Design of Farm Machinery

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Lecture 30 : Design of single seed metering unit

Hi everyone, this is Professor H. Raheman. I welcome you all to this SWAYAM NPTEL course on Design of Farm Machinery. This is lecture 30, where I will try to cover the design of a single seed metering unit. The concepts which will be covered here are the design of a single seed metering unit, then a few numericals related to single seed metering.

We discussed the design of a fluted roller, where we try to find out the volume of each flute because there the seeds are dropped by mass, not by single seeds. Now, precision planters or planters where we require to drop seeds at certain spacing in a row. So, for that, the metering mechanisms are a little different, not like this bulk flow metering unit that is the fluted roller. So, to design a metering unit for single seed metering, the first thing is we should know how many seeds are to be dropped in that area. So, area-wise, you say the number of plants or the number of seeds per hectare. So, if you know the seed rate and if you know the test weight, seed rate means kg per hectare, mass per unit area, and if you know the test weight, test weight is nothing but the weight of 1000 seeds.

So, we will find out how many seeds are to be dropped per hectare or per unit area. Then, all the seeds may not germinate. So, that is another constraint, you can say. So, what we do is we take the germination percentage of seeds, maybe 85 per cent or 80 per cent. So, then you find out what should be the actual number of seeds to be dropped per unit area.

So, if you denote the actual number of seeds to be dropped per unit area as N s, then you can find this out by $Q \times 100/(W_t \times GP)$, where, GP is the germination percentage, which is GP/100. So, 100 goes to the numerator. So, that is why I have written this. The next thing is how much area is covered in one revolution of the ground wheel. So, if you know the diameter and you know the width of coverage.

So, that will help you in finding out the area covered in one revolution, which is equal to $\pi D_g \times S_r$. Now, what is the number of seeds to be dropped in that area? So, that can be found out because we have already determined the number of seeds to be dropped per unit area, and we know the area. So, just multiply that, and it will give you the number of seeds to be dropped per revolution of the ground wheel, assuming that the gear ratio is 1. If you want to include the gear ratio in this calculation, then we just divide G i.e., $N_{sg} = Ns \times \pi D_g \times S_r \times Q/G$. So, that will give you the total number of seeds to be dropped. This is mass, this is the number of seeds to be dropped per revolution of the ground wheel. So, this is the diameter, as I said. This is the width of coverage, which is the width of the seed drill, and this is the gear ratio, the number of teeth on the ground wheel to the number of teeth on the feed shaft.

The percentage fill factor, because usually the metering units are of a cell type or a vertical plate with holes or an inclined plate with cells. So, in that case, all the cells may not fill at a time; there may be some missing. So, if you take that into consideration, then the total number of seeds to be dropped per revolution of the feed shaft, $N_{sff} = \frac{N_s \times \pi D_g \times S_r \times Q \times 100}{G \times F}$, where, G is the gear ratio, and F is the filling percentage. So, because it is in percentage, that is F divided by 100, so I have put 100 in the numerator. N_{sff} is the number of cells or cups to be provided in the metering unit, assuming that each cell is filled with only one seed.

So, this is the concept of a single seed metering unit. So, we have to take into consideration what the percentage of fill is, or you can assume that there is a 100 per cent fill. It may be possible, but in all cases, it is not possible. So, it is better to have a percentage fill factor into consideration while calculating the number of cells required for carrying out single seed metering.

Now, I will solve some problems which will further clarify your doubts if you have any. The first question is during the calibration of a horizontal plate planter having 72 cells on a 167 millimeter diameter circular plate with sugar beet seeds, 28.75 grams of undamaged seeds and 0.95 grams of damaged seeds were collected during 50 revolutions of the ground wheel in 68 seconds. A 6.40 gram sample contains 5056 seeds. The seed plate makes 0.76 revolutions for each revolution of the ground wheel. These are the information given, and what is asked is you have to find out what is the average percentage of cell fill? The second one is the linear speed of the cell, and the third one is the percentage of seed damage.

Now, we will come to the first one - the average percentage cell fill. That means, first, you have to calculate how many seeds are dropped during those 50 revolutions of the ground wheel. And the second thing is the number of revolutions of the ground wheel and the number of revolutions of the planter are not the same; there is a gear ratio. The gear ratio is given as - the seed plate makes 0.676 revolutions. So, for 50 revolutions of the ground wheel, the ground wheel speed is 50, and the speed of the horizontal plate is 50× by 0.76. So, for 50 revolutions of the ground wheel, the plate makes revolutions of 50 multiplied by 0.76. Now, the total seeds which are dropped in 50 revolutions will be equal to, there are some undamaged seeds plus damaged seeds - the damaged seeds are 0.95 grams. So, that way, the total amount of seed which is dropped will be equal to 2580, sorry, this many grams. So, a test weight is given, which means this many number of seeds weighs this. So, now, what is given is 556 seeds weigh 6.4 grams. So, now, in this much weight of grain which is dropped in 50 revolutions, what will be the number of seeds that we have to first find out. The number of seeds dropped in these many revolutions of the horizontal plate in 50 into 0.76 revolutions will be equal to 556 by 6.40 into 29.70. So, that way, we will get the number of seeds. The number of seeds comes to 2580. Now, in one revolution, there will be 72 cells, assuming that there is a 100 per cent fill, then only you have 72 cells. So, to drop this many seeds, how many rotations are to be made? Rotations are already given. So, in 50 into 0.76 revolutions, this is the number of seeds which are dropped.

So, in one revolution, the number of seeds dropped will be 2580 divided by 50 into 0.6. So, you will get a value. So, now, what is - if it is 100 per cent fill, then you should have got $72 \times 50 \times 0.76$, these many seeds you should have got, which is - which is coming to be 2736. What actually you are getting is 2580. So, now, you can find out what is the percentage, that means, $(2580/2736)\times100$. So, that will give you the average percentage cell fill. I hope I am clear.

Next is - the next problem is the linear speed of cells. To find the linear speed of a cell, we need to know the revolution. The revolution we have already calculated, like 50×0.76, which is the number of revolutions in 68 seconds. So, in 1 second, the number of revolutions will be $50 \times 0.76/68$.

So, the diameter is given as 167 millimetre. So, π D, if you denote π D into N, that will give you $\pi \times 0.167$, I have converted it into meters, then $50 \times 0.76/68$. So, that is the linear speed of the cell in meters per second, ok. So, it comes to 0.293 meters per second.

Now, the percentage of seed damage. So, for finding out the percentage of seed damage - out of this total sum, 0.95 is the damaged seed. So, 0.95 divided by 28.75 plus 0.95. So, into 100, that will give you the percentage of damage. So, this is all about this problem.

The next problem is soybeans are to be planted with a precision planter that meters 54 seeds per revolution of a metering disk. The row width is to be 75 centimeters, and the planter speed is to be 7 kilometers per hour. A plant population of 480,000 per hectare is desired. Calculate the required seeding rate or planting rate, assuming a seed germination percentage of 85 per cent.

So, let us now first try this one. So, the population desired is 480,000. And the germination percentage is 85 per cent; just divide it by 0.85. So, that way, these many numbers will be the seeds required to have the desired population. So, it will give you 564,705 point something. So, you can take 564,706. So, these many seeds are to be dropped per hectare.

So, this is for hectare. Now, what is given is a row-to-row spacing, row width is given. So, 0.75, then speed is given 7 kilometers per hour. So, V_a is equal to 7,000; if you divide by 60, that will give you meters per minute. So, in 1 minute, the area covered will be $7{,}000\times 0.75/60$. This will be the area which will be covered in 1 minute, and that way you will get 87.5 square meters per minute. Now, in this area, how many seeds are to be dropped? So, this is per hectare. So, in 10,000 square meters, seeds to be dropped - desired seeds is 564,706. Now, in this much area, 87.5 square meters, the number of seeds to be dropped will be equal to $(564{,}706/10{,}000)\times 87.5$. So, that way you will get 4,941.2. So, roughly you can take 4,941; this many seeds are to be dropped. Now, what is asked is the required seed spacing along the row. What is the seed spacing? So, in 1 minute, we are covering 7,000 meters/60. So, these many seeds are dropped in 1 minute because we have calculated. This is the square meter area covered per minute. So, that means per minute we are covering this much length. So, these many seeds are to be dropped in this length. So, the spacing between seeds will be equal to $(7{,}000/60)\times(1/4{,}941)$. So, that will be the spacing between 2 seeds. So, it comes to 2.36 centimeters.

Now, the third question is the required rotational speed of the metering device. What is given? The number of seeds to be dropped per revolution is 54 seeds. Now, per minute, this is the number of seeds which are to be dropped per minute. So, in one revolution, we are dropping 54 seeds. So, to drop this many seeds, what is the time? So, 4941 seeds are to be dropped in 1 minute. So, we are dropping in one revolution. So, the number of revolutions required to drop this many seeds will be equal to 4941/54. So, that will be the speed in rpm. Before that, we should know what is skid? Skid is nothing, but if I define skid, then skid is nothing but the distance traveled actually minus the distance traveled theoretically, divided by the distance traveled theoretically, multiplied by 100. So, if I write this, the distance traveled actually minus the distance traveled theoretically, divided by the distance traveled theoretically, multiplied by 100, that will be your 10 here. So, multiplied by 100. So, that way, 10/100, $0.1\ D_T + D_T = D_a$. So, that means $1.1\ D_T = D_a$. So, whatever

D_T you are getting, that has to be multiplied by 1.1 to find out the actual speed - the actual distance covered. So, this in 1 minute, we are covering 7000/60. This is the distance which you are covering. So, that will be equal to 1.1 times D_T. So, from here, you find out what will be the time required.

Number of rotations of the metering unit, you know. The radius of the wheel is given, and skid is given. So, you can calculate skid by using the formula, which I described just now,. So, $1.1 \times 2\pi \times R$, R is given as 0.38, that will be equal to 7000 by 60. So, here is the N, the N component will come. So, what is asked is, I think I have skipped this: $2 \times 2\pi \times R$, R is 0.38, × 1.1, which is because of the skid, × N, will be equal to 7000/60. Now, from here, we calculate the rotational speed of the wheel.

Now, the ratio of the metering disk speed, this is the ratio, this is the rpm of the ground wheel and the rpm of the planter, we have already calculated, knowing the number of seeds to be dropped, divided by 54, this is rpm. So, this is N_2, so N_1 by N_2, that is the ratio.

We will try one more problem. What seed spacing is required when planting corn in rows of 102 centimeters apart, if the desired plant population is 6000 plants per hectare and an average emergence of 85 per cent is expected? If the vertical plate planter is selected for metering, it has 16 cells in the seed plate with a diameter of 200 millimeters, what is the linear cell speed in meters per second, when planting at 4 kilometers per hour? The first thing is, there is some germination percentage given. So, the desired plant population is 6000. So, immediately divide by 0.85, which is the germination percentage, to find out what is the desired number of seeds to be dropped per hectare. So, this - this is the value. So, 7058.82. So, I can write it as 7059, which is the number of seeds to be dropped. Now, this planter is to be operated at 4 kilometers per hour, and the row-to-row spacing is 102 centimeters. So, the area covered in 1 minute - the area covered in 1 minute, if I denote it as A1, that is the area covered per minute. 102 centimeters - 1.02 ×4 kilometers per hour, 4000/60. So, that will be the area covered in 1 minute. Now, in 1 minute, how many seeds are to be dropped? That we have to find out. So, this way, you will get around 68 square meters per minute. Now, the number of seeds to be dropped, so, that will be equal to this, which is the number of seeds actually to be dropped. So, (7059/10000)×68. So, that will be the number of seeds to be dropped. So, these many numbers of seeds are to be dropped. 48 around in a length of, say, 4000/60, because in 1 minute, this is the distance covered. So, in this length, this many seeds are to be dropped. So, just divide by 48, that will give you the spacing between seeds.

Now, the first part is over; the second part is. if the vertical plate planter selected for metering has 16 cells in the seed plate with a diameter of 200 millimetres, what is the linear cell speed? So, to find out the linear cell speed, we need to know. So, what is given is the radius - the diameter is given. So, you can write π D N. So, then only you will find out by 60 if N is rpm. Now, these are the seeds, and these many seeds, 48 seeds, are to be dropped in this area, 68 square meters per minute. So, in 1 revolution, it has to drop - 16 cells, to drop 48 seeds, 3 revolutions. So, 3 revolutions per minute, that will be the value of N. So, D is given, N we calculated. So, N is nothing but $\pi \times$ D is 200/1000× (48/16) ×1/60. So, that will be the linear speed of the planter- cell speed.

So, I have given 3 problems, and I tried to solve these 3 problems, which will further clarify your doubts if you have any related to spacing determination. These are the references. And in brief, I can say I discussed the single seed metering unit and how to design that, and with the help of some problems, we try to find out how to design this, how to consider different parameters, so that we can maintain the desired spacing and we can find out the linear speed of the plate and forward speed of the ground wheel.

Thank you.