AMERICAN Journal of Engineering, Mechanics and Architecture
Volume 2, Issue 4, 2024 ISSN (E): 2993-2637

Effective Methods of Aspiration System and Development of Energy-Saving Constructions of Separation Devices

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Abstract: In this article, scientific researches were carried out on the preparation of plant seeds for processing, improvement of existing devices that meet the current requirements, creation of aspiration and separation processes and devices for the size and mass of seeds, creation of devices with low energy consumption.

Keywords: seed, raw materials, aspiration, separation, resource saving, modernization, diversification, energy, soy, oil.

Modern research methods of the aspiration system and methods of experiment planning are considered for cleaning soybean seeds in a combined separator and dividing them into fractions according to their mass. Soybean seeds grown in local conditions were taken as the object. Computer modeling of the technological process in the SolidWorks program and methods of planning a full factorial experiment were used in the article. The scientific novelty of the research is as follows :A method of calculating the movement of air flow during the movement of plant seeds along the surface of the aspiration device shelves was developed; A computer model of the aspiration device was developed in the SolidWorks system; The critical speed of air movement, product consumption, the angle of inclination of the perforated walls were determined and scientifically based; The rational mode of the process of separating soybean seeds into fractions determined and based; The combined aspiration-separator device was improved in cleaning soybean seeds from other impurities and separating them into fractions according to their mass.

The practical results of the research are as follows: the aspiration system of the combined separator device for the separation and fractionation of leguminous and spiked grains has been improved; Based on the conducted scientific research, soybean seeds are cleaned up to 98.3% without mechanical damage in the proposed combined separator device based on the conducted scientific research; The proposed cleaning and on the basis of structural solutions of the fractionation device, the energy consumption was reduced by 2 times; the optimal consumption of air flow was determined for separating soybean grain from light mixtures in the cleaning chamber of the proposed combinatorial separator device.

The reliability of the research results is based on the fact that modern high-precision instruments, electronic scales were used during the experiments, the theoretical and experimental results were processed using modern computer programs MATLAB 6.5, Microsoft Excel, SolidWorks, and mathematical and computer models adequate to the real process were developed.

Scientific and practical significance of research results. The scientific significance of the research results is explained by the determination of the optimal values of the air flow in the aspiration system and the optimal values of the location of the mesh barriers in the fractionation device in the process of cleaning soybean seeds from various impurities based on the conducted scientific research and analysis.

The practical importance of the research is explained by the determination of the optimal values of the air flow system in the aspiration system of the combined separator for cleaning and separating the seeds into fractions by mass, and the rational modes of the deviation angles of the mesh racks in the working zone of the proposed device.

The current state of the aspiration system for cleaning seeds and grain, physical-mechanical and biochemical properties of seeds (grain) of localized soybean varieties were analyzed. The efficiency of modern equipment for fractionation and separation of seeds (grain) of leguminous and grain plants, the main factors affecting the technological performance of these equipments have been identified. The degree of purification of soybean seeds from impurities was analyzed by the aspiration method.

In order to study the working parameters of the air system of the combined separator, a three-dimensional model was created using SolidWorks software. The width of the model was assumed to be V=0.1 m. Then, the aerodynamic analysis of the obtained model was recalculated in the Flow Simulation package. Figure 1 shows a computer model of an aspiration device for studying the aspiration process of soybean seeds.

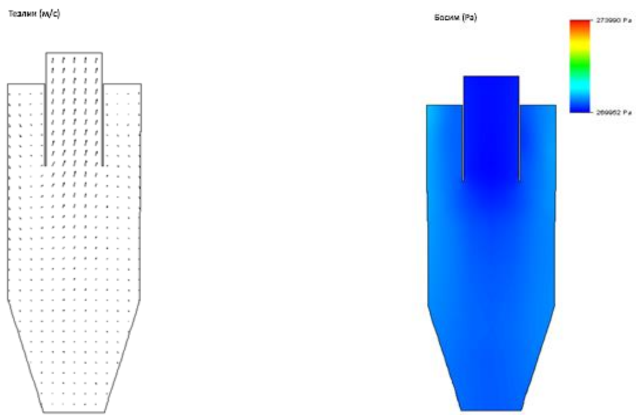

Figure 1. A computer model of the soybean purification process

In order to study the movement trajectory of the air flow inside the aspiration system and compare it with experimental data, a sketch of the movement of particles in the frontal plane of the model was made, which shows the trajectory of the air flow from the inlet section to the outlet section.

The initial parameters for modeling the process of aspiration and fractionation of soybean seeds were taken as absolute pressure R=101370 Pa and circulating air volume Q=0.006 m3/s taking into account gravity in the closed system of the operating mode (Fig. 4).

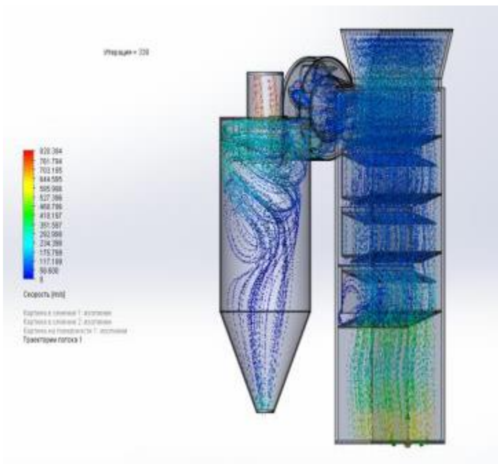

Figure 2. Three-dimensional model of soybean seed aspiration and fractionation process

Figures 1 and 2 show the total pressure distribution area in the closed air system, Figure 3 shows the static pressure distribution area in the closed air system, and Figure 4 shows the air flow trajectories. The color of the lines shows the dynamics of the parameter value change.

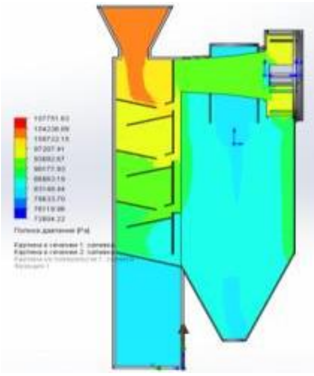

Figure 3. Total pressure distribution area in closed air system

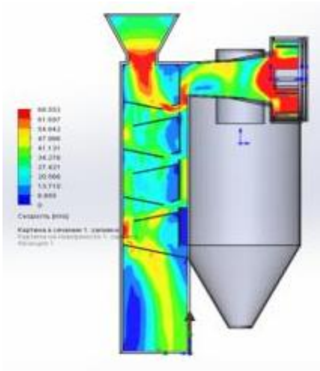

Figure 4. Air velocity distribution area in closed air system

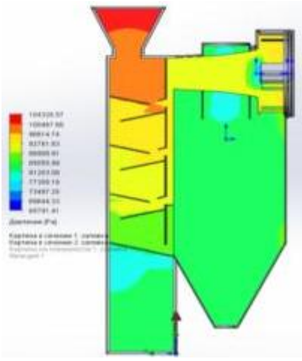

Figure 5. Distribution area of static pressure in closed air system

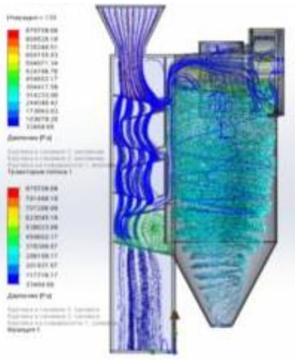

Figure 6. Air flow trajectory in a closed air system

Based on the conducted research, the laws of distribution of static pressure along the air flow trajectory were determined (Fig. 9).

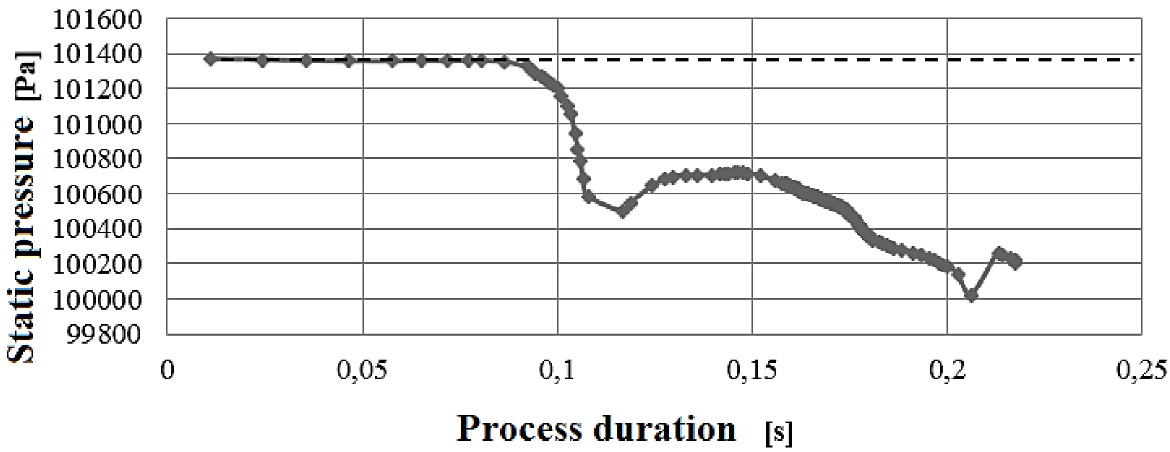

Figure 7. Distribution graph of static pressure (Ps) over the duration of air flow

As can be seen from the graph (Fig. 7), the line of static pressure in the aspiration zone is lower than the line of atmospheric pressure, which makes it possible to exclude the possibility of the release of dusty air into the working zone, in which case it is desirable to reduce the static pressure.

The model in which 10.0% of the air is separated from the recirculation channel without breaking the law of mass conservation and the balance of aerodynamic parameters in the air system was calculated. In this case, R=101370 Pa, Q=0.006 m3/s, QA=0.0006 m3/s, air suction at the inlet through the supply slot is 0.0006 m3/s (Figures 8, 9).

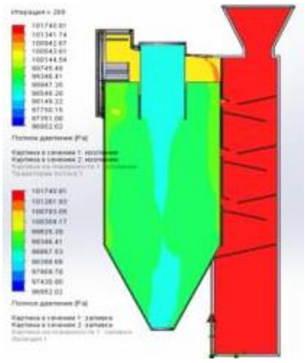

Figure 8. Total pressure distribution area in closed air system

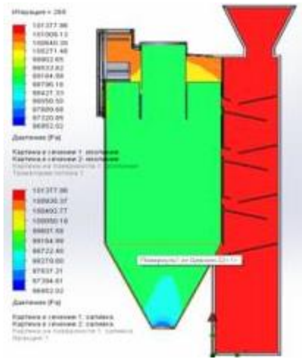

Figure 9. Air velocity distribution area in closed air system

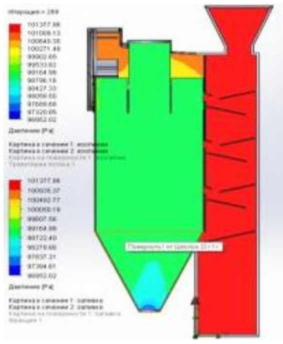

Figure 10. Distribution area of static pressure in closed air system

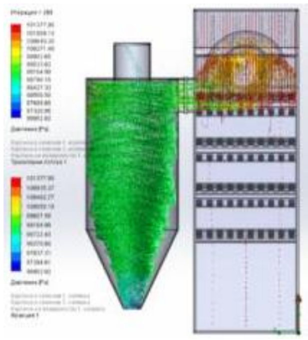

Figure 11. Air flow trajectory in a closed air system

Air flow velocity (Fig. 10) and trajectories of particles of different fractions are shown in Fig. 11, where blue trajectories indicate the main product shade, green trajectories indicate the direction of movement of medium impurities, and red trajectories indicate the direction of movement of light impurities.

The variation of static pressure along the air flow path in an open air system is presented in Fig. 12

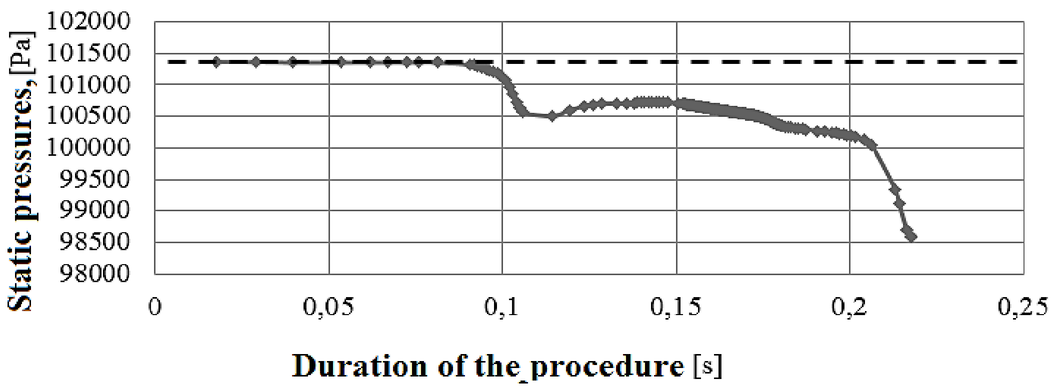

Figure 12. Static pressure distribution graph along the air flow path in an open air system

If the component of the velocity of the particle normal to the surface before its direct impact with this surface is V_1^n (Fig. 13), the component of the velocity of the particle is V_1^t perpendicular to the surface before its direct impact with this surface, the components of the velocity of this particle are their immediately after impact with the surface, denoting V_2^n and V_2^t respectively:

$$K_n = \left|\frac{V_2^n}{V_1^n}\right| \quad (3)$$

$$K_\tau = \left|\frac{V_2^\tau}{V_1^\tau}\right| \quad (4)$$

then in ideal reflection $K_n = K_\tau = 1$, and in non-ideal reflection $K_n < 1$ and $K_\tau < 1$

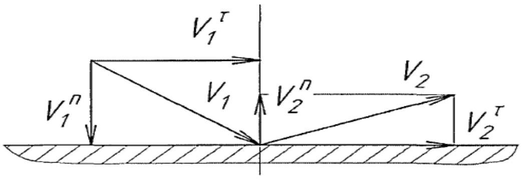

Figure 13. Reflection of a particle on a wall surface

The purified raw material outlet pipeline was installed with absolute absorption in mind to remove impurities.

The relevance of the research is based, the goals and tasks, objects and subject of the research, the compliance of the research with the priority directions of the development of science and technology of the republic are described, the scientific novelty and practical results of the research, the scientific and practical significance are stated, the information on this article is presented for the implementation of the research results in practice. .

CONCLUSION

Physical and mechanical properties of local soybean varieties were studied throughout the territory of our republic. Constructive and technological modes of improved soybean seed (grain) aspiration and separation devices were determined; a computer model was developed based on the SolidWorks system program for researching the movement of air and dispersed systems in the aspiration device during the cleaning of soybean seeds (grain) and various impurities contained in it; computer modeling and according to the results of the analysis, optimal modes of separating soybean seeds (grain) into fractions in the combined separator device were determined: air suction speed 4.5 m/s, deviation angle of perforated shelves 14^0, volumetric consumption 0,006 $м^3$/c, rotation speed of the supply shaft 420 rev/min, it was determined that the angle of inclination of the guide line is $\alpha=45^0$;

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