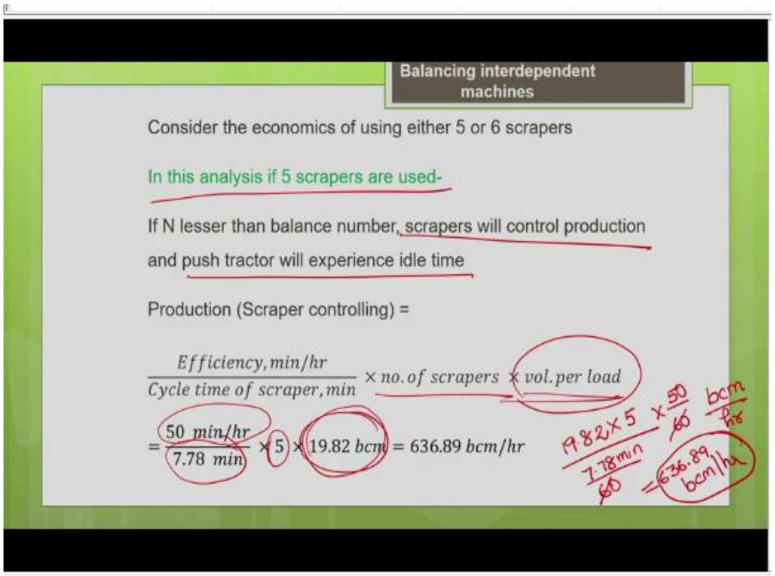

Now let us consider the economics of going for 5 scrapers. So, 5 in the sense you are going to use lesser than what is needed, you are assuming 5 that means you are going to use the number of scrapers lesser than what is needed. So, when the number of scrapers are lesser than the balanced number so obviously scrapers are more critical, but a pusher will have the ideal time. Your pusher will wait for the scraper.

So, unless a scraper is available you cannot complete the job. So, here the scraper will be controlling the production as a scraper is a lesser in number, but the pusher will have the ideal time. So, now, let us see the productivity this case of n equal to 5 scrapers. How to estimate the production of this scraper? The volume of your bowl volume per load, you know the value of 19.82 bank cubic meter.

$$Production\ (Scraper\ controlling)$$

$$= \frac{Efficiency, \frac{min}{hr}}{Cycle\ time\ of\ scraper,\ min} \times no.\ of\ scrapers \times vol.\ per\ load$$

$$= \frac{50\ \ min/hr}{7.78\ \ min} \times 5\ \times 19.82\ bcm = 636.89\ bcm/hr$$

We need the unit production cost in terms of the cost per bank meter cube. That is why we have to estimate the production also in the bank cubic meter. So, it is already estimated earlier the volume per load that is a volume of the bowl is 19.82 bank cubic meter. The payload in the bowl. Now the number of scrapers is 5. In this case we have taken it as 5, the cycle time of the scraper is 7.78 minutes and the job efficiency machine is going to go 50 minute in an hour.

Now you just multiply it and you will find it. So, basically the volume per load is 19.82 multiplied by the number of scrapers is 5. So, divided by the scraper cycle time is 7.78 minute. So, I need the production bank cubic meter per hour. So, let me convert this a cycle time in hour divided by 60. Then the job efficiency machine is going to work for 50 minutes an hour. So, 50 divided by 60.

So, these 2 things gets cancelled, so, the resultant value will be 636.89 bank cubic meter per hour. So, this is your production if you go for 5 number of scrapers per pusher. Similarly, let us estimate for 6 number of scrapers.

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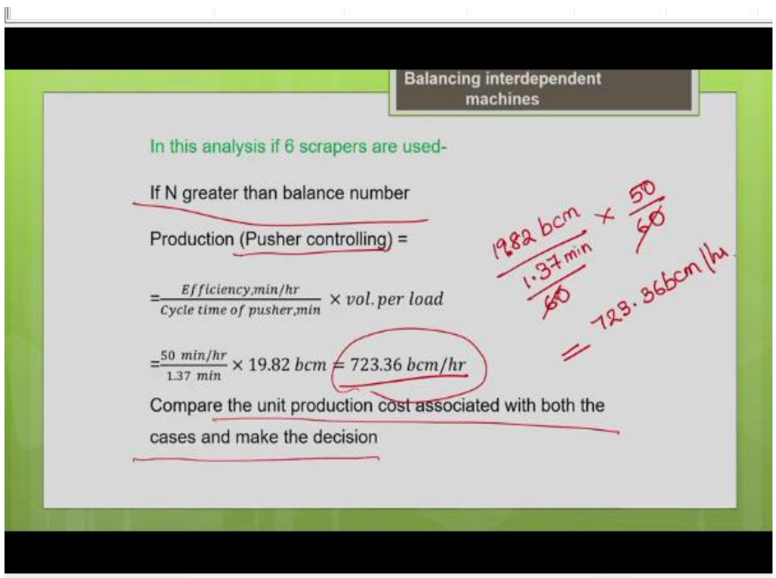

If n is greater than the balance number that means you are going to use more number of scrapers, then what is indicated by the balance number. In this case, scrapers will have the ideal time. Scrapers are not critical. So, the scraper will be waiting for the pusher. Pusher is critical here. So, unless the pusher is available, I cannot complete the job. So, in this case pusher will be controlling the production. Pusher cycle time is critical. So, unless a pusher is available, I cannot complete my job.

I have scrapers more than what is needed. So, in this case how to estimate the production?

$$Production\ (Pusher\ controlling) = \frac{Efficiency,\ min/hr}{Cycle\ time\ of\ pusher,\ min} \times vol.\ per\ load$$

$$= \frac{50\ \ min/hr}{1.37\ \ min} \times 19.82\ bcm = 723.36\ bcm/hr$$

Production is pusher controlling, so the volume per load is 19.82 bank cubic meter divided by the cycle time of the pusher. Cycle time of pusher is 1.37 minute convert it into hours divided by 60. Now multiply with a job efficiency machine is working for 50 minutes an hour, it gets cancel. So, the production will be 723.36 bank cubic meter per hour.

So, that is what is given here. So, basically when you use lesser number of the scrapers, scraper will be controlling the production, lesser than the balance number. When you are using more number of scrapers in that case pusher will be critical, pusher cycle time will control the production. So, that is only to estimate the production of the teamwork. So, now we have estimated the productivity.

Based on productivity if I select obviously I have to go for 6 number of scrapers per pusher, because 5 scrapers is giving you 636.89, 6 scrapers is giving you 723.36 bank cubic meters per hour. So, obviously 6 scrapers per pusher is giving you higher productivity. So, if you are more concerned about the productivity, if you have very tight deadline, you have to finish the project faster.

In that case people prefer to go for the combination which gives you higher productivity, but very often we see that people are more concerned about the cost only. So, people prefer for the combination which gives them minimum production cost. So, that is why now let us compare unit production costs associated with the both the cases and then let us make the decision.

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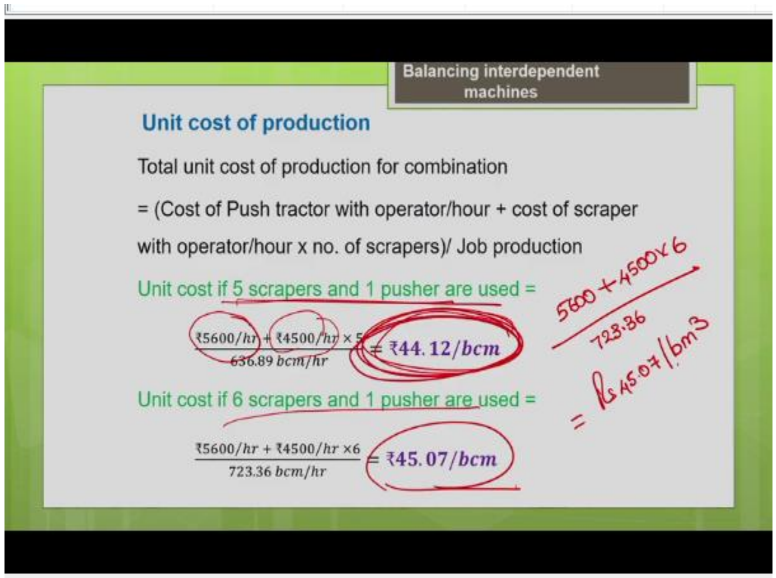

Let us now estimate the cost. How to calculate the unit production cost?

$$Total\ unit\ cost\ of\ production\ for\ combination$$

$$= \left[\frac{\frac{Cost\ of\ Push\ tractor\ with\ operator}{hour} + \frac{Cost\ of\ scraper\ with\ operator}{hour} \times no.\ of\ scrapers)}{Job\ production}\right]$$

So, cost per bank meter cube. So, it is nothing but you hourly cost by hourly productivity. Now, how to estimate the hourly cost? Already it is given to us input data in the question, but you know how to estimate the ownership costs and the operating costs of the machine which we have discussed in the earlier lectures.

So, in this problem, it is given to you that the hourly cost of the pusher is rupees 5600 per hour, hourly cost of the scraper is 4500 per hour. So, including the operator cost it is given to you. So, now it is estimated cost per bank per cubic meter for the case of 5 scrapers and 1 pusher. So, the pusher cost is given as 5600 per hour, scraper cost is 4500 for 1 scraper. So, we are going to use 5 scrapers and multiply it by 5 divided by hourly productivity for this combination is 636.89.

$$Unit\ cost\ if\ 5\ scrapers\ and\ 1\ pusher\ are\ used\ = \frac{₹5600/hr\ +\ ₹4500/hr\ \times\ 5}{\frac{636.89\ bcm}{hr}}$$

$$= \mathbf{₹44.12/bcm}$$

That is 5 scrapers and 1 pusher the productivity values 636.89. Now the answer will be rupees 44.12 per bank meter cube or bank cubic meter. Now let us estimate the unit production costs associated with 6 scrapers and 1 pusher.

$$Unit\ cost\ if\ 6\ scrapers\ and\ 1\ pusher\ are\ used\ = \frac{₹5600/hr\ +\ ₹4500/hr\ \times 6}{\frac{723.36\ bcm}{hr}}$$

$$= ₹\mathbf{45.07/bcm}$$

So, the cost of 1 pusher is 5600, the cost of 6 scrapers 4500 multiply by 6 divided by your productivity of combination is 723.36 bank cubic meter per hour. So, this gives you the cost is rupees 45.07 per bank meter cube.

So, if you are concerned more about your production cost only. In that case most of the cases people are concerned only about minimizing the production cost. So, in that case we have to go for the combination which gives you the minimum unit production cost. So, the combination of 5 scrapers and 1 pusher gives you the minimum unit production costs. So, let us go by this 44.12.

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The solution is we are going for 5 scrapers and 1 pusher. The associated production value is 636.89 bank cubic meter per hour and the unit production cost associated is rupees 44.12 per bank cubic meter. So, this is how we have to estimate the productivity and the unit production costs for the pusher loaded scrapers. So, we need to balance the number and for the balance combination for optimum combination we have to estimate the cost.

Now, let us work out the next problem on scraper. So, in this problem, we are going to check whether the rimpull generated is sufficient for doing the desired job, whether the rimpull is sufficient I hope you remember what is rimpull, the usable force is a tractive force at the point of contact between the wheel and the ground.

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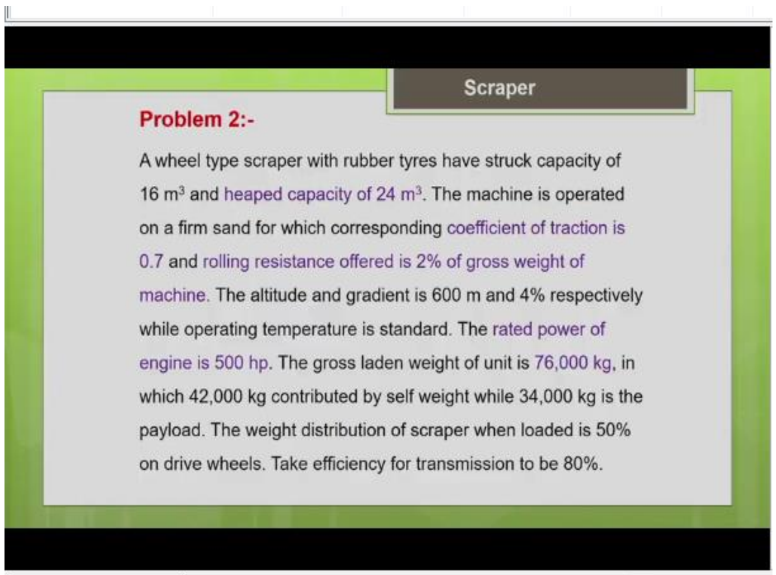

Whether the force generated is sufficient to do the required job or not, we need to check in this problem. So, here a wheel type scraper is given with rubber tyres having struck capacity of 16 meter cube and heaped capacity of 24 meter cube. Hope you know the difference between struck capacity and heaped capacity. So, we are interested in heaped capacity only. The machine is operated on a firm sand for which the corresponding coefficient of traction is 0.7.

And the rolling resistance offered is 2%. It is express as percentage of gross weight of the machine, the gross weight is nothing but your self-weight of the machine plus the weight of the load in the machine the payload in the machine. The altitude is 600 meter and the gradient is 4% and the operating temperature is standard temperature. So, that means you need not do any correction for temperature, but the machine is working at an altitude of 600 meter.

So, this associates some correction with respect to altitude. And the gradient is 4%, the rated power of the engine is 500 horse power and the gross weight is 76,000 kg which includes a self weight of 42,000 kg and payload weight of 34,000 kg, the weight distribution of the scraper when loaded is 50% of the drive wheels. So, only 50% of it is on the drive wheels. And take the efficiency for transmission to be 80% that means the machine is the efficiency in transferring the engine power to the usable rimpull is 80%. So, the efficiency in transferring the machine power the engine power into the usable power is 80%.

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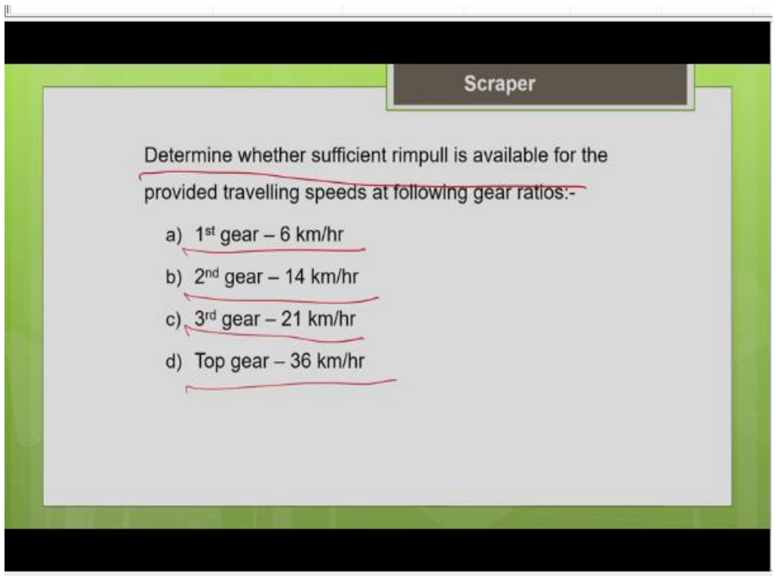

Determined whether sufficient rimpull is available for different speeds different gears you can see first gear 6 kilometer per hour, second gear 14 kilometer per hour, third gear 21 kilometer per hour and the top gear that is 36 kilometer per hour. For these different gears that is the rimpull is sufficient to do necessary job that is what we are going to find it.

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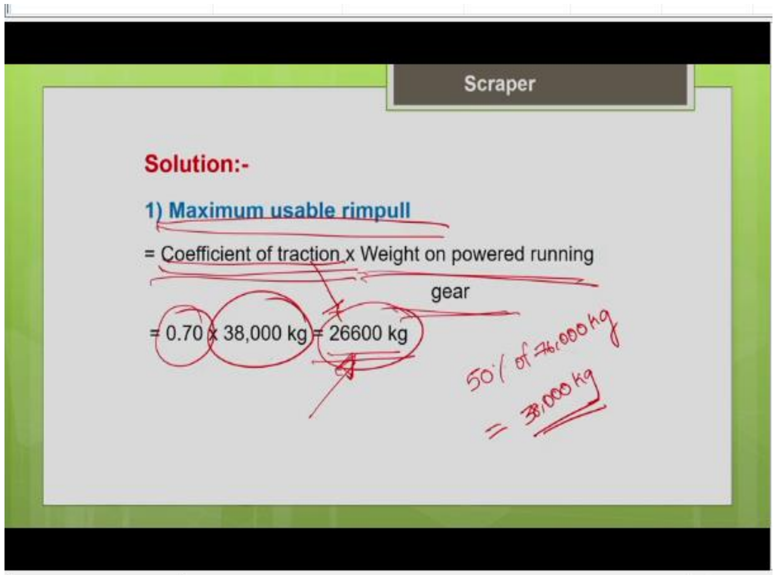

So, first what we need to determine is the maximum usable rimpull. As we discussed earlier the rimpull the maximum usable rimpull for any machine. So, depends upon the coefficient of traction between the wheel and the haul route, wheel and surface. So, irrespective of whatever may be the horsepower capacity of the machine. So, the usable rim power depends upon the coefficient of traction.

$$Maximum\ usable\ rimpul = Coefficient\ of\ traction \times Weight\ on\ powered\ running\ gear$$

So, your horsepower capacity of the machine may be very high, but if the coefficient of traction is insufficient. In that case most of your engine power will not be converted into usable power. So, how much amount of engine power will be converted into usable power depends upon the coefficient of traction? So, between your wheel and the surface, that is why sufficient traction is needed for the conversion of most of your engine power into usable power.

If there is no sufficient traction, there will be slippage of wheels. So, in that case conversion will be poor. So, that thing you should always keep in mind. So, the usable rim power depends upon the coefficient of traction and the weight on the power running gear. That means in your machine all the excess may not be power, only some access may be power and those corresponding wheels only will be driving wheels. So, we are concerned only on the weight of the driving wheels for the usable power generation.

So, that is why we take the weight of the powered running gear. So, the coefficient of traction in this problem is 0.7 and the weight on the powered running gear is given as 50%. It is given in the question as the weight distribution when loaded is 50% on the drive wheels and the gross weight you know it is 76,000 kg. So, 50% of 76,000 kg. So, that gives me the weight on the driving wheels as 38,000 kg. That is what is taken here.

So, 0.7 into 38,000 kg gives you the maximum usable rimpull 26,600 kg. Even if the rimpull based upon the horsepower of the machine is going to be greater than this. Say for example, if the horsepower generated rimpull is going to be greater than this. In that case, you have to go by this value only, only this will be the maximum limit. So, the coefficient of traction will decide the maximum usable rimpull.

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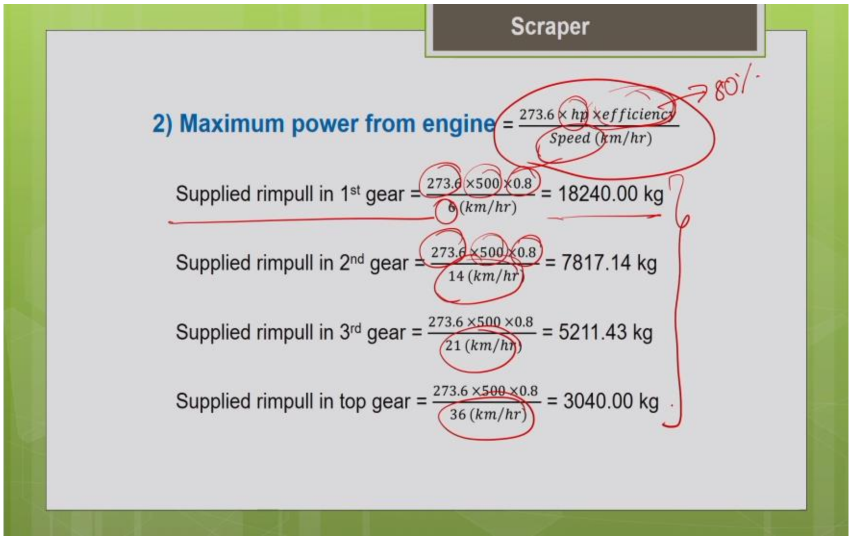

So, now let us estimate the maximum power from the engine based upon the horsepower of the machine, hope you remember this formula which we are discuss in the earlier lecture, it is nothing but rimpull equal to 273.6 into horsepower into the efficiency in transferring the horsepower into the usable power, here it has given as 80% in this problem and the speed which depends upon the gear. So, the supplied rimpull in the first gear equal to 273.6 multiplied by horsepower is 500, efficiency is 80% and the speed in the first gear is given as 6 kilometer per hour.

Hope you remember, the speeds are given here as input data. So, the supplied rimpull is 18,240.00 kg. Now the supplied rimpull in the second gear is 273.6 into 500 horsepower into 0.8 divided by the speed in the second gear is 14 kilometer per hour. Similarly speed in the third gear is 21 kilometer per hour, speed in the top gear is 36 kilometer per hour. So, correspondingly you can find the supplied rimpull in all the gear.

$$Maximum\ power\ from\ engine\ = \frac{273.6\ \times\ hp\ \times efficiency}{Speed\ (km/hr)}$$

$$Supplied\ rimpull\ in\ 1st\ gear\ = \frac{273.6\ \times 500\ \times 0.8}{6\ (km/hr)} =\ 18240.00\ kg$$

$$Supplied\ rimpull\ in\ 2nd\ gear\ = \frac{273.6\ \times 500\ \times 0.8}{14\ (km/hr)} =\ 7817.14\ kg$$

$$Supplied\ rimpull\ in\ 3rd\ gear\ = \frac{273.6\ \times 500\ \times 0.8}{21\ (km/hr)} =\ 5211.43\ kg$$

$$Supplied\ rimpull\ in\ top\ gear\ = \frac{273.6\ \times 500\ \times 0.8}{36\ (km/hr)} =\ 3040.00\ kg$$

So, one thing you should note that the maximum usable rimpull based on the coefficient of traction is 26,600 kg. Your usable rimpull the maximum power from the engine is 18240 kg in first gear. So, this is less than the rimpull determined based on the coefficient of traction. So, in this case obviously slippage of the machine would not occur. So, because there is sufficient traction and your usable rimpull will be this one.

So, you have to compare this value with this value with a usable rimpull based on coefficient of traction. So, in this case, since the rimpull from the engine is lesser, we will go by this value only. Now, the horsepower rating is determined based on at standard condition, standard temperature and pressure as we discussed earlier. Variation in temperature and the pressure will affect the efficiency of machine because all the horsepower rating done by the standard organization is it standard conditions of temperature and pressure.

In this case the problem it is given that the machine is working at a higher altitude say it is working at 600 meter. So, with increasing altitude as you very well know. The density of air will reduce. So, the ratio of fuel to air which is needed for the combustion will get affected for an internal combustion engine machine the combustion process should be efficient for that we need to maintain the fuel to air ratio. So, with higher altitude this efficiency gives this ratio fuel to air ratio gets affected. That is why for naturally aspirated machines, the efficiency of the machine will lesser at higher altitude, we have to take it into account when you deduct the rimpull.

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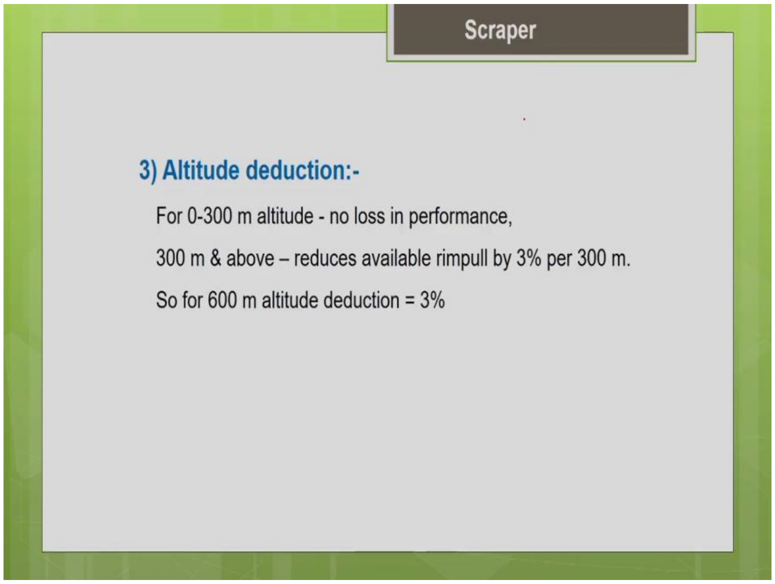

So, it is given to the manufacturer, that for 0 to 300 meter altitude, there is no loss in performance. So, beyond 300-meter altitude for every 300 meter, there will be 3% reduction in the rimpull. So, the available rimpull reduces by 3%. So, in our case, the project site is at 600 meters altitude. So, for the first 300 meter no loss. So, for the next 300 meters we are going to deduct it by 3%, 3% reduction in the available rimpull we have supposed to do.

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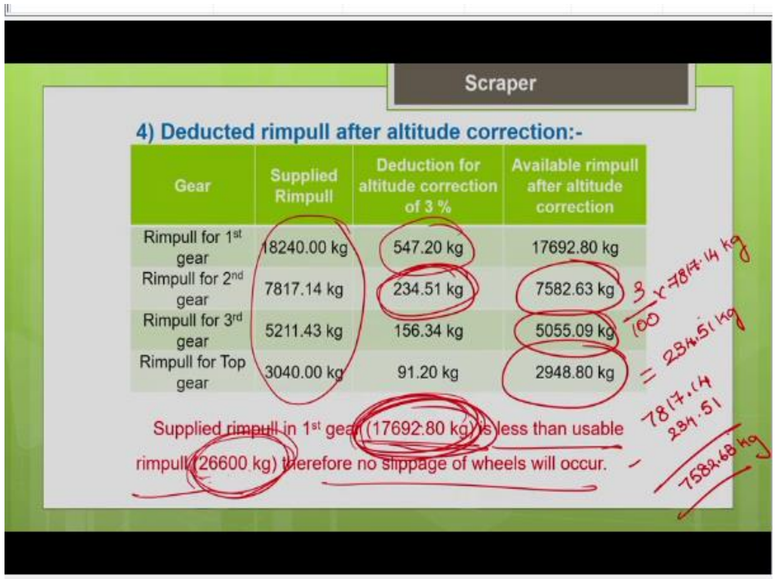

So, that is what is done here, this is your supplied rimpull. For different gear and the deduction for 3%, you calculate 3% of the available rimpull 18,240, this gives you the values is 547.2 kg. So, this much I have to deduct it from 18240 - 547.2. So, this gives me the value as 17,692.8 kg. So, this is my available rimpull after doing the altitude correction for the first gear. Similarly do it for the second gear.

Second gear it is going to be 3% of 7,817.14 kg, this gives me the value is 234.51 kg now, you are going to subtract this from this 7817.14 - 234.51 kg this gives me the value as 7,582.63 kg. So, I have deducted the rimpull according to the altitude. So, this is the available rimpull for the second gear after the altitude correction. Similarly, do it for the third gear and the top gear. So, one thing to be noted is the supplied rimpull is 17692.80 kg is lesser than the usable rimpull derived based upon the coefficient of traction.

So, based on coefficient of traction we have found the maximum usable rimpull is 26,600 kg. So, based upon the rimpull based on the engine power, so, we have found that it is 17692. So, this is less than this. So, now, the actual available rimpull is going to be 17,692.8 kg. The usable is 17,692.8 kg and then there would not be any slippage of the wheel. So, because it is less than 26,600 kg, there is sufficient coefficient of traction.

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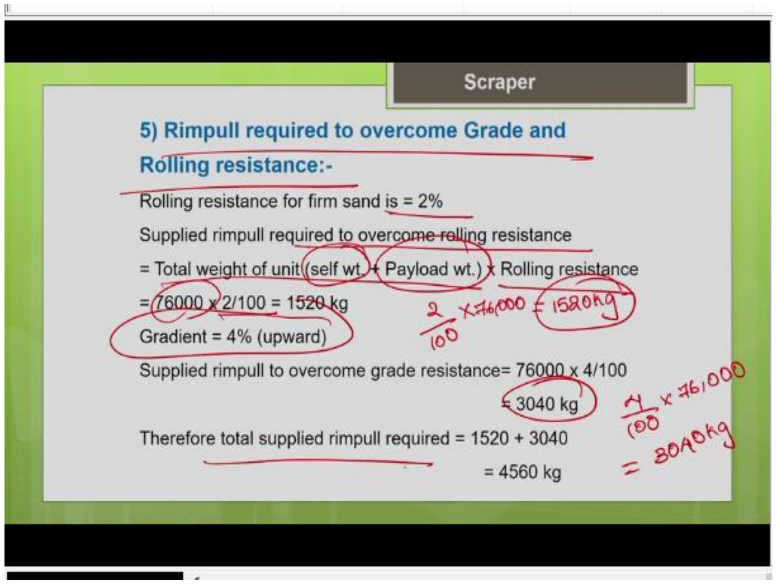

Now, that we have determined the available rimpull based upon the horsepower of the engine given by the manufacturer and after the based upon the project site location that is altitude we have done the altitude correction and after doing the altitude correction what is the available rimpull we have determined. Now, we are going to find what is available rimpull after correcting for the underfoot conditions of the project site. So, as we discuss earlier, we need some rimpull to overcome the resistances in the project site, rolling resistance and the grade resistance.

So, what is the required rimpull to overcome the grade resistance and the rolling resistance? That is what we are going to see now, the rolling resistance for the firm sand is given as 2% of the gross weight of the machine. So, the supplied rimpull required to overcome the rolling resistance is 2% 2 by 100 into the total weight of the machine gross weight, self weight plus a payload, there is nothing but 76,000 kg given in the question.

So, 2 by 100 rolling resistance is 2% of the gross weight 2 by 100 into 76,000 gives you 1520 kg. So, this much power is needed to overcome the rolling resistance. Similarly, the gradient is given as 4%. So, how much power is needed to overcome the grade resistance 4 by 100 into the gross weight of the machine 76,000 kg that gives me the value as 3040 kg. This much power is needed to overcome the grade resistance.

So, what is the total supplied rimpull required to overcome the grade resistance is 1520 + 3040 gives you 4560 kg. This is the total power needed to overcome the resistances in the project site. As we discussed earlier, what is the power available for towing the load. So, that we can know only after determining the required power for overcoming the resistance. So, from the available power generated based on engine, we have to detect the required power needed to overcome the grade and the rolling resistance, only the remaining power will be available for towing or pulling a load.

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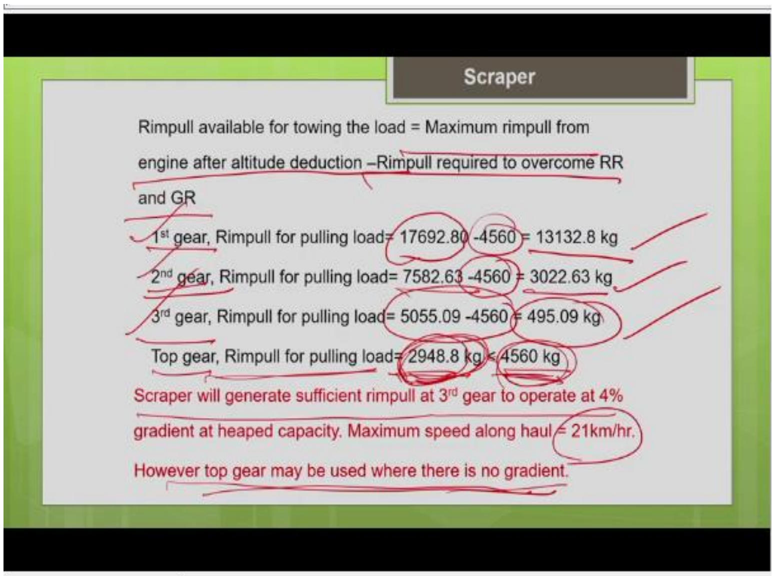

So, the rimpull available for towing the load is the maximum rimpull from the engine after the altitude deduction minus the rimpull required to overcome the rolling resistance grade resistance for the first gear. So, after the altitude after the altitude correction the available rimpull is 17,692.8. Hope you remember 17,692.8 minus the rimpull needed to overcome the rolling and the grade resistance is 4560 kg. So, you deduct this you will get what is the power available for pulling a load or towing the load for first gear.

Similarly for the second gear you know, what is available rimpull after the altitude say after the altitude deduction, this is a power available for the second gear 7,582.63. So, the power needed to overcome the rolling and grade resistance 4560. This is the remaining power available for pulling the load in second gear. Similarly, for the third gear 5055.09 is the power available in the engine - 4560 gives you the remaining power available for pulling the load at third gear.

Rimpull available for towing the load = Maximum rimpull from engine after altitude deduction – Rimpull required to overcome RR and GR

1st gear, Rimpull for pulling load= 17692.80 -4560 = 13132.8 kg
2nd gear, Rimpull for pulling load= 7582.63 -4560 = 3022.63 kg
3rd gear, Rimpull for pulling load= 5055.09 -4560 = 495.09 kg
Top gear, Rimpull for pulling load= 2948.8 kg < 4560 kg

Top gear you can see the power available is minimum 2948.8 kg. So, one thing to be noted is in the Top Gear, the power available the power generated by the engine is lesser than the power needed for overcoming the resistance rolling in the grade resistance. That is why we can not use the top gear when you climb the grade. So, top gear can be used when there is no gradient, but when you are climbing up the grade you cannot use top gear.

That is what we have found out in this problem. The rimpull is not sufficient in the top gear and when you climb up the gradient. Because the rimpull available is lesser than the rimpull needed to overcome the grade in the rolling resistance, but you can use a top gear when you are not climbing the gradient, but in this project is given, we have to climb the 5%. Hope you remember the gradient percentage is given gradient percentage is say 4%. So, we have to climb the gradient the 4%.

So, in this case, we cannot use the top gear when you climb up the grade. So, scraper will generate sufficient rimpull at the third gear. First gear it is sufficient, third gear is sufficient, the second gear it is sufficient. So, the maximum speed possible will be 21 kilometer per hour. That is in the third gear. So, the maximum speed possible is 21 kilometer per hour. Top gear may be used only when there is no gradient in places where there is no gradient.

So, the conclusion is the rimpull sufficient for the different gears first gear, second gear and third gear, only for the top gear it is not sufficient.

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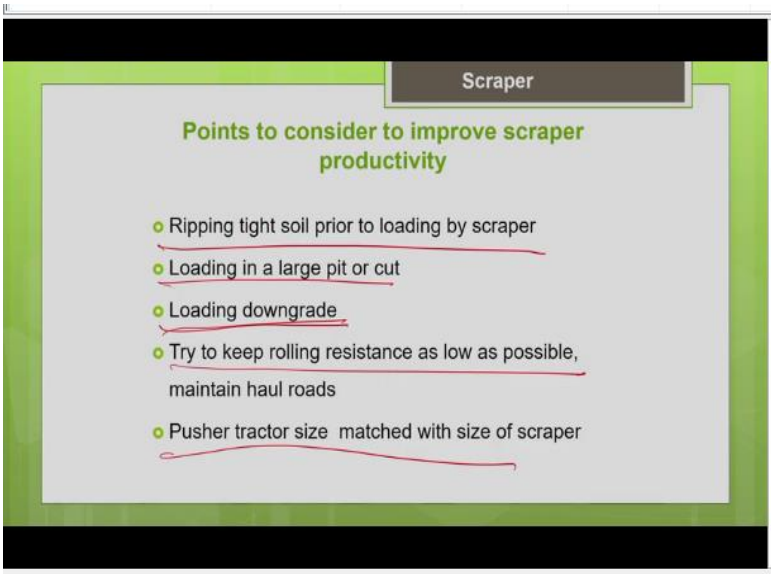

Now, let us see some basic guidelines how to enhance the productivity of the scraper? So, basically the scraper will give you maximum productivity when the soil is in loosened condition. So, that is why it is always advisable if you are going to handle a very hard terrain, like clay harden clay, in that case you have to go for a bulldozer with a ripper attachment, rip it first, loosen it, then use a scraper. Thereby you can enhance the productivity of the scraper.

Ripping tight soil prior to loading by the scraper. Then if you go for loading in a larger pit that will also enhance productivity it can reduce the congestion also and waiting time. Then we can load it downgrade when there is an option to use a downgrade for loading it is preferable to go for downgrade loading as it will reduce the cycle time and increase productivity. Try to keep the rolling resistance of the haul route as low as possible.

How to do that? You have to maintain the haul route, put some efforts for maintaining the haul route using a grader or a bulldozer a to avoid the deep pits, so that it will reduce the rolling resistance and reduce the cycle time and also extend the lifetime of machine. Select the pusher because conventionally what we use is a pusher a loaded scraper. So always choose a pusher size compatible with the size of scraper it should match.

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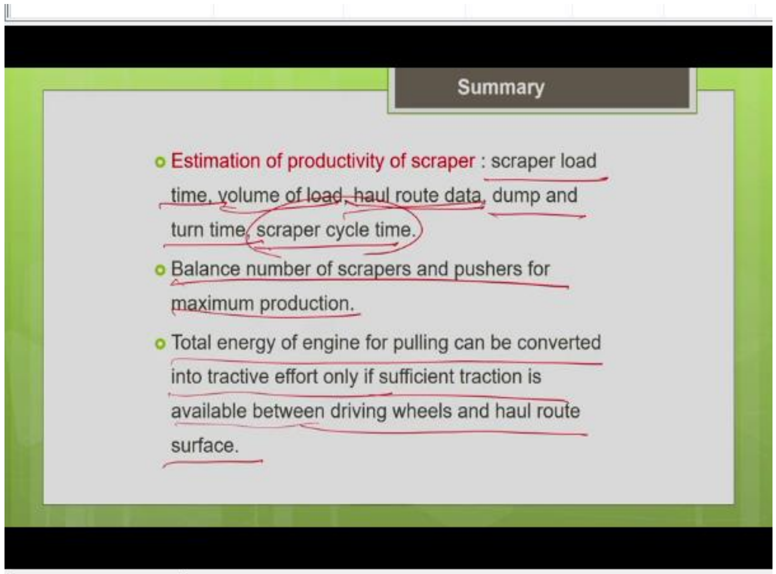

So, we have come to the end of this lecture. Let me summarize what we learned so far. So, we discuss how to estimate the productivity of the scraper. So, we need to determine the scraper loading time first, the optimum loading time from the load growth grow. You can get it from the manufacturer based on the loading time you can find the volume of the load, then if you know haul route data that is the distance and the rolling resistance and the grade resistance in different sections of your haul route.

Then you can find the haul time and the return time, then you need to find the dumping time and the turning time. So, all these things will help you to calculate the scraper cycle time. So, then you have to calculate the pusher cycle time based upon the loading method which we are going to follow we have discussed about different loading methods backtrack loading, chain loading, shuttle loading. So, according to that you have to find the cycle time of the scraper and the cycle time of the pushup.

Now, you balance the number of scrapers and the pusher. So, that there is minimum waiting time and the production will be maximum. So, and also you should always keep in mind that the amount of energy, amount of engine power that can be converted into usable power depends upon the coefficient of traction between the wheel and the ground. Only if there is sufficient traction, most of the engine power will be converted into usable power.

So, the total energy of engine for pulling can be converted into tractive effort only if sufficient traction is available between the driving wheels and the haul route surface and we have worked out the problem to estimate whether the rimpull is sufficient for the particular scraper for doing the desired job. So, with this, I will conclude this lecture, these are the references which I have referred for this lecture.

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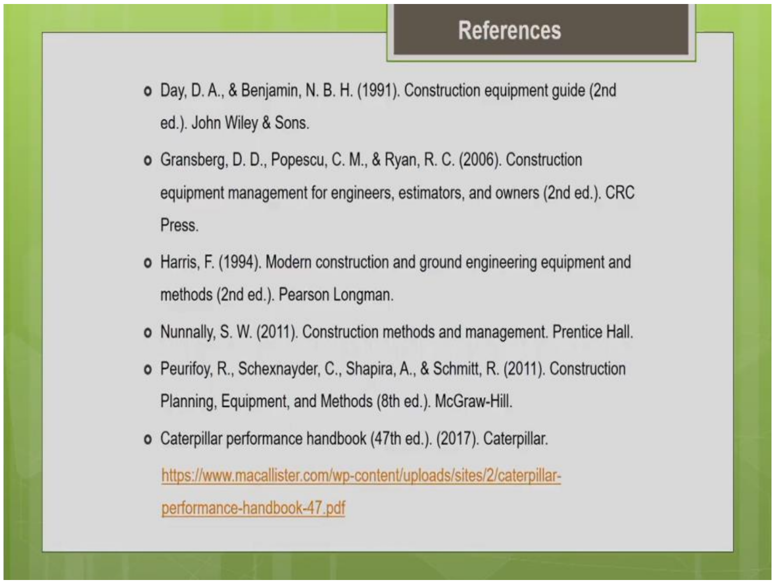

So, we shall meet in the next lecture. The next lecture we will be discussing about the front end loaders. So, what are all the different attachments for the loaders and how to estimate the productivity of the loaders. So, we will be discussing that in detail. Thank you.