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

Module – 04
Lecture – 17
Site and Rock Preparation Equipment: Motor Grader

Welcome back today's class on Site and Rock Preparation Equipment. In the Mining Machinery we have so far discussed our dozer, ripper, drill, then we also discussed about scrappers. Now, the other machine which is deployed at the time of site preparation is the motor grader.

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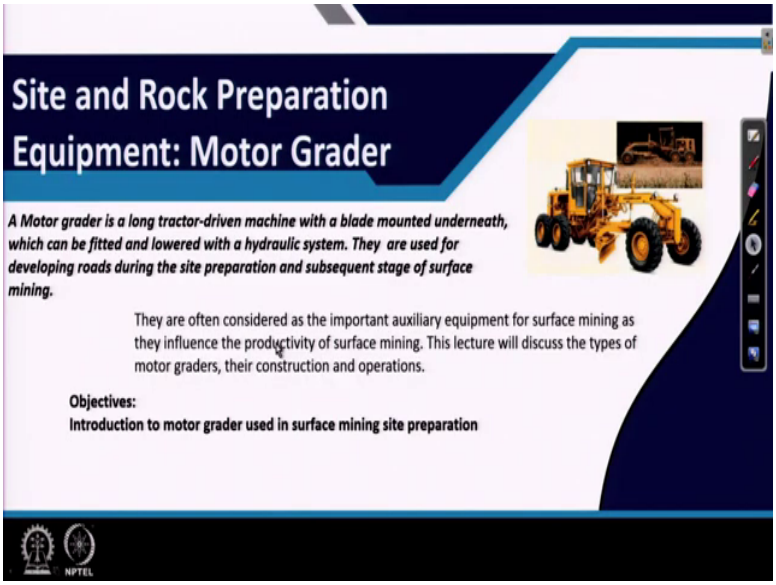

Today, I will be talking about this particular machine which is used in surface mining for preparing the mine for their next phase of operation. After getting the land, we need to make

the roads and that is why this is coming under the road making machinery. Along with that sometimes we are using the dozer simultaneously also with the compactor.

But, this is a tractor driven machine, this particular machine which is a tractor driven. And it has got underneath a blade by which it cut and that whole system is operated by a hydraulic system. And they have they are used as an auxiliary machines, but it has got a huge implications because as you will be learning slowly that in a surface mining different unit operations, their cost is also influenced by the road.

The haul road we say in surface mining it is a very, very important component. Sometimes the haul road itself is considered as a valuable asset for the mines because the evacuation of material. So that is why we will be knowing this machine, which is deployed in the mines for road making purposes. And this also sometimes it is used for levelling in the pit floor and benches. So, our objective of today's class is to introduce this motor grader in surface mining.

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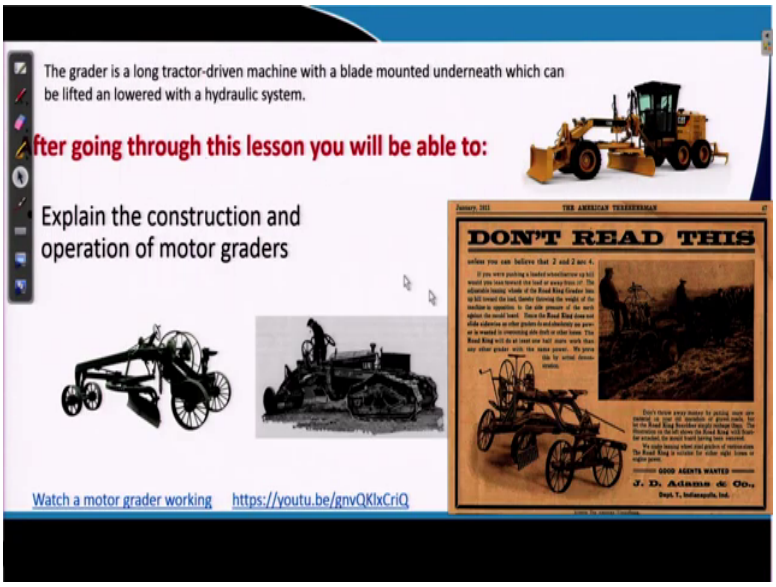

Now, you can see here this is a grader; it is a very old equipment. You can see here how this machine started developing in 1911 it came working with this, and there were in the early of the; early years of the last century, there used to be a they are trying different way of the scroller mounted the mechanizations in the 20th century, started with this machine used in the constructions operations.

Particularly in a construction sites this road motor grader were being used. So, after going through this lecture, you will be able to explain the construction and operation of motor graders. And also, you will be knowing the importance of it and how to exactly this machine knowledge will be helping you to manage a mines properly.

So, I suggest that you can see some of the motor grader working in some of these YouTube demonstrations; there it will help you in understanding this machine. Now you can see here how old it is, it is a 1911 advertisement.

You can see here this advertisement of 1911 where this J. D. and Adams and Company, they were preparing a motor grader. That is exactly the purpose was to prepare a road with a proper gradient and then there different type of functionalities at that time itself it was given. So, over the years this machine has developed a lot.

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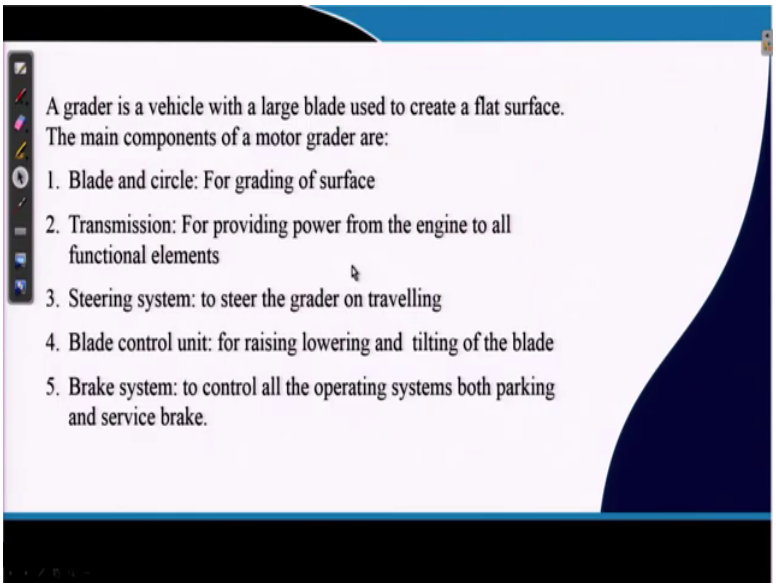

Now, this is a vehicle that is a, it is a machine in which we are having a large blade, that blade will be just scrapping a surface to make it as a flat surface, ok. So, if you see this machine as

you have seen in the first photograph it is having a machine a tractor, and at that front we are having another wheel and in between below the machines there is this blade.

Now, this blade can move and that is why it is mounted on a circle, and then that is why it is just like a automobile. It will also have to have a power transmission system. It will also have to have a steering system and the main operating unit which is exactly working with the road surface is the blade. So, that blade must be controlled.

Now, how will control; to make the gradient sometimes it will have to be tilted up, sometimes it will have to mate flat, and sometimes it will have to steer say for example, the road will have a crown that is a side edges you need to trim, sometimes even for a drain cutting and all you can use a lot of different type of uses this machines can have; for that you need to have a control unit.

Now, to do that control we are using this, the hydraulic control, sometimes electro hydraulically controlled. And nowadays, these machines are with a very sophisticated instrumentations have come with a laser device and a GPS mounted. So that it can be controlled even remotely and then the all the quality can be issued through that.

Now, as an automobile it has also got a braking system: the brake mechanisms and all. So, in the machine elements you have studied that the brakes, that power transmissions and you will see while studying this machine how they are working.

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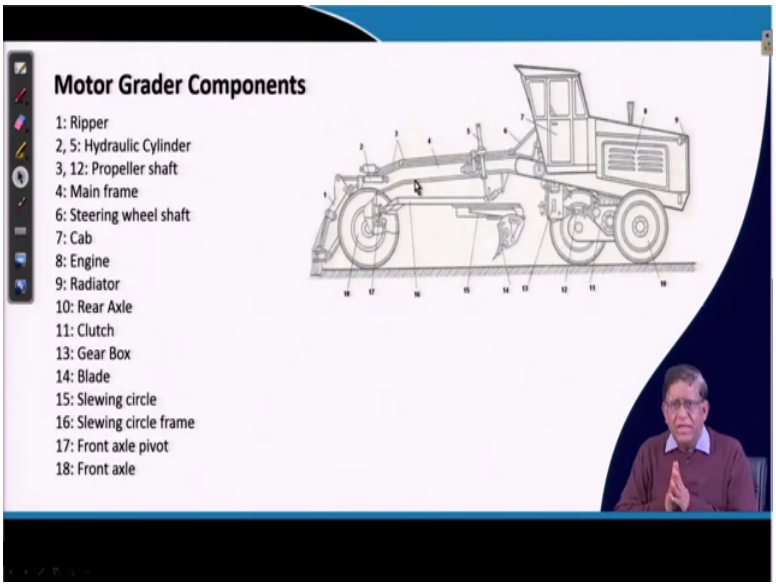

So, as you have seen at the beginning the other photograph you can see a sketch of it, what is here. You can see that, there is in front of it, that the, it can have a ripper just like at the back side of a dozer. We use a ripper to scavenge that surface of the road you can use this ripper, so that it can give a cutting in front of it.

Then, second thing it has got a hydraulic cylinder, this hydraulic cylinder can control the ripper. Then, there is also a hydraulic cylinder here, this number 5 you can see. This hydraulic cylinder is for controlling the blade, there is a circle here this circle and then this blade is mounted over here, this lifting and lowering that control is done by this hydraulic cylinder.

Then, there is a your that for propelling purposes, that is exactly to give the hydraulic motor the power we are having this propelling, then you have got the main frame you can see this is your the main frame on which this machine is exactly connected over here. Then, we have got

this steering, we have got this a operators cabin is there, we have got this engine, that there will be the cooling system for the engine, a radiator will be there and this has got two axles.

This is your the rear axle then there will be for the power, we have got a clutch mechanism by which the drive is given to here, then there is a gearbox which will be exactly doing the main power transmission to the wheel is being done over here. And then, the main operating member is this 14 number, which is the blade or it is also called a mold board is there.

And then there is a circle here, this is you are seeing that from the side view looking like a rectangular this is a slewing circle and this circle is sub mounted on a frame so that this blade can move in that frame. And then you have got a pivot point here for the front axle and this is your front axle.

So, basically when you describe what is a motor grader? Motor grader is having a three axel equipment, where two axles are there at the rear side with the tractor part and one axle at a wheels are there for connected with the your main blade part. The main cutting member is this your centrally located underneath the machine.

And it is exactly the conventionally it is a, you will be having a diesel engine from that diesel engine, you can get the drive by transmissions over here or also you can have some time a drive with a hydraulic systems you can make a hydraulically operated things. Then the, this machine are manufactured by number of company like Caterpillar, Camacho, BML they produce this.

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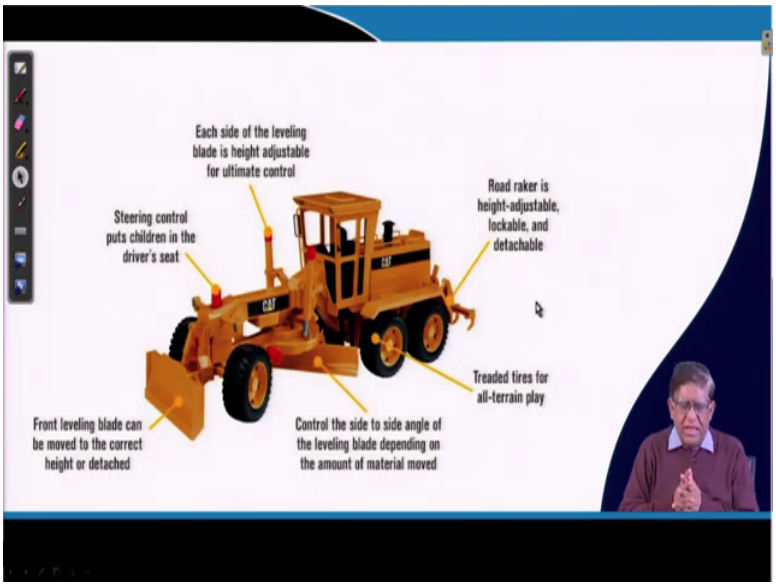

So, once you have learned that sketch now you can see a little photograph a Caterpillar machine. You can see that I was telling about the circle on this circle this blade is mounted over there. So, what are here you are having a, that is your this hydraulic mechanism here, which can exactly adjust the and the control this blade.

And then this hydraulic system here, by that which will be controlling this say puts the in the, you can just a driver can; any driver can operate from by controlling this hydraulic things over there so it is become the ease of operations. And there is also in the front you can have a front levelling just like a dozer blade or you can have a that is that your ripper; ripper teeth can be there in front, ok.

Now, that there is a in sometimes we are having a blade in the front like a dozer and a ripper you can see here as a back side there is a ripper and then these are all tire mounted machines. So, this is a you can control and that blade that is it can it has got number of control you can

steer it along the circular path on the circle, you can tilt it on the side and you can lift and lower.

So, these are the different degrees of freedom of movement of the blade is there which is controlled. Now, is it clear; that what is a, what is a motor grader that should be there clear in your mind. That is why when you have studied differentiation elements that exactly those elements are put together assembled together and then there is an engineering way of thinking how a new product can come and do some job. And these are the things way how it has developed you have seen that from the last century to now.

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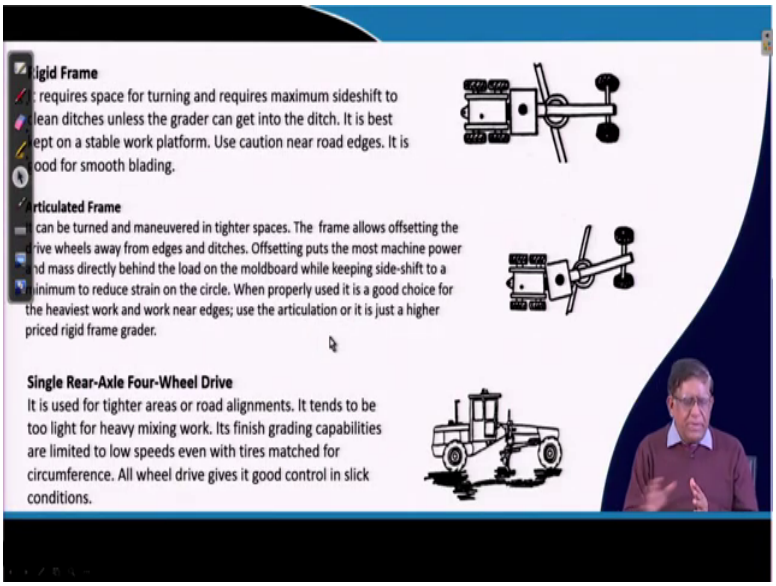

So, if you see that, this exactly what are here; that what are the different types of this motor grader could be made and they have been developed. So, initially there were a rigid frame;

that means, your this front that blade is connected to this your the two axle rear tractor and the front wheel and in between this is a rigid.

Now, when it is a rigid then what will happen? Whenever it is to take a turn the turning radius will be more. So, you are making a narrow road and all at that time you cannot use this because for making wide road and all, that is why the next things were develop they get this articulated frame. In the articulated frame; that means, there is a pivot or hitch point over here around which this portion this is a pin jointed thing and then it can move over here that is called your articulation.

The benefit of this articulation means your turning radius of the vehicle can be lower so that means, on the road itself it can easily take a turn and it can make a to and fro motions for preparing a road.

Now, there is also this sometimes when you are working in a that say the haul roads or that is a road which is on some aluminum soil or some type of very sticky soils and sometimes it is a buggy soil then, what may happen this tire may penetrate to into it and then, the whatever the traction force you are getting that tractive force is not sufficient to get it by from one axle.

So, normally your only two wheel drive will not work. So, there you will have to have a four-wheel drive. So that is why a single rear-axle you can see here the difference of this machine this is a smaller, but a very effective machine; what is there? Instead of this two rear axles here we have got these two axles one axle back one front, but all the four wheels; they have got the drive.

That means, it is a four wheel drive equipment just like you might have seen that jeep or some of this your cars where the four wheel drives are there particularly working in the hilly terrain. So, that in a high slope gradient and all that you need more power you get the four wheel drive so, this is a that type of motor grader.

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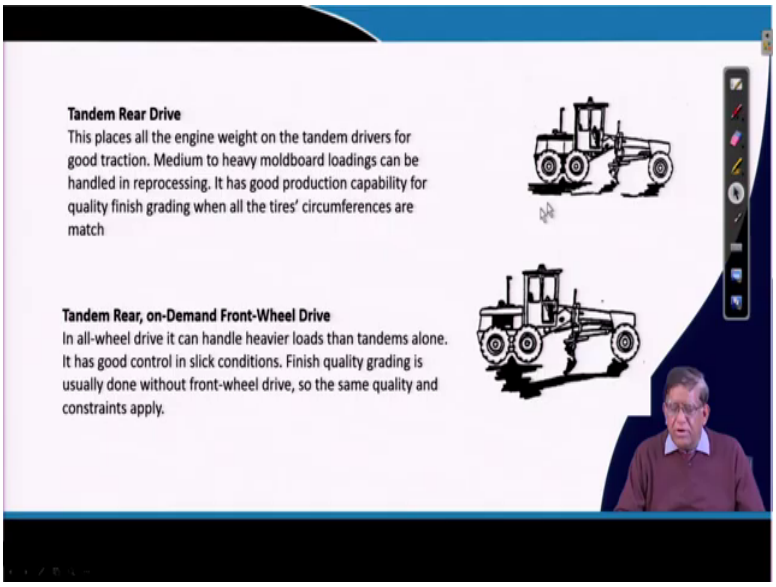

So, similarly you can have motor grader with tandem drive. Tandem rear drive; that means we have got the drive here as well as here. That is a this moldboard heavy moldboard; that means, that blade this loading when you are making a use resistance cutting resistance are more at that time you can have this the all the engines weight on the tandem drivers for good (Refer Time: 14:45) .

That means, you are giving a lot of weight; that means if the weight of the machine is more you are giving the pushing has also become more so that is to get more dropper pull this machines have got this we have got a tandem rear drive. Similarly, there could be front wheel drive also with this machine. So, these machines get more powerful and then it can work in the severe working conditions.

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So, here again I have sent you some of the links you can easily go through and find out that the different manufacturers this motor grader; how they work. So, this Caterpillar can you see that this blade, you can see in this figure very clearly this is the circle. So, by means of this hydraulic motions this blade can give a rotation. So, outside the that is your outside the that your working with of the machine this blade can be placed and you can exactly take care of the solder of the road also.

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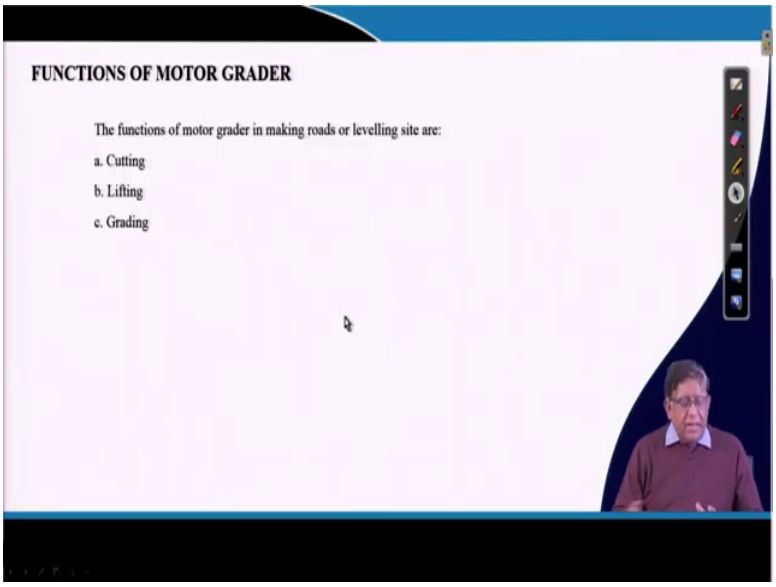

So, now you have understood the basically what are the different constructional components of this machines. Now, if I ask you that what are the main functions what it can do or where it is deployed? Now for that, your main job is that it will have to cut; that means, the road surface that upper layer wherever there is an undulations, either you can cut that or sometimes you want to remove the top surface there also you can cut.

And then what is there in a blade will have to be you can lift it up, so that is why the lifting operations is also is done by that and then it is a grading; that means, you maintain the gradient. If the road is to have a say; 1 in 200, 1 in 100 or 1 in 50 gradient so that the drainage is proper so, to do that type of things it can be done.

Now, initially when this was designed in the early 20th century, at that time it was all done by mechanically. And then there were at the middle of the last century there were these all the

levels that simple spirit level type of things were coming to get that what will be the gradient. Then, there were some good in those days of 40's and 50's instruments came up that by, which putting it over there the operator can know; at what gradient and what type of result it is coming.

And that grading nowadays is a controlled and then you can remotely where your machine is working over there you can have the sensors sitting in your office with the engineer controlling the work site can find out that whether the operator is maintaining the proper gradient as designed for the road.

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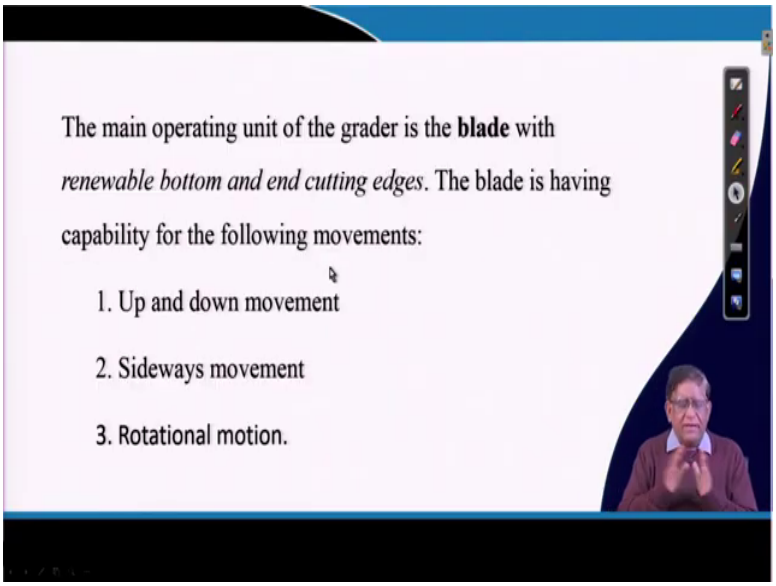

So, these are the possibilities of that. So, how that the blade it can it had got different type of designs of the blades are there. They it will have to have different motions and also it will have to give a cutting under different conditions. Now, to give the motions it will have to as I

said that it can rotate around a circle it can tilt over there and then it can also give a sideways movement and so that the cut can be done.

Now, to do that the rock hardness the abrasivity this can be different from site to site. Now to accommodate; that what is required? The bed blade tip it will have to properly design. I think by now you know very well that what is the material used for the teeth.

That is you have taught in a or whether the ripper teeth whether your dozer blade, whether is your scraper blade this, the teeth it should be durable and it should not wear faster and for that the tungsten carbide, which is a very hard material which is exactly placed over there.

Now, you need to you may study of this how this tungsten carbide their property and then how it, how it wear out and then how it is life can be increased can be seen. Even now there is another type of in say for example, in your drill bits and all poly crystalline diamond there another very good the synthetic material poly crystalline diamonds are nowadays being used in the drilling machines.

Maybe some of you can do this new investigations that; whether the that is your life cycle cost of the graders can be improved by having a new type of blade design with a tip with poly crystalline diamond can be or not these type of things need to be investigated.

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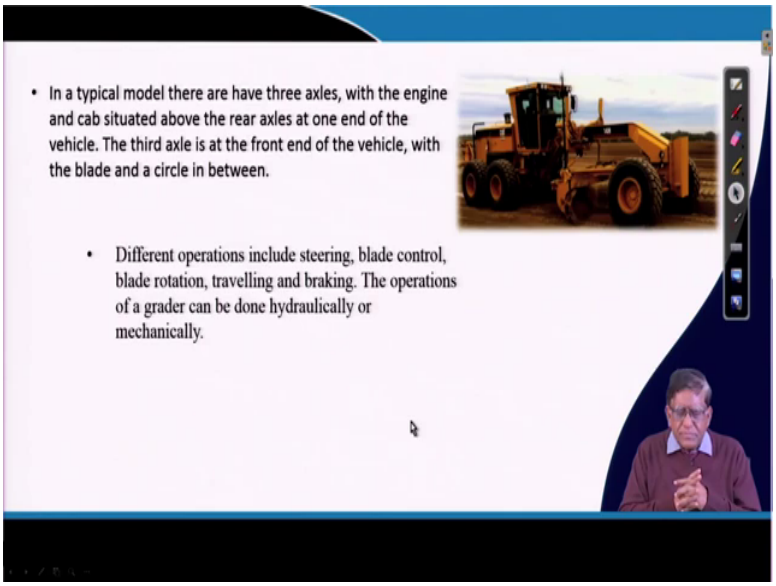

Now, this is as we have said I am repeating here that we are having this three axles, and then we have got a cab. Now, these cab design in the recent years have been very matter of interest for the occupational health and safety. Now, this is one thing when this type of machines will be working on a road there will be lot of undulations and that is why the seat on which the operator is sitting if it is not ergonomically designed then he may get a vibrations.

Now, that when the whole body vibration comes then his spine, it may get affected and also there he can be having some other diseases because of this body vibrations so that is why the operators cabin are nowadays design in such a way that the operational noise which will be coming from the engine noise and that cannot that should not give him trouble at the same time the dust should not be coming over there.

So, in a ergonomically designed operators cabin all these modern facilities can be provided. Of course, the cost of the machines will go high. Now, the and then the operators they say

ease; that means, it will be controlling only with few levers with the joysticks and some buttons by pressing the buttons.

Nowadays the electro hydraulic systems and the power transmission systems have got so much advancement's you can have there that; how the steering is done, how the blade control is done, how the blade rotation is done, how the travelling is done, how the braking is carried out.

Now, these main operations so this is an introductory class for as a mine manager you need to just see the whether these particular operations are being optimally done or not. And then if you want to do some more academic work on the machine design part of it, I will request you please go through some of the operators manual when you will be there that you.

Keep in mind that this equipment can be a matter of study you can, if you study one equipment in detail then you can understand all other machinery which are being used over there.

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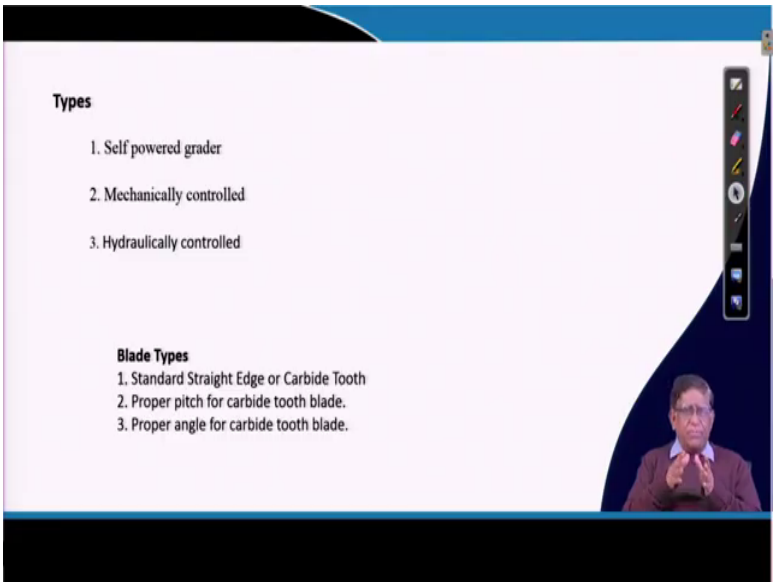

So, for that purpose as a student you need to study those things, but here in this class I am just giving you an introduction's then to for your interest. This it can be a self powered grader or it can be a mechanically controlled grader or it can be hydraulically controlled grader. That hydraulically controlled this one is nowadays maximum use.

So, you need to know for that; what is this hydraulic controls. So, when we are telling in our basics of machines at that time we told about that, hydraulic and pneumatic systems, which are there in a machine. So, the hydraulic circuits and that actuators which are used in a machines that you can now correlate with those points.

And then the blade which is there, there the modern blades are with a carbide tooth blades are being used. And then your the pitch and that with angle that are very, very important to put it over here.

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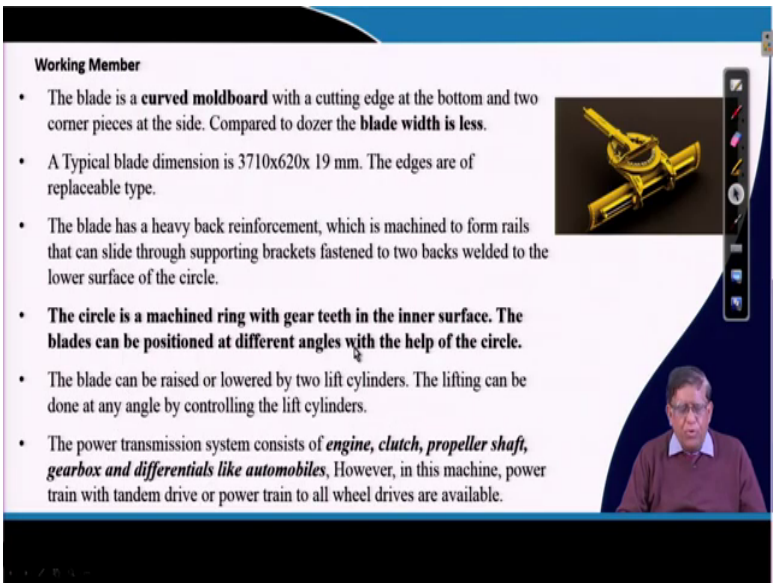

So, let us talk little bit of this working member. You can see now in this figure how the blade is exactly mounted on that there is a this circular wheel. And then it is mounted the blade is (Refer Time: 23:40) with that and these are movable you can rotate this frame by means of hydraulic systems, so that it can positioned at anywhere.

And then this whole thing can be lifted lowered and also tilted. So, this you can see the moldboard this is a curved one you can see from the figure there is a curved one. And then you can see here what is the difference with a dozer blade in a dozer blade you have seen

there is a heavy moldboard and that only a slight curve is also there, but compared to dozer blade here the curvature is more, ok.

And the dimensions it is a typical dimension I have given at 3.7 meter to that point 6 meter and which are 19 millimetre thick, but it is vary from model to model size to size. And then it has got a back reinforcement at a back side if you do not give a reinforcement that is for just giving it the necessary strength for cutting.

And then this circle which is also very important it has got some inside teeth on which exactly it is moving matching with a gear. And the blades can be positioned at different angles with the help of this circle only. That circle movement is a very, very important one. And it can be raised and lowered by hydraulic lift cylinder as I have shown in the previous diagram.

And the power transmission that is as you have learned in the basic power transmission system what we are having? we are having an engine, then we are having the clutch, then we are having the propeller shaft, then we are having the gearbox and the differentials. And like any other automobile whatever is there the same thing is there. So, there is no much complication in this machine.

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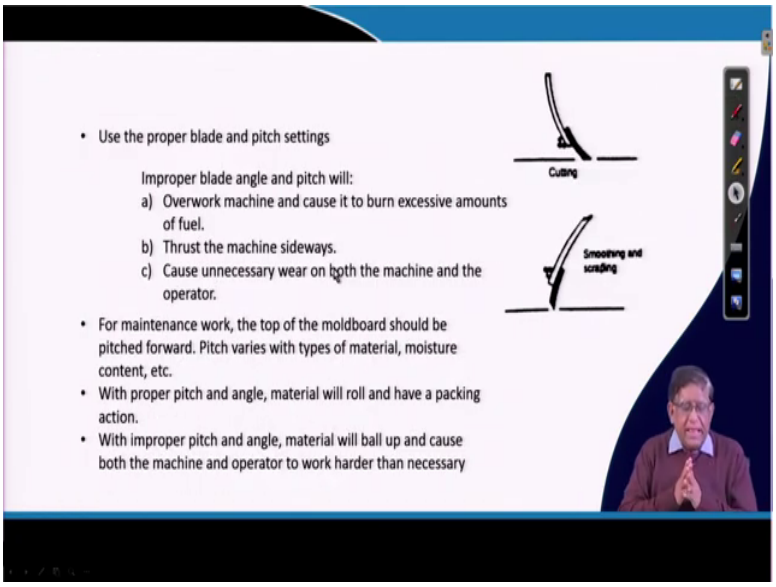

Now, the most important thing is to how you use this blade. So, you can see in the mold board there is this street portions are connected over there. And then whole operation you will have to take care of this that what angle you will be making for cutting or it is for the scrapping. So, you are doing a cutting actions here, and this is a scrapping actions just collecting over things over there.

So, and then they trust how much sideway trust you will be putting that also on the basis of your how the hydraulic force has been imparted to this. So, exactly the mechanism as a to give that particular force in a particular directions the design takes care of it. While operating we need to appreciate that; what are the things go behind designing this ingenuity and doing that engineering of such machine.

Now, they put the; this machine must be maintained properly. And that the maintenance things comes that exactly in a whether you have the if you do not select the right type of blade for the right type of soil; then you will be always getting a problem it will be wearing out and all.

So, that is why you will have to design out the maintenance. Whatever, the maintenance problem come on a particular site. What are the type of failure come on a particular site they are taken care of in the designing so that they can be minimized. Nowadays, whenever a manufacturer you are engaging or buying a particular thing giving an order they study your site and your working conditions. And accordingly in their design certain modifications can be made that such type of systems are available.

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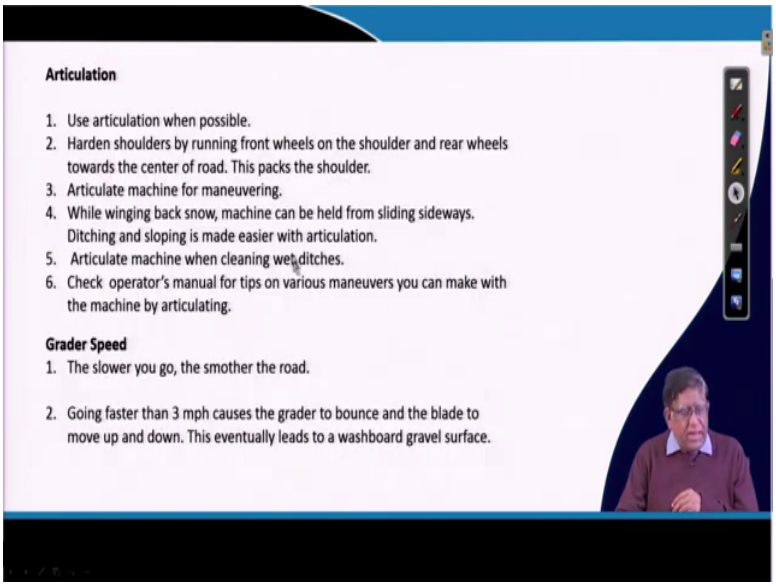

So, if your this pitch and angles are the then the articulation; I have said the articulation the front part then. Nowadays it is almost a standard that all these the motor graders they keep the articulations for their operational use. So, what you must do while instructing your operator and instructing your that maintenance crew will be working over here you will have to refer to the manual; because that same machine design to design it varies.

So, now, this one thing you should maintain that while you are working with a grader be patient towards the speed. If you speed it up you may spoil the road and while repairing it and you will be running into lot of operating costs. And then normally 3 mile per hour that is what is exactly the speed they suggest the manufacturer subject.

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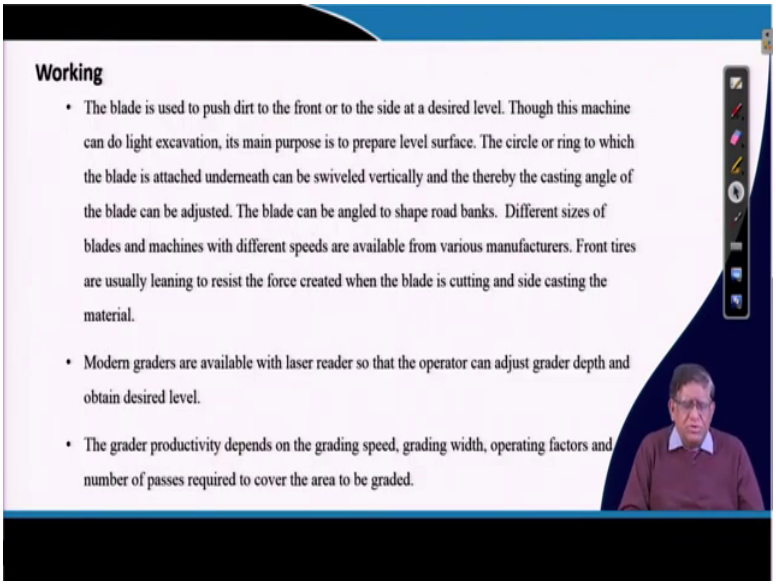

So, now how do you work it, the working is the blade is used to push dirt to the front of the side of the desired level. So, the machine it can do a light excavation it is not an excavating

machine. So, do not do like a dozer can do a taking a big dragging prism in front do not do that, right.

So, that you can select the size of the blade properly and then you can that is your the load, which will be coming to the it is on the machine and particularly and if your heavy load is taken then if it gets a skidding type of things your tire may get damaged. So, those things will have to be taken care of while working.

And then see nowadays this is a laser radar or the laser controlled and electronically controlled graders are nowadays available. And then by productivity of the equipment that is; how much meter cube of material it has moved and then how much kilometre of road it has prepared that is the productivity.

It will be depending on at what speed it is working and what width of the road it has managed and then what is exactly how many times you are requiring. So, preparing one road if you need to make the 5, 6 times of coming and then doing; then exactly you are spending lot of diesel.

So, that is why the productivity (Refer Time: 29:59) it depends on the skill of the operator also. This operator will have to be trained that how with taking a minimum pass it can do the grading operation. So, these are some of the things on the site it is controlled.

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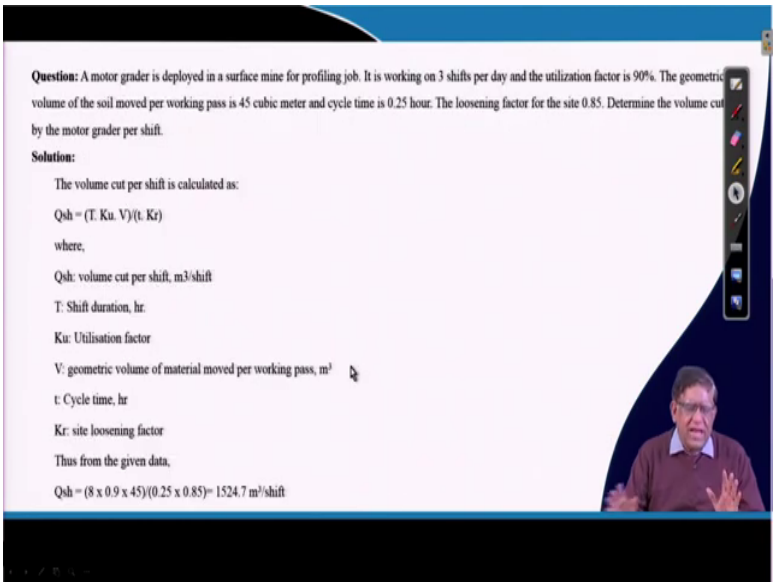

So, now try to understand that how we measure this exactly a volume of material which has been graded. You can write down this question that is a a motor grader is deployed in a surface mine for profiling job. It is working on 3 shifts per day and they utilizing utilization factor is 90 percent. And the geometric volume of the soil moved per working pass is 45 meter cube from one point to another point when it goes it is just moving 45 meter cube of soil.

And the cycle time; that means, going from there and again starting from the beginning to do that thing one operation's for this dosing that is your 0.25 hour that is 15 minute. Now, the loosening factor of this is 0.85; that means, that soil factor we have said that how when you loosen that part is 0.85.

Now the question is to how to determine the volume cut by the motor grader or how much material it has cut. So, if you know how much material it has cut in a per hour that will be the productivity. Now, this volume can be calculated by simple questions that equation.

You take that what is the shift durations in that shift duration in hour how what is your utilization factor. That means utilization factor is the effective working hours divided by available hours, so that means, during that shift that machine is used how much time. And then V is the geometric volume of the material moved per working pass that is; that if you are having this much width, this much thick and this much length that multiplied that give the volume this much volume of material has been cut.

So, sometimes it cannot be a straight line, but it can be you can estimate over there. Then, what is the cycle time that term of depending on the velocity of the machines. And then what is the site loosening factor in that how much exactly the, that material when it is from the bank volume it is cut how much it swell.

And then, if you give this data all these values are given and you can calculate. Then you can find out that is your as in this particular case you are having this is a productivity of that. That is a hourly or per shift production capacity.

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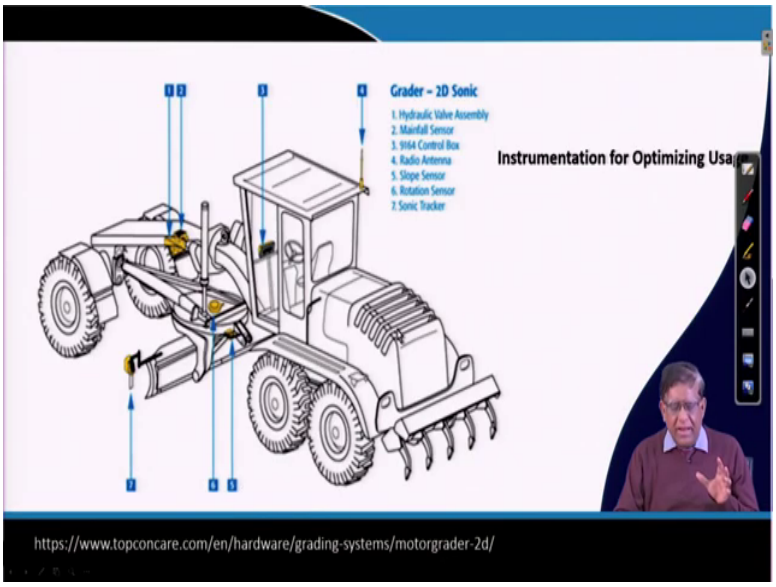

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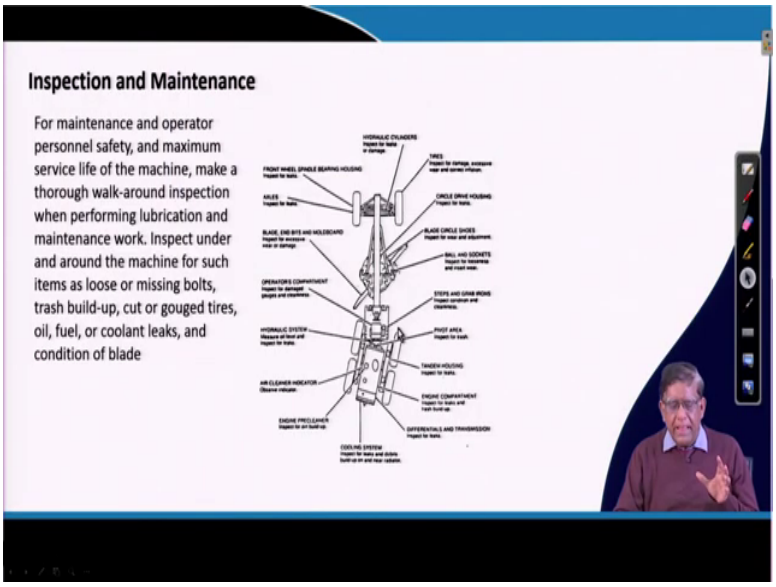

So, this type of calculations you may do in mining. But now to tell you the, this machines in a modern machines they get automatic sensors. Nowadays, mechatronics applications on the machinery the new researchers they find out by putting some sensors here that is your a in the valve assembly.

And then there is a mainfall sensors is there this how it is working. Then you have got some sensors for the control box is there in the operator's cabin. That operators cabin will be taking the signals from all that and on that basis they can decide that exactly; how much we will have to be steered, how much we will have to be lowered and all that. So, this is an area where you can create a new innovative use of it.

Say for example, to protect the tire; what type of information's we will have to be done. So, this type of small mini project or B. Tech project you can take up. Now, if you are going to

work in the mines then what will be there as a first when you do as an under manager or as a working persons in the mines you will have to learn how to inspect the machine.

Now, this exactly there are number of points while the starting of the shift if you are in charge of a vehicle you will have to go and check whether the tires are doing ok or not. Whether the circle drive housing it is proper or not whether the bowl and sockets on which exactly the articulations will be giving they are free or they are exactly properly lubricated or not.

Then your what is the steps on the grab that is by which you will be going up on that machine. Whether the stairs and everything is ok you come quickly go or not. That your this point of the hitch point if there is a, is there any problem in the articulations. Whether this random housing is that giving any leak if that any hydraulic oil or anything is coming out.

Then your the near the engine compartment you find out whether there is anywhere any fuel is coming or any oil is leaking those type of things. Then the differential and the transmissions also you should be inspecting for leaks. Because these are hydraulically operated machines if there is any leak means the hose pipes or the valves or somewhere the problem may be there.

So, then the machine cooling system the radiator there you need to check because, if the cooling system of the machine is not working, then it will be a hell lot of problem. In a diesel engine; such type of diesel engines which can be a 6 cylinder, 8 cylinder or even sometimes very big of a 8 cylinder inline or V line engines.

There if the as this high resistance of rock is also being cut more power is generated lot of heat will be generated. And then if the engine is not properly cooled that engine will stall and you will be losing your operating time. So; that means, the cooling system of the engine is very important.

Then engine pre cleaner: how the cleaning actions is done, air cleaner is properly working or not, if the air cleaner is not working sometimes you will find that when you start lot of black smoke will be started coming with the exhaust. Then, the hydraulic systems overall that is

whether the oil level is ok or not. That is your; if there is anywhere leaking this type of things need to be see.

Now, the operator compartment whether all the things are is a whether his conditions will be comfortable or not, whether this is exactly dust free environment has been maintained or not though those things. Then, your the main cutting member the blades.

Whether this blade and the moldboard there should be if there is any wear and excessive damage. Because while operating in the previous shift if there is a teeth is damaged, then you will find that in your shift while you are working you are going to give a very less production.

So, that is why when you start your shift starts at that time you should see that working member, so that if by any reason you are getting a less production by in your shift then you can know that where is the cause that is exactly you have damaged or somebody is damaged and then exactly the system should be set into right conditions immediately, so that type of; and then the axels the area (Refer Time: 36:56).

So, what is there you move a clockwise around the machines to each and every component. If you know and understand that what is the machine then you can deliver the goods.

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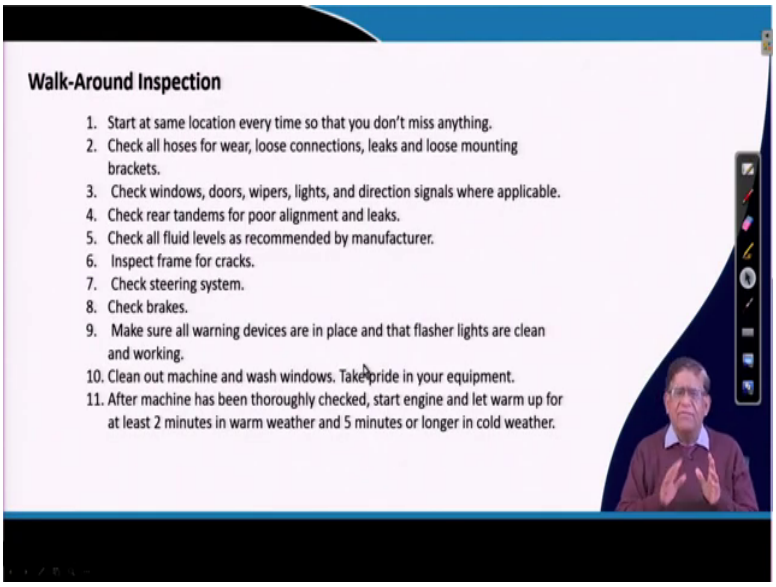

So, that is what exactly is called a work around inspections as a mine manager you will have to do this. So, that you can instruct the mechanical engineer, maintenance engineer whoever is in charge of it they can take the necessary actions on it.

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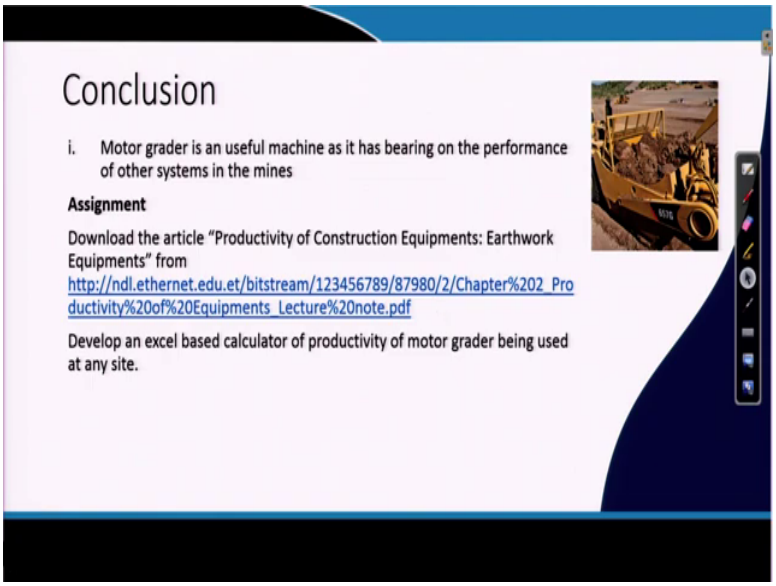

So, a motor grader is an useful machine and it has a bearing on the performance of the other systems, because if the haul road is not ok, you may produce in the mines, but the product must go back to the dispatching for selling. But, if your road is not properly maintained you cannot evacuate what you produce.

So, that the haul road will take a long that; haul road will make the dumper to take a longer cycle time, when the dumper will be taking a longer cycle time, either your shovel will be waiting for when the dumper will come and I will be loading on to the this. So, that is why the haul road if it is not maintained, then if it is the dumper when it is going with heavy load then the road is having lot of undulations it is have to change the gears every time in.

Along with the speed is reduced exactly every your shift of the change of the gear you are consuming more diesel. And the diesel consumption is more means you are giving an exhaust where exactly diesel exhaust is crunching more environmental pollution.

So, you can see that by maintaining the road you are exactly giving saving the idle time of your main production machine, you are saving your diesel also you are saving the environment. Now, are you understanding why this piece of machinery though it is called an auxiliary machinery, but how important it is for the mining industry.

So, I give you an assignment here, that is a you download one article that is; your "productivity and construction equipment: Earthwork equipment". This particular paper it will be giving you how the productivity of all these machines so far we have discussed they can be done. Whether it is a dozer, whether it is a motor grader, whether it is a this your scraper and also some of the machines now will be discussing from next classes are also there.

So, my request is reading this manual or this principles there you need to develop a very good either on r or in excel. You use excel develop a calculator or if some of one of you interest you can easily write a small code or a small software you can develop by using C plus plus or Java or any other language you know.

Or you can make a just a calculator on a mobile phone; so that the operator or the engineer can use this basic calculations with the machines by themselves. So, that is an exercise all of you can do, and if you need anything any help on that you can contact me at any time.

Thank you very much.