# Modernization of the thresher of a grain harvester

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**Abstract.** The article presents the results of laboratory studies of a modernized threshing device of a combine harvester. The change in the design of the thresher was carried out in order to change the parameters of air flows in the gap between the threshing drum and the concave deck. It is shown that the introduced design changes contribute to a better separation of grain from the straw grate of the separated material and prevent the reverse movement of air masses from the threshing gap between the thresher beaters.

## 1 Introduction

The principle of threshing grain in modern combine harvesters has not changed since the creation of the first trailed harvesters. This is based on the impact of the threshing drum with a whip on the ear and on the grinding of the grain mass layer in the threshing gap [1-3]. Increasing the throughput capacity of a combine usually comes down to increasing the threshing and separation area by increasing the concave wrap angle, drum sizes, and increasing their number. The allowable overall dimensions and weight of the combine limit further growth in the productivity of threshing machines. Particular attention is paid to the introduction of automation systems in the harvesting process.[4-6] Research in the field of intensification of the separation process is mainly carried out in various directions and is primarily related to the improvement of the design of threshers. Also, intensive work is underway to improve the concave: smooth, mesh and other types of threshing decks are introduced, in the classic concave the angle and spacing of the transverse bars and etc. [7-10]

When substantiating the design scheme of the modernized threshing machine, the authors proceeded from the following premises. When the drum rotates, an air cavity with reduced pressure is created in its internal volume, which is inevitably compensated from all sides, including the threshing zone. Zones with significant rarefaction are also created behind the surface of the threshing picks. As a result, this leads to the hanging of some part of the threshed mass near the drum, which is crushed when it meets its rotating elements.

To improve the efficiency of the threshing and separation process, several changes were made to the threshing machine design. The outer disks of the drum frame were completely dismantled and replaced with massive impellers, which simultaneously serve as both the

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blades of the axial fan and the supports for fastening the pickups. Thus, made in the form of axial fan blades, they provide two-way air supply to the inner cavity of the drum. Scourges are attached to the surface of the discs with a gap. Their working surface is made at an angle of inclination, which contributes to the best grain threshing in the concave direction. The inner surface of the whip is made in the form of a concave profile of the fan impeller and prevents the formation of turbulence. These design changes provide additional air flows in the threshing gap directed towards the concave plane and contribute to better separation of grain from the straw grate of the material being separated, as well as preventing the reverse movement of air masses from the threshing gap into the interflank space. Additional air inflow into the internal cavity of the modernized drum is carried out through axial holes in the flanges of the side panels of the thresher. The flanges are made in the form of radial blades emanating from the support bearing seat. To increase the speed of the air flow, the angle of installation of the guide part of the blades is opposite to the angle of installation of the blades of the outer disks of the threshing drum.

The transverse bars of the concave are installed radially to its surface. The distance between them is determined from the condition of the optimal balance between the amount of separated grain and the mass of the non-grain part supplied for cleaning the heap. The transverse bars of the concave are equipped with conical reefs above each of the holes of the bars, which prevent the transverse occurrence of the stems of the threshed crops. Additional air flows directed towards the concave contribute to the emergence of a force factor in the working gap that presses the threshed material to the deck surface. As a result, the speed of movement of the grain-straw heap near the surface of the deck decreases, with the speed of its upper layer remaining unchanged. The change in the layered velocity gradient contributes to the mutual movement and grinding of the layers of the separated material in the working gap.

As a result, a design of a threshing and separating device with practically open sidewalls was obtained, which makes it possible to compensate for the rarefaction created by the drum, which in this case combines the functions of a threshing device and a centrifugal fan (Figure 1).

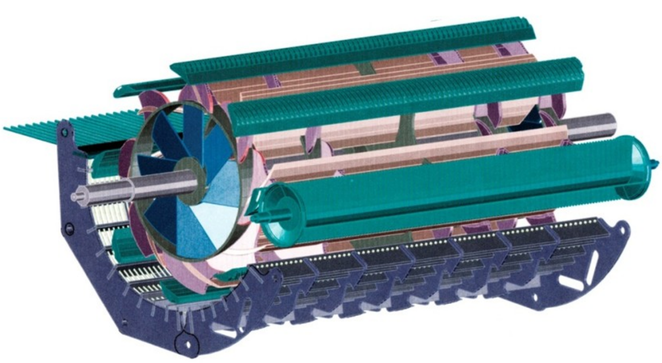

**Fig. 1.** General view of the modernized thresher.

## 2 Materials and methods

Comparison of various variants of the thresher was initially carried out in the laboratory. For this, a special stand was developed and manufactured, which completely imitates the thresher of a combine harvester. A 15-meter belt conveyor provided a uniform supply of grain mass for threshing. The required loading of the thresher was achieved by changing the feed rate of the layer of sheaf mass located on the conveyor. Sheaves of winter wheat with a yield of 57.3 c/ha were harvested during the harvesting period using a selective sheaf binder. The indicators of the state of the sheaf mass for the period of laboratory research were as follows: grain moisture - 13.4%, straw - 11.3%, absolute grain weight - 42.8 g, grain to straw ratio 1:1.6.

Under the threshing apparatus, 3 samplers were installed. In the first one, the threshing products that passed through the deck were collected. Its design was a 4-section mesh box with a width equal to the width of the thresher and a length equal to the length of the horizontal projection of the concave. The threshing products that passed through the straw walkers were collected in the second sampler, the length of which was equal to the length of the horizontal projection of the open separation grid of the straw walkers. The third sampler received the entire threshed heap that passed through the stand in order to determine the amount of loss of free grain behind the straw walker and the level of thresher concave. Experiments were carried out for each version of the threshing machine in 5 repetitions, with the same settings for the drum rotation speed - 900 rpm and installation gaps in the concave: 22x18x6 mm.

The parameters of the air flow that passed through the concave for each variant were evaluated indirectly, by measuring the dynamic head with Prandtl-Pitot-Tubes. For uniform measurement coverage of the entire surface of the concave, the latter was conditionally divided into 18 sectors. Measurements were taken at 21 points along the deck width in front of the plank and at 21 points behind it. A total of 756 measurement points for each option. Correct installation of the Prandtl-Pitot-Tube in the required area of the threshing deck was ensured using a special bracket (Figure 2). Based on the measurement results, diagrams of the distribution of air flow velocities in the plane of development of the separating grate of the threshing apparatus were constructed.

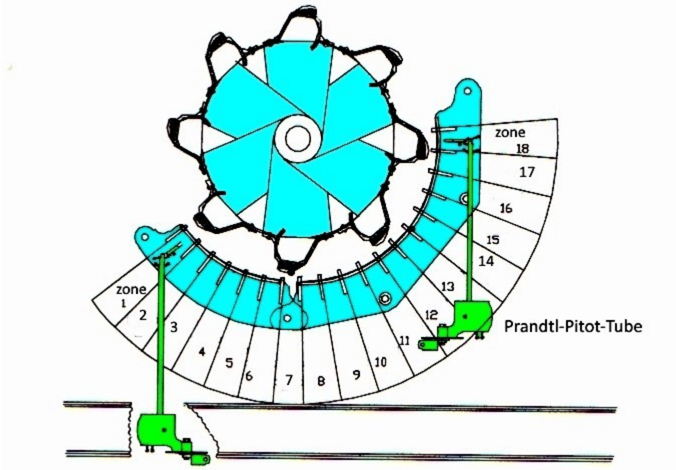


**Fig. 2.** Prandtl-Pitot-Tube installation scheme.

## 3 Results

The results of measuring the velocities of air flows created by the threshing drum in the concave grate of the serial and experimental threshers are shown in Figure 3 and Figure 4. in the central part of the concave reamer. In general, the distribution along the plane of the separating grid is extremely uneven. At its beginning, the speeds are slightly higher (up to 10 m/s), and at the end - lower (up to 5 m/s).

Darker shades of the surface of the diagram indicate the presence of negative air flow velocities behind the transverse bars of the concave frame, directed towards the drum and negatively affecting the separation of the threshed material. As a result, this can lead to some part of the grain mass hanging at the drum, which is crushed when it meets its rotating elements.

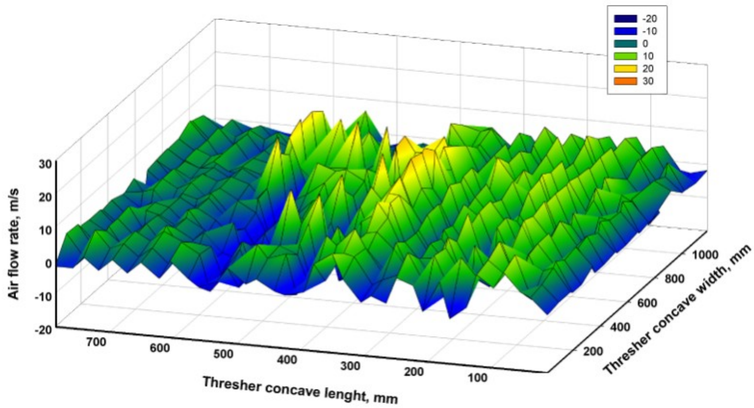


**Fig. 3.** Plot of airflow velocities through the deck of a serial thresher.

The change in the design of the thresher led to a radical change in the type of diagram of the speeds of air flows passing through the concave separating grate (Figure 4). Their values reached values of 20-25 m/s. The distribution of flows along the plane became more uniform, although there are differences in their intensity in the first half and in the second half of the concave. The proportion of concave zones with air flow velocities below 5.0 m/s was no more than 20% of the total area. In general, the total value of the speed of the air flow, integral over the area of the deck, passing through the separating grate of the experimental threshing apparatus is several times higher compared to the serial version. At the same time, at the exit from the separating grate of the thresher, zero and negative values of the studied velocities were practically not recorded.

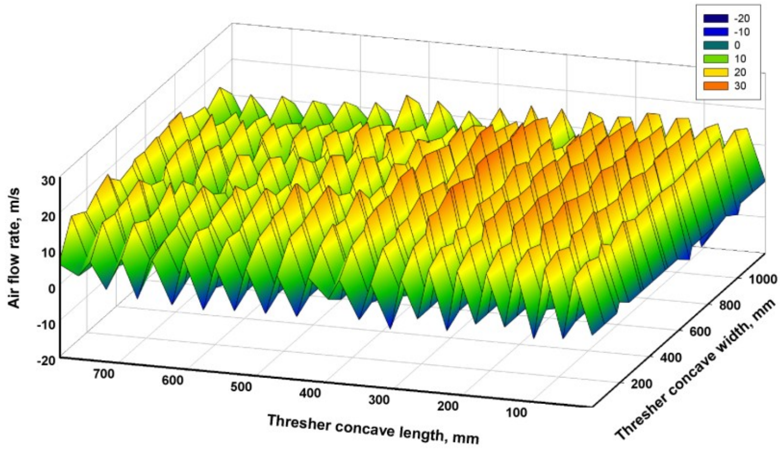


**Fig. 4.** Plot of airflow velocities through the deck of an experimental thresher.

# 4 Discussion

An increase in the intensity and uniformity of the air flow passing through the concave grate should contribute to an increase in the efficiency of the process of separating grain from the grain-straw heap in the threshing gap. To test this hypothesis, a number of experiments were carried out.

Sampling of the separated material was carried out from 4 concave zones, and for each series of experiments, the same drum revolutions and installation clearances in the concave were set. Because of bench tests, it was revealed that the reduced supply of grain mass to the serial (reference) thresher was 3.92±0.09 kg/s. Separation in zone 1 (deck extensions) averaged 51.7% of the total mass of concave threshed grain. In the second zone - 29.6%, in the 3rd - 11.8%, in the 4th - 6.9% (Figure 5). The total separation through the deck was 92.7%. A straw separator separated the remaining amount of grain (7.3%).

In a series of experiments with a modernized version of the thresher design, the reduced supply of grain mass to the threshing gap was 4.15±0.12 kg/s. The percentage of grain material separation in the deck head (zone 1) was 60.0%, which is 16.1% higher than the separation level of the serial sample. The shift in the amount of threshed grain to the beginning of the concave made it possible to unload the separation intensity of the remaining 3 zones. The corresponding figures in the 2nd zone amounted to 25.1%, in the 3rd - 9.7%, in the 4th - 5.3%. The total level of separation in the concave zone was 95.0%, which makes it possible to somewhat unload the straw separator and reduce grain losses behind the latter. The indicators of grain crushing behind the threshing machine in the reference version amounted to 1.69%, in the experimental one - 1.91%. Thus, the modernized version has proved its performance, namely, a higher level of separation, in comparison with the serial one, with satisfactory, albeit somewhat higher grain damage rates.

Field studies were carried out in accordance with the above methodology, for serial and modernized versions of the design of threshing and separating devices, which were alternately installed on the same combine harvester.

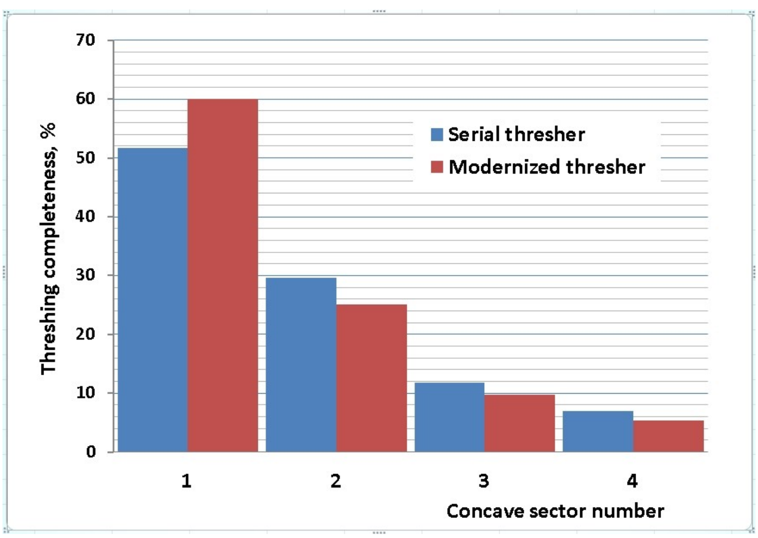


**Fig. 5.** Grain separation level by concave zones.

The indicators of grain loss behind the threshing machine with the same adjustments and a throughput of 7.2 kg / s, in the modernized version amounted to 2%, and in the serial version - 4%. Permissible standard losses behind the thresher of a combine harvester (1.5%)

were achieved when the standard sample was fed 5.8 kg/s, and the experimental sample - 6.5 kg/s. As a result of field experiments, it was revealed that a combine with a modernized version of the thresher showed higher productivity at a given level of losses than a serial sample. Studies have also shown that through the open holes in the sidewalls of the thresher, there is no loss of free grain, that is, the suction air flow prevents it from flying out.

## 5 Conclusion

Laboratory tests have shown that the proposed modernization allows, without fundamental changes in the design of the thresher of a grain harvester, to significantly increase its efficiency. The method of aerodynamic impact on the threshed material, in one form or another, can be adapted to the vast majority of currently used threshing and separating devices and is a promising direction for improving the threshing machines of grain harvesters.

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