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PRZEGLĄD PRAC BADAWCZYCH NAD WPŁYWEM GEOMETRII NACHYLONEGO SITA ŻALUZJOWEGO NA JEGO PRZESIEWALNOŚĆ

A REVIEW OF THE RESEARCH WORK ON THE IMPACT OF THE GEOMETRY OF THE INCLINED ADJUSTABLE SECTION SIEVE ON ITS SCREENING ABILITY

W niniejszym artykule przedstawiono prace badawcze poszukujące rozwiązania zapewniające pełną skuteczność segregacji i czyszczenia masy poomłotowej podczas pracy kombajnu na terenach o nachyleniu do 15^0. Badania prowadzono nad zastosowaniem sit żaluzjowych ukształtowanych cylindrycznie, daszkowo i wzdłużnie dwupłaszczyznowo.

***Słowa kluczowe**: sito żaluzjowe, geometria sita, separacja, nachylone poprzeczne i wzdłużne, kombajn zbożowy*

The paper reviews the studies aimed at finding the solution to guarantee the full effectiveness of segregation and cleaning of the treshing mass for the combine-harvester operating on the slope up to 15^0. These investigations were carried out with the adjustable section sieves shaped in a cylindrical, canopy or longitudinal two-plane form.

***Keyword**: adjustable section sieve, sieve geometry, separation, transverse and longitudinal inclination, combine-harvester*

1. Introduction and research genesis

Now there is careful attention to change the construction of the combine-harvester as it is and will probably still be, considered the main harvesting machine not only in Poland but also all over the world. In fact, these are the separation-cleaning units that are an integral part of the combine harvesters and other treshing machines. To make it possible for the combine-harvesters to collect crop seeds that vary in shape and size, the adjustable section sieves need to be applied. There is no objection to the work of the separation-cleaning sieve unit while it is operating in the horizontal position. The significant negative changes may occur both on the transverse and longitudinal slopes, as the kinematics of the grain screening becomes modified. This leads to reducing the effectiveness of screening and cleaning grain mixtures on flat sieves [5,6,9,11].

There were some earlier solutions to improve the screening effectiveness of the combine harvesters working on the slopes and they were focused on the: automatic body levelling system [10], automatic system of the levelling sieve basket complex [7,8], evening up the grain mass surface by air stream and controlling sieve vibration. Those solutions, and in particular automatic levelling system are, unfortunately, very expensive [1].

The aim of the tests carried out at the Institute of Agricultural Engineering of the Wroclaw University of Environmental and Life Sciences since 1998 was to find such solutions that could guarantee the full segregation and cleaning effectiveness of the threshing mass, while the combine-harvester is operating on the slopes up to 15^0, and application of which will not necessarily increase the machine costs [2].

Due to multidirectional movement of the combine-harvester, there is a need to take into account the impact of both the transverse and longitudinal sieve inclination. Therefore, the working hypothesis has been assumed that the modification of geometric sieve features with maintaining basic kinematic parameters of the flat sieve may prevent the grain mixture from moving. This happens as the components of the gravity force, acting on the material particles both at the plane transverse and longitudinal to the movement, change their values.

The paper presents some of the research achievements in the application of the adjustable section sieves shaped in a cylindrical, canopy or longitudinal two-plane form. When the combine-harvester is operating on the transverse slope (movement along the contour lines), the threshing mass tends to slide down to the lower side of the separator unit. To counteract this problem, it was suggested that the sieve surfaces should have either the cylindrical or canopy shape. On account of the longitudinal inclination it was also considered to apply together two-plane and canopy sieve. The cylindrical sieve was designed as a longitudinal section sieve with changeable angles of section inclination. Figure 1a provides a hypothetical mass distribution on the flat sieve transversely inclined at an angle α. The mass distribution on the sieve having a cylindrical form is presented in Figure 1b [4]. The other solution suggested by the authors is to divide the sieve plane into longitudinal working sections of the canopy shape. Figure 2a shows the cleaned mass on the above-mentioned sieve working in the levelled position. When the sieve is inclined, there is a change in the force distribution acting on the material and this prevents it from moving into the inclination direction (Fig. 2b). It results in reducing the thickness of the mixture and also removing (totally or party depending on the inclination value) the sieve planes out of operation [5].

Two-plane sieve consists of two planes, and it has been assumed that while combine-harvester is operating on the slopes inclined at an angle β (up the hill) the main plane would be working under unfavourable conditions i.e. the screening effectiveness will be reduced. The additional half-open part of the separator will be running at an inclination opposite to the main plane (Fig. 3). During the tests two angles were adjusted: β - deflection angle of the sieve basket main plane in a way to simulate the operational conditions of the combine-harvester moving „up the hill" and „down the hill" and δ - bending angle

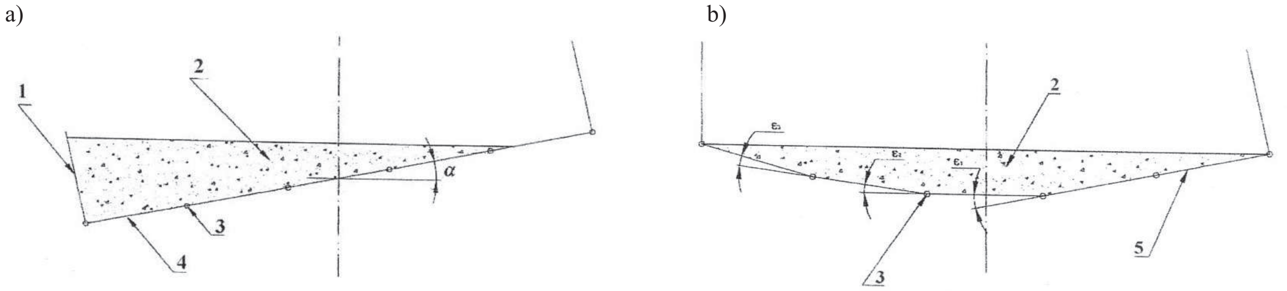

Fig. 1. Distribution of the screened material on the cylindrical sieve in the transverse inclination: a– sections of the cylindrical sieve arranged in a flat way (flat sieve model), b–extremely raised sections, 1- side passive surface, 2- cleaned material, 3- articulated joint of the section, 4- flat-arranged sections, 5- section of the cylindrical sieve, α – inclination angle of the flat sieve, ε_1, ε_2, ε_3, - inclination angle of the cylindrical sieve section

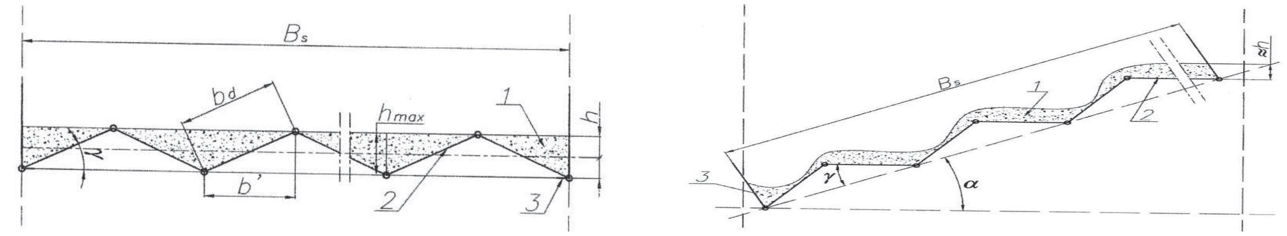

Fig. 2. Distribution of the screened material on the canopy sieve. a- operating in a horizontal position, b- operating inclined at α; 1- cleaned material, 2- element of the canopy sieve section, 3- frame of the sieve basket, B_s- sieve width, b_d- width of the canopy sieve element, h_{max}- maximum thickness of the cleaned mass at the beginning of the process, $h = h_{max} / 2$ – average thickness of the cleaned mass at the beginning of the process, α- angle of the lateral inclination of the sieve basket (≈ land slope), γ- inclination angle of the canopy sieve element

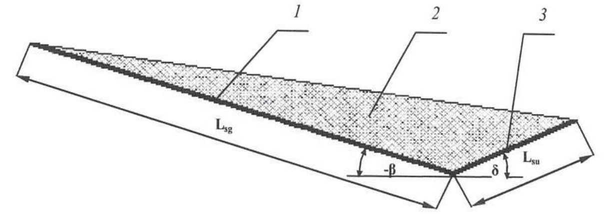

Fig. 3. Distribution of the screened material on the two-plane sieve inclined at β; 1- main sieve plane, 2- grain mass to be cleaned, 3- adjustable half-open part of the sieve, L_{sg}- length of the main sieve plane, L_{su}- length of the half-open part of the sieve, β- inclination angle of the sieve basket (up the hill), δ- angle of the additional sieve plane inclined from the horizontal plane

m o

	X1	X2	X3	X4	X5
Y1	1	1	1	1	1
Y2	2	2	2	2	2
Y3	3	3	3	3	3
Y4	4	4	4	4	4
Y5	5	5	5	5	5
Y6	6	6	6	6	6
Y7	7	7	7	7	7
Y8	8	8	8	8	8
Y9	9	9	9	9	9
Y10	10	10	10	10	10

z

Fig. 4. Position of the measurement zones under the sieves; X1 – X5 number of the sieve section, Y1 – Y10 number of the measurement zone under the sieve section, m o – threshing mass, z - contaminants

of the half-open part from the main plane. Figure 4 shows the range of the applied inclination angles of the main and additional sieve planes from the horizontal and main plane of the sieve, respectively [6].

2. Materials and methods

The tests were carried out at the tilting stand to make it possible to incline the sieve basket in many planes, from 0^0 to 15^0. The inclination angle of a whole stand had been changed to simulate the real conditions on the slope and change the inclination angles of the particular sieve sections. The amounts of the sieved mass were measured at each position of the sieve sections and various sieve inclination simulating the slope. Such measurements were run in five replications. Kinematic design of the stand was presented by the authors before [3]. The main dimensions of the sieve basket and the sieve complied with those applied in the Bizon Z058 combine-harvester. There were also the same kinematic parameters of the sieve basket drive.

During the tests the grain mass with contaminants was delivered into the sieve surfaces. Its quantity and the way of delivering corresponded to the operation of the transverse, radial-tangent threshing unit of a general flow capacity of 6÷8 $kg \cdot s^{-1}$. The following symbols were assumed to determine the angle of the stand frame (sieve) towards the horizontal plane: α – transverse inclination (simulation of the movement along the slope), β – longitudinal inclination (simulation of the movement

„up the hill" and „down the hill"), δ – inclination of the half-open part of the separator from the main sieve.

There were fifty measurement zones, ten along each section, under the main sieve (Fig. 4).

Additional 40 measurement zones were installed in the area of the half-open part of the sieve (Fig.5). Grain mass was recorded at each measuring point. The research results were analysed using the computer statistical package EXCEL and STATISTICA.

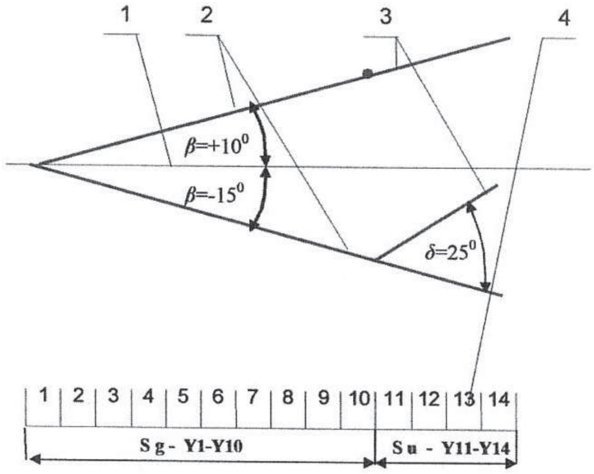

Fig. 5. Deflection scheme for the main and half-open planes' of the two-plane sieve from the horizontal plane β, δ- deflection angle of the half-open plane; 1- horizontal plane, 2- main sieve of the separator, 3- half-open sieve of the separator, 4- measurement points, S g - Y1 – Y10 – measurement zones under the main sieve, S u - Y11 – Y14 - measurement zones under the half-open sieve

3. Discussion

The screening tests with the transversely inclined sieve began with the modification - it was suggested that a cylindrical sieve would be assembled instead of a flat one. The terminal sections of the sieve remained inclined as shown in Figure 1b. The sieve basket frame together with the stand body was due to the changes of the inclination simulating the operation of the side-inclined separator. Distribution of the cleaned mass in the Y1 – Y10 measurement zones seemed to follow the rule of the longitudinal grain movement on the sieve, reaching the maximum at the border of the Y2 – Y4 zones. The load of the longitudinal sieve sections marked as X1 – X5 in Figure 6 increased with the decline of the frame inclination reaching the highest amounts of the cleaned mass on the X4 and X5 sections.

The second part of the tests was directed to assess the screening of the canopy-shaped sieve (Fig. 2). These studies included all combinations of the canopy positions ($\gamma = 0^0, 5^0, 10^0, 15^0$) and stand inclination ($\alpha = 0^0, 5^0, 10^0, 15^0$).

The paper presents grain distribution under the sieve for the example position of the canopy sieve – land slope angle $\alpha=10^0$ and inclination angle of the section canopies $\gamma=10^0$. The distributions achieved prove that the application of the canopy sieve seemed to be beneficial. The adjustable canopy sieve turned to meet the expectations as its application led to improve the effectiveness of grain separation, what is indicated by a better distribution of the mass under the sieve. Improved screening was recorded on the X1 and X2 sections and the grain load reduction - on the X4-X5 sections (Fig.7).

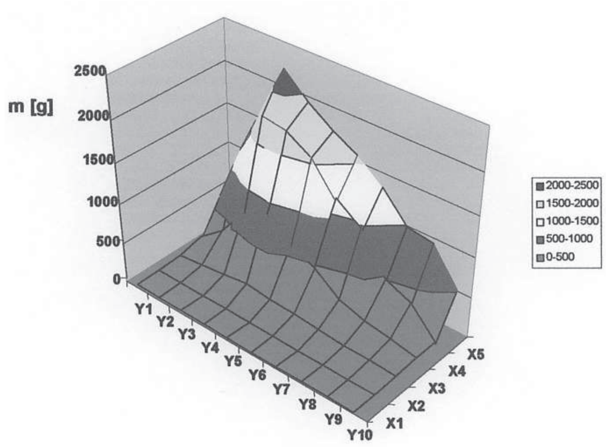

Fig. 6. Distribution of the grain mass m under the cylindrical sieve inclined at an angle $\alpha=10^0$ "simulation of the movement along the contours ", X1 – X5 sections of the cylindrical sieve, Y1– Y10 measurement zones

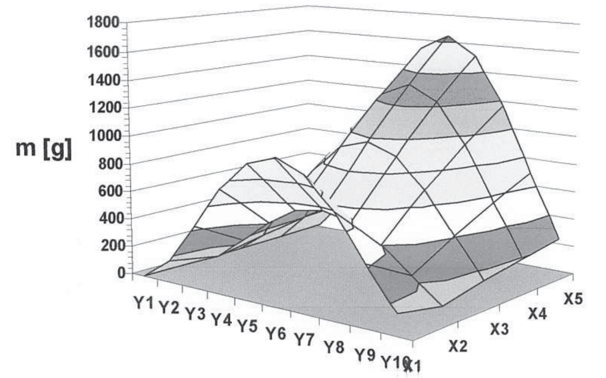

Fig. 7. Distribution of the grain mass m under the canopy sieve inclined at an angle $\alpha=10^0$; inclination angle of the section canopies $\gamma = 10^0$, X1 - X5 – sections of the canopy sieve, Y1-Y10 – measurement zones

Except for the experiments at the stand, there were field experiments carried out simultaneously. They pointed out the direction for further activities that should be focused on limiting the unfavourable effect of sieve inclination on the separation. In particular, the impact of inclination for the separator (combine-harvester) moving up the hill must be reduced. When the sieve is inclined at an angle $\beta = 10^0$ to simulate the longitudinal inclination (movement "up the hill"), there is a strong tendency that the grain on the standard one-plane sieve is screened mainly at the sieve edge (Y14). Then, during the continuous operation of the sieve, the losses may reach up to 33%. The application of two-plane sieve and increasing the inclination angle of the half-open section δ to 25^0 resulted in shifting the extreme of the screened masses into the middle part of the Y8 zone (Fig. 8). It means that the effectiveness of grain separation increases while the combine-harvester is going up the hill and with reducing the speed of the cleaned mass on the sieve, grain losses became almost totally reduced.

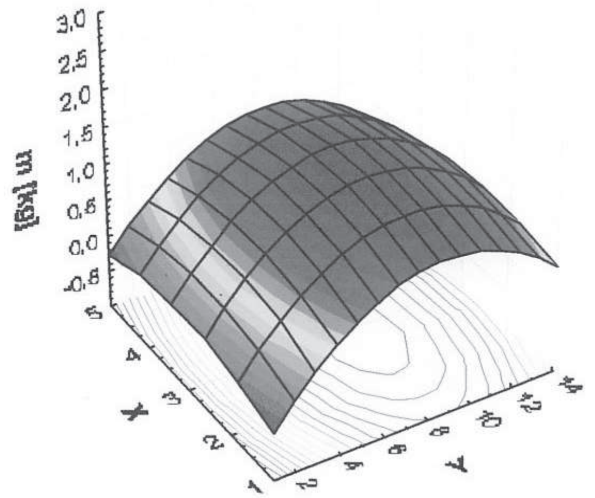

Fig. 8. Distribution of the grain mass m under the two-plane sieve at the main plane inclined at an angle β = -10⁰ „simulation of the up hill movement" for α = 0⁰ and inclination angle of the half-open section δ = 25⁰, X1 - X5 – sections of the two-plane sieve, Y1-Y14 – measurement zones

4. Conclusions

The analysis of grain mass distributions under the geometrically-shaped section sieves made it possible to formulate the following conclusions:

1. All of the sieves of changed geometry were found to improve the effectiveness of grain mass separation when the sieve basket is inclined up to 15^0.
2. The effects of properly-operated sieve models indicated that they could be applied in traditional combine-harvesters and thus, grain mass losses would be reduced on the hilly lands. Particularly good effects were achieved for the two-plane sieve with the automatic regulation of the inclination angle of the half-open section.

5. References

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