Design of Farm Machinery

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Lecture 36 : Design of multi-crop drum seeder

Hi everyone, this is Professor H. Raheman. I welcome you all to this SWAYAM NPTEL course on Design of Farm Machinery. This is Lecture 36, where I will discuss the design of a multi-crop drum seeder. The concept that will be covered is the design of a multi-crop drum seeder. That means how a drum seeder can be made to sow seeds for more than one crop.

So, the components will remain the same that means it will have a drum, a shaft, cage wheel, shank, and frame. So, I will not spend more time because the same drum has to be used. You cannot change the drum, the shaft, the frame, or the cage wheel, because if you change them, there is no point in saying it a multi-crop drum seeder. So, we have to make the same seeder operational for more than two types of seeds.

So, the design requirement will be the agro-technical requirements - that means, the agronomical requirements. Agronomical requirements: suppose you are making the drum seeder to sow wheat seeds, because wheat will be continuously dropped. So, for wheat seeds, the requirements will be row-to-row spacing - this is for sowing wheat seeds. So, 20 centimeters, seed rate is 100 kg per hectare, test weight is 49.5 grams, bulk density is 750 kg per m^3, and the hole size required for sowing wheat seeds that we have decided from laboratory tests - comes to 6 millimeters in diameter. We assume 3 to 4 seeds per hole to be dropped, ensuring continuous dropping of wheat seeds in the row. So, the power available, as discussed in the last class, is a maximum of 0.1 hp, and the average power a person can exert is 0.05 hp. Taking the forward speed as 1 kilometer per hour, we limit the number of rows. So, to determine the number of rows, we need to know the unit draft and the depth to which we are opening the furrow, because furrows must be opened to drop the seeds directly from the holes.

So, furrow opener as usual you have taken 3 centimeter width and the openers are shovel type. So, width is 3 centimeter, depth of operation is 5 centimeter, unit draft is 0.2 kg/cm^2 that comes to the draft per row or per shovel is 3 kg. Now, if you take a factor of safety as

1.5, then the draft requirement is 4.5 kg and the draft available is 13.5 kg. So, the number of rows will be equal to 3. So, here for wheat seeds we are going to take 3 rows. So, in the previous case we have taken that means, for sowing mustard you have taken 2 rows now you are taking 3 rows. So, the if you look at the drum there will be three sets of holes, this one, this one and this one. So, these two are - these two sets of holes are for mustard seeds. So, the cross ones are rows for sowing wheat seeds So, there are 3 rows so number of furrow openers will be 3.

So, design of drum - you cannot change the drum diameter or you cannot change the length. So, the length is fixed which you have already taken as 60 centimeter and diameter also you have taken as 23 centimeter for the drum. So, you cannot change it. So, maximum weight of seed which can be accommodated that is important in because since the size is fixed, so, the maximum weight which you can weight of seed which you can take which can put into the drum will be equal to 10 kg. That means, the volume of this 10 kg should be accommodated in the one third volume of the drum. So, with that concept we have taken 10 kg. The other concept is: If you take more than 10 kg, it becomes difficult for the operator to pull. So, draft requirement will increase and the person who is engaged in operating the sowing equipment, he will be getting exhausted. So, that way the volume comes to - for 10 kg it comes to 0.0133 m^3. So, now, design of the wheel is same. Diameter plus some clearance have to be taken and then the lug height and the diameter of the cage will remain as 38 centimeter. The test weight of the wheat seeds is 49.5 gram. So, in one revolution, the area covered is this much. So, $\pi \times D_g \times$L is the area covered. The seed rate is 100 kg per hectare in case of wheat. In this area, how much seeds are to be dropped?

So, this much quantity of seeds is to be dropped in 3 rows. So, in one row the quantity to be dropped is this much kg. Now, we are not interested for weight, we are interested for numbers. Because the seeds will be coming out from the holes in numbers. So, if you know the test weight we have given as this. So, if you multiply this one that will give you the number of seeds to be dropped in one row.

So, as I said, we require 3 to 4 seeds for continuous dropping of seeds in the row. So, if you assume 3 seeds to be dropped per row per hole, then the number of holes required will be equal to 16 holes. Now, the periphery of the drum we know is $\pi \times$ D. So, that way it comes to divided by 16 number of holes. So, that will give you the peripheral distance, which means 4.5 centimeters. So, the size of the hole is decided as 6 mm, and the peripheral distance is 4.5 centimeters. The length of the drum is 60 centimeters, and the diameter of the drum is 23 centimeters.

The next is the design of the shank. The same procedure we have to follow; the only thing is what is the draft, then what is the throat clearance. So, if you know draft and throat clearance - draft will be equal to 4.5 kg. So, 4.5 kg × 9.81 × the clearance. 9.81 we have converted into Newton. So, this is the throat clearance. So, this much will be the bending moment which will be acting on the shank. Again, the stress due to bending will be equal to BM - bending moment × Y/I. And again, assuming the shank to be a solid square section of size b, so the moment of inertia will be $b^4/12$, and Y = b/2. So, that way we will find out the value of b as 10 millimeters.

Next is the frame. Here, the difference between - I will discuss the difference in the end, may be in the coming class. But since there are 3 furrow openers, the frame has to carry these 3 furrow openers, and the spacing between two adjacent furrow openers is now t01, which is equal to 20 centimeters. Row-to-row spacing is t_{01}, which is 20 centimeters. Now, the length of the shaft we are not going to change. The length of the shaft will remain the same, which means 37.5 × 2, 75 centimeters. That will remain the same. So, what we have done is kept the length of the frame the same, and only the number of furrow openers will change. So, the size of the frame will again be dependent on - because the frame is subjected to both bending and torsion. So, to find out bending, we need to know the vertical forces that are acting. So, assuming the weight of the frame as 2.5 kg and the summation of the vertical forces acting on the tip of the working element here - there are 3 elements - so, $\sum K_v$ means 3 times K_v. So, we know K_v. How to find that out? That means, if you know the draft and the load angle, you can find out the value of K_v. So now, you find out K_v, and we have taken W_f.

So, R_A and R_B will be equal to 15.73 kg. Now, the bending moment R_A into - because R_A and R_B are acting upward and assuming that the weight of the frame is uniformly distributed, then $R_A \times (t_{01} + t_{01}/2 + 0.075)$ that means the distance from here to here is this one $- (W_f/2)\times(t_{01} + t_{01}/2 + 0.075)/2$. So, $W_0 = W_f/2$, half of the weight is acting here - and half into this distance. $- K_{v1}\times t_{01}$. So, you are taking the bending moment about the center line. Now, the total bending moment comes to 36.63 Newton meter. Now, the torsional moment will be equal to the total draft into the height from the tip - that means the throat clearance if you take. So, that way, you are getting 3 into - that will be 3 furrow openers. So, 3 × 4.5 - this is the draft, this is the Newton, conversion of kg to Newton -and this is the throat clearance. So, that is the value for the torsional moment, and this is the value for the bending moment. And then, applying the maximum shear stress theory and taking a shock and fatigue factor as 1.5 for both cases, and the design stress as 50 Mega Pascal, we found out the value of b as 0.00834, which is equal to 8.34 millimeters. Here, we have again considered the ratio between b to h because the frame has a rectangular cross-section. So, the b to h ratio is 1:3. So, h will be equal to 25.02 mm, which means 25 mm.

Now, the next thing is the design of the shaft. The shaft is supported on the frame, and there will be a cage wheel at the end of the drum on either side. The weight of the seed and the weight of the drum are the things acting on the shaft. The shaft will be subjected to both bending (due to the vertical force, meaning the weight) and torsion. Torsion is due to the rolling resistance or the motion resistance - how much force is required to rotate. So, if you know that and the rolling radius, you can find out the torque acting - the torsional moment. Now, to find out the bending moment, you need to know the total vertical force acting. So, R_A and R_B, which I have indicated, are nothing but the supporting points. So, $R_A = R_B =$ [2W_g (meaning the weight of the cage wheel) + the total vertical force, W_s (which includes the weight of the seed plus the weight of the drum)]/2. So, the weight of the ground wheel or the cage wheel is taken as 3 kg, and the weight of the seeds plus the weight of the drum is taken as 12 kg. Now, the weight of the wheel is acting at this point, which is at a distance of $t_{01} + t_{01}/2$, and the weight of the seed and the weight of the drum are uniformly distributed along the shaft. So, that way, $R_A = R_B =$ 9 kg. Then, the bending moment due to the vertical force will be equal to R_A multiplied by this distance - you are taking the bending moment about the central line (this dotted line). So, R_A multiplied by this distance - from here to here, which is equal to $t_{01} + t_{01}/2 + 0.075$m. You can take any clearance, but since I have taken the same clearance in case of mustard seed drill so mustard drum seeder. So, that's why I am maintaining this one, otherwise the choice is yours, but there should be some gap, so that, the cage wheel will be free to rotate, it does not strike the frame So, this amount which I have written it is dependent on how much clearance we are going to give. In my case I have taken 0.075, you can take 0.05 also. Now, W_g is the weight of the cage wheel × $t_{01}/2$ that means this distance from here to here. So, $t_{01} + t_{01}/2$. This distance plus this distance. Now, $W_s/2$ will be acting at a distance of $(t_{01} + t_{01}/2 + 0.075)/2$. So, that way the bending moment comes to this much.

Now we will find out the torsional moment, if you know the rolling resistance then we will find out the torsional moment. How to find out rolling resistance? Usually we take 8 per cent because this is a seed bed, so, the rolling resistance is not that much. So, we are taking 8 per cent of the total weight of the seeder. If the total weight of the seeder including seeds is 30 kg, then the motion resistance that is rolling resistance will be equal to 2.4 kg. So, 2.4 kg × 9.81×throat clearance - the radius, radius of the cage wheel. So, that will give you 4.47 Nm, this is the torsional moment which is acting on the shaft of the drum. We know the bending moment, we know the torsional moment and the shaft is a solid circular shaft. So, Tequivalent (T_{eq})will be equal to 13.24 Nm. Shock and fatigue factor we have taken 1.5 for both the cases for the bending moment as well as the torsional moment then square root of that will give you T_{eq}, equivalent torque. Now considering the design stress as 50 Mega Pascal. So, stress due to this bending and torsion, $\tau_s = T_{eq}/Q$, Q is the polar section modulus. Since this is a solid circular section. So, polar section modulus will be $\pi \times d^3/16$. So, from there putting in this value the value of diameter of the shaft can be calculated. If you want to take hollow circular shaft then we can do that. So, this will be the polar section modulus for hollow circular shaft $Q = \frac{4\times\pi^2\times r^2\times t^2}{6\times\pi\times r+1.8t}$. t is the thickness. r is the radius. So, if you substitute thickness as 4 mm then this will be the equation and τ_s = 50 Mega Pascal. So, if you solve this equation you will find out the dimensions to be 1.29 centimeter. So, either you follow this one or you follow this one does not make much difference. Only the difficulty is : here the shaft will be little lighter here the shaft is little heavier that is the difference. So, this is about the design of drum seeder design of drum seeder for sowing wheat seeds.

Now, the question is how to make the same drum seeder suitable for both seeds, that means for mustard and wheat seeds, that is important. So, the dimensions we have got: a set of dimensions for mustard, and we have got a set of dimensions for the wheat seeds. Then, how to finalize this thing. So that the same drum seeder can be utilized for sowing both types of seeds. So, that is what we are going to discuss in the coming class. So, here is what we have discussed.

These are the references.

So, finally, what we have discussed is: the procedures remained the same. The only thing is we need to know the values of agronomical parameters, that means, what is the row-to-row spacing, what is the bulk density, what is the seed rate, and what is the test weight. These parameters are going to decide how many rows are to be put in the drum, how much weight of seed we can carry at a time, and then, knowing the hole size, you can find out the number of holes to be put in the periphery of the drum. And the number of rows will be decided by the draft availability. Since the draft availability is fixed, this is the manual drawn type. So, we cannot change that. So, draft availability divided by what is the draft consumed per row. So, that is going to decide the number of rows. So, the question is if you can increase to more than 3 rows or more than 5 rows. The only problem will be during turning, while taking a turn, you will find difficulty. So, that's why you have to limit the number of rows to not more than 3 or depending on the row-to-row spacing. So, in short, we can say we discussed the components of the multi-crop drum seeder, and the design of these components was discussed. How the design of the multi-crop drum seeder is different from a drum seeder used for a single crop was also discussed.

Thank you.