CONSIDERATIONS ON THE TECHNICAL EQUIPMENT USED FOR SEPARATING SEED MIXTURES BASED ON THE AERODYNAMIC PRINCIPLE
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CONSIDERATII PRIVIND ECHIPAMENTELE TEHNICE UTILIZATE LA SEPARAREA AMESTECURILOR DE SEMINTE PE PRINCIPIUL AERODINAMIC

PhD. Eng. Brăcăcescu C, PhD. Eng. Găgeanu P., PhD. Eng. Sorică C., PhD. Stud. Eng. Zaica A., PhD. Stud. Sorică E., Eng. Bunduchi G.
INMA Bucharest/ Romania
E-mail: *carmenbraca@yahoo.com*

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ABSTRACT
Cereal seeds pre-cleaning and cleaning, prior to their storage or processing is a complex technological process that includes a multitude of constructive types for technical equipment designed to separate and remove existing impurities in the seed mass, which are based on various separation principles. The paper presents some theoretical aspects regarding the separation of seed mixtures based on the aerodynamic principle, which were the basis for the development of an innovative technology to obtain the seed material for the efficient establishment of agricultural cultures and the design of a new type of aeration cleaning separator SCA for seed mixtures cleaning and sorting. At the end of the paper, we present the advantages of using this equipment in the process of pre-cleaning/cleaning cereal seeds and industrial plants.

REZUMAT
Precurăţirea şi curăţirea seminţelor de cereale înaintea depozitării sau procesării lor reprezintă un proces tehnologic complex, care include o multitudine de tipuri constructive de echipamente tehnice proiectate pentru separarea şi îndepărtarea impurităţilor existente în masa de seminţe. echipamente care au la bază diverse principii de separare. Lucrarea prezintă câteva aspecte teoretice privind separarea amestecurilor de seminte pe principiul aerodinamic. aspecte care au stat la baza elaborării unei tehnologii inovative de obţinere a materialului semincer pentru înfiinţarea eficientă a culturilor agricole şi conceperii unui nou tip de separator curatitor prin aerare SCA. destinat curăţirii şi sortării amestecurilor de seminţe. La finalul lucrării sunt prezentate avantajele utilizării acestui echipament în procesul de precurăţire/curăţire a seminţelor de cereale şi plante tehnice.

INTRODUCTION
Primary processing is an important link to the process of capitalizing plant origin products and is a primary operation of the conditioning chain. This is primarily based on removing foreign bodies from the product mass, providing optimal processing dimensions, preventing or limiting chemical or biochemical processes during storage, leading to deterioration in quality and even the alteration of plant material. (Costin I. 1999. Danciu I. 2001).

Taking into account these considerations, the attention of the specialized researches (in Barsky E. Barsky M. 2004; Didyh V.F. 2002. Geankoplis Chr.2003) focused on the study of the phenomena that influence the process of separating the impurities, the aim being to minimize the impurities that reach the final processing stages of cereals.

Also, primary grain processing operations play a particularly important role in preparing the product for various future uses because:

- the percentage of impurities, seeds of some other crops, or pieces of the basic crop seeds contained in the mass of agricultural products harvested with the combine, reaches fairly high values;
- the processes of increasing the purity of agricultural products differ according to their nature and the destination they receive after harvesting (conservation, consumption, industrialization, marketing, sowing, etc.);
- these operations aim at eliminating impurities of any nature, creating better storage conditions and reducing the volume of transport and storage [2. 4. 8. 11. 14].

In order to obtain the maximum quality with minimum energy and labour consumption it is necessary a thorough knowledge of the technology used, the functioning of the technical equipment specific to the technology as well as the regulation of the technical and functional parameters of this equipment (see Căsăndroiu T. 1993. Rus Fl. 2001).

The paper presents several reference theoretical aspects regarding the separation of seed mixtures based on the aerodynamic principle, aspects that were underpinnings of elaborating an innovative technology to obtain seed material for the efficient establishment of agricultural cultures and designing a new type of aeration a world-class performant cleaning separator SCA 5 destined to cleaning and sorting seed mixtures.

MATERIALS AND METHODS

Impurities in the seed mass are different from the main crop seeds (grain seeds or industrial plants) in terms of aerodynamic properties. These aerodynamic properties take into account the different movement resistances of seeds in an air stream.

In order to carry out the aerodynamic separation process of a mixture of solid particles (seeds in particular), we must take into account a number of factors which have a major impact on the way of its development, among which [1.10. 12.15]:

- the properties of solid particles subjected to aerodynamic separation;
- the properties of the air stream, respectively: the direction of the air stream and the flow regime;
- the way of making the biphasic gas-solid (G-S) mixture.

The resistance of the seed mass layer to the passage of air or gas is a property of particular interest in aeration, gas, drying processes.

The total resistance of the granular material layer to the passage of air or gas is calculated with the relation:

$$R = A \cdot h \cdot W^n \text{. mmH}_2\text{O} \quad (1)$$

where: *h* - the thickness of the material layer, in m;

W - the conventional air or gas velocity relative to the entire section of the seed laye,. in m/s;

A. n - coefficients determined experimentally according to the characteristics of the seeds (Table 1)

Table 1

The values of coefficients A and n for the main cereals [5]

No.	Cereal	Seed diameter, mm	Coefficients value		Observations
			A	***n***	
1	wheat	3.48	1.43	1.41	Layer thickness varied between 0.05 and 0.5 m
2	maize	7.37	1.55	0.67	
3	rye	3.82	1.41	1.76	
4	barley	3.50	1.53	1.44	
5	rice	3.73	1.41	1.76	

Table 2 shows the resistance of 0.01 m seed layer for different air velocities and different cereals.

Table 2

Resistance values of 0.01 m seed layer for different cereals

No.	Cereal	Coefficients value		Seed layer resistance R. mmH₂O					
		A	***n***						
1	wheat	1.41	1.43	0.52	1.41	2.53	3.81	5.23	14.1
2	maize	0.67	1.53	0.19	0.55	1.04	1.62	2.28	6.7
3	rye	1.76	1.41	0.68	1.81	3.22	4.84	6.62	17.6
4	barley	1.44	1.43	0.53	1.44	2.58	3.89	5.35	14.4
5	rice	1.76	1.41	0.68	1.81	3.22	4.84	6.62	17.6

At its turn, the seed floating capacity is defined by the air velocity for which the seeds in a vertical duct are in a steady state (floating) and is particularly important for the separation based on the difference in aerodynamic properties, for aspiration calculation, etc.

Table 3 shows the floating velocity of the main cereals at the temperature t=20°C.

Table 3

Floating velocity values of different cereals [6.10]

No.	Cereal	Floating velocity. m/s. determined at 20°C
1	wheat	8.5...10.5
2	maize	12.5...14.0
3	rye	8.5...10.0
4	barley	8.5...10.5

Floating velocity at temperature t ≠ 20°C is re-calculated using the relation:

$$W_t = W_{20} \cdot \sqrt{\frac{\rho_{20}}{\rho_t}} \qquad (2)$$

where: W_t is the floating velocity at temperature t, in m/s;
W_{20}- the floating velocity at temperature 20°C, in m/s;
ρ_{20}. ρ_t- air density at 20°C and t°C in kg/m^3

The floating velocity depends on the specific mass, surface condition, shape and geometric dimensions of the particles forming the components of the seed mixture.

Table 4 shows the aerodynamic characteristics of different cereals.

Table 4

Aerodynamic characteristics of different cereals

Product	Aerodynamic characteristics		
	Specific mass. g / cm^3	Aerodynamic drag coefficient	Floating velocity. m / s
Wheat	1.3 – 1.4	0.18 – 0.26	8.1 – 12.3
Rye	1.2 – 1.5	0.16 – 0.22	8.3 – 9.9
Barley	1.2 – 1.4	0.19 – 0.27	8.4 – 10.7
Rice	1.1 – 1.2	0.19 – 0.26	8.0 – 10.8
Maize	1.2 – 1.5	0.16 – 0.24	12.5 – 14.0
Millet	1.1 – 1.2	0.04 – 0.07	9.8 – 11.8

The air flow(m^3/s) for processing a mixture with a mass flow rate of 1 kg/s depends on the nature of the product and the purpose of the work being carried out.

For preliminary cleaning, the air flow can be determined with the relation:

$$Q_{ap} = k_u \cdot S_{cp} \cdot v_{a1} \qquad (3)$$

while for sorting, it is determined with the relation:

$$Q_{as} = k_u \cdot S_{cs} \cdot v_{a2} \qquad (4)$$

where: k_u is a uniformity coefficient of the air stream on the sieve (k_u=0.65);
v_{a1} and v_{a2} – air stream velocities in the two cases;
S_{cp} and S_{cs}- sections of channels for the transport of separated fractions that are determined by relations:

$$S_{cp} = \frac{Q \cdot (100 - q_{cp})}{100 \cdot q_s} \qquad (5)$$

$$S_{cs} = \frac{Q \cdot (100 - q_{cp} - q_{cs})}{100 \cdot q_s} \qquad (6)$$

where: Q is the feed flow rate of the installation;
q_{cp} and q_{cs}- flow rates of the fractions that must be removed;
q_s- product specific feed rate for an installation that is supplied with an air flow rate of 1 m^3/s.

The total air flow rate (m^3/s) required by an aeration cleaning separator can be determined by the relation:

$$Q_a = \sum_{i=1}^{n} Q_{si} + \sum_{i=1}^{n} Q_{ti} \qquad (7)$$

where: Q_{si} is the air flow rate required for separation in step i (for an installation with n separation steps);
Q_{ti}- the air flow rate required to transport the product from step i to the next step.

The total pressure losses h of the aerodynamic separation unit are determined with the relation [13]:

$$h = h_t + \sum_{i-1}^{n} h_{li} = \frac{\gamma_a}{2 \cdot g} \cdot v_a^2 \cdot (\lambda \cdot \frac{l}{d_i} + \sum_{i=1}^{n} \xi_i \qquad (8)$$

where: h_t is the loss of pressure during air transport from the source to the separator;

h_{li} - local pressure losses;

ξ - the coefficient of local resistances;

λ - loss coefficient;

v_a - air velocity in the channel;

l - channel length;

d_i - inner diameter of the circular channel.

If the channel has a section form other than circular, we consider an equivalent diameter d_e. which for rectangular channels is determined with the relation: $d_e = \frac{2 \cdot a \cdot b}{a+b}$ (where *a* and *b* are the dimensions of the rectangular channel section).

The air streamworking velocities are chosen according to the aerodynamic characteristics of the mixture components, respectively the critical floating velocity of these components (Table 3).

The determination of the total air flow Q_a (m^3/s) required for the separation and transport of a particle mixture depends on the specific feed rate q_s. (kg/s) and the static pressure losses in the installation air ducts.

Experimental data show that admissible loads can be considered those presented in Table 5.

Table 5

Admissible load q_a (kg/sm^2) for different types of cereal seeds [6.10]

Type	**Admissible load q_a. kg/sm^2**	
	Pre-cleaning duct	**Sorting duct**
Wheat	3.5...4.0	1.8...2.0
Rye	3.5...4.0	1.8...2.0
Oat	2.5...3.0	1.3...1.5
Barley	2.5...3.0	1.3...1.5

The working capacity of a separation equipment takes into account the volume of material separated in a given period of time, under the conditions of a directed medium feed flow rate and a use coefficient of the calculated working time (e.g. k_t = 0.7).

RESULTS

The proposed aeration cleaning separator SCA 5 (figure1) designed by INMA is intended for seed cleaning and removal of all impurities (weed seeds, broken grains, plant debris, soil, dust, etc.) of the main product mass in order to be as pure as possible and for seed sorting, namely the division of the main product into several categories according to well-defined criteria (dimensions, weight, shape).

Technical characteristics of SCA 5:

Processing capacity. kg/h:

- pre-cleaning	5,000
- cleaning (selection)	2,500
Air flow ratefan I, m^3/min.	150
Aspiration air flow rate fanII, m^3/min.	120
Installed power, kW	depending on the fan used
Overall dimensions:	
- length (with dust decanting cyclone), mm:	
- without cyclones battery	4,100
- with cyclones battery	5,350
- width, mm	1,300
- height, (with cyclones battery). mm	3,650
Weight, kg	
- with cyclones battery	500

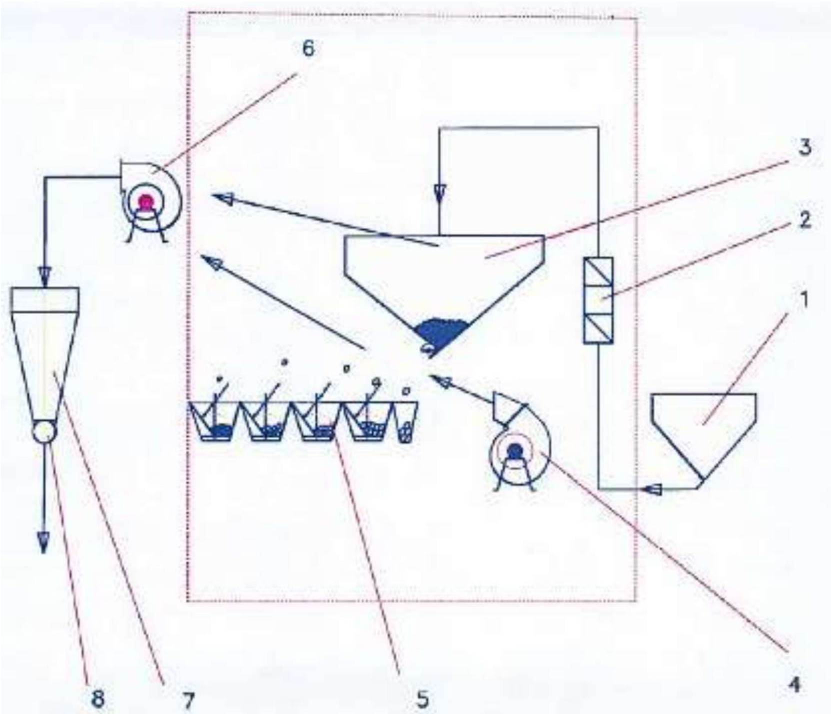

Fig.1 - Technological flow scheme of the aeration cleaning separator SCA 5

1- supply funnel; 2-conveyor; 3- intermediary funnel; 4-radial-axial fan I; 5-collecting funnel; 6- radial-axial fan II; 7-cyclones battery; 8-lock

The product is inserted into the hopper and from there it is taken up by the conveyor buckets, it is raised to the upper part of the machine and inserted into the levelling chamber.

By free fall the product falls into the separating chamber where it meets the air that has been discharged by the radial-axial fan I. The chaff, the dust and light impurities are guided by the air flow provided by the fan II to the impurities collecting cyclones battery, and the seeds, depending on their specific weight, are thrown into the outlets: the lightest in the farthest outlets and the heaviest in the nearby ones. The working capacity is adjusted according to the purpose for which the machine is used: pre-cleaning or cleaning.

The aerodynamic separation takes place in a differentiated way, depending on the particle mass, the air pressure and the flow direction. Dust removal is justified by the fact that it impurifies the raw materials, making them unfit for processing and consumption, as well as due to the premature wear of the transport and processing equipment, by its abrasive action.

The equipment allows for the best possible preparation of seeds for use as seed material, consumed or stored, at the level of European standards in the field, observing the ecological requirements.

CONCLUSIONS

Based on the difference in aerodynamic attributes, the components of the cereal seed and industrial plant mass can be separated by entraining them in an air stream.

The aeration cleaning separator SCA 5 has the ability to clean and sort seeds according to the specific weight in a single working cycle, respectively, separating into distinct fractions by a single passage of the raw material through the machine. The separator can process all seed classes, irrespective of culture (cereal, legume, perennial herbs, medicinal plant seeds and other cultures such as beet, sunflowerseeds). Also, the machine can clean and sort the groats and their products. The execution of the above-mentioned operations ensures obtaining seeds, which will present differentiated qualities for sowing (if seed lots are processed), for proper storage and for a different valorisation depending on the quality indices of the fraction.

The introduction to manufacturing of the Aeration cleaning separator SCA 5 does not require special facilities, the economic agents specialized in the execution of this type of technical equipment having the technical facilities needed to assimilate it.

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