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THE PROBLEMATIC OF PRECISION SOWING

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Abstract
The paper deals with the principle of precise seed dosing using a high - frequency pneumatic nozzle. Design of equipment for testing and measurement in order to achieve the highest possible accuracy of seed frequency. Transport the seeds to the places of their germination in the soil. The seed hopper, the conveyor to the high-frequency sorting mechanism, the sorting nozzle and the output from the seed conveyor to the row were tested. The measurement results are given in this publication. The tests were performed on the seeds of black lentils and red lentils.

Key words: *precision sowing, two-segment sowing device, high-frequency pneumatic nozzle.*

INTRODUCTION

The seed for sowing contains not only the seed, but also protective pickling and growth-promoting substances. In order to reduce the cost of buying seeds for sowing and increase yields with regard to soil quality, controlled sowing is necessary (*Ram, Lohan, Singh, 2014*). The sowing frequency depends on the seed type and ranges from 30 to 400Hz. This frequency also depends on the travel speed of the seed drill or the towing device. The device can be imagined as a two-segment device. The segments are relatively independent. The first segment sets the number of seeds to the length, or otherwise the frequency with which the seeds are to be placed in a row. The second segment ensures the seed output speed, such that the relative travel speed of the seed drill and the seed output speed are equal. The impact velocity of the seed relative to the soil should be equal to 0 so that the name does not jump in the row (*Parrish, 2014*). The aim of the study was design of high frequency precision seeding mechanism.

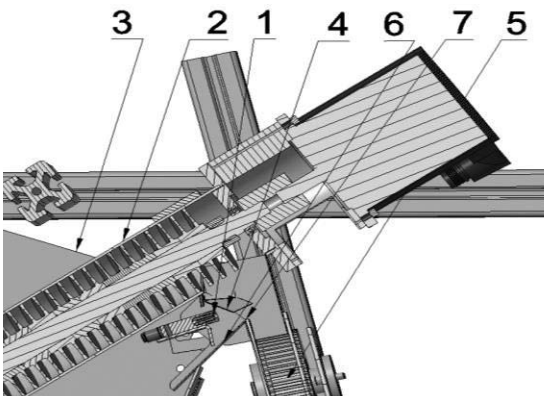
Tab. 1 Sowing frequency depending on the travel velocity of the seeder

Type of seed	Sowing speed 10 km/h	Sowing speed 15 km/h	Sowing speed 20 km/h
Sugar beet	11-17 Hz	17-26 Hz	22-35 Hz
Soybeans	75-100 Hz	112-150 Hz	150-200 Hz
Peas dry	78-106 Hz	116-160 Hz	155-213 Hz
Rye	173-312 Hz	260-468 Hz	347-625 Hz

The highest values of the required sowing frequency are for flax, even over 2600 Hz and a seeder speed of 20 km/h. The principle of the proposed device is based on a high-frequency pneumatic nozzle reaching a frequency of up to 600 Hz. The valve must be lubricated with oil contained in the compressed air.

MATERIALS AND METHODS

The seed is added to the 5-liter hopper 3, Fig. 1. The inlet opening of the screw conveyor 2 is immersed below the seed level in order not to distort the tests by reducing the amount of seed transported. The inclination of the two-pass screw conveyor was adjusted to suit the required transported quantity as much as possible. The transported seed at the end of the conveyor descends along a sheet metal chute to its edge, which is hit by a pulse of air flow from the nozzle 1. Several types of chutes 4 have been designed, manufactured and tested with regard to sowing different crops. It is important that the seed has the lowest possible forward speed at the end of the slide, ie low kinetic energy. This changes the direction of the seed by rotating over the breaking edge of the chute. At the end of the rotation, some of the seeds should be struck by an air pulse. The other seeds (about 70%) fall back into the hopper after the slide 6.



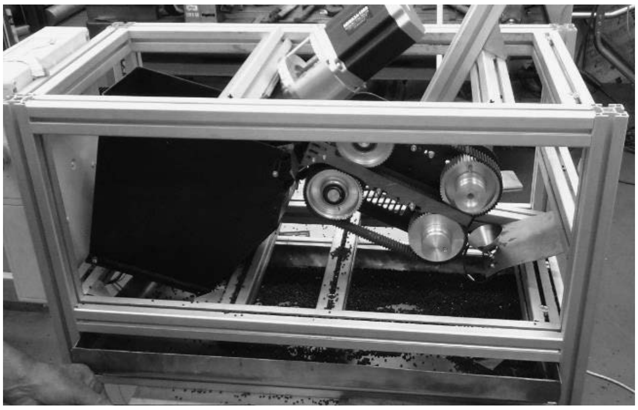


Fig. 1 Principle of model operation

Fig. 2 Stationary device for parameter verification

The position, distance and inclination of the nozzle from the chute edge have been optimized. The optimal diameter of the nozzle orifice and the shape of its edge were also sought. The nozzle was redesigned several times during the tests. It was necessary that the air flow was not constant even for higher nozzle frequencies. If the seed is hit, it flies over the edge 7 to the seed transport system 5. If it is not hit by the air stream, it slides back into the seed hopper after the slide 6. Tests with lentil, rape, radish and pea seeds were performed on the device of Fig. 2.

The control system of the unifying device must allow the setting of the following parameters:

1. Nozzle valve frequency from 0 - 600Hz.
2. Air pressure in the nozzle 0.01 - 0.8 MPa.
3. Screw feeder speed 0.2-10 rpm.
4. Nozzle opening percentage in the cycle - air pulse length. It is a parameter that sets the percentage of nozzle valve opening during one cycle.
5. Single seed conveyor speed in the line 2-50 rpm.
6. Counts the pulses sent to the air nozzle valve
7. Lists the number of seeds passed through the sensor.

Fig. 3 is a copy of the control system settings screen. It was taken with the following parameters:
Nozzle valve frequency 70 Hz, air pressure in the nozzle 0.6 MPa, screw feeder speed 6 rpm, nozzle opening percentage 50% in one cycle.

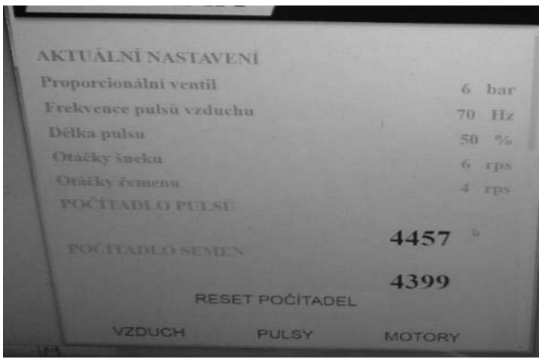


Fig. 3 Screenshot of the control system

Fig. 4 Used seed count sensor

The data in Fig. 3 are at a frequency of 70 seeds per second. Sensor of number of seeds is in Fig. 4, It is possible to obtain a match between the number of pulses on the nozzle and the number of seeds passed through the sensor by setting the parameters. The picture shows 4457 pulses and 4399 seeds registered by the sensor. In case the data would differ, the parameters would have to be changed so that they could be balanced. Tests have shown that the error can be kept at 5%. Fig. 4 shows a seed count sensor in a row.

RESULTS AND DISCUSSION

The results of measuring the number of seeds over time are shown in Fig. 5. The horizontal axis shows the time in seconds, the vertical axis the number of seeds sensed by the sensor every tenth of a second. At the beginning of the graph is the start-up of the machine and the setting of the quantities so that the required seed frequency of 50 Hz is achieved. Due to the possible error of the sensor, which must round the seed numbers at the time limits, a moving average of three measurements (solid line in the graph) was made. The polynomial trend line (dotted line in the graph) corresponds to the setpoint.

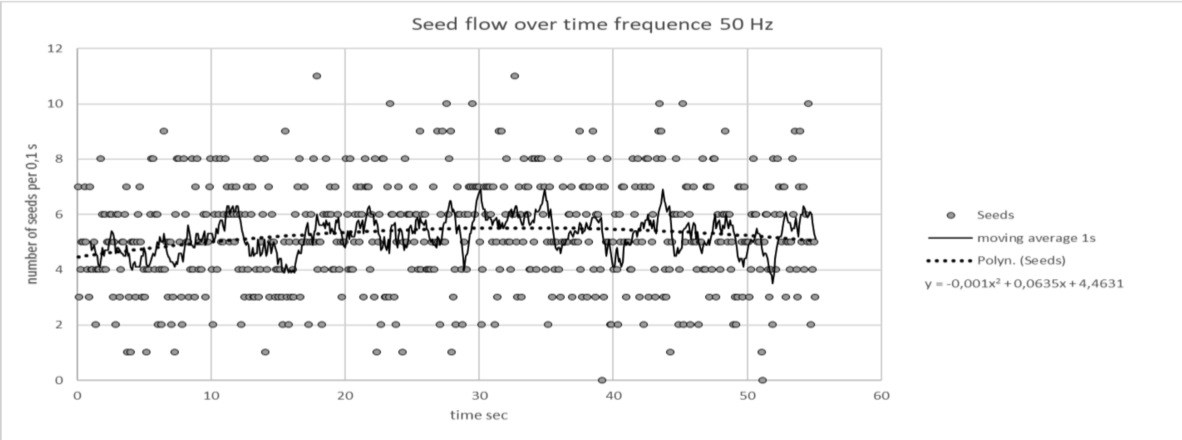


Fig. 5 Time distribution of the number of seeds at a sowing frequency of 50 Hz

The results of measuring the number of seeds over time at a frequency of 90 Hz are shown in Fig. 6. The time in seconds is plotted on the horizontal axis and the number of seeds scanned every hundredth of a second on the vertical axis. The control of the air pressure in the nozzle, the speed of the feeder, and the percentage of the nozzle opening was switched on so that the required frequency of 90 seeds per second was achieved. Due to the possible error of the sensor, which must round the seed numbers at the time limits, a moving average of three measurements was made (solid line in the graph). The polynomial trend line (dotted line in the graph) corresponds to the setpoint.

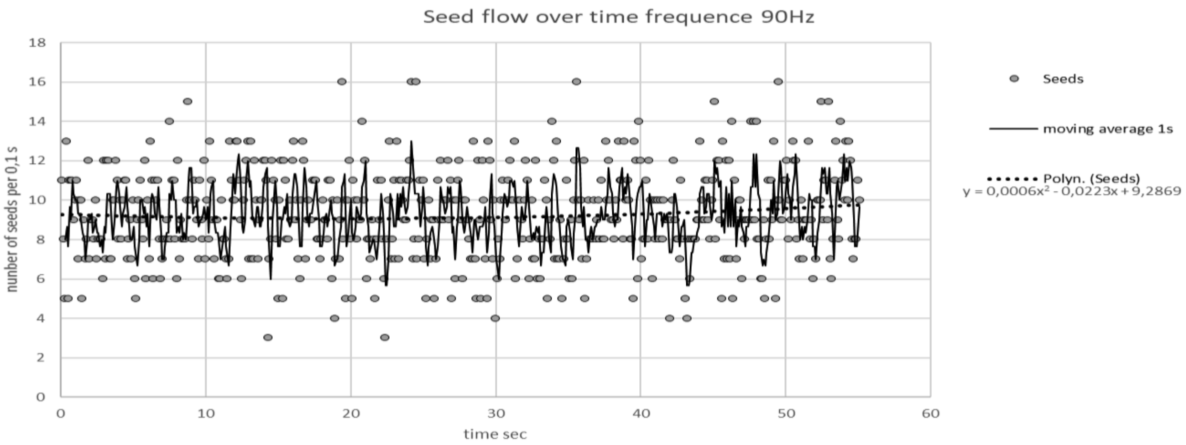


Fig. 6 Time distribution of the number of seeds at the sowing frequency of 90 Hz - onset of regulation

The results of measuring the number of seeds over time at a frequency of 90 Hz are shown in Fig. 7. The time in seconds is plotted on the horizontal axis and the number of seeds scanned every hundredth of a second on the vertical axis. The control of the air pressure in the nozzle, the speed of the feeder, and the percentage of the nozzle opening was switched off so that the value of the required frequency of 90 seeds per second could be seen. The graph shows how stable the process of steady state regulation is. Due to the possible error of the sensor, which must round the seed numbers at the time limits, a moving average of three measurements was made (solid line in the graph). The polynomial trend line (dotted line in the graph) corresponds to the setpoint.

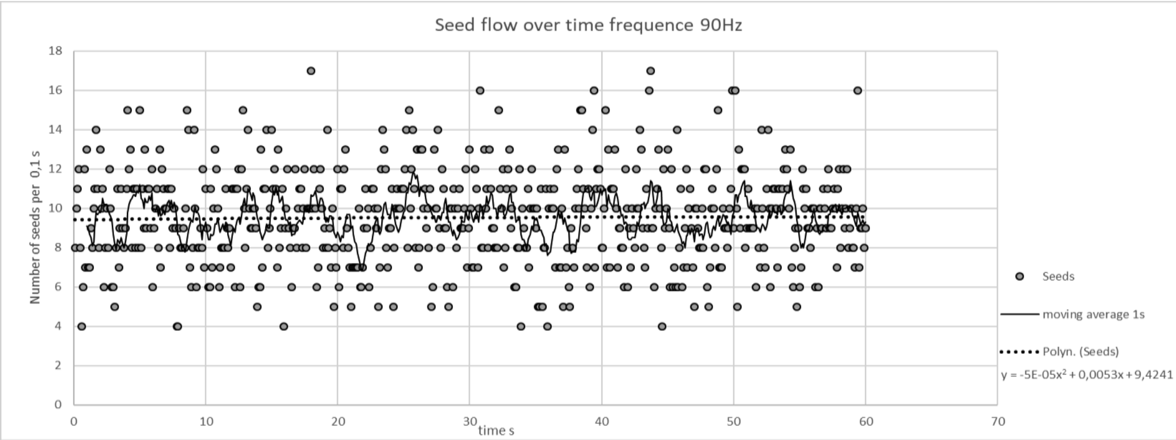


Fig. 7 Time distribution of the number of seeds at the sowing frequency of 90 Hz - end of regulation

CONCLUSIONS

The seeds from the unifying device fall between the belts of the transport device. The straight-line speed of the conveyor belts is 5.5 m/s at 20 km/h when the seed drill travels (*Shannon, Clay, Kitchen, 2020*). The speed of the sorted seed from the energy of the compressed air of the nozzle is approximately 0.1 m/s. If the seed hits the fast-moving belt at low speed, it will gain a large acceleration, which will cause its uncontrolled rebound. (*Virk, Fulton, Porter, et al., 2020*). This had to be managed structurally. Many tests and adjustments have been made to reduce the difference between seed and conveyor speeds. Mechanical rebound barriers of various shapes were also made. However, the desired result was not achieved. (*Akhalaya, Shogenov, & Starovoitov, 2021*).

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