RESEARCHES CONCERNING IMPURITIES SEPARATION PROCESS FROM MASS OF CEREAL SEEDS USING VIBRATING SIEVES IN AIR FLOW CURRENTS

Carmen Bracacescu[1], Iuliana Gageanu[1], Simion Popescu[2], Kemal Cagatay Selvi[3]
[1]National Institute of Research-Development for Machines and Installations Designed to Agriculture and Food Industry- INMA, Romania; [2] Transilvania University of Brasov, Romania;
[3]Ondokuz Mayis University, Turkey
carmenbraca@yahoo.com

Abstract. The cleaning processing represents an important link of the process of capitalization of vegetal-origin products and, at the same time, an essential operation of the cereal seed conditioning chain. Taking into account all considerations, the experts′ attention has been drawn by the study of phenomena which influence the process of separating impurities, aiming at a maximum reduction of impurities. The paper presents experimental researches of qualitative indexes of impurities separation out of cereal seed mass for equipment using combined principles of separation (according to specific mass and aerodynamic properties of seeds). The experimental equipment used for the experimental research was composed of a gravity separator and an aspiration installation with a fan. Also, the influence on the separation quality index of the following operating parameters is determined: material flow rate of the shaking separator, air flow of the aspiration installation, work surface tilting, work surface oscillation amplitude. The results obtained during the experimental researches reveal that the working process of the gravity separator is efficient and it achieves high cleaning of wheat for milling.

Keywords: vibrating sieves, cleaning, specific mass, index of separation quality.

Introduction

The cereals used as raw material for milling represent a heterogeneous mass consisting of basic culture grains (which are to be milled) and foreign bodies (impurities). Therefore, before being milled, the grains are subjected to cleaning operations aiming mainly the elimination of foreign bodies from the mass of seeds.

Elimination of the impurities being in the grain mass is carried out by more technological procedures depending on their physico-mechanical characteristics. In this way, a part of impurities are eliminated depending on their size (width, length, thickness), other are separated depending on their lift coefficient [1; 2].

Depending on the principle of separation and the type of impurities a wide range of technical equipment and installations are used for carrying out the separation of impurities (suction separators, winnowers, vibrating separators) [3; 4]. To reduce the number of technical equipment and implicitly of technological spaces, the modern milling units use complex installations carrying out separation by combined principles, the most used is the specific mass difference and aerodynamic properties of various components of seed mixtures [5-7].

The separation of the mixtures after specific mass achieves both the effect of the combined action of one continuous, ascendant air flow having constant pressure that crosses the grain stratum being on wire cloth surface, inclined after two directions (longitudinal and transversal) and of this surface vibration. So, due to simultaneous action of the vibration and the air flow, it obtains the stratification and the imposing of the different trajectories to seeds [8-10].

Literature in recent years attests that equipment with vibrating systems driven by electric motovibrators gives to the vibrating platforms used for separation high yield and low energy consumption [8; 11].

Materials and methods

In the article the installation and the experimental determination research methodology are presented used to determine the qualitative indices of the separation process of impurities from grain seeds in the case of combined separation systems (relative to the specific mass and the aerodynamic properties of seeds). The installation realized according to the scheme in Figure 1, consists of the gravity separator 1 (Figure 2), connected to a suction installation with air composed of the fan 2 and the cyclone 3.

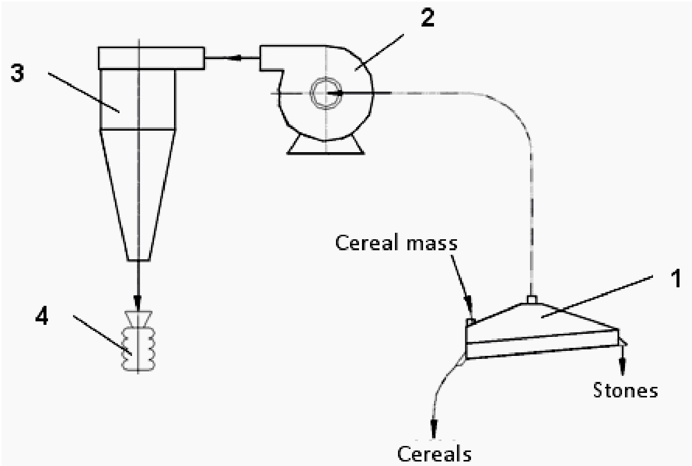

Fig. 1. **Functional scheme of the device for separating impurities:** 1 – gravity separator; 2 – suction fan; 3 – cyclone; 4 – bags for light impurities and dust collection

The main component parts of the gravity separator SP-00 are shown in the constructive scheme in Figure 2.

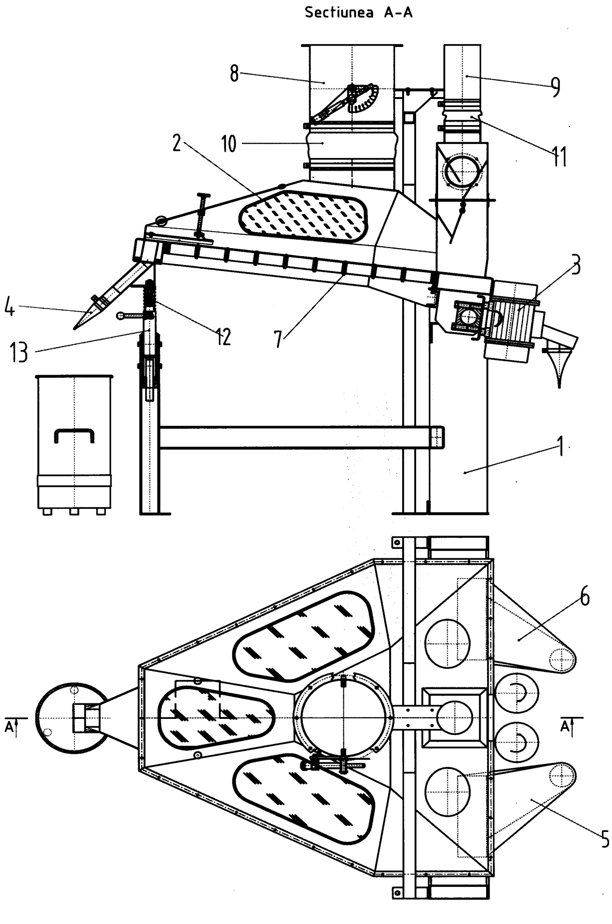

Fig. 2. **Constructive scheme of gravity separator SP–00:** 1 – framework for support; 2 – vibrant housing, 3 – motor–vibrator for the acting platform of the working surface; 4, 10 and 11 – elastic sleeves; 5 and 6 – pipes for exhausting of cleaned product; 7 – working surface from wire fabric; 8 – air–intake pipe; 9 – pipeline for supplying with product; 12 – elastic support system (springs) of the vibrating platform; 13 – screw device for adjusting the angle of inclination of the platform working surface

The separator is a complex structure equipped on the inferior part with operation surface made up from wire cloth and discharging pipes of the product after separation. On the upper part, the case is provided with aspiration and feeding pipes. Each pipe has one clack for regulating the air flow, respectively feeding the product flow. The case is provided with a plastic visor for controlling of the operation process. The inclination angle of the operation surface is continuously regulated (between limits 5…10^0) by means of the screw mechanism that fixes the case against the frame. The amplitude of the oscillatory motion is regulated between limits 1.5...2.5 mm by modification of the position of the motovibrator eccentric masses.

The testing of the experimental model of installation was made at INMA, in accredited laboratory and exploiting conditions, using own experimental methods. The apparatus used at testing: inductive displacement transducer – model W10 (Hottinger company) for measuring the oscillation amplitude of the working surface – nominal (rated) output span ± 1 % tolerance; anemometer 4000-type Testovent - Germany, for measuring the speed of air currents; electronic level with bubble type IncliTronicPlus for measuring the inclination of the work surface, accuracy: 0º and 90º: ± 0.05º from 1º to 89º: ± 0.2º. For amplification and acquisition of the measured data, the MGC plus model module was used.

The material used at the experimental research was wheat (as seeds) obtained from experimental plots cultivated within INMA Bucharest and it has a hectolitrical weight of 78.5 kg·hl^{-1}. This material was first introduced in the intensive vacuum separator, being subjected to the operation of separation by size.

For experimental measurements measurement devices were used and/or registration of the following sizes (parameters): masses of products and impurities in the separation process; inclination angle respect to the horizontal of the working surface of the separator (vibrating sieve); air flow rate of the suction installation by determining the velocity of air currents in the suction pipe; oscillation amplitude of the working surface. The air flow rate from the suction pipe was determined indirectly by calculation measuring the air velocity.

For calculation of the technological effect index by weighing and calculation the following sizes were determined, reported to 1000 kg of wheat processed by the separator: total quantity of impurities separated, kg; the quantity of eliminated stones, kg; the quantity of other impurities eliminated (seeds of other nature including broken, non-eliminated light seeds, soil, etc.), kg; the quantity of lost good seeds, kg.

The coefficient of loss of good seeds C_{ps} is calculated with the relation [12]:

$$C_{ps} = (m/M) \cdot 100\ \%, \tag{1}$$

where m – the good seed mass which are found at the exit from the equipment in the quantity of total impurities eliminated;
M – good seed mass at the entry into the equipment.

The index of the technological effect E_{cs} represents the percentage of foreign bodies (impurities) eliminated from the mass of processed product and is determined with the relation [12]:

$$E_{cs} = \left[\left(C_{csi} - C_{cse}\right)/C_{csi}\right]x100\ \%, \tag{2}$$

where C_{csi} – the content foreign bodies (impurities) at the entrance of the material in the equipment, %
C_{cse} – content foreign bodies (impurities) at evacuation of the material from the equipment, %

The working capacity Q of the gravity separator was determined by calculating with the relation [12]:

$$Q = 3600\frac{m}{t}\ \text{kg·h}^{-1}, \tag{3}$$

where m – the initial material mass (m = 1000 kg);
t – time required for experimental determinations.

The values that resulted from processing the material using the determined parameters are mentioned in Table 1.

Table 1

The results of the tests conducted for determination of the optimal regime of the gravity separator

Working capacity, kg·h^{-1}	Air flow, m^3·min^{-1}	Angle of operation surface, degree	Amplitude of operation Surface, mm	Quantity of impurities separated at 1000 kg of wheat processed, kg
0	1	2	3	4
2000	100	5	1.5	37.6
			2.0	40.2
			2.5	43.4
		7.5	1.5	35.6
			2.0	38.9
			2.5	39.9
		10	1.5	33.3
			2.0	35.4
			2.5	36.7
	125	5	1.5	28.1
			2.0	31.4
			2.5	34.9
		7.5	1.5	26.6
			2.0	27.4
			2.5	29.1
		10	1.5	23.1
			2.0	25.1
			2.5	26.0
	150	5	1.5	21.2
			2.0	23.0
			2.5	24.9
		7.5	1.5	17.8
			2.0	19.8
			2.5	21.6
		10	1.5	17.1
			2.0	18.3
			2.5	19.2

Results and discussion

By processing the obtained experimental data synthetic tables were made with the parameters determined experimentally for options established by the experimental research program. For an intuitive analysis of the influence of various constructive and functional parameters of the combined separation installation on the global technological index values E_{CS} graphics were drawn expressing the following technological dependency of the index values of functional parameters (adjustment) of the separator: the supplying flow rate with product subjected to processing (wheat), the air flow rate of the suction installation, the angle of inclination respect to the horizontal working surface of the separator and the oscillation amplitude of the separator working surface.

Applying the linear regression method at the determined experimental data processing the technological effect function *ET* is obtained, as a function of the supplying flow rate with material (wheat) Q_g (in kg·h^{-1}), flow rate air suction Q_a (m^3·min^{-1}), angle α (in sexagesimal degrees) of inclination of the working surface and the amplitude of oscillation A (in mm), expressed by the relation:

$$ET(Qg, Qa, \alpha, A) = -0.015892Qg - 0.848367Qa - 3.256444\alpha - 2.736111A + 237.645463 \quad (4)$$

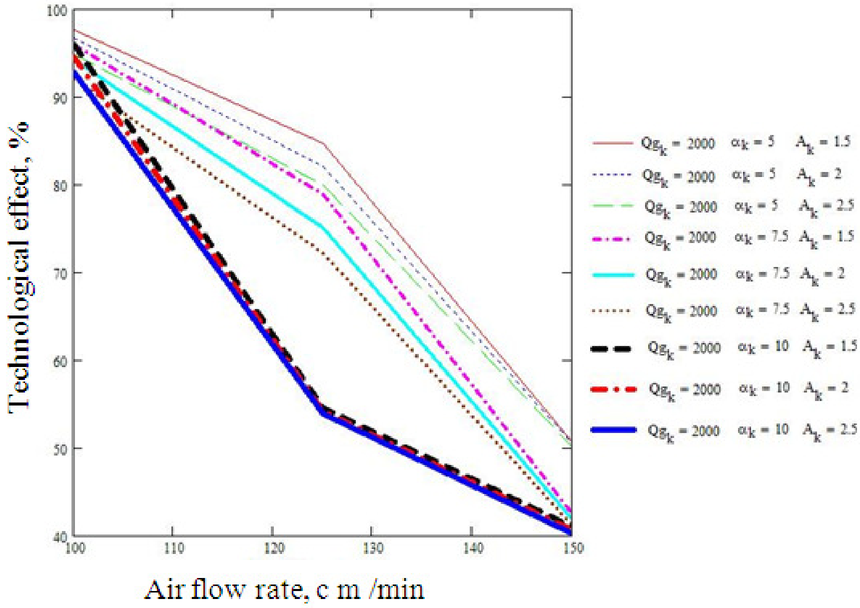

Fig. 3. **Variation of the values of technological effect index E_{CS}, depending on the air flow rate Q_a for supplying the flow rate with material (wheat) Q_g = 2000 kg·h^{-1} for the following adjustment parameters:** inclination angle of the working surface α = 5; 7, 5; 10º, working surface amplitude A = 1.5; 2; 2.5 m

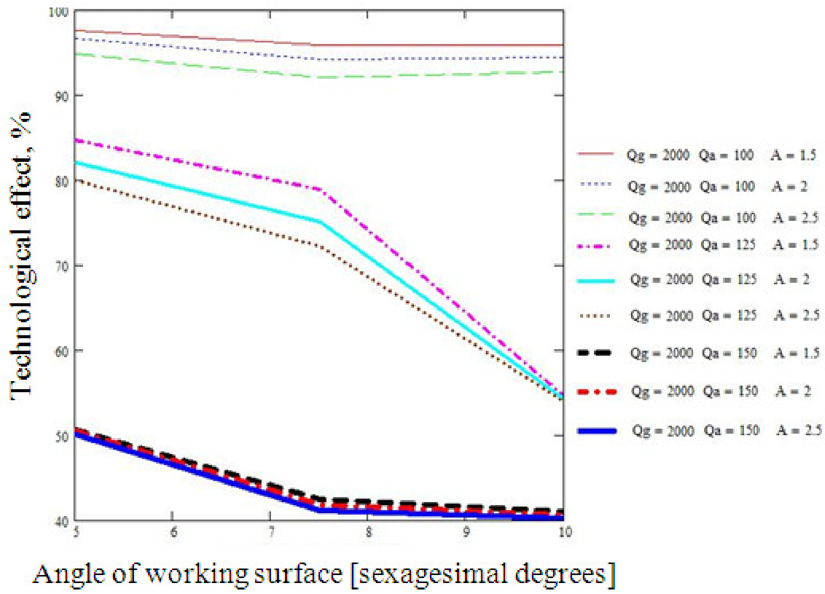

Fig. 4. **Variation of the values of technological effect index E_{CS}, depending on the angle of the working surface α at the supplying flow rate with material Q_g = 2000 kg·h^{-1}, for the following adjustment parameters:** air flow rate Q_a = 100; 125; 125 m^3·min^{-1} and working surface amplitude A = 1.5; 2; 2.5 mm

From the graphical representation in Figure 6 of the formula (4) it results that the index of global technological effect decreases with the increase of the supplying flow rate with material, of the working surface angle, of the working surface amplitude and of the suction air flow rate.

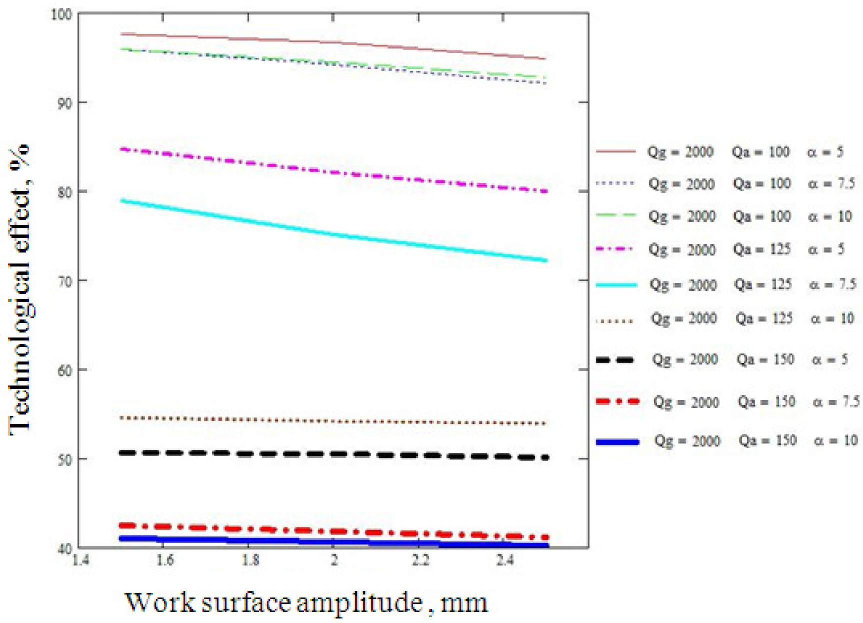

Fig. 5. **Variation of the values of technological effect index, depending on the working surface amplitude *A* for the supplying air flow with material Q_g = 1500 kg·h^{-1} , for the following adjustment parameters:** air flow rate Q_a = 100; 125; 125 m^3·min^{-1} and inclination angle of the working surface α = 5; 7.5; 10º

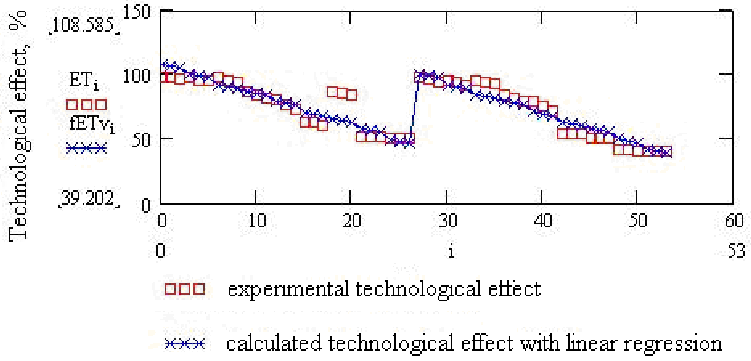

Fig. 6. **Comparison of the experimental data with those obtained by linear regression at determination of the technological effect index**

Conclusions

The experimented working range in the researches on installation showed that the index of the technological working effect had an approximately linear variation with the oscillation amplitude of the working platform surface. Overall, there was a decrease in the technological effect index with increasing of the amplitude of the working surface; although the amount of separated heavy impurities is higher an increase is found in the mass of good seeds eliminated in the mass of impurities.

The technological parameters obtained during the tests depend on the regulation of the operation surface (oscillation amplitude and inclination angle) of aspiration the air flow as well as the wheat feed flow.

The results obtained during the experimental researches reveal that the installation used consisting of the gravity separator model SP-00 and the suction installation model IASP-0 complies with the requirements in terms of destination, of the purpose and functioning mode, of the possibilities for adjustment and servicing, working having a working capacity suitable for technological flows from milling units.

The gravity separator designed and achieved is of a rugged construction, operates non-vibrantly and allows easy adjustment. The working process is efficient and achieves high cleaning of wheat for milling.

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