Design of Farm Machinery

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Lecture 34 : Seed flow sensing in a seed drill

Hi everyone, this is Professor H. Raheman. I welcome you all to this NPTEL course on Design of Farm Machinery. This is Lecture 34. I will cover seed flow sensing in a seed drill. The concepts which will be covered are detection of seed flow, then detection of choking.

What are the problems associated with seed metering? So, the problems are: the performance of a seed drill depends on whether the seeds are dropped into the furrow or not, as the seed drill is just pulled by a tractor and the furrows are covered with soil. After the seeds are dropped into the furrow, it is covered with soil by the furrow closure. Then, the operator does not have any chance to see whether the seeds are dropped into the furrow or not. So, only he will know once the seeds start germinating. So, by that time, it is difficult to maintain the seed rate. So, this is one of the problems.

The other problem most of us encounter during the operation of a seed drill is choking - choking of the seed delivery tube due to sticking of damp soil and accumulation of agricultural residues. If the soil bed is not prepared properly, some residues are there, then that will try to choke the seed delivery tube, that is, the boot, resulting in accumulation of seeds in the delivery tube. Seeds are dropped, but they are not reaching the furrow. Hence, to increase the mechanization level in sowing, these problems are required to be overcome.

So, while operating a seed drill, missing of seeds in the furrow occurs due to many reasons. What are those reasons? There could be no flow of seeds from this seed metering mechanism, or the boot of the seed drill is choked. These are the possibilities. These problems could be due to several factors such as machine factors, seed factors, field factors, and operator factors. So, let us see now what are these problems and what are the factors? So, machine factors related to improvement in design of a metering mechanism may be faulty design in the metering mechanism, may be due to boots, faulty design in

boots of furrow opener and ground wheel, shifting of the stopper wheel, which is provided to control the exposure length of the rotor due to vibration.

Then, seed factors include higher moisture content, shape and size - that means, variety of seed and surface friction of seed, which may be the reason for no free flow. Then, field factors include bigger clod size, higher soil moisture content, presence of agricultural residues, and undulation of the field. Then, operating factors or operator factors include forgetting to lower the seed drill after taking a turn during sowing and to refill the hopper with seeds when it is empty. So, these are the reasons or the factors for missing seeds. Now, despite all these reasons or factors, the desired population of seeds for getting more yield is possible if the operator gets information on whether the seeds are dropped into the furrow or not.

So, with the increased use of electronics in agriculture, attempts are required to be made to sense the seed flow from the seed metering mechanism to the furrow opener, to the furrow opened by the furrow opener, and to know the choking of the boot of the seed drill. So, only sensing will not help because the sensor senses, but that has to be fed to the operator. So, the operator should know that yes, the seeds are missing. So, we have to have some device to create some sound or blink the LEDs, so that the operator's attention will be there, and he will know that yes, something is going wrong on the back side. So, he will try to rectify those defects.

So, with this background, I have taken up this class how to design and develop a system by which the flow of seeds can be sensed or choking of boot can be sensed successfully. and at the same time only sensing as I said, that is not enough. So, the operator has to be given instruction or warned - warning. So that he should know what is happening and he will try to rectify those defects . So, with this background, a seed flow sensing system was developed at IIT Kharagpur, I am going to discuss about that. The seed flow sensing system, it is made up of two IR emitters and one thin small outline package, TSOP receiver, were used to cover the seed flow in a seed tube. The seed tube diameter as recommended by ASABE standard, that should not be more than 25.4 millimeter that means, equal to 1 inch and there are less number of electronic components with higher ruggedness of sensor. Therefore, we tried to attempt to use a special type of receiver called TSOP based IR receiver, it basically receives the IR signals for detecting the flow of seed. And it can be easily fit into the delivery tube of the seed drill that is the main thing. So, the concept of the developed system is : there should be an embedded system which is developed for a 9 row sheet drill. The developed system comprises of two sets

of sensor: one for detection of seed flow, the other one is for detection of choking of boot of a seed drill.

Then question arises here is : why the same sensor cannot be used for detecting the seed flow and choking? The sensors used are different and the mechanism are different. So, that is why we put two sensors. The mechanism is just opposite to each other. So, first I will discuss is sensors for detecting the seed flow, which will sense the flow of seeds when the receiver receives the rays reflected from the seeds. Whereas, choking is detected when the receiver does not receive rays emitted by the emitter, the mechanism is different I said, due to accumulation of seeds in the tube.

In one case that is the seed flow, we want to measure the reflected rays, we want to sense the reflected rays whereas, in case of choking if the receiver does not get rays that means, there is a blockage. So, the mechanisms are different. So, that is why you use two different sensors. In the embedded system two IR emitters with an indirect incidence infrared TSOP receiver were used for detecting seed flow inside the seed delivery tube and a direct incidence infrared sensor for sensing choking the boot of a seed drill. The output of these sensors were fed to an Arduino UNO microcontroller board, Based on these output signals of sensor, and an embedded programming code , the microcontroller provided the output signals which would result in activating a visual LED and audible buzzer. So, that this will give an indication to the operator that something is wrong or everything is running perfectly.

The block diagram for the developed sensing - the embedded system is : there is a seed metering mechanism, seed metering mechanism then it goes to the seed delivery tube and the seed delivery tube we have provided the sensing unit and and in the boot at the end of the seed delivery tube there is a boot and the boot also we provided a sensing system and these are to be powered. So, we provided power through: from a battery through a microcontroller because the voltage requirement is 5 volt. So, that is why we supplied through a microcontroller. Then the signals - output signals from the TSOP sensors as well as the IR sensor they go through the microcontroller to indicate the LED and the buzzer to activate the LED and buzzer. So, this is the concept. Now, looking at the sensing system for seed flow, if you look at this, there is a pipe in the conical pipe you can say, on the top there are two IR sensors. So, which will emit light and then when there is a seed flow. So, the light will be falling on those seeds and it will be reflected back. So, this is the receiver, TSOP receiver which will receive the signal that is the concept. So, this has been mounted in a specially shaped conical shaped pipe and the top

of which there is a seed tube and through which the seed will enter into the system. So, that the light if you look at this diagram, you can see the two IR LEDs they are sending lights at an angle of 30 degree. So, that means a diameter of 2.54 centimeters is sufficiently covered by these 2 IR LEDs. So, light - whatever seeds are passing through the seed tube, this circle will be sensed by the TSOP receiver because the light will strike those seeds, and the light will be reflected back, and the TSOP receiver will receive that. So, that is the concept on which the embedded system has been developed. So, we have painted the rest of the pipe black so that there is no reflection. The reflection falling on the wall otherwise, there may be a possibility that after the light strikes the wall of the pipe, it may reflect back. So, that can be sensed. To prevent that, we applied black color. So, that will further increase the detection capacity of the sensor and accuracy in detection. Now, this is the system where the IR LED - with a sensitivity angle of plus or minus 15 degrees and a peak wavelength of 940 nanometers - and the TSOP IR receiver, which has a 38-kilohertz carrier frequency, were placed side by side, even close enough. And the radiations emitted from the IR LED spread to a horizontal plane in a 30-degree cone, and the TSOP receiver could not receive any direct radiation from the IR LEDs within the specified range of 75 millimeters reflection range because the total diameter is 75 millimeters. When an opaque object like seed passes through the IR emitted radiation zone, which is this circle, the incident rays striking the seeds are reflected back, and these reflected rays are received by the TSOP receiver. The positions of the 2 IR LEDs and the TSOP IR sensor installed inside the cone-shaped pipe are shown above, and the output signal from the TSOP IR sensor was fed to the Arduino UNO microcontroller board as well as to the red LED. Based on the output signals and embedded programming code, the microcontroller generated the output signal, which would result or not in producing both visual and audible alerts simultaneously. This is the circuit diagram of the sensing system for detecting seed flow. The sensor was powered by 5-volt DC taken from the Arduino UNO board using a regulator chip to step down the supply voltage from 12 volts to 5 volts DC. Then, the resistances R1, R2, and capacitor C1 are the timing resistances for the 555 IC to generate these 38-kilohertz square wave signals. Then the TSOP 1738 receiver decoded the signals and gave the pulse to input port of the microcontroller board and also to the red LED in IR sensor circuit.

Now, development of direct incidence IR sensor for detecting of choking. Now, we have finished the sensing part of free flow of seed and now we will come back to the IR sensor direct incidence IR sensor for detection of choking. So, the conical shape of pipe which is shown here this will be fitted to the boot end of the pipe. So, this - the lower portion is

threaded. So, then it can easily threaded to the boot and the two IR sensors are put on this side one on this side the other one on the other side. One is IR IR LED the other one is IR receiver - infrared receiver. Now, if you look at this diagram then you can see that the rays which are emitted, if there is a blockage what will happen this rays will not reach to this receiver. So, what will happen when the receiver will not receive the signal then it will give that there is a blockage. So, this is the concept. So, when there is a blockage the IR receiver could not - IR receiver will not receive the signal and this will be again affecting to the microcontroller board as well as to the red LED IR sensor circuit board. So, that will give an indication to the operator and this is the circuit diagram for the developed sensing system for sensing choking in a boot. The R 2 resistance and the IR emitter are the source of IR light and it is received by the IR receiver. When the infrared ray falling and the IR receiver is interrupted because of the accumulation of seed between the IR emitters and IR receiver the LM358 IC comparator that will compare the signal before and after the accumulation of seeds between the emitter and receiver with the specified voltage level depending on the setting of the potentiometer. The comparator gave the output signal after comparing these signals which was then fed to the microcontroller board and the red LED. The developed IER sensor circuit board is shown. It has two major persons that is lower person for sensing.

This is for sensing; the upper portion is for producing an intermittent buzzer sound. So, that will alert the operator that something is wrong or needs to be checked. The sensor for detecting choking was mounted at the left corner - this one is for choking, and this one is for flow sensing. The two buzzers consist of - the display unit consists of two components: one is an LED, and the other is an intermittent buzzer. The indication for seed flow includes a green LED and an intermittent buzzer, mounted at the right corner of the upper portion. The indication for boot choking includes a green LED and a continuous buzzer, mounted at the left corner. One is an intermittent buzzer; the other is a continuous buzzer.

Now, the flowchart for the program used in developing the embedded system for controlling input and output signals is provided. First, you must define the input-output pins and local variables. Then, initialize the input-output pins, setup, and serial port communications. Next, define the local variables. The TSOP will be used for sensing. So, if it senses something, then the intermittent buzzer will turn on. If it does not sense anything, the buzzer will turn off. The IR object detection sensor, if triggered, will activate the continuous buzzer; if not, the continuous buzzer will remain off.

So, that is the concept or flowchart of the program used. The first and second division boxes in the program flowchart represent seed flow sensing and boot choking detection, based on inputs from the TSOP IR sensor and IR sensor, respectively. So, this is the final setup. To monitor seed flow, these circuit boards were designed for the 9-row seed drill, and these display units were mounted in front of the operator. During calibration, we tested this setup. That is why the entire seed drill was jacked up, and we will rotate it to check whether the seeds are flowing. Now, the metering shaft is not rotating that means, there is no seed flow. Now he started rotating. So, that means, the ground wheel is rotated the seeds are flowing. So, all the LEDs are on, that means, seeds are flowing there is no no-flow of seeds. All the seed tube, seeds are flowing. Now, one channel is blocked that means, that is channel number 7. So that he wanted to show. He has manually done it to show that whether the sensor is working or not. So, that is what he is doing. There is no flow of seeds. So, that means, the seed - the sensing system is sensing the seed flow. Now, again when you start that - remove that one. Now he is forcibly blocking this one, he is not allowing the seed to flow. So, this is channel number 8.

So, we will again verify. It is a foreign material this has happened. So, 8 - channel number 8, this is off. The rest of the channels are working. So, this is how we have to do. Then for choking - the one which you saw is for seed flow sensing, the other one is for choking. Choking will be at the bottom, which is at the boot. Now, seeds are flowing. At the bottom, you can see this is the portion fitted to each of the boots. He is choking the boot now. He has put intentional choking; the plate has been placed. So, there is no flow of seeds. So, that is in row number 1, and in row number 1 - you can see - row number 1, there is a light on. So, when the light is on, it means there is choking; when the light is off, it means there is no choking. So, this is - now he has opened that one. So, now the light is off. So, this is what that means he is doing the same exercise for the third furrow again. The third row seed is flowing, but it is blocked. So, it is not going out from the boot. So, the third one is lighted. So, that means the sensors are working perfectly. So, this is what we verified in the laboratory. Then, we have to evaluate the performance of the embedded system when fitted to a tractor-drawn seed drill.

And so, for doing that you have to install - to this 9-row seed drill is fitted with those sensors and they have been tested in the plot size with 3 replications - plot size of 50 by 25 meter. Then during operation in the field, all 9 red LEDs in the display board and the buzzer were verified for glowing and producing any sound or not to ensure that seeds are dropping continuously to the furrows opened by the 9 furrow openers without any

discontinuity. The output signals obtained from the embedded system during the flow of seeds at different seed rates that means, different seed rate kg per hectare and forward speeds of tractor are also recorded in the form of binary value either 0, intermediate buzzer off and red LED on or 1, 0 or 1 that we measure. The samples of seed detection data recorded were at an average frequency of 600 data per minute. So, 60,000 milliseconds and then from the serial monitor Arduino IDE from these recorded data, data on seed detection were randomly selected for a duration of 60,000 milliseconds for seed rates of 80, 100 and 120 kg per hectare with 3 forward speeds of the tractor 3, 4 and 5 kilometer per hour.

This is how it is fitted to the different furrow openers and this is the developed sensor circuit board. Then during turning also that is important because during turning if the operator forgets to lift the seed drill then what will happen you know the seeds will be falling in the corner. So, that is again a loss. To do that the sensors once you lift it there will be no flow the sensor will indicate to the operator that yes seed drill is not working during turning. Then from the data which we took from the binary the number 0 and 1, we tried to plot it for different flow rates, seed rates and for different forward speeds. What we observed is very interesting. Interesting in the sense for any seed rate when we increase the forward speed your number of observations are increasing is obviously, more this forward speed more will be the number of seeds dropped. Hence, more will be the signal. So, that is what we are getting. The same is the case for 100 kg per hectare and 120 kg per hectare.

Only thing instead of getting say 216 because there are 8 flutes, hence theoretically the number of seed flow detection per minute should have been 216, 280 and 352 times, but what we observed at fluted roller of this, this and this (27, 35 and 44 rpm), respectively. That means, 27, 35 and 44 rpms these are - these will be the numbers we should get, but what we have got is little higher. This is because the detector - there will be more than one seed dropped. So, that is why there will be more number of detections. The only thing is - it detects that's it.

Because, we are not interested for number of seeds because these sensors are not developed for single seed dropping, these are for continuous seed droppings like wheat or paddy. So, this factor which we have indicated here may not be a distracting factor, we want that, there should be continuity of flow and that is what we are getting. And the other thing which I discussed is number of seed flow detections should increase with increase in seed rate with increase in forward speed and that is what we are obtaining

from the output. Then the other factor which is has to be checked is during the operation at the turning time there should not be any seed flow. I will give you the video where you can see that during turning how nicely it gives indication to the operator that yes the implement has been raised from the field.

Now, the seeds are flowing. So, now, he has lifted it up so that there is no flow and the operator will be indicated by a sound. I am not giving the sound otherwise you will know this. And when there is no seed in the hopper it should also give sound. So, that is also another indication which we received.

Now, during operation, we tried to verify the workability of the developed embedded system and I will show you again some video. All the lights are on, they are missing and that means, everything is working finally, that is there is seed flow and if you look at the blockage side you can see there is some - there is one light on that means, that number is blocked that row is blocked. This side if you look at the arrow this side is number 8. So, light is on that means, that row is blocked. Blocked at the boot, choking is there then number 3. So, there will be sound which is not hard here. So, if you go to the row number 8 and row number 3 you can see this is blocked. You can verify that when the seeds are accumulated here it is not going to the furrow and that is blocked because of the crop residue the total pipe is jammed. So, this is how the system which we developed was verified both in the laboratory as well as in the field. So, what we conclude from this is : the developed embedded system could successfully sense the flow of seeds for seed rate starting from 80 to 120 kg per hectare at different forward speed starting from 3 to 5 kilometer per hour.

for a 9-row seed drill the binary output which you received in form of 0 and 1 along with the visual indication that is red LED on or off and audible indication intermittent buzzer off or on whenever there was flow of seed or no flow of seed they are working perfectly. Now, the developed system could sense choking of boot of the seed drill indicating output in binary form 0 or 1 with visual indications and a red LED on and audible indication with continuous buzzer on and or a red LED off and audible indication continuous buzzer off whenever there are choking or free flow of seeds from the seed metal mechanism, those are also working perfectly. This type of detection with indication could allot the operator. So that he will know yes the seed drill is working alright or not whether the metering mechanism is working or not.

The time delay between - the only difficulty which we felt is the sensors which you put to the boot. They were put at a little higher height, so that it takes some time by the time it comes to the sensor level. So, it gives signals - some accumulation is still there. So, immediately, a response was not there otherwise it was working nicely.

This can be overcome if you can lower the sensors, if the sensors will be put closer to the boot outlet then immediately when the boot started choking - immediately it will indicate the red LED and the sound should be on. So, that the operator will know, yes these systems are not working or it is working perfectly. So, if you look at this system, the time delay between the choking actually started and sensed by the developed embedded system varied on an average from 1503 to 3750 milliseconds due to the position at which sensing unit was installed. So, this problem can be easily overcome otherwise the developed system work very nicely. In brief I can say sensors used, sensors are developed and they are working effectively and their effectiveness was verified both in the laboratory as well as the field and the drawbacks like the delay in sensing in case of choking of boot, it was minor and it could be rectified by just lowering the sensor, position of sensors and those can be utilized. So that the workability of seed drill will be further enhanced.

Thank you.