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EXPERIMENTAL RESEARCH REGARDING THE WORK PROCESS OPTIMIZATION OF THE GRAIN CYLINDER SEPARATOR REGARDING ITS ROTATION SPEED

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Abstract: *In this article we present the results of the experimental research regarding the work regime optimization of the grain cylinder separators, with regard to its rotation speed. The researched elements were the energetic consumption, technological effect and the percent of the good grain beans lost in sub products. The experimental researches were made on an adapted technical stand correspondingly equipped and on a normal cylinder separator type TCU-5, existing in INMA - Bucharest laboratory, based on a program judiciously prepared and rigorously transposed into practice. The apparatus that we used was state-of-the-art, therefore the obtained results have the necessary credibility.*

Key words: *cylinder separator, conditioning, grain, optimization.*

1. Introduction

The optimal functioning of the cylinder separators for grain been conditioning can be defined and approached from many points of view. In general, through optimal functioning, we understand the functioning in a work regime characterized by a combination of parameters which produces the extremization (minimization and maximization) of a characteristic functioning parameter, with a role of measurement for the work process. The functioning optimum is defined in a strict sense (intrinsic) - if the extreme point exists strictly inside the interval and has improper sense or if it is located on the parameters work domain border [1], [5].

Finding some eventual optimal points (combinations) in the cylinder separators functioning depends on the set of considered parameters, on their variation intervals and, first and foremost, on the definition of the objective function which must be extremized (minimized or maximized in conformity to the physical sense) [2].

For cylinder separators the following objective functions can be singled out:

- the *finite product quality*, expressed through technological effect or by the impurity quantity in the finite product and the *general quality of the separation process*, which includes, in comparison to the previous one, two additional characteristics as well as the percent of good grain beans remaining in sub products, and also their

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eventual combinations which minimize/ maximize simultaneously two of the above mentioned quality characteristics;

- the general quality of the process, respectively the finite product quality reported to energetic consumptions; such an object function being the energetic consumption reported to the quality unit of the finite product; energetic consumptions;
- working capacity etc.

Between some of the process parameters there are not and there can't ever be any established theoretical mathematical relations, a reason for which in these cases we speak about a theoretical - empiric study in which the experimental researches have a central role [3]. For example, the main performance characteristic of a cylinder separator, respectively the technological effect, can not be deduced theoretically, a situation in which emerge other performance characteristics such as: the percent of good grain beans remained in sub products, the quantity of small foreign bodies out of the machine etc. [4].

2. Material and Method

The main objective of the experimental researches was a lot of common grain (triticum aestivum), Dropia variety, with the following physical - mechanical characteristics (determined in laboratory):

- humidity: 12.40%;
- mass per storage volume: 73.66 Kg/hL;
- mass of 1000 grain beans: 46.12 g;
- impurity percent: 1.40% from which:
  - black foreign corps: 0.52%;
  - white foreign corps: 0.88%;
- broken grain beans: 0.32%;
- quaggy grain beans: 0.14%;
- undeveloped grain beans: 0.42%.

Also, during the experimental researches two technical equipments were used: one adapted stand for investigation of the cylinder separator working process (Figure 1) and the universal cylinder separator type TCU-5 (Figure 2), existing in the INMA Bucharest laboratory.

Fig. 1. *Adapted stand for investigation of the cylinder separators working process*

Fig. 2. *Universal cylinder separator type TCU-5* (http://www.instirig.ro)

The technical stand (Figure 1) is composed of the proper cylinder separator and the electrical control panel. The cylinder separator has a diameter of 250 mm, a length of 500 mm and contains "pocket" type alveoli with diameters of 5.6 mm. Inside the cylinder a chamfer is placed to collect impurities and broken grain beans from the base agriculture culture or from other types of agricultural cultures. The clean product and eliminated impurities have different transit circuits.

In order to check some hypotheses, during the experimental researches, the universal cylinder separator type TCU-5

(Figure 2), design at INMA Bucharest and manufactured at S.C. INSTRIRIG S.A Bals was also used.

The cylinder of this separator has a diameter of 630 mm, an active length of 2440 mm and contains “pocket” type alveoli with diameters of 5.25 mm.

For the experimental researches many modern equipment such as the SHIMADZU AW 220 analytical balance, the Memert stove, the EXTECH digital tachometer, a high precision mechanical chronometer, a Toshiba Tecra notebook, a Phantom V10 high speed video camera, specific software etc. was used.

To conduct the experimental research, the general procedure presented in Figure 3 was devised and followed.

In conformity to the experimental research procedure, probes for 7 different values of the cylinder separator speed rotation were made. The speed rotation values were fixed so that they cover a large interval of values for the indices of cylinder separator cinematic regime. These 7 values of the speed rotation were: 20, 25, 30, 35, 40, 45 and 47 rot/min, the last of it is the maximal constructive speed rotation of the separator included in the stand used for investigating the work process of the cylindrical separators. For each

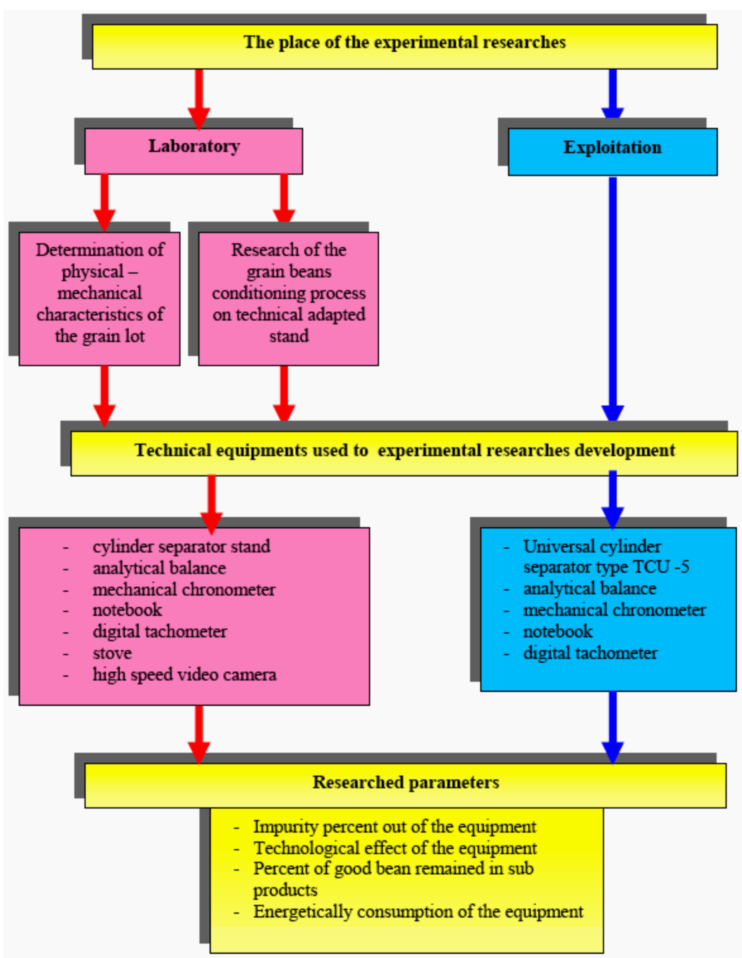

Fig. 3. *General procedure for experimental research covered in the paper*

precise speed rotation, adjustments of the inclination angle of impurity collection chamfer were made, in such a way as to include in the adjustment limits, all important considered positions in terms of separator exploitation. These positions of the chamfer permit the investigation of the separator functioning not only on optimal adjustment position but also in positions that are considered unfavorable, which have a smaller technological effect and bigger quantities of good grain beans remained in impurities.

The constant parameter in the cylinder separator functioning process was the cylinder radius, with the value of $R = 0.125$ m.

The cinematic regime was determined with formula: $k = \frac{R \cdot \omega^2}{g}$ and varies between 0.056...0.309, where ω is the angular speed of cylinder and g the gravitation acceleration.

For each of the combinations (n, α) possible in the considered intervals the following parameters were measured: time (t) necessary for cleaning inside the separator, a probe of 100 g, expressed in [s], voltage at the electrical motor terminals (U), expressed in [V] and the intensity of the absorbed electrical energy by the engine from the electrical network (I), expressed in [A]. Based on the power factor known for the existing electrical motor, cos φ = 0.74, the electrical power and then the electrical energy consumed for processing each grain probe was calculated using the relations: $P = \sqrt{3} \cdot U \cdot I \cdot \cos\varphi$ and $W = P \cdot t$. Based on these data and after analyzing the composition of each grain probe were, the quality indicators of the separation process according to length were calculated, namely:

- the percent of small foreign bodies out of the equipment C_{sme} [%];
- the technological effect of the equipment $E_{csm} = [(C_{smi} - C_{sme})/C_{smi}] \cdot 100$ [%];
- the percent of good grain beans remaining in sub products $C_{ps} = (\Sigma mk / M) \cdot 100$ [%],

where: C_{smi} represents the percent of small foreign bodies inside the equipments, in %; mk - mass of good grain beans lost in impurities, in g; M - mass of good grain beans remaining in the initial probe, in g ($100\text{ g} - \frac{1.4}{100} \cdot 100\text{ g} = 98.6$ g).

3. Results and Discussions

The measured results, with processed data are presented in Table 1 (partially).

The optimization of some quality parameters of the cylinder separator working process is made with experimental data obtained from the technical adapted stand, combined with the interpolation results using the least - square method. Experimental results were used because they contain information regarding the energetic consumption, the technological effect and the percent of good grain beans remaining in sub products. If the first two indicators admitted a theoretical expression, the third parameter respectively the percent of good grain beans remaining in sub products, does not admit, in the limits of the actual theoretical models, a satisfying description. Even in terms of energetic consumption, the purely theoretical estimation is affected by errors of measurement precision and of the randomness of the process.

In Figure 4 is presented the variation of the technological effect depending on the cylinder separator rotation speed is presented, with x representing the experimental data and with a continuous line, the second degree function which interpolates data, having the expression:

$$E_{csm}(n) = 0.0099\, n^2 - 1.0134\, n + 99.061, \quad (1)$$

in which E_{csm} is the technological effect and n the speed rotation, in rot/min. Is observed that the technological effect

Table 1

Processed experimental data for grain conditioning on technical stand for different inclining angles γ for collecting chamfer

***n*, [rot/min]**	**γ[°] (α = 46° – γ)**	**Percent of small foreign bodies inside the equipment C_{smi} [%]**	**Percent of small foreign bodies outside the equipment C_{sme} [%]**	**Technological effect of the equipment $E_{csm} = [(C_{smi} - C_{sme})/C_{smi}] \cdot 100$ [%]**	**Percent of good grain beans remaining in sub products $C_{ps} = (\Sigma mk / M) \cdot 100$ [%]**	**Consumed electrical energy, $W \cdot 10^{-3}$ [kWh]**
47	50	1.40	0.38	72.85	8.11	9.62
	45		0.51	63.57	8.97	8.81
	40		0.58	58.57	5.55	9.22
	35		0.54	61.42	4.41	9.37
	30		0.49	65.00	2.91	9.63
	25		0.46	67.14	1.62	10.50
	20		0.45	67.85	0.92	10.57
	15		0.42	70.00	0.43	11.14
	10		0.62	55.71	0.24	10.30
	5		0.67	52.14	0.10	9.29
	0		0.50	64.28	0.27	9.83
	-5		0.35	75.00	0.09	9.43
	-10		0.49	65.00	0.14	10.24
	-15		0.35	75.00	0.06	9.91
	-20		0.33	76.42	0	11.27
	-25		0.80	42.85	0	10.44
	-30		0.83	40.71	0	11.55
	…		…	…	…	…

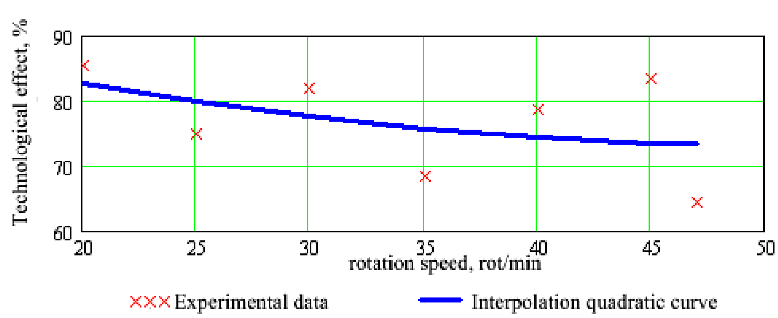

Fig. 4. *Variation of technological effect depending on the cylinder separator speed rotation*

decreases as the rotation speed increases and in the limits of the work parameters' intervals of the cylinder separator with which these results were obtained, the maximization (optimization) is produced in the left extreme (inferior) of the speed rotation interval, respectively to the minimum considered speed rotation. This is a normal result which validates the results of the experimental research.

Afterwards, eventual optimal points were searched through the minimization of the energetic consumption specific to the technological effect unit. The ratio variation between the energetic consumption and the technological effect (specific consumed energy for a quality percent), is presented in Figure 5, and in the variant resulted from the experimental researches (*x* points) and through the interpolation quadratic curve, given by formula (2):

$$E / E_{csm}(n) = -0.000046404\, n^2 + 0.0014\, n + 0.1845. \quad (2)$$

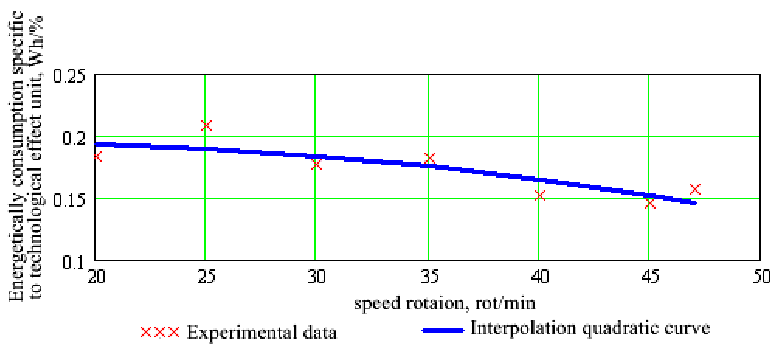

Fig. 5. *Variation of energetic consumption specific to technological effect unit depending on the cylinder separator's speed rotation*

It is observed that the energetic consumption specific to technological effect unit doesn't present optimal points in a strict sense either. As the main goal is to minimize this ratio, the calculus indicates toward the right extreme of the variation interval of the cylinder separator rotation speed, respectively to a maximum, but limited by the cinematic condition, which imposes a subunit value for the cinematic indices.

The search for other possible optimal points can be continued with the other important quality factor, respectively the percent of good grain beans remaining in sub products, which must be minimized. The variation of this quality parameter with the cylinder separator rotation speed appears in Figure 6, in the variant resulted from the experimental researches (*x* points) and the interpolation quadratic curve, given by formula (3):

$$C_{psm}(n) = 0.009\, n^2 - 0.4832\, n + 7.3431. \quad (3)$$

It is observed that on the interpolation quadratic curve, a minimum own point appears at a speed rotation of 26.853 rot/min.

To combine the quality effects and to obtain one optimal point which can simultaneous satisfy the technological effect (its maximization) and the percent of good grain beans remaining in sub products (its minimization), we studied the ratio variation between these two parameters, for which a maximum point is desired and obtained as shown in Figure 7 in which the variation curve of this ratio depending on the cylinder separator speed rotation is presented. The optimal point for this quality parameter of the finite product is situated around the 27 rot/min value.

If we compare the energetic consumption to the technological effect according to the percent of good grain beans remaining in sub products, we obtain an optimal point, which minimizes the energetic consumption for a satisfying quality at a speed rotation of around 27 rot/min, as it is presented in Figure 8.

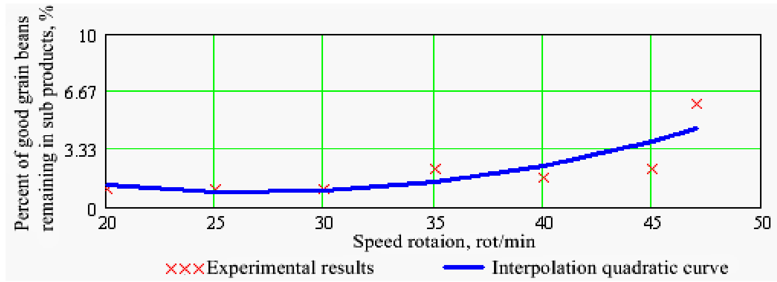

Fig. 6. *Percent variation of good grain beans remaining in sub products depending to cylinder separator speed rotation*

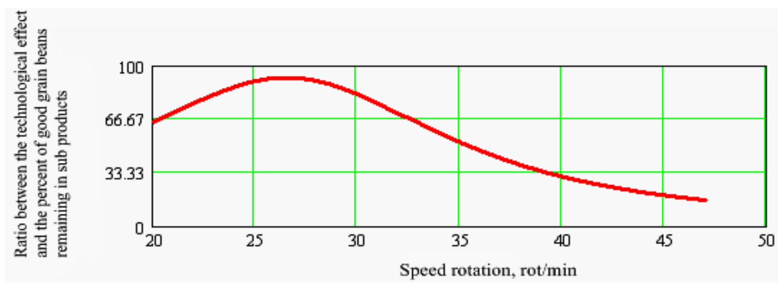

Fig. 7. *Ratio variation between technological effect and the percent of good grain beans remaining in sub products depending to the cylinder separator speed rotation*

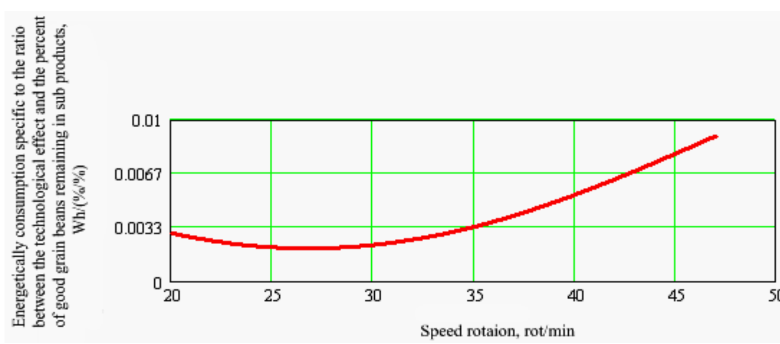

Fig. 8. *Variation of energetic consumption specific to the ratio between the technological effect and the percent of good grain beans remaining in sub products depending on the cylinder separator speed rotation*

4. Conclusions

1. The technological effect decreases as the rotation speed increases and in the limits of the work parameters' intervals of the cylinder separator with which these results were obtained. The maximization (optimization) is produced in the left extreme (inferior) of the speed rotation interval, respectively to the minimum considered speed rotation. This is a normal result which validates the results of the experimental research.

2. The variation of the percent of good grain beans remaining in sub products with the cylinder separator rotation speed, in the variant resulted from the experimental

researches and the interpolation quadratic curve, has a minimum own point, at a speed rotation of 26.853 rot/min.

3. To combine the quality effects and to obtain one optimal point which can simultaneous satisfy the technological effect (its maximization) and the percent of good grain beans remaining in sub products (its minimization), we studied the ratio variation between these two parameters, for which a maximum point, situated around 27 rot/min, was aimed at and obtained.

4. If we compare the energetic consumption to the technological effect on the percent of good grain beans remaining in sub products, we obtain an optimal point which minimizes the energetic consumption for a satisfying quality, at a speed rotation of around 27 rot/min.

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