Parameters of air flow over the upper sieve in the cleaning chamber

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Abstract. The value and direction of the resultant vector of the airflow coming out of the upper sieve, depending on changes in the gap between the blinds in purification of the combine harvester, is assessed. The volume and direction of the resultant vector of the airflow, as well as its components were evaluated in the study. Dynamic pressure was measured over a sieve with Pitot tubes in 6 points along the length, in each section at a distance of 50 mm from the blinds mounting axes. During the purification with a serial sieve by $S_{vr} = 7...13$ mm speed is almost constant, but when $S_{vr} > 13$ mm, it intensively reduces from 4 to 2.50 m/s. This mentioned pattern of speed changes of serial sieves affects undoubtedly negatively on the separation of grain. In fact, by increasing of the supply of straw heap, $S_{vr}$ gap between the louvers is increased to reduce static resistance of network. However the increase of $S_{vr}$ reduces the air flow speed and its loosening impact on heap. Thus, one reason for intensive grain losses increase in empty glume by higher feed rates of heap of straw is a decrease in the function $ν(S_{vr})$. Under the influence of the vertical component of velocity and vibrations of sieves the heap layer comes into a quasi-fluid state and the frictional force between particles decreases. It facilitates the passage of grains through the layer. During the tests in purification units of harvesters measurements of air flow velocity over the sieves were made.

1. Introduction
Cleaning of modern combine harvesters operate in conditions of higher loads and do not have enough reserve capacity to ensure minimal losses in the overtails from purification in any conditions of harvesting. Low throughput capacity of purification constrains further intensification of the process of threshing and separation of heap of straw, thus increasing the throughput capacity of the combine is needed [1–3].

The separation of grain in the process of cleaning of a grain harvester is influenced by many factors: the value of non-grain fraction feed, composition and content of straw impurities in the heap of straw, moisture of grain and non-grain fractions, the uniformity of flow, structural and kinematic parameters of purification, performance of the air system, and others [4].

The amount of feed for purification and composition of straw heap is determined by feeding of the plant mass into grain harvester thresher, its technological parameters, structural and kinematic parameters of the threshing and separating device (TSD).

Factors that influence the feeding amount of straw heap for cleaning are unmanageable (technological characteristics of the plant mass) or can not be changed (the feeding of plant mass into a TSD, the parameters of TSD) because of the desire to get maximum grain release from the straw and the best performance of threshing and separating device [5–7].
Separation of grain in screen-air cleaners depends much on their structural and kinematic parameters, changing which we can increase the intensity of grain separation from heap of straw and reduce losses.

2. Experimental

The volume and direction of the resultant vector of the airflow, as well as its components were evaluated in the study. Dynamic pressure was measured over a sieve with Pitot tubes in 6 points along the length, in each section at a distance of 50 mm from the blinds mounting axes.

The overall picture of the process for studied sieves is represented as follows.

Airflow with a serial sieve, leaving the fan nose, is divided with cross bar of the lower sieve into two unequal parts (Figure 1). The upper, smaller part of the air stream, skirting the bar, is directed at an angle of 75–80° to the plane of the lower flap of louvered comb of upper sieve and passes through 6–9 rows of combs. Another part of the air flow moves between the upper and lower sieves. At the same time attacking the lower flaps of the upper comb of the sieve the airflow partially goes through them. Turbulence is created and a layer of heap on the top sieve is blown ineffectively. The lower, bigger part of the flow, attacking the lower sieve, passes through the first 10÷12 rows of combs. After that at the length of 2/3 of the sieve between the combs intensive secondary eddy currents - «separated bubbles» are formed. It is connected with the location of lower claps (comb elements that are placed at a big angle to the main flow). A head-on impact and boundary layer separation happen. They reduce the air flow cross-section between the combs because of the formation of the vortex and the air flow through the sieve. This leads to a reduction of air flow speed, leaving a series sieve, in 1.5 time (from 2.30 to 4 m/s). An airflow loses its ability to blow through and loosen a thick layer of straw heap, thus causing increased losses for purification.

![Figure 1. Flow of series sieves by airflow in purification unit of combine SK-5ME-1 "Niva-Effect".](image)

In addition, the grain that was dressed through a layer and got on the surface of the louveres comb is thrown again by vortex current in a heap.

In experimental sieves the angle between the direction of the airflow and plane of the lower flap of the comb is small, so the punch of the air flow on them is eliminated. Dynamic pressure changes less than with serial sieves, eddy currents in the zone between the flaps are eliminated. Absence of the latter increases the speed of passage of grain in the space formed by flaps, and recurrent release of grain into the flow moving over sieves is decreased. Along with this, the direction of air flow, leaving the space between the flaps, varies immaterially depending on the position of the louveres. Its main vector is inclined to the plane of movement of the heap at a larger angle.
Figure 2 shows a diagram of the main directions of the main vector airflow over series (a) and experimental (b) sieves of purifications.

As can be seen from the figure, the direction of the principal vector in serial sieve purification varies in range $\beta=35...60^0$ with $S_{vr}$ louver opening from 13 to 20 mm. In the experimental sieve the vector is diverted from the plane of the sieve at a larger angle $\beta$ ($65...90^0$ by $S_{vr}=13...20$ mm). When $S_{vr}\leq 10$ mm, the angle of direction of the main vector in the experimental purification is 2 times bigger than in series one, i.e. 55 and 25$^0$.

![Diagram of vector airflow](image)

**Figure 2.** Changing the direction of the resultant vector of the air flow over the sieves of serial (a) and experimental (b) purification units.

The direction of the resultant vector affects greatly on the interaction of air flow with a heap: in the experimental purification (Figure 3) the air loses and fluffs a heap more intensive and contributes to its transportation along the sieve less. In the series sieves its transporting role, especially when $S_{vr}\leq 13$ mm, is essential.

![General view of velocity field](image)

**Figure 3.** General view of the velocity field over the upper sieve.

It is characteristically noted that the average speed of the main vector of air flow in purification with experimental sieve changes (Figure 4) with increasing $S_{vr}$ from 7 to 13 mm with a greater intensity than by $S_{vr}>13$ mm. When $S_{vr}>13$ mm, then $v = 5$ m / s.
Figure 4. Change in the average speed of the main vector of the air flow over the sieves because of increase of the gap $S_{vr}$ between the louvers of the upper sieve.

3. Results and considerations
During the purification with a serial sieve by $S_{vr} = 7 \ldots 13$ mm speed is almost constant, but when $S_{vr} > 13$ mm, it intensively reduces from 4 to 2.50 m/s.

This mentioned pattern of speed changes of serial sieves affects undoubtedly negatively on the separation of grain. In fact, by increasing of the supply of straw heap, $S_{vr}$ gap between the louvers is increased to reduce static resistance of network. However the increase of $S_{vr}$ reduces the air flow speed and its loosening impact on heap. Thus, one reason for intensive grain losses increase in empty glume by higher feed rates of heap of straw is a decrease in the function $ν(S_{vr})$.

Greater understanding of the regulation results gives the dependence of the results of vertical $ν_y$ and horizontal $ν_x$ components from the average speed from the opening of louvers (Figure 5). It should be noted that the horizontal component has an influence on the velocity of the heap of straw on sieves, and the vertical one has – on loosening effect. With an increase of the opening of series sieves blinds vertical velocity component varies slightly, and the horizontal is constant before the opening of louvers on 10 mm, and then gradually decreases. Vertical velocity component of the experimental sieves increases from 2.40 to 3.60 m/s, and the horizontal decreases from 2 to 1.40 m/s.

Figure 5. Influence of $S_{vr}$ gap between the sieves’ louvers on horizontal $ν_x$ and vertical $ν_y$, which are the components of the velocity of the flow over sieves.
Under the influence of the vertical component of velocity and vibrations of sieves the heap layer comes into a quasi-fluid state and the frictional force between particles decreases. It facilitates the passage of grains through the layer.

During the tests in purification units of harvesters measurements of air flow velocity over the sieves were made. The air flow speed over the sieves of experimental purification unit was measured in the gap \( S_{vr} \) between the louvers 22 mm and serial – by \( S_{vr} = 18 \) mm.

Figure 6 shows the velocity distribution diagram for air flow over sieves purification units.

In the Figure 6b it can be seen that the speed of serial purification decreases from 6 to 3 m/s at a distance of 200–300 mm from the beginning of the sieve, and then at the length of 1.20 m remains at the level of 3.50 m/s.

This is because of the situation when \( S_{vr} = 18 \) mm (65°) in the louvers space, decrease of circulation velocity and swirl of air flow happen. The air velocity at the exit of the sieves thus decreases, because of it the heap is not loosened enough. The main part of the air passes between the upper and lower sieves.

![Figure 6](image)

**Figure 6.** Diagrams of distribution of the air flow speed over the sieves of the purification unit of combine SK-5ME-1 "Niva-Effect", where a – experimental, \( n=610 \text{ min}^{-1} \); \( S_{vr} = 22 \) mm; b – serial, \( n=610 \text{ min}^{-1} \); \( S_{vr} = 18 \) mm

In the experimental purification unit (Figure 6b) a smooth decrease in the speed of the air flow from the beginning to the end of the sieve (from 7.60 to 3.50 m/s) happens, so the heap layers are sufficiently loosened. The grain losses are reduced in comparison with the serial purification unit.

4. **Summary**

It follows from the foregoing that with the increase of the gap \( S_{vr} \) between the combs of experimental sieves the air flow velocity increases in the output. This increases the vertical velocity component, whereby a heap of straw, being in a suspended state, is actively purged and loosened.

Increasing of \( S_{vr} \) between combs of serial sieves results in a reduction of the speed at the output, and this leads to insufficient loosening of the heap.

**References**

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