Design of Farm Machinery

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Lecture 33 : Seed tube and furrow closer

Hi everyone, this is Professor H. Raheman. I welcome you all to this SWAYAM NPTEL course on Design of Farm Machinery. Today is lecture 33, where I will try to cover seed tube and furrow closure. The concepts which will be covered : seed tubes, covering devices and some numerical problems. As the name says seed tubes that means, these tubes are to be provided at the outlet of metering units to carry the seeds which is metered from the end of the metering unit to the furrow opener.

So, that is seed tube as the name says tube. So, it is a tubular structure, it could be made up of steel or it could be made up of plastic. So, the target is to convey the seed from the metering unit that means, the lower end of the feed cup, then the seeds will travel from the top end of the feed cups to the lower end of the feed cups to the boot. As I said they are made up of different materials, but nowadays plastic is the most common material which is used -polypropylene. Earlier steel tubes are provided maybe some telescopic units are there I have given the figures of those units.

1, tabular 1, funnel shaped corrugated, spiral wire wound type then telescopic type. The advantage of telescopic type is it can be - the length can be increased or decreased to take care of the clearance. Now, the lower end of the seed tube will be connected to the boot. Boot is the part of the sewing equipment which receives the seeds from the seed tube and delivers it to the furrow. So, it is made up of mild steel or cast iron.

So, the seed tube is a connecting link between the lower end of the feed cup and the boot. The aim of providing the seed tube is the seed should be carried from the feed cup to the furrow. If seed tubes are not functioning properly, there may be choking. Seeds may not be available to the furrow to the furrow. So, what will happen now that will increase the inefficiency of the seed drill or seed showing of seeds. So, the target is that the seed which are falling in the seed tube should not strike, should not strike the walls of the tube otherwise that will affect the uniformity.

So, uniformity of distribution in the furrow. So, for that the diameter should be sufficient and usually we take 2.5 centimeter, 3 centimeter in that way and then there should not be any sharp bend, sharp bend of the tubes should be avoided. Most preferably the seed tubes should be vertical. So, we cannot, we cannot provide sharp bend, so that there will be blockage of seeds. So, preferable position is vertical or a deviation to the maximum of 20 to 25 degree from the vertical. So that, seeds can easily travel to the furrow. So, the two things are required here, there should not be any blockage, there should not be any striking of seeds to the pipe wall. These are the two things which have to be taken into consideration. Now, the next important item is furrow closure. We need a furrow closure in seed drill to cover the seeds which are put into the furrow.

So, and the at the same time the seeds - when the seeds are covered the soil should be little compacted. So, that moisture and temperature are available to the seeds. So, that the seeds can be germinated easily. So, the purpose of providing a furrow closer is to cover the furrows. So, that seeds can avail the temperature and moisture ah present in them. So, furrow closure is a device which is used to close the furrow with soil after the seed has been dropped into the furrow. ok. So, after seeds are dropped into the furrow the soil has to be put into the furrow back.

So, covering is usually drawn by many equipments available like rollers, chains, press wheels and there are various shapes and sizes. I will show you some of the commonly used covering devices. One such device is your steel press wheel. So, this will simply roll over the furrow. So, that will give you compaction as well as covering of soil. Then this is a zero pneumatic press wheel. This is a rubber coated.

So, the first one is a steel one, this is a rubber coated one and this is a drag bar type. So, the V link which is shown here. The V-link which is shown is there it will drag the soil after opening of the furrow the soil should be on the side. So, this will drag the soils and put it into the furrow and so that way it will close it and the weight of this V-link will give little bit compaction of soil. Then you can have double disk type.

So, that it will press the soil from the sides of the furrow. So, the furrow will be automatically closed and this has to be put along with the boot. Then chains. So, instead of bar you can put chains. So, the chain will also simply drag the soil and it will put the soil into the furrow and the weight of the chain will give you the desired compaction.

These are in mass when it is connected to the seed drill. So, they depending on the number of furrow openers we can have number of press wheels, number of V-links and number of rubber wheels or simply you can remove these and put a plank that is enough to drag the soil into the furrow. So, long bar can be long wooden bar that is sufficient, but it should have weight so that it can give little bit of compaction. So, these are some of the devices which are used for closing the furrow.

So, the seed drill components we discussed starting from metering unit, starting from the hopper, then metering unit, seed tubes and then furrow openers and furrow closers. This is a vertical cell planter which has 35 cells around a disk of 28 centimeter diameter and this is operated at a forward speed of 3.5 kilometer per hour. The planter is having seed tubes of diameter 2.5 centimeter and vertical length 70 centimeter. The seeds are released 20 centimeter above the ground by vertical rotor rotating at a peripheral speed of 25 meter per minute. If each seed is released at the rear end of the tube, then the questions which are asked : to find out the seed to seed distance along a row, then the time required to strike the ground after the seed is released from the rotor cell neglecting the air resistance. Then the distance by which the seed moves horizontally before striking the ground after the release from the seed tube. These are the three sets of questions which are asked related to the data given.

The first thing is to find out the seed-to-seed spacing. What is given? The forward speed is given as V = 3.5 kilometers per hour, and the rotor speed is given as 25 meters per minute. The rotor diameter is given as D = 28 centimeters. That means, in one revolution, the distance covered will be equal to the distance covered by the cell-type planter.

That means, the plate π into 0.28 is the distance covered multiplied by n, which will be equal to 25 meters per minute. Now, what is the rpm? From here, you can find out. 25 ÷ (π × 0.28). So, that way, you will find the rpm to be 28.42 - these many revolutions. Now, coming to the forward speed: the forward speed is 3.5 kilometers per hour.

So, in 1 minute, the distance covered - say, if you denote it as capital D, will be equal to 3.5 × 1000 ÷ 60, which will be the distance covered. In 1 minute, these many revolutions occur in the planter. So, the planter has 35 cells. So, that means, in these many revolutions, the number of seeds dropped assuming 100% filling, since no filling percentage is given, so, we assume that the filling percentage is 100%.

So, this will be equal to 28.42 × 35. In one revolution, it should give 35 seeds. So, in 28.42 revolutions, these many seeds have to be dropped, which is equal to 994.7. Now, these many seeds are to be dropped in this distance. In 1 minute, the planter is covering a distance this much. So, seed-to-seed spacing will be this distance: 3.5 × 1000/(60 ×

994.7). That way, you are getting a spacing of 5.9 centimeters. This will be the spacing. That is, the first part is over now. Now, let us look at the second part. This is a bit interesting in the sense that it relates to the basic fundamentals we have learned.

The time required to strike the ground after the seed is released from the rotor cell, neglecting air resistance. So, when the seed is released from the rotor unit, that means the metering unit, which is a vertical cell planter. Let that velocity be 0. Initial velocity is 0. Initial velocity we say, u. Final velocity after 70 centimeters is V. So now, u is equal to 0, and $V = u + at$. Now, u is equal to 0, and to find out the velocity at the end of 70 centimeters - that pipe length, then you need to know the value of t. a is the acceleration due to gravity. So, to find out t, we know that the distance covered is equal to $ut + \frac{1}{2}at^2$ square.

This is the distance covered, which is given as 70 centimeters. I can take it as 0.7 meters. Then, u initially is 0. So, this component becomes 0. Now, $\frac{1}{2}at^2$ becomes your 0.7. Acceleration due to gravity is known. Now, from here, t will be equal to 0.377 seconds. You can find out t. Now, if you substitute in this equation this value, then I find out the velocity at the end of the pipe. The velocity at the end of the pipe will be 3.698 meters per second. Now, at the end of the seed tube, a boot is there. So, the seeds are released 20 centimeters above the ground.

So, that means the seed has to travel another 20 centimeters along the boot. So, there the initial velocity is V in the boot, and the final velocity is something else. So, you are not interested in the final velocity; you are interested in the time, the time which is required to strike the ground. So, now if I put again S_1, S_1 will be equal to $Vt + \frac{1}{2}at^2$. So, V is now this 3.698 meters per second.

So, S_1 is 0.2 meters. So, now if I substitute this, this will be a quadratic equation. So, which will be coming in the form $4.905\,t^2 + 3.698\,t - 0.02$ will be equal to 0. From here, we will find out what the value of t. So, t comes to be around 0.05 seconds.

So, you have got a value of t here 0.37 seconds, 0.377 seconds, which is corresponding to the pipe length of 70 centimeters. Now, we got a value of t, 0.05 seconds, corresponding to the 20-centimeter length. Now, if you add these two, then the total time, if you denote it as t, t will be 0.377 plus 0.05. So, 0.427 seconds will be the time required by the seed to reach the ground. So, this is the second part. Now, the third part is the distance by which the seed moves horizontally before striking the ground after the release from the seed tube. That means this much time is required, and the forward speed is given as 3.5 kilometers per hour. So, the distance traveled will be $(3.5 \times 1000/3600) \times 0.427$, this is in seconds. So, that is why I have converted into seconds. So, this will be the distance covered, which comes to 41.5 centimeters. This is all about how to calculate this problem. So, just now we discussed that there is a seed tube, and seeds are released from the lower end of the feed cup, and then they go to the boot.

Now, what is given here is 70 centimeters as the length of the seed tube. So, let me draw the seed tube. Suppose this is your seed tube, and at the end, there is a boot and the furrow opener. Now, this length is given as 70 centimeters. The seed, the point at which it is released, let the velocity V be equal to 0. Initial velocity, let u be equal to 0. Now, it will gain velocity after traveling this much distance.

So, V is the velocity at this point. So, $V = u + a\,t$. Now, the time required has to be found out to find out the value of V. For finding out the time requirement what is the distance travelled if you follow the second law of motion $S = at + \frac{1}{2}at^2$, distance travelled will be equal to acceleration × time + $\frac{1}{2}at^2$. So, now t is the time to reach from this point to this point. Now, S is given as 70 centimeter and acceleration we know as 9.81 m/square second.

So, if you substitute here then we will find out the value of t. So, time required to reach the seed from this point to this point. So, now if I substitute this t here then I will find out the velocity at this point velocity of seed at this point. ok. So, that way it gives you : the time requirement would come around 0.377 second and velocity will come around 3.7 meter per second. The next thing is again there is a boot of height say 20 centimeter. Now, here the velocity at the beginning of the boot will be V will be equal to 3.7 meter per second and when it travels 20 centimeter what is the time it requires that we have to find it out. So, again I apply this equation S is equal to at + $\frac{1}{2}at^2$. Now, S is 20 centimeter. Now I have to find acceleration is 9.81 meter per second square. t has to be found out this t, I can write as t_1. So, that will give you more clarity.

So, now, I have to find out t_1 from this expression. So, 20 centimeter I can write as 0.2 meter. So, 0.2 will be equal to $at_1 + \frac{1}{2}at_1^2$. So, that way I will find out t_1 - will be equal to - t_1 will be equal to 0.473 second. Now what is asked is the time required to strike the ground after the seed is released from the rotor cell neglecting the air resistance.

So, since there is no air coming directly in contact with the seed, because the seed tube is there. So, the total time requirement will be $t + t_1$. So that way, it gives you 4 point sorry, 0.424 second. This is the time by which the seed will travel from the lower end of the feed cup where the seeds are released from the metering unit and to the furrow. The distance by which the seed moves horizontally before striking the ground after the release from the seed tube.

The problem here is : when the seed is released it takes some time to reach to the bottom by the time the seed is moved, the entire seed drill is moving forward. ok. So, that means, what is the forward speed? Forward speed is given as 3.5 kilometer per hour. And the time required by the seed to reach to the ground is just now calculated 0.424 seconds, time is 0.424 seconds. Now, in this much second or this much time, what is the forward distance the seed drill has moved, that has to be calculated.

So, just simply multiply. So, that is nothing but $3.5 \times 10{,}000$, sorry, $(1{,}000/3{,}600)\times 0.424$. This will be the distance by which the seed will travel horizontally before striking the ground. So, that way it comes to 0.4122 meters, 0.4122 meters. This much is the distance.

So, this is not going to affect the seed-to-seed spacing because every seed has to follow the same thing. So, this is not going to affect the seed spacing. So, only this gives you the distance the seed has traveled before touching the ground. I hope it is clear. The next problem is related to a tractor-operated 9-row seed drill with a row-to-row spacing of 20 centimeters. This needs to be calibrated for a seed rate of 65 kg per hectare.

The fluted roller metering unit has flutes. 8 flutes with an exposure length of 1 centimeter. The radius of the ground wheel is 35 centimeters, and the bulk density of the seed is 550 kg per cubic meter. The amount of seed obtained after 25 revolutions of the ground wheel is 0.8 kg. So, what is asked is: discuss the ways to get the desired seed rate. That means whether you are getting the desired seed rate or not during calibration, that you have to find out. And then we will see how to satisfy the requirement of the seed rate, which is 65 kg per hectare.

So, what is given is the diameter of the ground wheel, sorry, the radius of the ground wheel is given as 35 centimeters, and the number of revolutions made is 25. So, immediately you can calculate the distance covered. The distance covered in 25 revolutions will be equal to $2 \times \pi \times r$, where r is given as 35 centimeters. So, this I can write as $2 \times \pi \times r \times 25$ that will be the distance covered. And what is the width covered? The width covered is equal to the width of the seed drill. The width covered will be equal to 9×20, which gives you 180 centimeters.

So, the area covered - the area covered in 25 revolutions is equal to this multiplied by this one. If you multiply these, that will give you the area covered in 25 revolutions. So, in this area, what should be the quantity of seed to be dropped to satisfy the seed rate? The seed rate is given as 65 kg per hectare. So, if I now convert it into per meter square, then 65 by 10000. Now, I should convert this one also to meters.

So, 180 by 100. So, I can write 1.8 and 35 is 0.35. So, that way, I will get the area in meter square and then multiply it by this seed rate. So, if I denote this as A, that will give you the desired seed rate that comes to: you can calculate from here. So, $(65/10000) \times 2\times \pi \times 0.35\times 25 \times 1.8$. So, that will be the quantity of seed in kg.

0.64 kg, this is our requirement. Now, what is given is: you are getting a weight of 0.8 kg, which means you are getting excess. So, how to bring it back? So, to bring it back, we can just take the volume. If you know the volume of seed, then in one revolution, in one revolution of the ground wheel, the volume of seed dropped to satisfy the desired rate will be 0.64 divided by 25 divided by the bulk density. Because this is the quantity you are getting in 25 revolutions.

So, in one revolution, I just divided by 25 and then by the bulk density, which will give the volume. So, this volume should be equal to: if there are n number of cells, the number of cells is given as 8. So, if the area of each flute is A_f, then $A_f \times L_f \times$ number of flutes will give you the volume of the flute. So, volume of flutes. Now, in addition to the volume of flutes, there will be a thickness or a layer of seed that will be displaced.

So, if you go back to my previous classes where I have given the expression, the volume of seed which is displaced or given by one revolution will be equal to π this + π D, where D is the outer diameter of the flute, multiplied by the thickness of the layer into L_f. Now, if I take L_f common, so that way $A_f \times L_f$. Sorry, $A_f \times L_f \times N_f + \pi D S L_f$, this is the expression for volume. Now, this volume should be equal to what I get here. Now, the same volume, volume of flute. So, what I am getting now is 0.8 kg.

So, the volume which I am getting now is Vs is equal to 0.8/25 into I think number of rows I have not multiplied there are 9 rows. So, this has to be multiplied with the number of rows also number of rows 9. So, this into 9 or you can divide whatever I am getting it and I just divide by 9. So that, I can get in one revolution what will be the volume of seed required, directly I can do that. So, that is better rather than multiplying here, I can do this. So, that will be the volume in one flute. Now, Vs will be equal to the desired one will be equal to 0.8/25 this will give you per revolution in 9 rows. So, I have divided by 9 then bulk density, this is the volume which we received by 1 flute. So, this volume and and this would be equal to for exposure length of say $(A_f \times N_f + \pi D S)\times$ our exposure length which is taken as 1 centimeter already given. Now, you want to bring this back to this condition that means, 0.8 has to be reduced to 0.64. So, that means, these are not changing, these are remaining same only the variable is L_f or L_{f1} that means, length of the flute has to be changed.

So, what we have to do is you have to reduce the length of the flute. How much you reduce? So, if I take the ratio of this expression then what I get is L_f by L_{f1} will be equal to 0.64 by 0.8. I can take volume, I have not taken volume directly I have taken the mass. So, that will also do the same thing. So, now L_{f1} is 1 in our case.

So, now L_f , L_{f1} is 1. So, now L_f will be equal to 0.64 by 0.8 into 1. So, that means, that is the ratio which you have to find out. So, that way you are getting L_f / L_{f1} is how much we are is 0.8. So, that means, the length of exposure has to be reduced from 1 centimeter to 0.8 centimeter. So, that you can get the desired feed rate, feed rate sorry seed rate that is 65 kg per hectare. So, now, I like to discuss here is : what are the possibilities by which we can ah increase or decrease the flow rate. So, if you look at this equation $(A_f \times N_f + \pi D S)\times L_f$. So, here we can increase area of the flute or we can increase number of flutes, we can increase the diameter of the flute, we can increase this thickness of layer which is active with the rotation of the flute or you can increase the length of the flute. So, there are 5 variables by which you can vary the flow rate or the seed rate, but the easiest one is this length of flute. Why because when you want to change the area of flute, area of flute means the shape of the flute has to be changed. cross-sectional area has to be changed which is not an easy task that means, you have to replace the metering unit. So, this is not desirable. The number of fluids also if you want to change same thing. So, you cannot do this you have to change the metering unit and here diameter also these are all related to changing the metering unit, but the length of the flute, you do not have to change it there is a provision in the seed drill where you can increase or decrease the exposure length. So, we follow this one.

The other method which you can do this, this we have calculated for per revolution. So, the revolution part is not coming into picture, the RPM is not coming into picture. So, when you take for number of revolutions what you can do is that is also going to increase or decrease the seed rate. So, when number of revolutions are more then seed rate will be increased, but we do not prefer higher number of revolutions that may damage the seed. So, the best way is to control the exposure length and if it is not possible then go for changing the rpm. For changing the rpm you have to change the transmission that means, the belt pulley or the gears whatever is there you have to change those. So, that is why we prefer to change the length of the flute rather than the other variables which are also used to change the feed rate.

One more problem design a horizontal plate planter for a seed to seed spacing of 6.5 centimeter using a ground wheel of diameter 65 centimeter with 80 per cent fill and gear ratio between rotor and ground wheel is given as 3 is to 5 and the rotor has a peripheral speed of 30 meter per minute with a plate diameter 30 centimeter and then decide the forward speed of travel and number of cells to get the desired spacing. So, what is given is: peripheral speed of the plate is given, it is 30 meter per minute and the plate diameter is given as 30 centimeter.

So, from here we can find out what is the revolution per minute. So, $30/(\pi \times 0.3)$. So, that will give you the number of revolutions per minute. Now, the gear ratio is given as 3 is to 5 that means, between rotor and the ground wheel. So, for 3 revolutions of the plate there will be 5 revolutions of the ground wheel. Now, per minute we are getting some revolutions here. So, corresponding to this what will be the number of revolutions in the ground wheel. So, we have to find out what will be the revolution of the ground wheel per minute. Now, diameter of the ground wheel is given rpm is computed. So, $\pi \times$ d $\times$ rpm, that will give you the forward speed of travel.

Now, in these many revolutions, 5 revolutions of the ground wheel the distance covered is $\pi \times$ d $\times$ 5, d is 65. So, you can find out how much is the distance covered. In this distance there will be 3 revolutions. So, 3 revolutions means if percentage of fill is given as 80 per cent and we have to find out the number of cells for a spacing of 6.5 centimeter. So, this by 6.5 centimeter. if I divide the distance which is covered in 5 revolution by 6.5 that will give you the number of seeds to be dropped.

But since it is 80 per cent filled that means, number of seed drops will be less than this. So, that means, I have to divide by 0.8 to get the actual number of seeds to be dropped to get the spacing of 6.5. Now, these many seeds are to be dropped in 3 revolutions. So, in one revolution so, number of seeds dropped by, (number of seeds dropped/0.8) × 1/3. So, that will be the number of cells required that means, number of seeds to be dropped in one revolution with 80 per cent filling and then that will be the number of cells which are required.

So, what is asked is find out the forward speed of travel and the number of cells to get the desired spacing. Hope I'm clear. That is all.

So, some of the references Bernacki and Kepner - Principles of farm machinery and in conclusion I can say we discussed about seed tubes, what are the different seed tubes used in the metering then we discussed about furrow closures, what are the different types of furrow closures and then we solve some problems that will give you more clarity while calculating or while designing a seed drill. That is all.

Thank you.