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CORRECTION METHOD OF THE UNIFORM DISTRIBUTION OF GRAIN IN THE PNEUMATIC DRILL HEAD

Summary

Currently, in the commonly used pneumatic drills a control of grain movement in the seed line is not envisaged. The paper presents a method for correcting the uniformity of distribution of the grain material on the basis of an innovative device prototype designed and made at Poznan University of Technology. The main objective was to develop an improved manifold used to ensure uniformity of the grain distribution to a pneumatic drill by registering the change in slope angle depending on grain falling on a control disc. In order to characterize the correction process, further investigation is scheduled. The prototype's mechanical parts and electrical system are expected to correct the grain distribution process by feedback, self-adjustment and manual control from an external computer.
Key words*: distribution correction; piezoelectric sensors, seed drill distributor head*

METODA KOREKCJI RÓWNOMIERNOŚCI ROZDZIAŁU ZIARNA W GŁOWICY SIEWNIKA PNEUMATYCZNEGO

Streszczenie

W aktualnie stosowanych siewnikach pneumatycznych nie przewiduje się na ogół możliwości kontrolowania ruchu ziarna w poszczególnych przewodach nasiennych. W pracy zaprezentowano metodę korekcji równomierności rozdziału materiału ziarnistego na bazie innowacyjnego prototypu urządzenia wykonanego w Politechnice Poznańskiej. Głównym celem było skonstruowanie ulepszonego kolektora równomierności rozdziału mieszanin ziarnistych do siewnika pneumatycznego poprzez rejestrację zmian kąta pochylenia w zależności od spadających pionowo na tarczę sterującą ziaren. W celu scharakteryzowania procesu korekcji zaplanowano dalsze badania. Od zbudowanego prototypu oczekuje się, że elementy mechaniczne oraz układ elektryczny pozwoli na korekcję rozdziału w sprzężeniu zwrotnym, samonastawnym oraz ręcznie z zewnętrznego komputera.
Słowa kluczowe*: korekcja rozdziału; czujniki piezoelektryczne, głowica rozdzielcza siewnika*

1. Introduction

In the commonly used drill heads, the grain stream distributed uniformly over the cross-section of vertical diffusion pipe hits a distributor head dome, scattering randomly in different directions, and is carried along by the flow of air into the seed tubes connected with coulters.

In drills with a central sowing unit, a problem of even distribution of the grain flow to the seed tubes in the distributor head exists. The non-uniformity of distribution can result from the inaccuracy of the distribution head, the inclination of the drill when operating on slopes, the difference in distance between seed tubes and the like. In extreme cases, it clogs can occur in lines, which stop the sowing process.

The most frequently used drills don't ensure that the movement in the individual lines will be controlled. In the patent literature, however, examples of such solutions based on piezoelectric, microphone, or photoelectric sensors can be found. Solutions that could enable dynamic correction of grain distribution asymmetry in the drill head, that could use sowing control system information were not found. These control systems are installed on grain seeders and conform with precision farming purposes [13].

The use of the invention should allow for better meeting the standards of the seeding process, which are hardly met by pneumatic drills and thus provide increase in yield and decrease of the seed volume used, which becomes more expensive.

2. Previous achievements

During the review of the professional and scientific literature, there was no findings on identical and similar designs for intelligent distribution for both the sowing of cereal seeds and other crops, as well as other systems where an even distribution of granular materials is required. The proposed, fully innovative solution is characterized by the placement of sensors counting the granular material inside the distributor head, the so-called control screen. This solution provides in particular the use of piezoelectric sensors [1] and a microphone, but does not preclude other types sensors to enable counting or monitoring the flow of grains. Previously, piezoelectric transducers were used in keyboards of electronic devices, where a small force converts into small voltage. This solution was patented [11] for measuring gas pressure [3] or as a source of energy [8]. Piezoelectric sensor was also used to measure the amount of engine rotation [10]. During the analysis of the scientific literature, results of research related to the evaluation coefficient of restitution, the degree of seed damage, and energy required to damage grain, using a piezoelectric transducer [4, 5] were found. The patent literature also shows attempts to use capacitive sensors [2], although due to small changes in capacitance, this method is not promising. As optical sensors are quite sensitive to dust present in the pneumatic systems, they are not a viable option as well.

Work done at the University of Paderborn was found, in which a honeycomb-form piezoelectric sensor for counting the seed flow monitoring was mounted on top of the distributor head and pipes [14]; also on using a piezoelectric sensor for monitoring loss in a combine harvester [12]. This concept does not include the tilting deflector with mounted sensors and use of piezoelectric film whose properties have also been studied [9].

3. Aim of the study

The aim was to construct a seed distribution uniformity collector for pneumatic seed drill by registering the change of the angle dependent on the grain falling vertically on the control disk. The planned functional studies will be expected to prove the correctness of the assembly (both mechanical and electrical system).

4. Construction of the solution

Developed and built in the Division of Heavy Machinery at Poznan University of Technology, the model of the new seed distribution uniformity collector for pneumatic seeding is shown in Fig.1 in a perspective view from above, at Fig. 1b in a perspective view from below. Made within the frame of young academic staff project (no 503222/05/51/3363 DS-MK), the developed prototype is shown in Fig. 3. It was made as a movable disc embedded in the dome of the distributor head on crossed axes, tilted with servomotors to the desired angle - in relation to the vertical axis of the head. The value of the tilt angle and direction are calculated by the computer program installed in the cylinder head controlled electronically based on data from the sensors distributed over the circumference of the controlled disc (deflector). When the system detects an unbalance of stream, it will automatically tilt the disc (deflector) and direct seed appropriately. Tilting disc in the opposite direction will support even distribution.

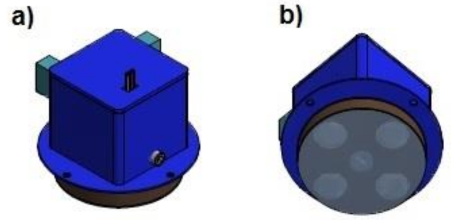

Fig. 1. Model of improved seed distribution uniformity collector for pneumatic seeding [7]
Rys. 1. Model nowego kolektora równomierności rozdziału nasion do siewnika pneumatycznego [7]

According to Fig. 2, the new collector consists of a frame (1), to which a deflector (2) is mounted articulately with the use of tilting unit (3). The deflector is tilted in two planes by means of the control arm (6) and a slider (5) with two servomotors (4). Specially shaped filling plate (7) with sensors (8) is fastened with a screw (10) to the plate of the tilted deflector. This solution foresees the use of three types of sensors: piezoelectric ceramic, piezoelectric film, and a microphone [7].

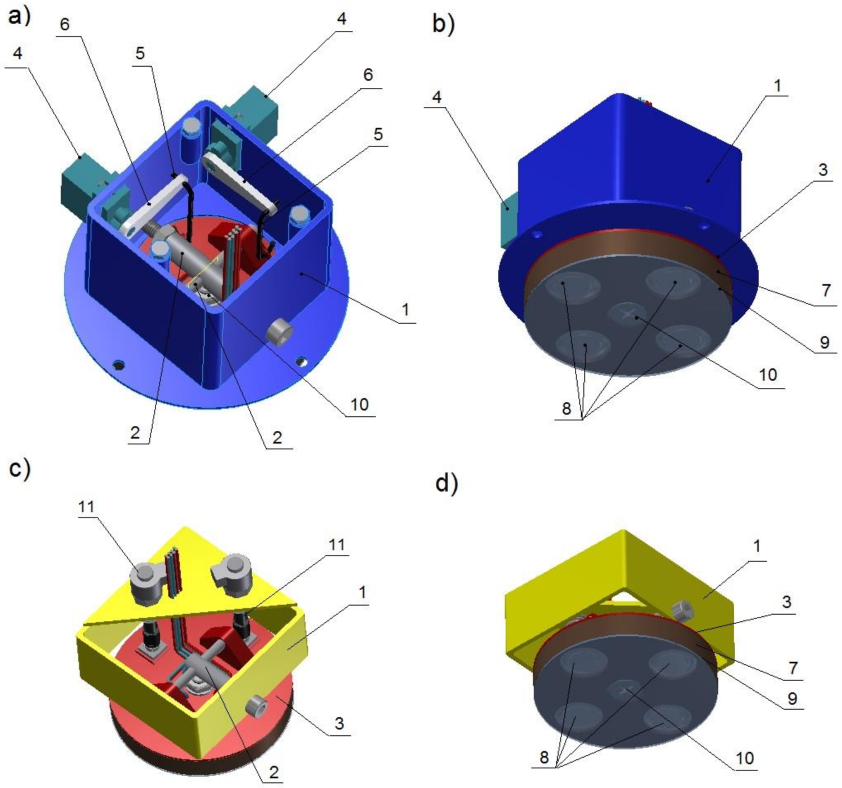

Fig. 2. Model of improved seed distribution uniformity collector for pneumatic seeding, where a) collector with servomotor shown from above, b) collector with servomotors shown from below, c) collector with screw actuators - top view, d) collector with screw actuators – bottom view: 1 – frame, 2 – crossed axes, 3 – deflector, 4 – servomotors, 5 – slider, 6 – control arm, 7 – filling plate, 8 – sensors, 9 – shielding screen, 10 – retaining screw [7]
Rys. 2. Model nowego kolektora równomierności rozdziału nasion do siewnika pneumatycznego z odnośnikami a) korektor z serwonapędami rzut z góry, b) korektor z serwonapędami rzut z dołu, c) korektor z siłownikami śrubowymi rzut z góry, d) korektor z siłownikami śrubowymi rzut z dołu: 1 – rama, 2 – skrzyżowane osie, 3 – deflektor, 4 – serwonapędy, 5 – wodzik, 6 – ramię sterujące, 7 – płyta wypełniająca, 8 – czujniki, 9 – ekran osłaniający, 10 – śruba mocująca [7]

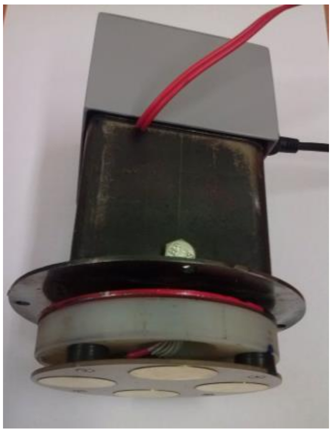

Fig. 3. Seed distribution uniformity collector prototype [7]
Rys. 3. Prototyp ulepszonego korektora równomierności rozdziału nasion do siewnika pneumatycznego [7]

Fig. 4 Seed distribution uniformity collector prototype mounted on the drill head
Rys. 4. Prototyp ulepszonego kolektora równomierności rozdziału nasion zamontowany na głowicy rozdzielczej

a)

b)

Fig. 5. Sensors: a) piezo-ceramic b) piezoelectric film, mounted on the distribution collector
Rys. 5. Zamontowane na korektorze rozdziału czujniki: a) piezo-ceramiczne b) folia piezoelektryczna

Fig. 2 shows the filler plate adapted to the microphone and piezoelectric sensors distributed crosswise.

Filling plate (7) with sensors (8) is attached to the deflector (3) and protected against premature wear with a shield screen (9).

During the process of sowing, the particulate material strikes the sensors (8) fixed to the deflector between the filler plate (7) through the shielding (9). The produced frequency signal of the seed impact frequency is transmitted to the electronic control unit, which analyzes data from the sensors and the actuators by means of two servomotors (4) and two screw actuators (11). It controls the tilt of the deflector (3) and aligns the distribution of the granular material in the drill head. Fig. 3 shows the seed distribution uniformity collector prototype, while Figure 4 shows the prototype installed on the distributor head. According to the concept of the collector, it is possible to implement any type of sensors to count the seed volume. Fig. 5 shows an example of four a) piezo-ceramic b) piezoelectric film sensors being installed [7].

5. Summary and conclusions

Preliminary working conditions tests of seed distribution uniformity collector in a pneumatic drill show that the developed and described idea could work. Developed for the needs of the present work, the *Distribution Collector* application is used to test and manually control the angle of the deflector shield.

The driver, located in the electronic system of the new seed distribution uniformity collector can correct the distribution independently or from a remote computer (it sends the sensor data to an external computer, but also executes commands via the serial port). This program was written in Microsoft Visual Studio.

Based on functional testing planned later, it was intended to obtain results showing if the new seed distribution uniformity collector will allow the correction of seed distribution with feedback and self-adjustment, as well as whether it can be manually controlled from an external computer.

In order to fully characterize the process of correcting the uniformity of distribution in the distributor head, execution of a series of tests on a grain sowing process test stand is planned [6].

6. References

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