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The use of an electroseparator with bifilar winding for extracting germ from crushed rape seed

***Abstract**. The paper presents the results of tests using the electroseparator for extracting the hull from crushed rape seeds. For this purpose, a prototype electroseparator was built that uses a bifilar winding in its construction. The winding is wound on a rotating drum and is supplied with a high DC voltage. The conducted research proves that there are differences in the efficiency of hull and germ separation up to 40% with suitably selected operating parameters of the electroseparator and appropriate parameters of the particulate material*

Streszczenie.** W pracy przedstawiono wyniki badań elektroseparatora do wydzielania łupiny z rozdrobnionych nasion rzepaku. W tym celu został zbudowany elektroseparator z uzwojeniem bifilarnym. Uzwojenie to nawinięte jest na obracający się bęben zasilany wysokim napięciem. Badania dowiodły różnice w sprawności separacji łupiny i zarodka. - Wykorzystanie elektroseparatora z uzwojeniem bifilarnym do wydzielania zarodka z rozdrobnionych nasion rzepaku. (**Zastosowanie elektroseparatora do wydzielania łupiny z rozdrobnionych nasion rzepaku)

Keywords: rapeseeds, electroseparator, bifilar winding
Słowa kluczowe: rzepak, elektroseparator, uzwojenie bifilarne

Introduction

Among the many crops raised in Poland, a significant part is rapeseed. It is estimated that the share of rapeseed in the national sown area is approximately 8% [1]. Among oilseeds, this gives Poland the first place, while in the world it is third after soy and cotton [2]. The area of winter rape cultivation in Poland, according to the data of the Central Statistical Office, has in recent years amounted to 635-900,000 ha, for example in 2016 it was 786,000 ha, while in 2017 it rose to over 900,000 ha [3]. Such results give Poland the third place in Europe in the production of rape after Germany and France [1].

After Poland's accession to the European Union, a constant increase in rapeseed production is observed. This is due to the growing demand for this raw material from the domestic and foreign biofuel sector. Rape seed is a source of esters, which are added to conventional fuels [1]. The seed is also used in many industrial fields, such as the agri-food or pharmaceutical industry [4].

The problem to be solved remains obtaining a homogeneous material free of impurities and undesirable fractions. Each insertion affects the technological value of rape seeds, so it is important to remove these inclusions. The quality of harvested seeds should be taken care of throughout the whole production process, starting with the harvest of plants [5, 6], through appropriate storage conditions [7, 8].

When the seeds are already collected, numerous methods are used to purify them. In addition to conventional ones using sieves, triads or pneumatic separators, more and more often devices are found using the electrical properties of the material being cleaned. Among the electrical properties that can serve as a distribution criterion may be electric permeability or electrical conductivity [9]. Numerous solutions of electroseparators for separating selected seed fractions from electrical properties have been described in the literature [10, 11]. One can recall the work [12] in which a pneumatic-electric separator for extracting perennial grass seeds was used. On the other hand, [13, 14] present research on the purification of wild radish seeds (Raphanusraphanistrum L.) from buckwheat seeds (Fagopyrumesculentum L.). There is also a publication in which an electric field is used to separate mechanically damaged rape seeds in order to obtain a uniform material [15].

Rape seeds in their structure consist of hull and germ with different physicochemical properties. According to the study by [16], the germ contains about 10 times more fat, 3 times more protein, 6 times less crude fiber. If these two fractions are separated from each other, a more homogeneous material will be obtained, which is important in further processing. The literature describes works in which attempts have been made to separate these two components [17].

This paper presents a prototype model of an electroseparator, which uses a bifilar winding as the source of an electrostatic field. This issue is presented in the work by Majcher [18]. The use of bifilar winding in cleaning processes is also known from the literature [19].

The designed electroseparator is to be characterised by the possibility of continuous operation, low voltage supplying bifilar winding and smooth regulation of operating parameters.

Materials and methods

The research used seeds of the Sherlock variety of population rape, harvested in 2017. The moisture content of the seeds during the harvest ranged from 7.2-8%. The seeds were stored in the warehouse for a period of eight months. The seeds were then crushed using a roller crusher. The gap between rollers was reduced every 0.2 mm to prevent oil from rape seed being pressed out. The next step was to manually separate the hull fragments from the germ fragments so that the efficiency of the electroseparation for each fraction was investigated separately. Such a procedure gives the opportunity to assess the differences in the efficiency of separation of both fractions, and thus the possibility of separating one material. One of the important factors affecting the dielectric properties of shredded rape seeds is their moisture, which is why this parameter was determined using the weight method.

The construction of the test stand is shown in Figure 1. It consists of a rotating drum with a radius of R = 100 mm, and a working width of 65 mm. The drum is wound with a bifilar winding along the. Bifilar winding is made of DY wire (single core with PVC insulation). The transfer of the supply voltage to the rotating drum is carried out by means of slip rings. The material is fed to the rotating drum by means of a vibratory feeder, with smooth adjustment of the material supply. The seeds from the feeder go to a rotating drum wound with a bifilar winding, which is fed with high DC voltage. A non-homogeneous electrostatic field is produced around the winding that affects the rape seed.

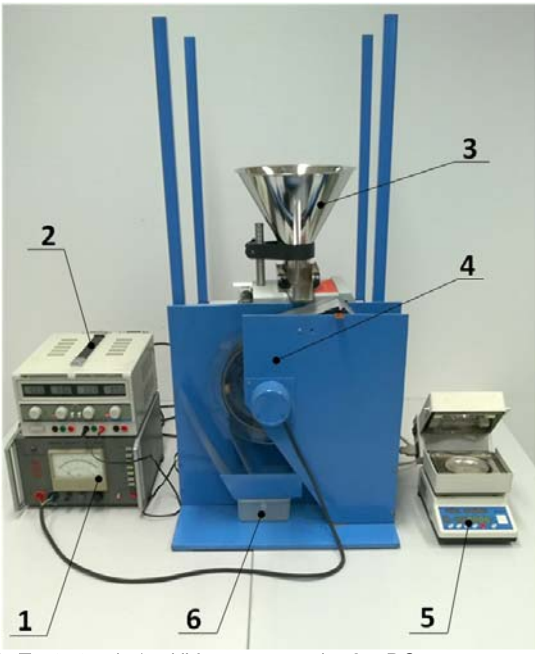

Fig. 1. Test stand: 1 - HV power supply, 2 - DC power supply for drum drive, 3 - material feeder, 4 - electroseparator with bifilar winding, 5 - moisture analyser, 6 - divisible container for 2 chambers

Then the seeds go into a container, which is divided into 2 chambers. The container is arranged in such a way that the seeds that have been electrified reach chamber 2, while the remaining ones go into chamber 1. Figure 2 shows the principle of operation of the electroseparator.

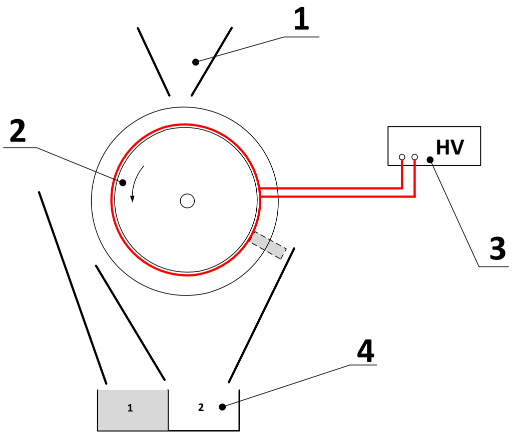

Fig. 2. Electroseparator model: 1 - material feeder, 2 - electric separator with bifilar winding, 3 - HV power supply, 4 - container divided into 2 chambers

To calculate the efficiency of the separation process, a coefficient was introduced, which was calculated from the following formula:

$$\eta = \frac{m_2}{m_z} \cdot 100\% = \frac{m_z - m_1}{m_z} \cdot 100\% \quad (1)$$

where:

m_2– mass of particles in chamber 2,
m_z– particle mass set,
m_1– mass of particles in chamber 1.

Results and discussion

The intensity of the electrostatic field between the bifilar winding is influenced by the voltage supplying the bifilar winding. Therefore, in the first stage, the influence of the voltage supplying the bifilar winding on the efficiency of separation was examined. Due to the control capabilities of the PSU, the voltage was changed in steps. The test results are presented in Figure 3.

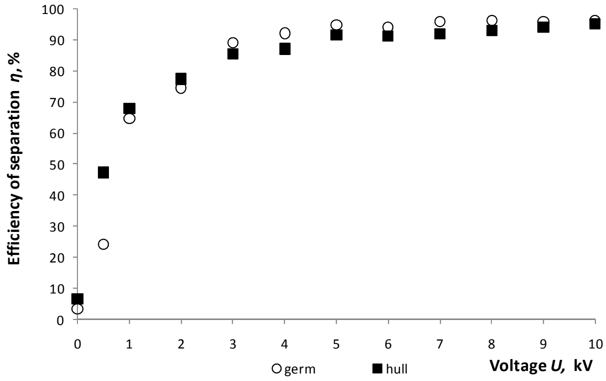

Fig. 3. Efficiency of separation as a function of the voltage supplying the bifilar winding

The remaining parameters of the electro-separator operation were kept constant and amounted respectively to:

- seed moisture 7,8%,
- cross-section of bifilar winding wires – 1 mm^2,
- rotational speed of the drum – 13,4 revolutions per minute.

On the basis of the test results, it can be noticed that with the increase of the voltage supplying the bifilar winding the efficiency of separation increases. In the absence of the supply voltage, part of the seeds goes into chamber 2, which can be explained by the jamming of seed fragments between the bifilar winding. The biggest differences in separation efficiency were noticed at the voltage supplying the 500 V bifilar winding.

The next stage of the research was to examine the impact of the moisture content of the fragmented material on the efficiency of separation. Due to the differences in moisture content of the hull and the germ, the humidity of both materials was tested separately. The test results are shown in Figure 4.

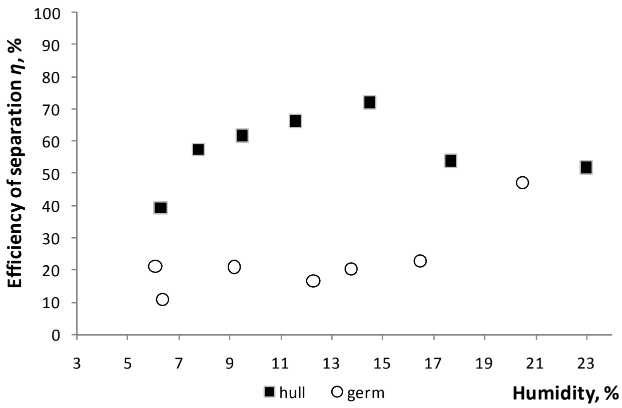

Fig. 4. Efficiency of separation as a function of humidity

The biggest differences in the efficiency of separation of both factions were obtained for humidity in the range of 9-15%. With further increase in humidity, the efficiency differences decrease, which may be due to the higher water content in the crushed fractions and thus similar electrical properties. At low humidity values, differences in efficiency are lower and the field effect on separation efficiency is also lower.

Conclusion

1. It is possible to use an electrostatic field to extract hull from rape seeds.

2. Bifilar voltage winding can be used as a source of non-homogeneous electrostatic field.

3. The value of the voltage supplying the bifilar winding affects the efficiency of separation. The higher its value, the higher the efficiency. The largest differences in the separation efficiency of the hull and the germ were observed at voltages of several hundred volts.

4. Moisture of shredded rape seeds has an effect on the efficiency of separation: the largest differences in efficiency were obtained for material moisture of 9-15%.

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REFERENCES

[1] Kowalski J., Jak pisać tekst do Przeglądu, *Przegląd Elektrotechniczny*, 78, nr 5, (2002), 125-128

[2] Johnson B., Pike G.E., Preparation of Papers for Transactions, *IEEE Trans. Magn.*, 50 No. 5, (2002), 133-137

[1] Rosiak E., Changes on the Polish rapeseed market after the integration with the european union.*Research Papersof Wrocław University of Economics*. No. 402. Wrocław, (2015), 338-347

[2] Kovalyshyn S. J., Shvets O. P., Grundas S.and Tys J.,Use of the electro-separation method for improvement of the utility value of winter rapeseeds. *International agrophysics* 27.4. (2013), 419-424

[3] Główny Urząd Statystyczny.Wynikowy szacunek głównych ziemiopłodów rolnych i ogrodniczych w 2017 r. (2017), Warszawa.

[4] Bojanowska M. and Pabich M.,Oilseed crops in poland and in the world in recent years. *Autobusy: technika, eksploatacja, systemy transportowe,* 13, (2012),159-162.

[5] Boguta A. and Majcher J., Using the physical parameters of rape seeds to assess germination force. *In Electromagnetic Devices and Processes in Environment Protection with Seminar Applications of Superconductors (ELMECO&AoS),* 2017 International Conference on IEEE, (2017), 1-4

[6] Liao Q., Wan X., Li H., Ji M. and Wang H., Design and experiment on cyclone separating cleaning system for rape combine harvester. *Transactions of the Chinese Society of Agricultural Engineering*, 31(14), (2015), 24-31.

[7] Gawrysiak-Witulska M., Siger A.and Rusinek R., Degradation of tocopherols during rapeseed storage in simulated conditions of industrial silos. *International Agrophysics*, 30(1), (2016), 39-45.

[8] Tys J. and Rybacki R., Rapeseed - seed quality. Harvesting, drying and storage processes. *Acta Agrophysica*, 44, (2001), 33-38

[9] Majcher J., 2011. Electrical properties as another criteria of the distribution seeds of mustard from the seeds galium aparine. *Advanced numerical modelling. Electrotechnical Institute*. Warsaw. (2011), 117-118

[10] Kovalyshyn S.and Dadak V., Theoretical studies of the ellipsoidal-shaped particles' behaviourin the channel of pneumo-electric separator bumping into its walls. *ECONTECHMOD: An International Quarterly Journal on Economics of Technology and Modelling Processes*, 5 (2016)

[11] Flynn K., Gupta A. and Hrach F., Electrostatic Separation of Dry Granular Plant Based Food Products (2017).

[12] Kovalyshyn S.and Dadak V. 2018. Investigation of the process of separation of hard-to-divide weeds from seed mixtures of perennial grasses. *In BIO Web of Conferences* (Vol. 10, p. 01010). EDP Sciences, (2018).

[13] Požėlienė A., Lynikienė S., Šapailaitė I.and Sakalauskas A.,Utilization of strong electric field for special cleaning buckwheat seeds. *Agronomy research*, 6, (2008), 291-298.

[14] Majcher J., Sposób i urządzenie do zwiększenia zdolności kiełkowania nasion Nr patentu B1 232596 ; Nr zgłoszenia patentowego A1 424789, *Wiadomości Urzędu Patentowego*, 2, nr 6, (2019), 1643

[15] Kovalyshyn S.and Shvets O.,Study of Extra Cleaning of Rapeseeds in an Electric Frictional Separator. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 66(3), (2018), 677-683.

[16] Minkowski K. Influence of variety and size of winter rapeseed on content and chemical composition of hull and embryo (In Polish).*Rośliny Oleiste-Oilseed Crops*, 21(1), (2000), 157-166

[17] Szwed G. and Majcher J., Wykorzystanie pola elektrostatycznego w separacji rozdrobnionych materiałów roślinnych (In Polish). *Acta Agrophysica* vol. 15. zesz. 2. (2010), 417-427

[18] Majcher J., Wykorzystanie uzwojenia bifilarnego w procesie elektroseparacji rozdrobnionych materiałów pochodzenia roślinnego. *Prace Instytutu Elektrotechniki* (In Polish). *Proceedings of Electrotechnical Institute*. No 247. Warsaw. (2010), 117 – 126

[19] Sumorek A., The influence of construction of bifilar winding on efficiency of electrostatic bifilar deduster. *Przegląd Elektrotechniczny*, 92(7), (2016), 49-52.