Design of Farm Machinery

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Lecture 58 : Performance parameter for evaluation of threshers

Hello everyone, this is Professor H. Raheman. I welcome you all to this SWAYAM NPTEL course on Design of Farm Machinery. This is lecture 58, where I will try to cover the performance parameters for evaluation of threshers. The performance parameters for evaluation of thresher, what will be the corrected output of the thresher, then a few numericals - these are the concepts to be covered. For evaluating the performance, we need to know some of the performance parameters in terms of efficiency. So, how do we calculate those parameters? I am going to discuss that.

So, we assume that B is the weight of threshed grain - both whole and damaged per unit time at the main grain outlet, and C is the weight of threshed grain - both whole and damaged per unit time at the outlet other than the main grain outlet. Then, D is the weight of unthreshed grain from all outlets per unit time. So, threshed grain, unthreshed grain then the total grain input per unit time, A = B + C+ D.

Now, if you want to calculate the percentage of damaged grain at all outlets, then it is nothing but the ratio of the quantity of damaged grains collected at all outlets per unit time to the total grain input. So, percentage of damaged grains = $\frac{\text{Damage grain at all outlets}}{\text{A}} \times 100$

Then, the percentage of blown grain, this is applicable when a blower or aspirator is fitted with the thresher. So, it is the ratio of the quantity of whole grain collected at the bhusa outlet per unit time to the total grain input.

Percentage of blown grain = $\frac{\text{Whole grain at bhusa outlet}}{\text{A}} \times 100$

Then, the third parameter is the percentage of grain loss. This is a very important parameter. So, it is the ratio of grains - all threshed and unthreshed, as well as damaged, collected at all outlets other than the main grain outlet per unit time to the total grain input. So, if you consider the previous case, C plus D will be the grains which will be collected at other outlet. So, percentage of grain loss = $\frac{\text{C+D}}{\text{A}}\times 100$

Then percentage of unthreshed grain. So, this is the ratio of quantity of unthreshed grain at all outlets per unit time to the total grain input.

So, percentage of unthreshed grain = $\frac{C+D}{A}\times 100$.

Now, threshing efficiency = 100 $-$ percentage of unthreshed grain.

Now cleaning efficiency - it is the ratio of quantity of whole or clean grain at the main grain outlet per unit time to the total grain input.

Cleaning efficiency = $\frac{\text{Whole or clean grain at mainoutlet}}{\text{A}} \times 100.$

Then percentage of spilled grain is the ratio of clean grain dropped through the sieve and overflow from the sieve with respect to total grain input, total grain input.

Then optimal input capacity - the feed rate at which the efficiency of thresher is within the specified limit given by BIS. So, that will be the optimal input capacity. Then output capacity - it is the mass of grain mixture when collected at main grain outlet at the optimal input capacity that becomes your output capacity or throughput capacity. Then the maximum input capacity is the maximum feed rate at which choking or no stalling of engine occurs, because if you increase the feed rate that means, you are going to overload. So, engine as the source power, either the belt will slip, so the rpm will reduce, when you over-feed. When you feed less then rpm will increase just like we calculated in the design of threshing operation.

So, maximum input capacity is with the maximum feed rate at which no choking or no stalling of engine occurs at the speed specified by the manufacturer. So, you have to follow the speed which has been specified by the manufacturer and at that speed what is the maximum feed rate which can be achieved without choking or without stalling of the engine. Then the rated optimal capacity is 75 per cent of maximum input capacity. So, directly you can calculate, if you know the maximum input capacity.

Now in addition to these, there is another parameter which is called corrected output capacity, because threshers are being evaluated at different moisture content, at different grain-to-straw ratio. So, if you want to compare one thresher with other thresher then you have to convert this output of the thresher with respect to some standard parameters. Standard parameters means the moisture content - standard moisture content that is 12 per cent and the standard grain-to-straw ratio that is 40 : 60 that means, 40 per cent. So, that is the standard moisture content and grain ratio – grain-to-straw ratio specified by Bureau of

Indian standards. So, if I want to convert that to the corrected output then if W is the output which you are getting from the thresher that has to be converted to W 1 with respect to the moisture content 12 per cent and with respect to the grain-to-straw ratio 40 per cent.

Now, W_1 is the corrected output capacity = W [1- $(\frac{M-12}{88})] \times \frac{40}{R}$. So, grain-to-straw ratio you have to measure what was the grain-to-straw ratio when the thresher was evaluated and then our requirement is 40 per cent. So, we convert it to 40 per cent. So, that we can now have a value of a thresher output where you can compare between two threshers or between threshers. Because they have been converted to a standard moisture content and grain-to-straw ratio, because these are the parameters which are affecting the performance. So, if you carry out (evaluate) a thresher with some other moisture content and some other grain-to-straw ratio and try to compare with another thresher, so it is not advisable. That will not give the clear picture. So, now, what I will do is : I will try to solve a few problems related to the design which we discussed in these two classes.

First one is a rasp bar type thresher with cylinder diameter 45 centimeter and it has 6 bars. The concave subtends an angle 100 degree at the centre of the cylinder. So, find out the frequency of radial vibrations occurred in the crop mass for a peripheral speed of 28 meter per second. So, basically how many strikes are there to the crop during that 100 degree that means, the concave is enclosing certain area - within that area how many times the crop is struck that becomes your frequency of radial vibration. Now there are z number of teeth which are the bars - are given as 6.

So, in one revolution actually that means, in 360 degree, we are getting 6 strikes. Because there are 6 bars so there are 6 strikes ok. So, in alpha, alpha is the angle subtended by the concave at the cylinder centre. So, in alpha, this will be equal to $6\times \alpha/360$, α is given as 100 degree. So, $6\times 100/360$. Now, the rpm you have to find out, because we do not know the rpm, what is given is peripheral speed and what is given is the diameter. So, from this, peripheral speed, $u = \pi \times d \times n/60$.

So, now, from here you can find out what is the value of n? So, $n = u \times 60/(\pi \times d)$. The value of d is given as 45 centimeter and u is given as 28 meter per second. So, you can convert this 45 centimeter, you can take as meter. So, that way you can find out what is the value of n and the value of n comes to 19.81, this is in rpm. So, now I put this value. So, the number of strikes will be equal to - in that angle, it will be equal to $(6\times100/360)\times n$. So, that way we are getting $6\times100\times19.81/360$. So, that way we are getting a value of 33.01.

So, roughly around 33 number of strikes. So, 33 radial vibrations will be there in a revolution per minute.

The second question is about a peg tooth thresher with a drum diameter of 450 millimeters, a length of 1200 millimeters, and a permissible feed rate of 0.25 kg per second per tooth, to be used for threshing wheat. The distance between adjacent paths of teeth, and the number of teeth moving in the same path, are 40 millimeters and 2, respectively. So, determine the throughput capacity of the thresher.

So, we know that the number of teeth, $Z = m_p(\frac{L_p}{a} + 1)$, where m_p is the pitch, Lp, the length of the drum, a is the distance between two adjacent paths. This is the relationship we know. So, to find out Z, what values are required? The length of the drum, okay. Then, a is given as 40 millimeters, m_p, the pitch is given as 2. Now, m_p is given, L_p is given, a is given. So, we have to find out what is the number of teeth. So, we can simply put in the formula. So, $2\,(\frac{1200}{40} + 1)$. So, that way we are getting 62. So, now the permissible feed rate is 0.25 kg per second per tooth. So, the total output will be equal to the permissible feed rate, which is 0.25 kg per second, multiplied by the number of teeth, 62, to directly find out the total output, which is equal to 15.5 kg per second. This is kg per second, and this permissible feed rate is per tooth. If it is given per meter of length, if this permissible feed rate is given per meter of length, then only you have to multiply with the length. Because the length is not matching with 1 meter, but since it is given only 0.25 kg per second per tooth. So, that way, directly this is the output. So, if it is kg per second per meter of length of the drum, then it becomes 15.5 into 1.2 because the length is not 1 meter; the length is now 1.2 meters. So, this value will increase to 18.6 kg per second. That means we have to look at what permissible feed rate is given, whether it is given per meter or only per tooth; that is important.

A peg tooth thresher with a drum diameter of 450 millimeters and a permissible feed rate of 0.04 kg per second per tooth is to be used for threshing. Now, the distance between adjacent paths of teeth, the number of teeth moving in the same path, are 40 millimeters and 3, respectively. Determine the length of the cylinder for a throughput capacity of 200 kg per minute.

Again, we have to find out the number of teeth. So, for finding out the number of teeth, we know that the equation is, $Z = m_p(\frac{L_p}{a} + 1)$. So, what is given is m_p is given, a is given, L_p is not given, and L_p has to be found out. What is given is throughput capacity, and we know that throughput capacity is equal to the permissible feed rate into the number of teeth. So, now the permissible feed rate is 0.04, which means this is 0.04 kg per second, and this is

200 kg per minute. So, from here we can find out Z will be equal to 200 by 0.04. So, the only thing is this is in kg per second, and this is in kg per minute. So, you have to take care of the units. So, this has to be divided by 60. So, into 1 upon 60. So that we will find out the total number of teeth is around 83.33. That means you have to take a value of 83, or if you do not make it round, then directly after putting this in this equation, so Z value is 83.33, m_p value is 3, that is pitch, then L_p by a is 14 millimeter plus 1. So, this will be equal to $((83.33/3) - 1) \times 40$. So, that will be the value of L_p in millimeter. So, it comes to 1071.66 millimeter. So, if you make it round here then the dimension will change. The values, the value will change little bit, if you take 83. So, this value can be removed and then it will be reduced little bit. So, the only thing here is what is the permissible feed rate? And what is the throughput capacity given? The permissible feed rate is given per tooth and that is given per second. Now, the throughput capacity is given per minute that means, 200 kg per minute. So, while calculating these are to be made same otherwise you will land up with some other value.

Then we will solve another problem, where following the Goryachkin's drum theory, find out the power requirement of a thresher with a rasp bar type cylinder of length 110 centimeter used for threshing wheat at a cylinder peripheral speed of 28 meter per second. Feed rate of the grain is 3000 kg per hour and coefficient the material rubbing is 0.7. Assume velocity of the grain as 80 per cent of the peripheral velocity of the drum, this is important.

So, while calculating the power requirement following the Goryachkin's drum theory, we need to know the values of some constants those values I have already discussed in the class. So, it comprises of two components. Total power requirement comprises of two components one is A u and B u^3. This is the idle power requirement and the actual power requirement is $\frac{\dot{m}V^2}{1-f}$. Here, in this expression we have assumed that the grain has attaineded a velocity which is equal to peripheral speed of the drum. But, if you look at the question it is given as the velocity of the grain is 80 per cent of the peripheral velocity. That means, this equation has to be changed little bit.

So, it becomes A u + B u^3 + $\frac{\dot{m}V}{1-f} \times u$, in place of V, I can write as u. So, instead of V, I can write 0.8 into u is the peripheral speed. So, now, this divided by $1 - f$ and this value of f is given as 0.7. So, peripheral speed is given, f value is given. Only thing you need to know the value of A and B. For a rasp bar type cylinder the value of A is 0.8 and the B value is 0.0715. So, now if I substitute here, the power requirement becomes A u + B u^3. So, that will give you - A u comes to 22.4, B u^3 comes to 1569.568 then this component will come as 1742.22 These are all in Watts. The summation of this will give you 3334.19 Watt that means, roughly around 3.334 kilo Watt. Now suppose somebody will not consider this one, let us now see somebody will not consider this one assume that the velocity of grain is same as the peripheral velocity of the drum. Then the factors which is - which is going to change is this third factor. That means, here I do not have to multiply with 0.8, now I have to write directly as $\frac{\dot{m}V^2}{1-f}$. So, that way we are getting the third component as 2177.77 Watt. Now, if I take the sum, this will remain same. So, this will get a power requirements around 3.77 kilowatts. So, there is not much difference in this. So, we discussed about the Goryachkin's drum theory and we discussed about how to utilize this Goryachkin's equation to find out the power requirement. So, only thing is the coefficients which you are going to select these are different for different types of thresher like it has a value for rasp bar type, it has a value for spike tooth type. Some values are given for a particular diameter. But since no other data are available, the same data have been taken for calculating the power requirement for other drum diameters. So, that is the only limitation. The main aim is to show you how to utilize that equation so that you can find out the power requirement of a thresher, whether it is a spike tooth type or a rasp bar type.

Now, another problem we are going to solve: while carrying out threshing with paddy crop, the following data were collected. And we have to compare the performance of the threshers. So, what data are given? The moisture content at which the threshing operation was carried out with the different threshers, the grain-to-straw ratio that has been given, then throughput capacity, that means output capacity is given as kg per minute, and the percentage of damaged grain is given. Now, what percentage of damaged grain is given? So, now what you have to do is compare the performance. So, we cannot say that thresher 1 is better than thresher 2 by looking at the data, that is not the right way of comparison.

So, first what we have to do is calculate the corrected output capacity because if you look at the moisture content, they were carried out at different moisture contents. So, directly you cannot compare - they were carried out at different grain-to-straw ratios. So, we cannot compare directly. So, you have to take the help of corrected output capacity. The equation is $W_1 = W \times (1 - (M - 12)/88) \times (40/R)$. So, R is the grain-to-straw ratio in percentage at which the thresher was evaluated.

So, in the first case, suppose we consider thresher 1. So, in thresher one, the moisture content M is 13, R is 50, and W is given as 212 kg per minute. So, now if I substitute these values in this equation, then the corrected output capacity comes to 167.67 kg per minute. Similarly, I will try to find out the corrected output capacity for thresher 2, where the moisture content was 14 per cent, the R value is 49, and the thresher output is 200 kg per minute. So, if I substitute in this equation, then corrected output W_2 will be equal to 159.55

kg per minute. So, there is not much difference, you can say, only a matter of 8 kg, and then you can say what is the percentage of damage. This is only minimal, and there is not much difference. So, what you can say is both are equally good - that is one solution or if you are very accurate, then you can say that thresher 1 is better than thresher 2. So, thresher 1 has a corrected output capacity of 200 sorry, 167.67 and the damaged grain is little higher at 0.2 per cent. So, you can say that if you sacrifice damage of 0.2 per cent, then thresher 1 is better than thresher 2. Else, you can say because there is not much difference in the percentage of damaged grain, there is not much difference in the output capacity. So, you can say that both are equally good.

So, these are the references we took. We discussed in this class how to evaluate the performance parameters when you carry out threshing with different threshers, different efficiencies, how to calculate the capacity, optimal capacity, rated optimal capacity. Then, maximum input capacity, and then we tried to discuss how to compare two threshers in terms of weighted corrected output parameters if you are calculating or if you are evaluating the thresher at different moisture content and grain-to-straw ratio. And then we tried to solve a few problems related to design, which will be helpful while designing a thresher. That is all.

Thank you.