. And then you are having a bleed valve from where this exactly any gas or whatever is generated over there, that will be going out. Then is you are having the piston housing; from here when that your brake oil that gives the pressure, it will be coming over here and then it will be giving a push, so that by that you have this the brake, brake shoe will be getting engaged over this hub and then it will stop that thing.

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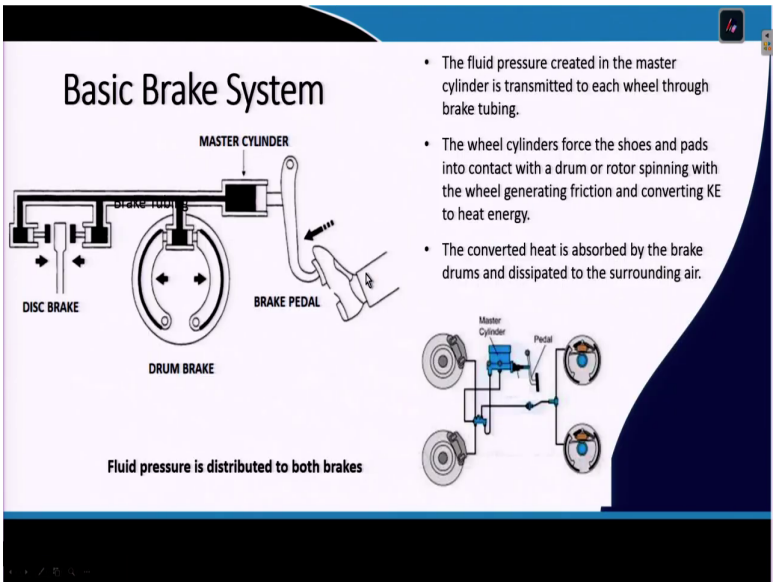

So, these arrangements of breaking in a normal car you are having. But what exactly the brake system work; if you are giving a brake pedal at that time, there is a master cylinder, from the master cylinder that fluid brake oil is distributed; either it is going to the front and the rear side. As you can see over here, there is by pedaling over here; from the master cylinder fluids are going and then they get distributed to the their front wheel and the rear wheel.

And that front wheel and rear wheel they may have different type of brakes; in the here you may have a shoe brake, there could be an internal expanding brake, so that brakes are actuated by electric system hydraulic system.

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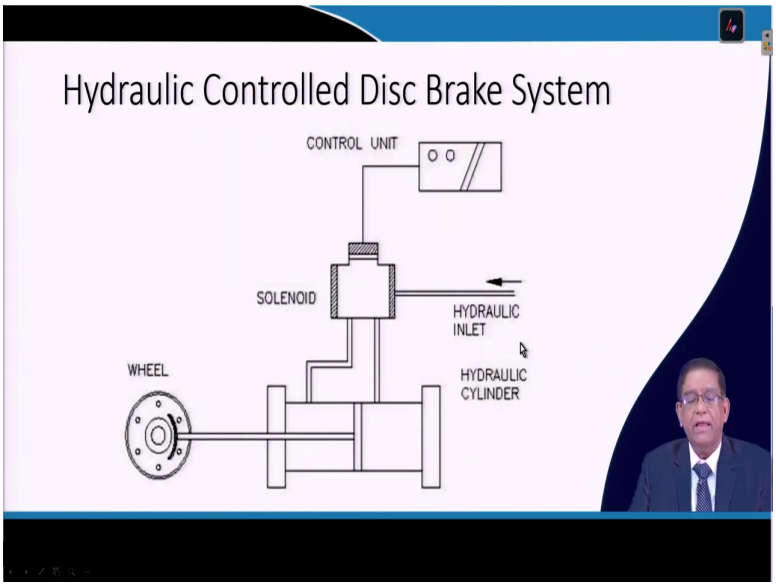

So, that is what exactly in a hydraulic brake your, the control operation is basically done by this hydraulic oil system.

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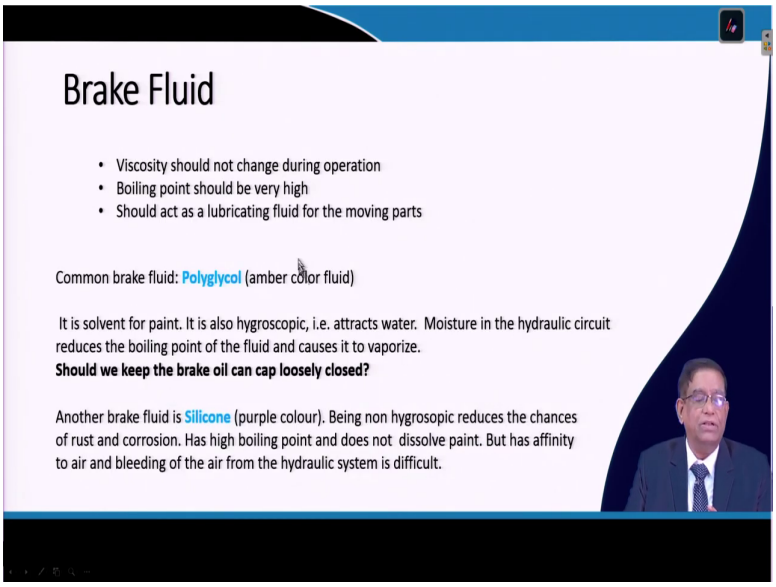

Now, this brake fluids normally the polyglycol or silicone fluids are used; but one need to be very careful about selecting this brake fluid, its a it should not be at contaminated with water, because that water will be deteriorating the things.

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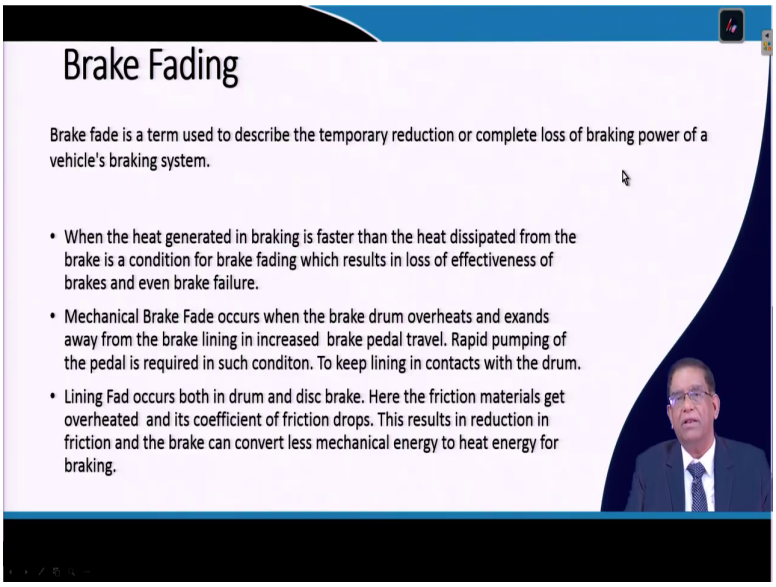

And then what happens in any brake, whether the brake shoe is there on the drum; then because of the frictions over there, there will be always wear and tear, that at that time that phenomena is called your brake fading, where exactly the temporary reduction of the complete loss of braking. If the brake is fading, then your there will be a that is it will take the longer distance to stop or sometimes it may not stop and which may lead to accident. So, that need to be system.

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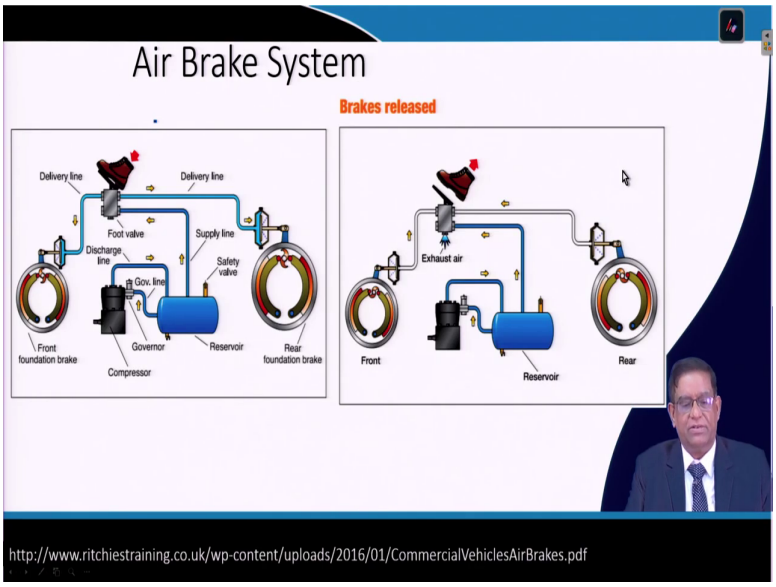

And then all the mining machinery, mining trucks and all there you will be finding a air brake system. In the air brake system also, this is just like in your oil; here you are having a compressor, that compressor will be compressing the air into a reservoir and from there this when you press this pedal, your air will be going and by that this pneumatic pressures you will be getting over there. So, this is a type of brake and then sometimes in a parking brake at the back of it, there will be a another device by which a spring loaded you will be making it, making it to work.

So, that during the when the machine is not running, at that time a parking brake is mechanically applied, so that it cannot that; even if you are on a slope machine should not move. So, this type of the brake, when it is a brake it released; you can see that brake is

released, so the wheel is free to rotate. So, when the brake is engaged that time, there is a no free space and that time wheel will be stopped.

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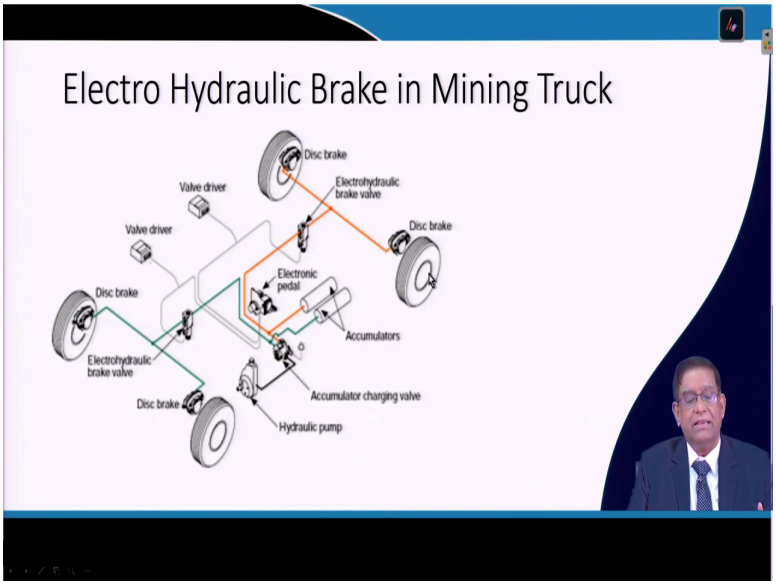

So, this is how exactly how a brake works; in a mining truck, we have got this electro hydraulic brakes also there which is. So, basic principle is same from your either whether by air or by your fluid; you are applying the pressure, so that this main brake components which are there. If in your second year you have studied this basic mechanisms and then the how the force calculations of brake, you can do it over there.

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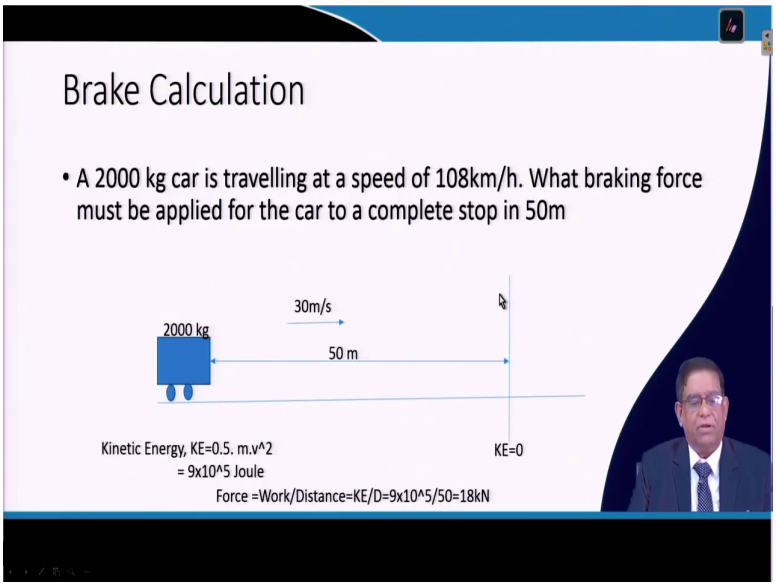

But here you can do one small calculations; if you are having a 2000 kg car is travelling at a speed of say 108 kilometer per hour; what braking force must be applied to that car to be complete stop at 50 meter? So, if it is coming over there, within this 50 meter it will have to serve. So, what is the basic principle?

You find out if it is running at a particular speed; what is the kinetic energy over here? That kinetic energy you can calculate this; it is coming as out your 9 million Joule. So, at that time, this is to stop means, here kinetic energy will be 0. So, this force is a work divided by distance. So, simple by that calculations, you can find out that what will be the force to be applied over there.

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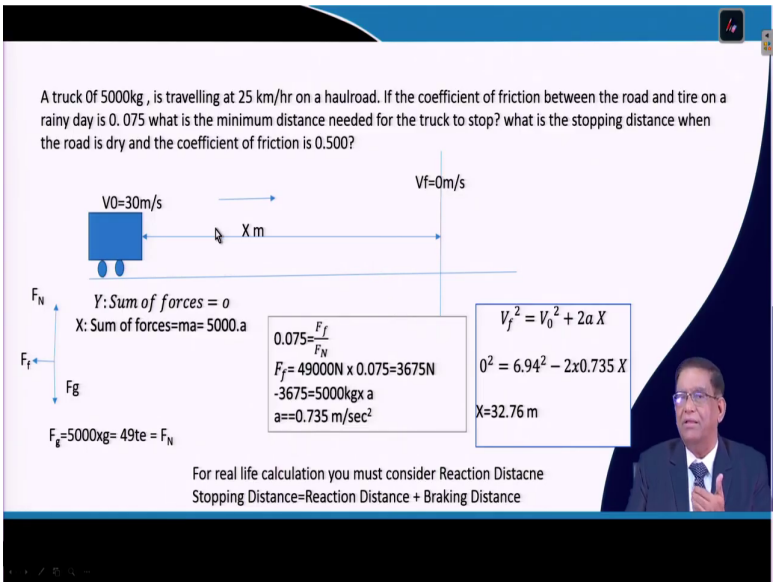

So, some such type of problems you can do; even sometimes a problem can be say, if you are having a truck with 5000 kg is travelling at a 25 kilometer per hour on a haulroad. If the coefficient of friction between the road and the tire is given, it is 0.75; then what will be the minimum distance?

Now, here in the initial discussions you can think that, your brake has been applied over here; but normally sometimes you consider a reaction time, some (Refer Time: 34:30) as you apply, there it if you see some obstruction there and you want to apply a brake.

But then you will have to taking a decision some distance will be going, we are not considering that reaction distance over here; but with this speed when it is going over there, you can simple use that your formula of that our laws of motion. By considering the laws of

motion, you can easily calculate out that what will be this distance, this is a very simple calculations, please do that.

Now, most important point to note is; if the road surface coefficient of friction was 0.075 in the rainy season, because of the clay and that behavior of shale with water. Now, in a dry season, the coefficient of friction will be high.

Now, you will have to do solve such problem, if the coefficient of friction increases; what will be the that your stopping distance? So, that means the driver will have to be trained in the mind, so that the how he will be behaving under different weather conditions and which is very very important in mining.

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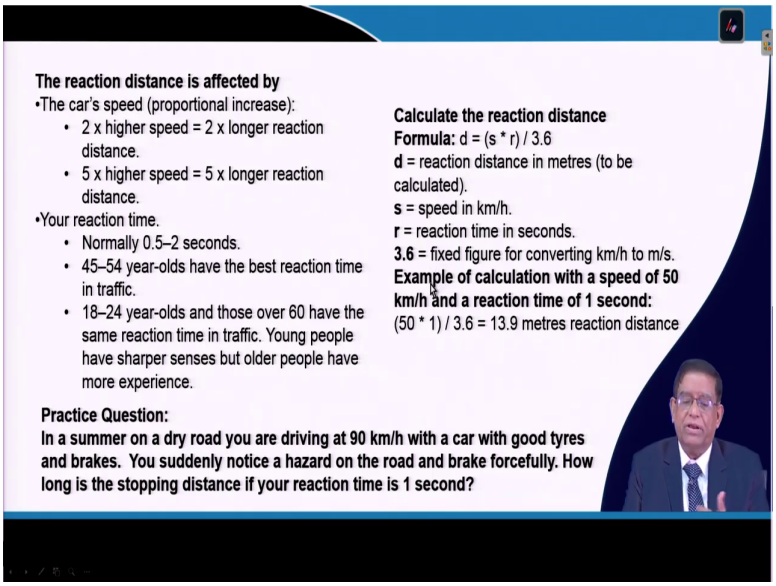

So, that is why you must study about this. And also the reaction distance as I was telling that, depends on the particular person to person; normally the old persons their reaction time may go from 0.5 to 2 second and sometimes some people may take even longer time. So, there you must see that the machine should get stopped at a distance, so that the accident do not take place.

So, there is some exercise you can do it say, if the you are running at a 90 kilometer per hour; then suddenly if you notice the road and then if your reaction time is 1 second, then you must know that whether you are able to save that obstacle or you will be hitting the obstacle. So, in such type of things, such problem can be easily solved by taking the reaction distance and your reaction time you take 1 second or 2 second; depending on that you can find out, how what is your risk level, you can calculate it out.

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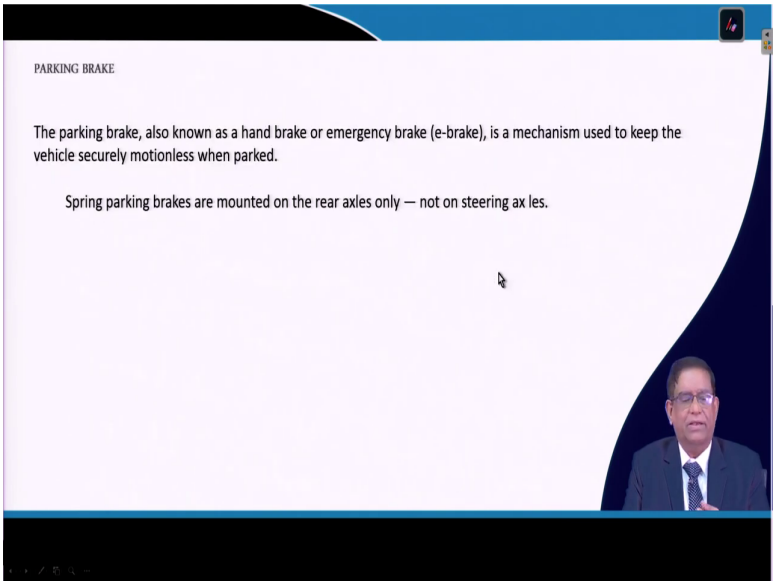

Similarly, I have told already the parking brake is a brake it must be there in all vehicles or all machines, so that during the operations it does not give much problem.

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So, that is sometimes if your parking brake is not proper and you are resting the machine on a slope; then it automatically start falling and that is why all mines act and regulations, it make that all machines which are working in a mines must have a parking brake. Parking brake it can be electric brake or pneumatic brake on which there will be a mechanically engaged systems by which the parking will be there.

As you have seen in our car also, we have got the parking brake; in that parking brake we take the lever up, at that time there will be an anchor exactly engaging the that your brake shoe onto the wheel and that vehicle will not be moving.

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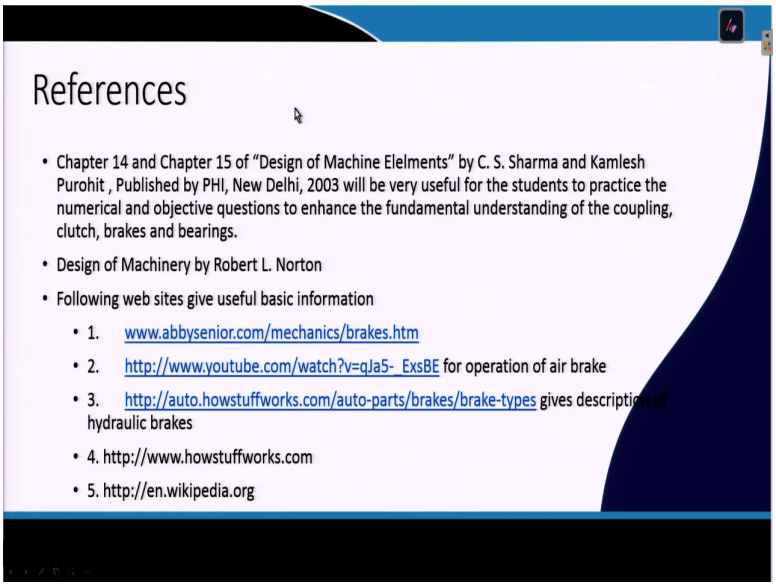

So, today I have just told you about some of this very important component. And I hope this these references are given and you will be able to study the machines much better way, once you know this basic components how they work.

Thank you very much.