OPERATIONAL EFFECTIVENESS OF A SIEVE-AERODYNAMIC SEPARATOR UNDER THE CONDITIONS OF THE VARIABLE LOAD OF SIEVES

It was found on the basis of the testing conducted that the supporting air flow essentially affected the effectiveness of the aerodynamic separation on a laterally inclined sieve. As a result of the choice of the air flow in side fans the zones of increased cleaning effectiveness were determined.

**Keywords**: cleaning unit, fan output, shutter sieve, grain purity, grain losses.

1. Introduction and objective of the testing

The sieve-aerodynamic separation process in cereals combine-harvesters operating in mountainous areas is subject to a disadvantageous impact of the area inclination [3, 6]. On slopes of an inclination above 10° the operational quality of combine-harvesters provided with flat shutter sieves worsened considerably [1, 2, 4]. The decrease in the separation effectiveness under those conditions is due to the gravitational displacement of the threshing mass separated from the straw (grain, minor straw fractions, chaff, etc.) onto the lower-located side of the sieves of the cleaning unit and its local overload. In order to eliminate the negative effects of the operation of the inclined cleaning unit the model of a sieve-aerodynamic separator was made at the Agricultural Engineering Institute of the Wroclaw University of Environmental and Life Sciences in which, in addition, a lateral system of nozzles that directs the regulated air flow under the top shutter sieve was implemented to the conventional central blowing system [5]. The operational parameters of the sieve-aerodynamic separator should be optimized taking into account two criteria: the level of air purity obtained and the size of generated losses. Tending towards the optimization of those indexes, variations of the cleaning air flow rate and variations of the air flow direction were assumed.

Considering the foregoing, the aim of this paper is to present the impact of the multidirectional air flow rate at the operation of the sieve-aerodynamic separator under the conditions of an inclination.

2. Testing methodology

A test bench designed and made at the Agricultural Engineering Institute of the Wroclaw University of Environmental and Life Sciences was used to perform the testing (Fig. 1).

The basis constituted a sieve separator maintaining the geometrical and kinematical parameters of the sieve that is generally used on Bizon combine-harvesters. The test bench was provided with a system of lateral nozzles that allow obtaining the proper size of the aerodynamic flow directed locally under the top cleaning sieve. A screen was mounted on the test object the goal of which was to catch the mass of well-aimed wheat grains leaving the area limits of the sieve basket.

The first stage of the testing comprised the measurements of the impact of the side air flow on the grain purity under the sieve surface at various outputs of the air flow-generating fans.
was $\beta = -5^\circ$, the supply of the sieve with the grain flow was 3.5 kg/s.

The testing was performed at the following outputs of the fans:
- main fan WGL only switched on with the outputs $(Q_1, Q_2, Q_{II}, Q_4)$,
- main fan WGL $(Q_4)$ and side fan WB switched on $(Q_{II}, Q_3, Q_4, Q_5)$,
- main fan WGL $(Q_0)$ and side fan WB switched on $(Q_2, Q_3, Q_4, Q_5)$.

where:

- $Q_{II} = 1.01$ m$^3$/s
- $Q = 1.28$ m$^3$/s
- $Q = 1.30$ m$^3$/s
- $Q = 1.73$ m$^3$/s
- $Q = 1.95$ m$^3$/s

3. Test results

In the first testing stage the impact and the effectiveness of the cleaning air flow on the grain purity and losses was assessed. Figure 3 presents the variability of the purity indexes for the screened-out cereal mass. The generated air flow $Q_{II}$ from the main fan WGL allows obtaining the purity deemed sufficient at ca. 97% in the zone (A) only. As the screened-out mass displaces towards the sieve outlet the indexes decrease, reaching 94.21%. The results obtained indicate clearly that the transverse inclination of the sieve basket at the angle $\alpha = 10^\circ$ significantly worsened the cleaning operation on the shutter sieve when supplied with the main fan WGL only.

When studying the function curve runs presented on the diagram it can be stated that the use of an additional – side air flow (side fan WB switched on) considerably affected the run of the purity indexes, first of all in zone B. Upon supplementing the air flow from the main fan WGL with the air flow from the side fan WB with a gradually increasing output there follows a considerable rise in the purity indexes obtained. The highest value of the purity index exceeding 99.0% is observed for the system WGL$(Q_0)$+WB$(Q_0)$.

A second component of the testing conducted was to determine the impact of the air flow of a various output on grain losses.

The variability of the parameter of average grain losses depending on the air flow rate $Q$ in the air flow from the main fan WGL is presented in Figure 4. The analysis of the diagram showed that the one-directional air flow generated by the main fan WGL shaped the level of the grain loss index at the acceptable level up to 2.5%. At the air flow rate of 1.90 m$^3$/s the level of average losses did not exceed 0.54%.

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The diagrams of the grain loss variability in function of the air flow rate from the main fan $O_{II}$ are shown in Figure 5. The obtained diagrams of average losses were measured at two constant settings of the main fan output $O_{II}=0.95$ m$^3$/s and $O_{II}=1.22$ m$^3$/s. Thus the determined levels of average grain losses are the result of the summary interference by the main and side fans. It can be seen that the level of average grain losses grows jointly with the increase in the „summary” air flow rate. The diagram of that relationship has the nature of a growing exponential function.

The size of the determination factors $R^2$ shows a good matching of the runs of the tendency curve lines to the variability of the determined average magnitudes. Both in the group of lower flow rates $O_{II}$ and in that of higher flow rates $O_{III}$ there follows the excess of permissible losses by -2.5%.

With the assumed constant values of the main fan outputs $O_{II}$ and $O_{III}$ the outputs of the side fans WB were changing within the range of $O_{III}=1.01$-1.95 m$^3$/s.

The highest level of losses for the main fan and side fan system (WGL+WB) was observed for the main fan output at the level $O_{II}$ equal to 1.22 m$^3$/s. The excess of the level of permissible losses followed at the output $O_{II}$ already above the value of 1.29 m$^3$/s.
4. Conclusions

1. The use of a longitudinal air flow from the fan with standard parameters for the Bizon combine-harvester results, at the side inclination of the sieve, in the lowering of purity indexes down to ca. 94% while maintaining relatively low grain losses at the level of 0.54%.

2. Both in the system of the one-flow air supply and multi-flow air supply the rise in the air flow rate results in a rise of grain purity indexes with a simultaneous level of grain losses.

3. The analysis of tendency curves has showed that the limit level of the air flow rate in the multi-flow system should not exceed the value of $Q_s = 1.20 \text{ m}^3\text{s}^{-1}$ at the set constant output of the main fan $Q_{III}$, and the value $Q_s = 1.7 \text{ m}^3\text{s}^{-1}$ for the constant output of the main fan $Q_{II}$.

4. The results obtained show a need for a multi-flow supply of the sieve with air relatively to its surface load and the use of the Monte-Carlo optimization procedure for the determination of both the air flow rates from the main fan WG and the side fan WB.

5. References