

MECHATRONIC CONTROL SYSTEM IN A TILLING-AND-SOWING COMBINED MACHINE

Szczepaniak Jan, Pawlowski Tadeusz, Rogacki Roman,
Wojciechowski Jacek, Pawel Dudziński
Industrial Institute of Agricultural Engineering, Poznan, Poland
janek@pimr.poznan.pl

Abstract

The article concern to the scientific and research works related to the development of mechatronic control system of sowing unit in the tilling-and-sowing combined machine. The essence of the project is the use in the combined machine of innovative control system responsible for the seeding process. The system will control the work of seeding unit (drive) and will maintain a predetermined depth of seeds sowing. Grooved or pinned units used in seeding are characterized by variability in application rate as a function of the changing conditions of work (e.g. on the slopes). In the proposed solution, on the basis of the identification of the sensitivity of the sowing machine on the changing conditions of work, the control algorithm will be developed, which after application to a controllable propulsion system equipped with the necessary sensors will eliminate inaccurate dosing. Project/Grant No K2/IN2/64/182979 is co-financed from the budget allocated for science.

Keywords: MECHATRONIC, CONTROL SYSTEM, COMBINED MACHINE, TILLING-AND-SOWING, PROTECTION, STABILITY

1. Introduction

Seeding is one of the main agricultural operations in a crop production. Correct sowing process, seeds selection and respecting the agricultural dates has a great influence on the final crops.

Nowadays tilling-and-sowing combined machines which are on the European market, are the part of a classical seed drills with studded seed roller (Siebersleben type) or force feed roller (Hoosier type) as a seeding units. In some applications, pneumatic drills are extensively used. In the prior art seed drills constructions mentioned sowing units are driven by a driving wheel through a speed variator or a transmission with gears. Sometimes sowing units can be also driven by an electric motor or by a hydraulic drive with control system which allow for adjusting the seeding unit based on the seed drill speed.

The main drawback of commonly used drills is that values of dosages and indicator of a drill work changes with changing operating conditions. These factors include: drill's inclination, (especially in the direction of movement), driving speed, seed level in the tank. Under the effect of changes in drill's inclination on uneven or wrinkled ground quite significant changes can occur in the amount of seeding grains and in the inequality index of transverse seeding.

Occurrence of this phenomenon is confirmed by a number of studies conducted by Institute of Building Mechanization and Electrification in Agriculture in Warsaw and Industrial Institute of Agricultural Engineering in Poznan. Institute of Building Mechanization and Electrification in Agriculture was testing a seed drill with studded seed roller on a inclined ground at the angle of 12 deg, and it was found that the greatest changes in a fixed amount of seeding occur when a tractor-seeder aggregator drives uphill or downhill. Comparing the operation on an even ground while seeding rape to operation during the uphill driving it came out that the amount of seeded seeds per unit area are about 11% larger, while during the downhill driving the amount is reduced by about

20%. This changes are smaller and are in both cases approximately 5% when sowing cereal seeds.

In Industrial Institute of Agricultural Engineering in Poznan tests on a seeder with force feed roller as a seeding unit were conducted, during which the impact of the seeder back and forth inclination on the persistence of a fixed amount of seeded rye was determined. The results showed that, comparing to the even position of the seeder, the backward inclination increases sowing fixed amount of about 12%, while the forward inclination - reduce it by about 4%.

From an agro-science point of view, the occurrence of uncontrolled variability of the amount of seeded seeds per unit area during the seeder operation (basing on the "curly" pre-sowing trials) adversely affects the yields quality.

While a concentrated sowing, which occurs on the filed during the uphill movement of a seeder, crops growth, comparing to crops on even ground, is a bit slower. Slower is also the plant curvature process.

The uneven plant growth also makes difficult to choose the optimal date of the care treatments, for example fertilization.

In order to increase the functionality and quality of existing aggregator constructions, for pre-sowing and simultaneous cereals sowing, manufactured and operated in Poland and other European countries, the Industrial Institute of Agricultural Engineering in Poznan has taken steps to develop an tilling-and-sowing combined machine with mechatronic controlling system for adjusting the seeding process. As a part of preliminary works, patent application was developed [1], which contains a concept device for maintaining a constant seeding dose, regardless of seeder operating conditions. This type of solutions have not been used so far, neither in domestic tilling-and-sowing combined machines constructions, nor in "well-known" European companies.

2. Tilling-and-sowing combined machine

The machine consist of cultivation aggregator and seed drill (Fig. 1).

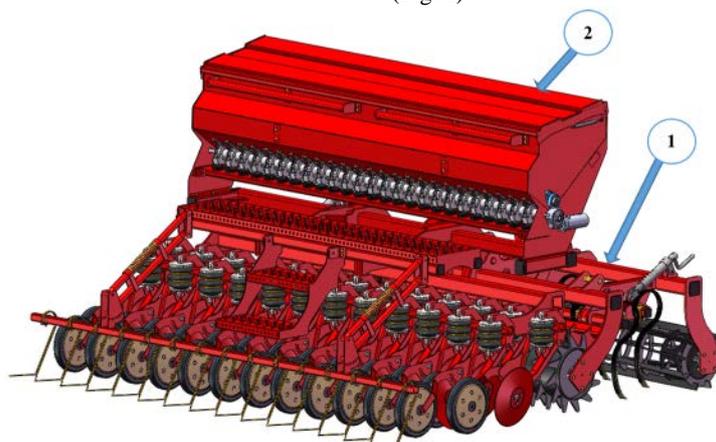


Fig. 1. Tilling-and-sowing combined machine with a mechatronic control system: 1- tilling-sowing aggregator, 2- seeder [2]

The whole creates a modern and compact tilling-and-sowing combined machine for pre-sowing soil cultivation system, both after a ploughing and minimum tillage as well as for simultaneous sowing cereals and catch crops. Application of a such set allows to prepare a soil for sowing and sowing alone within single trip.

The use of a tilling-and-sowing combined machine will improve the agronomic and economic effects (reducing the number of trips, full tractor power extraction, saving labor and fuel).

3. Research stand

The research, carried out on the seeder model (Fig. 2), was conducted to evaluate the accumulative influence of variable

operating parameters on seeding dose. Collected results enabled for developing an accurate mathematical model describing the sowing operation of seeder, and use it to develop a correction algorithm, controlling the seed dispensers drive [3].

The usage of an appropriate correction algorithm for controlling the drive parameters of sowing shaft, will allow to limit adverse influence of external factors, and therefore improve the work quality factors of a seeder.

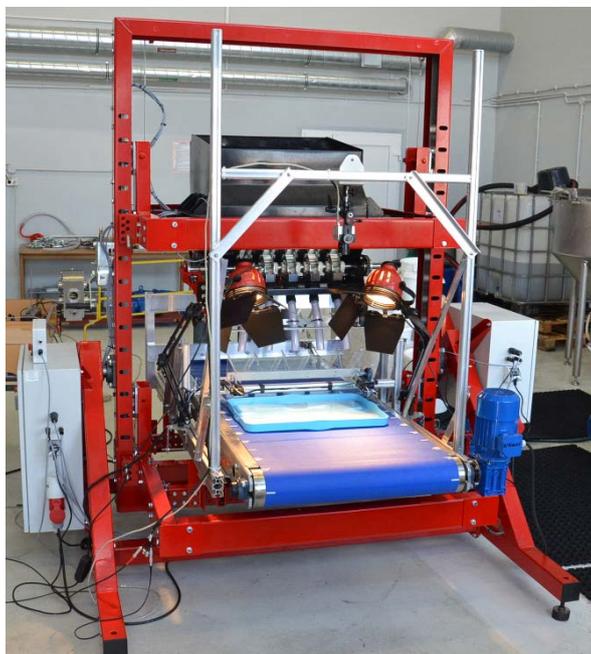


Fig. 2. Research model of seeder allowing to simulate variable operating conditions in laboratory environment [1]

The test stand was equipped with a control and monitoring system which allowed for realization of the research program. The heart of the system was the MicroDAQ module [4, 5], which combines the properties of control and measurement cards with real time processing thanks to DSP processor. The module was operated by Matlab-Simulink software (Fig. 3). The module measuring inputs were connected with test stand's sensors .

Within the research, the work parameters of drive system of sowing units were defined (range turns number of sowing shaft, torque shaft), for different types of seeds and different applied doses of sowing. Correction database was created, which contains collection of work parameters for different grain species or seed varieties for changing operating conditions of a seeder.

Afterwards, algorithm for controlling the sowing shaft was developed.

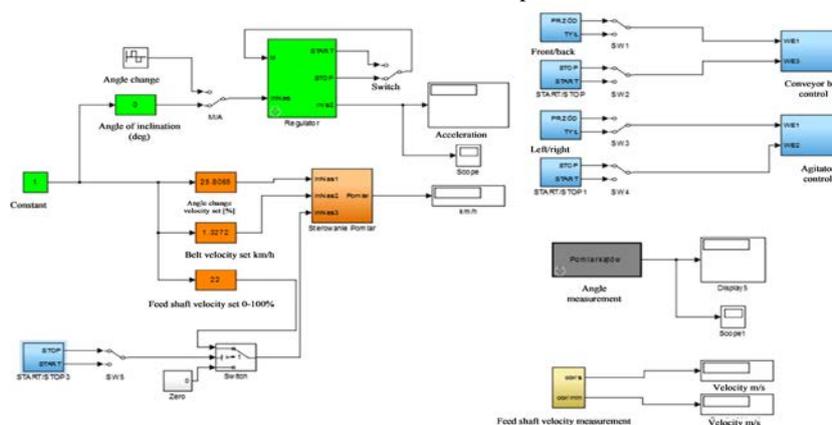


Fig. 3. Control program implemented in Matlab-Simulink environment [1]

In order to keep the speed value constant, the control system was equipped with PID regulator and sensor for feedback signal of

rotational speed (Fig. 4). PID factors were selected using an automatic tuning procedures in the Matlab [6].

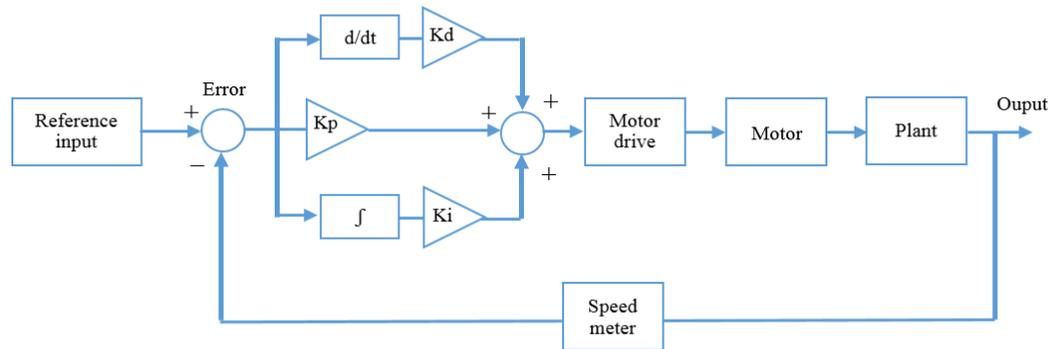


Fig. 4. Block scheme of rotation speed regulation of a sowing shaft [7]

4. Conclusions

Developed tilling and sowing combined machine has some innovation solutions such as: electronic control unit and automatic system to maintain the seed placement depth. At present, research on the target control system is being carried out.

Improved constructional and exploitation features of the tilling and sowing combined machine will allow to extend the universality of its use and improve its operation precision providing beneficial agronomic effects.

These effects are expressed through:

- the stability of the set amount of sowing seeds per ha,
- the ability to increase the speed of movement of the working unit and as a result achieve high productivity,
- the achievement of equal germination and plant propagation,
- optimal soil preparation for sowing ensured by configuring tillage equipment.

5. Reerences

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Acknowledgement

This study was supported by the National Centre for Research and Development

Project No. INNOTECH-K2/IN2/64/182979/NCBR/12.