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DETERMINATION OF GRAIN PERIPHERAL SPEED IN A SEED PICKLING MACHINE DEPENDING ON THE PRESENCE OF SCRAPER ELEMENT

Summary

The method of determination of grain speed in a seed pickling machine depending on the presence of scraper elements have been described in the paper. Results of high speed video analysis have been presented. Grain speed changes as a function of current frequency powering the seed pickling machine engine have been presented. The influence of scraper element inside the working chamber on the grain flow and its speed have been examined as well.
***Key words**: seed, seed pickling machine, scraper elements, high speed camera, seed flow*

WYZNACZENIE PRĘDKOŚCI OBWODOWEJ ZIARNA W KOMORZE MIESZANIA W ZALEŻNOŚCI OD WYSTĘPOWANIA ELEMENTÓW ROZGARNIAJĄCYCH

Streszczenie

W artykule przedstawiono metodę oraz sposób pomiaru prędkości obwodowej ziarna w komorze mieszania zaprawiarki w zależności od występowania elementów rozgarniających. Zaprezentowano wyniki pomiarów prędkości obwodowej ziarna z użyciem kamery do szybkich zdjęć. Określono zmiany prędkości obwodowej ziarna w funkcji zmiany częstotliwości prądu zasilającego silnik elektryczny zaprawiarki. Zbadano wpływy obecności elementów rozgarniających wewnątrz komory roboczej zaprawiarki na prędkość obwodową i sposób ruchu ziarna wewnątrz komory roboczej.
***Słowa kluczowe**: ziarno, zaprawianie, komora zaprawiająca, elementy rozgarniające, kamera do szybkich zdjęć, przepływ ziarna*

1. Introduction

Currently seed pickling method is one of the oldest methods of protecting plants from diseases and pests, which is commonly used in Poland. Thanks to the pickling process the growth of plants is better and more even, also young plants are more resistant to dangerous diseases and pests, especially in the very first stage of grow [1-5]. The process of seed pickling is one of the processes with the largest amount of labor and energy consumption, for example, in oats production it is a 8.1% of overall workload [1]. It is important for the process of seed treatment to be conducted in the most efficient manner, but quickly and accurately, so that the grain as a whole is covered with proper fluid [2].

In the literature you can find the information that the flow of grain is influenced by grain mass properties and design features of the seed pickling machine. The grain properties include humidity, amount and type of impurities present in grain mass and textural features. With increasing water content of the grain mass, mechanical properties of individual grains are changing by an increase in susceptibility to deformation and a reduction of their elastic properties [9, 11]. Studies on the effect of humidity on the coefficient of friction led many investigators who showed that the value of the coefficient of friction depends on the moisture content but also on the species and varieties of grains, as well as the movement velocity [7, 10]. Also, the change in humidity changes tribological properties of grain mass, what decreases hardness and increases the contact surface of grains, thereby the cohesion and internal friction rise [8]. Contamination of grains depends on many factors, including soil conditions and cultivation techniques, climate conditions, as well as the efficiency of harvesting machinery and purifying equipment [14]. Contamination of grains adversely affects both storage and seed conservation treatments. Conducted cleaning of grain prior to storage and pickling removes the grain contamination thus improves its good looks and grade and increases the weight of 1000 grains and bulk density [13, 17, 18]. To textural features affecting the flow of grain include grain size, its shape and disordered orientation. Classification of grain quality based on vision systems is simple, fast, does not require sample preparation (eg. shredding) and the use of chemical reagents. We are currently using a computer image analysis to analyze the surface texture, the geometry as well as to identify the variety of cereal grain [12, 15, 16].

Based on the literature analysis a short summary shows that the seed pickling process is affected by two groups of factors. The first group is associated with material and the second group with properties of the device (machine construction). At the current stage of the project a group of design factors (constructional) have been investigated, that could be modified in a certain range. Therefore, actions were taken to change the flow of grain in the mixing chamber and and to select various speed of mixing plate.
The study was conducted in collaboration with the Company AGRALEX, which is a manufacturer of seed pickling machines and carries out research and development work in this field [6, 17]. This article presents attempt to answer the posed research problem "How the occurrence of grading elements inside the dresser mixing compartment affected to grain movement?".

2. Preparation of the real model of the mixing chamber

The object of the research was the moxing compartment with a rotating plate and pickle sprayer disc of the bath seed dresser (Fig. 1). Laboratory tests were performed on the real model of the mixing chamber of seed pickling

machine, powered by an electric motor equipped with an inverter to provide the ability to change speed of the electric motor. In order to perform research and observation of grain movement within the mixing chamber a rectangular box measuring 60 x 200 mm have been cut out. In this window a transparent acrylic plate have been installed (Fig. 1). Window allowed observation of the movement of grain in the mixing process inside the chamber on the inner wall and defining its movement speed. In the course of testing scraper elements have been mounted in the chamber pushing aside the grain from the wall. The test model of the mixing chamber was open at the top, which allowed us to observe the effect of scraper elements presence on the way of movement of grain mass within the mixing chamber. The view of mixing chamber on the testing station with a camera for high speed video images recording is shown in Fig. 2.

Fig. 1. Observation window in the seed pickling machine on the side wall
Rys. 1. Okno obserwacyjne wykonane w płaszczyźnie bocznej komory roboczej zaprawiarki

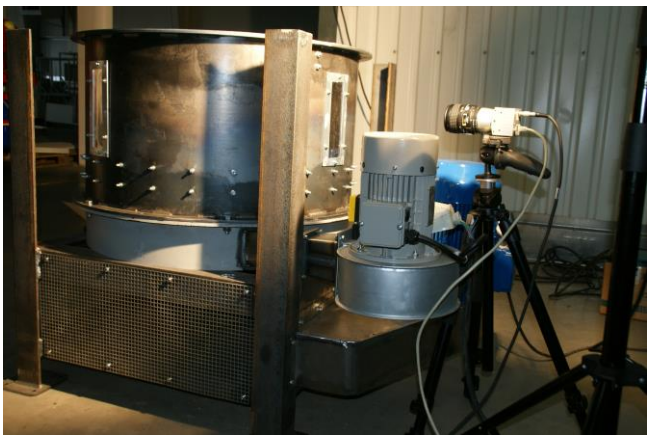

Fig. 2. Testing stand with high speed camera
Rys. 2. Widok stanowiska badawczego z kamerą do szybkich zdjęć

3. Methodology of research

The study was performed using a high-speed camera images FASTEC 4 with computer for archiving and visualization of the research results, lamp with a power of 1.25 kW, indoors at temperature +15°C, with artificial light. The study was conducted in a mixing chamber of seed pickling machine in two constructional variants, with different settings of the frequency of the supply current. The first variant of the research included the study of the grain flow in the mixing chamber without scraper elements installed in its interior. The second variant of studies was performed with scraper elements installed inside the mixing chamber. The rotational speed of the electric motor have been controlled by varying the frequency of the supply current at 5 Hz, using the inverter.

Circumferential speed of the grain was determined on the basis of images taken by the high speed video camera at specified time. Thanks to the observation window in the working chamber, it was possible to observe the movement of grain on the measurement section on distance 60 mm. The resulting footage shot with frequency of 2000 fps made it possible to track the movement of individual grains (Fig. 3). On the basis of image analysis the speed of movement have been determined as the quotient of the difference of distance traveled (L2-L1) within 0.025 s. Time 0.025 s represents the number of 50 video recorded frames. The rotational speed of the mixing plate and the seed pickling plate in the course of the study were measured using an electronic tachometer CT6.

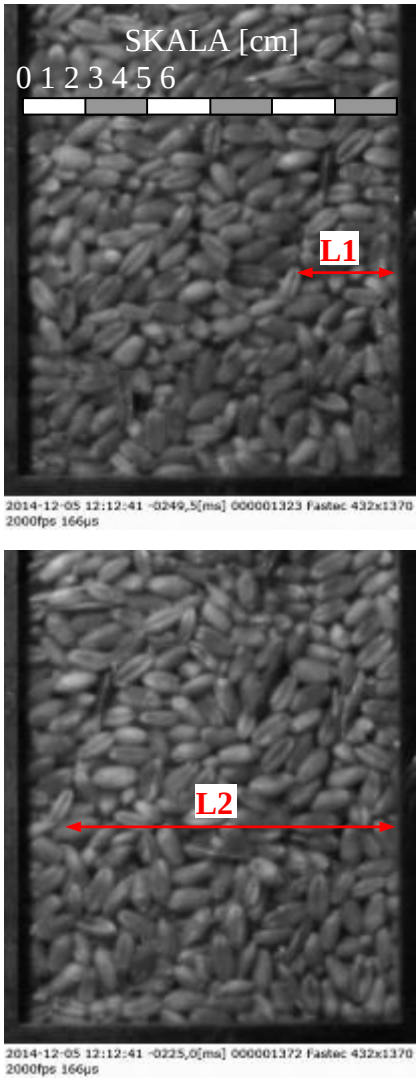

Fig. 3. The view of grain in the chamber at power supply frequency 50 Hz: a) initial picture, b) picture after a time of 0.025 s (50 frames)
Rys. 3. Widok ziarna w komorze mieszającej przy częstotliwości prądu zasilającego 50 Hz: a) fotografia początkowa, b) fotografia po czasie 0,025 s (50 klatek)

4. Results

The results of measurements of the rotational speed of the mixing plate and the seed pickling plate as a function of frequency of electric current set at the power inverter powering the electric motor of machine are summarized in Table 1.

Table 1. The settings of the frequency inverter and corresponding rotary speed of electric motor, the mixing plate and pickling plate (own work)
Tab. 1. Nastawienia falownika (przemiennika) częstotliwości i odpowiadające mu prędkości obrotowej silnika elektrycznego, talerza mieszającego i zaprawiającego (opracowanie własne)

No.	Supply current frequency setting [Hz]	Rotation speed [rpm]		
		Electric engine	Mixing plate	Pickling plate
1.	50	950	297	1650
2.	45	872	272	1450
3.	40	782	244	1300
4.	35	679	212	1130
5.	30	582	181	968
6.	25	481	150	800
7.	20	397	124	660

The results of measurements of the peripheral speed of the grain depending on the rotational speed of the mixing plate and the presence of scraper elements are summarized in Table 2.

Table 2. **G**rain peripheral speed depending on the mixing plate speed and the presence of scraper elements (own work)
Tab. 2. Zestawienie prędkości obwodowej ziarna w zależności od prędkości obrotowej talerza mieszającego i obecności elementów rozgarniających (opracowanie własne)

No	Supply current frequency setting [Hz]	Mixing plate rotation speed [rpm]	Circumferential grain speed [m ⊙ s^{-1}]	Circumferential grain speed with scraper elements [m ⊙ s^{-1}]
1.	50	297	1,44	0,88
2.	45	272	1,56	1,04
3.	40	244	1,52	1,12
4.	35	212	1,48	1,12
5.	30	181	1,52	1,12
6.	25	150	1,56	1,12
7.	20	124	1,56	1,12

Based on the research a various peripheral speed of the mixing plate and seed pickling plate as a function of the frequency of electric current set on the inverter have been obtained. Also a different peripheral speed of the grain depending on the rotational speed of the mixing plate and the presence of scraper elements have been measured.

It was found out that the change in frequency of the supply current causes a reduction of the grain range on the inner surface of the drum by approximately 15 mm by change of the current frequency from 50 Hz to 20 Hz (Fig. 4). Simultaneously, the peripheral speed of the movement of grain slightly changed in the range of 1.44-1.56 [m ⊙ s^{-1}]. Grain movement on the inner surface during the pickling process was laminar, and the vertical component of movement had a minimum value.

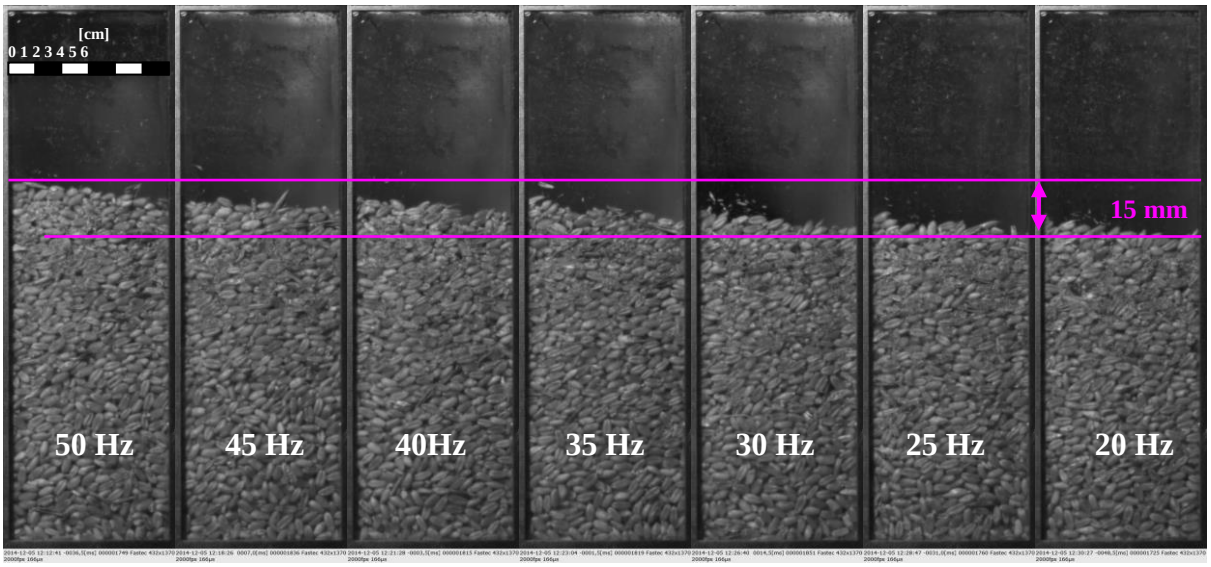

Fig. 4. Comparison of the seed distribution and range of grain on the internal surface of the working chamber depending on the supply current frequency during operation without scraping elements
Rys. 4. Porównanie sposobu rozmieszczenia oraz zasięgu ziarna na powierzchni wewnętrznej bębna zaprawiającego wraz ze zmianą częstotliwości prądu zasilającego podczas pracy zaprawiarki do nasion bez elementów rozgarniających

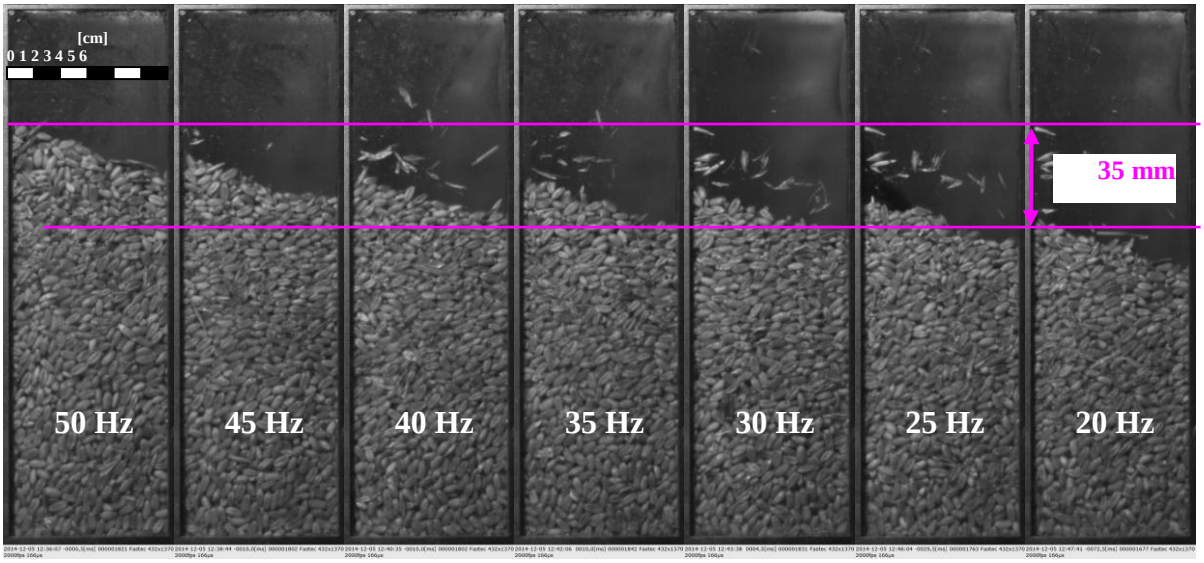

Fig. 5. Comparison of the seed distribution and range of grain on the internal surface of the working chamber depending on the supply current frequency during operation with scraping elements

Rys. 5. Porównanie sposobu rozmieszczenia oraz zasięgu ziarna na powierzchni wewnętrznej bębna zaprawiającego wraz ze zmianą częstotliwości prądu zasilającego podczas pracy zaprawiarki do nasion z nożami rozgarniającymi

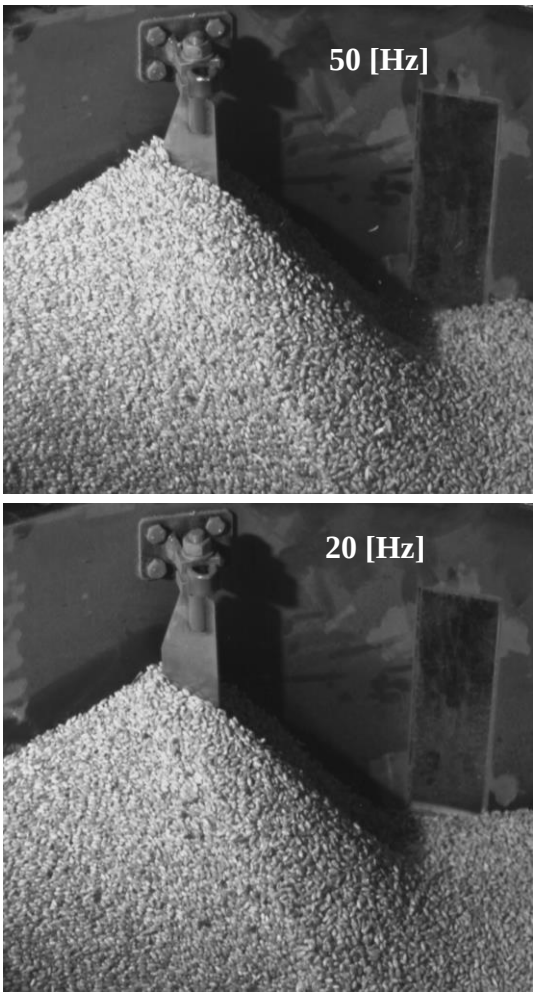

Fig. 6. Comparison of the seed distribution and range of grain on the internal surface of the working chamber depending on the supply current frequency during operation with scraping elements

Rys. 6. Porównanie sposobu rozmieszczenia oraz zasięgu ziarna na powierzchni wewnętrznej bębna zaprawiającego wraz ze zmianą częstotliwości prądu zasilającego podczas pracy zaprawiarki do nasion z elementami rozgarniającymi

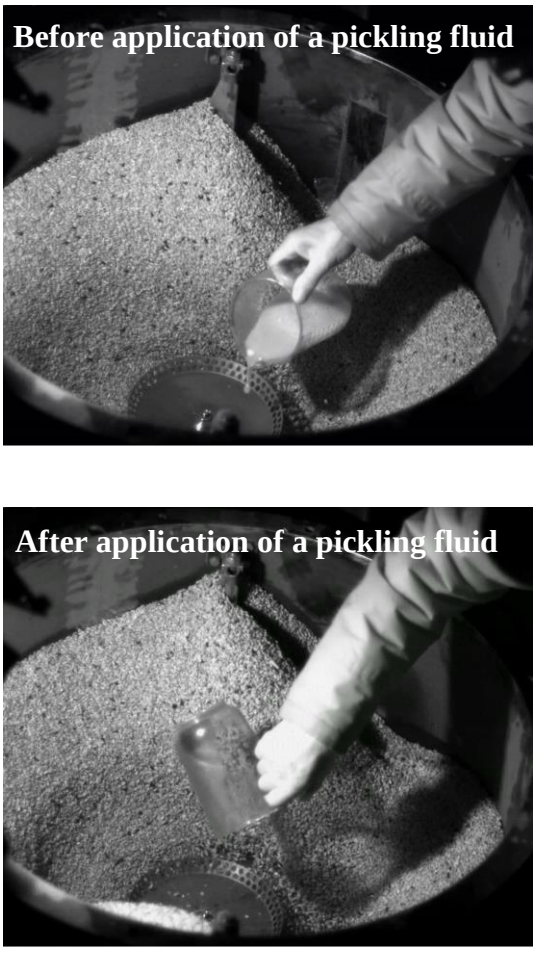

Fig. 7. Seed distribution and range of grain on the internal surface of the working chamber depending on the presence of seed pickling fluid during operation with scraping elements for supply current frequency 35 Hz

Rys. 7. Sposób przemieszczania się ziarna wokół elementu rozgarniającego wewnątrz komory zaprawiającej podczas pracy zaprawiarki i aplikacji zaprawy do nasion, dla częstotliwości prądu zasilającego 35 Hz

5. Conclusion

The study of the grain flow in the real model of the mixing chamber of seed pickling machine have been done. Based on the obtained results it was found out that the introduction of additional scraper elements inside the chamber positively influenced the movement of grain in the chamber, which should greatly improve the efficiency and the degree of coverage of grain with pickling fluid.

The use of highly specialized equipment to perform high-speed video analysis have revealed that:

- When operating the seed pickling machine without scraper elements the peripheral speed of the grain inside the mixing chamber is 1.44 to 1.56 m ⊙ s^{-1}. The maximum difference in the measured speed of the grain inside the mixing chamber was 4%. It was found out a small change of the peripheral speed of the grain with the change of frequency current and the rotational speed of the plate. During operation without scraper elements the grain was moving around the circumference at a relatively constant speed, and its movement was laminar;

- When operating the seed pickling machine with scraper elements the peripheral speed of the grain inside the mixing chamber decreased by approximately 30% and ranged from 0.88 to 1.12 m ⊙ s^{-1}. At the same time the measured range of grain speed within the chamber was 20%. During operation with scraper elements an increase in the mixing of the grain and increase in the grain movement component in vertical direction have been observed, resulting in additional rotation of the grain. The current rectilinear movement along the circumference of the grain was highly disturbed, which increases the circulation of the grain inside the mixing chamber. The introduction of scraper elements into the mixing chamber caused a change in the method of grain mixing from laminar to turbulent;

- The change in frequency of the engine supply current caused a change in distribution of grain on the inner surface of the mixing chamber during operation. Reduction of the grain range on the lateral surface of the chamber with decreasing frequency current have been observed. Range of changes of approximately 15 mm when working without scraper elements and approximately 35 mm when working with scraper element have been measured;

- Application of the pickling fluid into the mixing chamber results in increased resistance of grain movement inside the drum. The decrease in grain peripheral speed, and increase of the range of grain on the inner surface of the mixing chamber have been observed after fluid addition.

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