# MACHINE BUILDING AND MACHINE SCIENCE
# МАШИНОСТРОЕНИЕ И МАШИНОВЕДЕНИЕ

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## Comparison of graphic expression of dependences of transporter cut profile of threshing-separating unit on the second volume and spike fraction humidity***

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## Сравнение графического выражения зависимостей профиля среза транспортирующего устройства молотильно-сепарирующего агрегата от секундного объема и влажности колосовой фракции*

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*Introduction.* Threshing is a multifactorial process which is affected, in particular, by the feedrate of the crop, the specific weight of the threshed grain and return, separation rates, weediness and moisture of the crop. From this point of view, the issues of optimizing the profile of the transporter cut, which allows for threshing and separation with the least effort, are also relevant. It was also experimentally established that the threshing process is affected by the volume of grain material delivered per second (second feed) and the unit velocity.

*Materials and Methods.* The studies were conducted on a test bench equipped with a threshing-separating device in the form of a single-cavity hyperboloid. When performing the work, the width of the drum was divided into three zones, and the length – into five cells. Wheat grain, obtained through threshing and separation in each zone and cell, came to individual containers. Straw was collected separately. Then, the grain and straw were weighed. The resulting data was processed by statistical and mathematical methods.

*Research Results.* The lengths of each cell were calculated based on the ratio of the total separation and the amount of grain mass per unit length. The lengths of each cell were calculated depending on changes in humidity. Indicators of the ratio between mass humidity and cell length are presented in the form of a table.

By the given table values for different moisture levels of the grain mass, graphs were constructed, each of which was described by a mathematical model considering the drum length and width. An averaged cut profile is presented for the treated plant mass with humidity of 8%, 12%, 16%, 20%, and 24%.

*Discussion and Conclusions.* Analysis of the data in this paper

*Введение.* Обмолот представляет собой многофакторный процесс, на который влияют, в частности, скорость подачи растительной массы, удельный вес обмолоченного зерна и недомолота, показатели сепарации, засоренность и влажность растительной массы. С этой точки зрения актуальны и вопросы оптимизации профиля среза транспортирующего устройства, которая позволяет проводить обмолот и сепарацию с наименьшими усилиями. Опытным путем установлено также, что на процесс обмолота влияют объем подаваемого зернового материала за секунду (секундная подача) и скорость движения агрегата.

*Материалы и методы.* Исследования проводились на испытательном стенде, оснащенном молотильно-сепарирующим устройством в форме однополостного гиперболоида. При выполнении представленной работы ширина барабана была разделена на три зоны, а длина — на пять ячеек. Зерно пшеницы, полученное при обмолоте и сепарации в каждой зоне и ячейке, поступало в отдельные контейнеры. Солома собиралась отдельно. Затем зерно и солома взвешивались. Полученные в итоге данные обрабатывались статистическими и математическими методами.

*Результаты исследования.* Рассчитаны длины каждой ячейки исходя из отношения суммарной сепарации и количества зерновой массы, приходящейся на единицу длины. Вычислены длины каждой ячейки в зависимости от изменения влажности. Показатели соотношения влажности массы и длин ячеек представлены в виде таблицы. По заданным табличным значениям для различных уровней влажности зерновой массы построены графики, каждый из которых описан математической моделью, учитывающей длину и ширину барабана. Представлен усредненный профиль среза для обрабатываемой растительной массы влажностью 8%, 12%, 16%, 20%, 24%.

*Обсуждение и заключения.* Анализ данных этой и более ранних работ позволил сравнить графическое выражение



*** The research is done within the frame of the independent R&D.
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and earlier ones provides the comparison of the graphic expression of the dependences of the transporter cut profile on the second volume and humidity of the grain mass entering it. It has been established that the cut profile curves are identical along the entire length of the drum. The confidence factor is close to 1, which indicates the accuracy of the model. The identity of the averaged cut profiles is obviously dependent on moisture of the plant mass and on the second feed.

зависимостей профиля среза транспортирующего устройства от секундного объема и влажности поступающего на него зернового вороха. Установлено, что кривые профиля среза идентичны по всей длине барабана. Коэффициент достоверности близок к 1, что говорит о точности модели. Очевидна идентичность усредненных профилей среза в зависимости от влажности растительной массы и от секундной подачи.

**Keywords:** threshing and separating device, grain mass, spike fraction, plant mass input, transporter, cut profile, return, separation, weediness, humidity.

**Ключевые слова:** молотильно-сепарирующее устройство, зерновой ворох, колосовая фракция, подача растительной массы, транспортирующее устройство, профиль среза транспортирующего устройства, недомолот, сепарация, засоренность, влажность.

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**Introduction.** Improving the quality indicators of grain is one of the important factors in the yield enhancement [1, 2]. In the process of grain harvesting, especially threshing, severe damage to grains occurs [3]. In a combine harvester, the grain is separated from straw impurities. At this stage, the grain gets damaged, its quality deteriorates, quantitative losses occur [4].

Negative impact of these factors can be reduced if the path of the mass in a uniform layer along the entire length of the drum during the threshing process will be increased. Previous studies show that the threshed grain passes in a denser layer in the middle of the drum [5], and separation increases in this zone. Closer to the edges of the drum, the mass is much less dense, and the volume of separated grain here is 2–3 times less than in the middle [6, 7]. From this point of view, the most promising is the design of the threshing-separating device of the tangential-axial type, which evenly distributes the threshed mass along the entire length of the drum.

Losses during threshing and separation depend on the quality indicators of grain and on the technical specifications of the drum [8, 9]. Optimization of the profile of the transporter cut which provides threshing and separation with the least effort is also relevant. The profile of the transporter cut is a part of the separator transition grate designed for uniform and continuous movement of the spike fraction along the width of the tangential axial threshing and separating unit (TSU) in the form of a rotation hyperboloid.

In the day, the dependence of the cut profile on the cutter speed, its height setting and the angle of the reaper cutting elements [10] was determined. In addition, it was experimentally established that the threshing process is also affected by the volume of supplied grain material per second (second feed) [8], as well as the speed of the unit [11].

The work objective is to develop a mathematical model of the threshing process with a uniform supply of the processed mass along the entire length of the threshing and separating drum.

**Materials and Methods.** The studies were performed on a test bench equipped with a threshing and separating unit in the form of a one-sheet hyperboloid (Fig. 1).

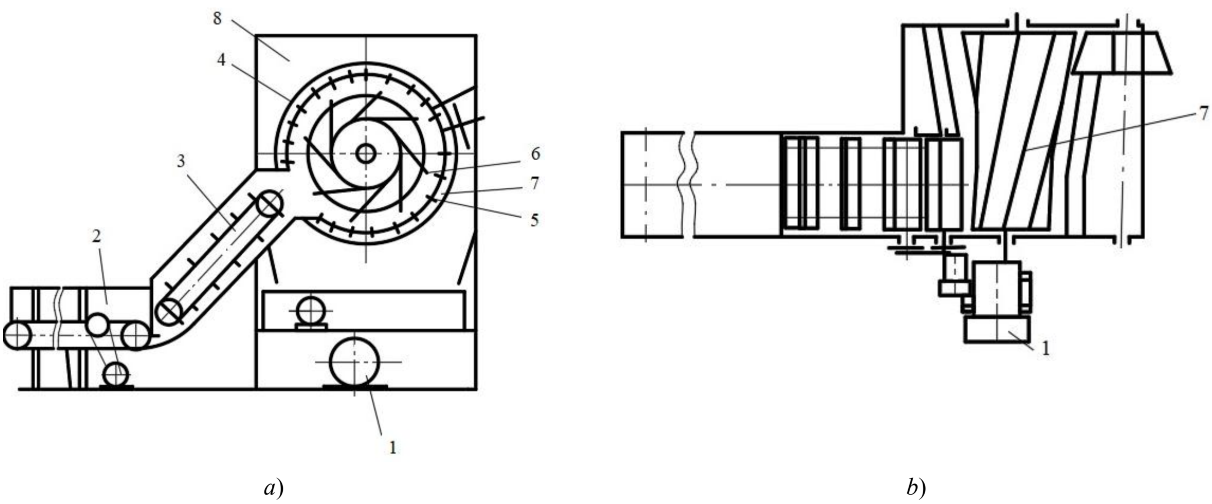


Fig. 1. Diagram of the stand equipped with threshing and separating unit: side view (*a*); top view (*b*)

The test bench consists of an electric motor (1). From it, rotation is transmitted to the drive drum (4) through a belt drive. A threshing and separating unit is installed on the drum. Its shape is a rotary one-sheet hyperboloid (7). The threshing and separating unit (7) consists of rear beaters (6) and a deck (5). The test bench is protected by a cover (8). An ear fraction enters the feeding section (2). This mass is fed through the conveyor belt (3) to the threshing and separating unit (7).

When studying, the width of the drum was divided into three zones, and the length – into five cells. Wheat grain obtained through threshing and separation in each zone and cell came to individual containers for collection. Straw was collected separately. Then the grain and straw were weighed.

The data obtained as a result of the study were processed by statistical and mathematical methods [10, 11].

Preliminary investigations [6, 7, 12] afford the following statement: as the threshed grain mass moves through the TSU, the total grain separation increases from the first zone to the third.

Within the framework of the presented paper, the cut profile was determined experimentally.

The objective of the study is to compare the dependence of the profile on:

- the volume of plant mass feeding per second;
- humidity of the plant mass.

The relationship between the cut profile and the second feed rate was established earlier [13, 14]; therefore, it is necessary to determine a similar dependence of the profile and the humidity index of the threshed mass. Table 1 shows the absolute values of cell separation depending on humidity [12].

Table 1

Absolute total cell separation values as a function of mass moisture

| Grain moisture | $\sum S_1$ | $\sum S_2$ | $\sum S_3$ | $\sum S_4$ | $\sum S_5$ | $\sum S$ | Const |
|---|---|---|---|---|---|---|---|
| w = 8 % | 10.8893 | 6.74 | 4.578 | 4.401 | 7.4922 | 34.1004 | 0.0341 |
| w = 12 % | 8.2186 | 5.291 | 3.603 | 3.264 | 5.3326 | 25.7084 | 0.02571 |
| w = 16 % | 6.7987 | 4.569 | 3.317 | 3.115 | 4.8956 | 22.6958 | 0.0227 |
| w = 20 % | 6.3305 | 4.172 | 3.154 | 2.916 | 4.4444 | 2.017 | 0.02102 |
| w = 24 % | 6.0782 | 3.906 | 3.029 | 2.786 | 4.2682 | 2.065 | 0.02007 |

**Results and Discussion.** To determine the cut profile, the following condition should be fulfilled: maintaining a constant (const) amount of the processed mass per unit length of the TSU. The const value is determined through the ratio of the total separation to the length of the drum L = 1200 mm. The determination technique was applied earlier when constructing cut profiles corresponding to various values of the second feed [14].

To calculate the length of each cell, it is necessary to determine the ratio of the total separation and the amount of grain mass per unit length:

$$\ell_i = \frac{\sum S_i}{const}, \qquad (1)$$

where $\sum S_i$ is the absolute total separation value in the i-th cell; const is the volume of the processed mass per unit length of the TSU at a given moisture content of the plant mass.

Substituting the values from Table 1 to the formula (1) and calculating the length of each cell depending on the change in humidity, we obtain the results given in Table 2.

Table 2

The ratio of mass moisture and cell lengths

| Grain moisture | $\ell_1$, mm | $\ell_2$, mm | $\ell_3$, mm | $\ell_4$, mm | $\ell_5$, mm | $\sum \ell$, mm |
|---|---|---|---|---|---|---|
| w = 8 % | 319.331 | 197.7 | 134.3 | 129.1 | 219.71 | 1000 |
| w = 12 % | 319.685 | 205.8 | 140.1 | 127 | 207.43 | 1000 |
| w = 16 % | 299.558 | 201.3 | 146.2 | 137.3 | 215.71 | 1000 |
| w = 20 % | 301.209 | 198.5 | 150.1 | 138.7 | 211.47 | 1000 |
| w = 24 % | 302.925 | 194.7 | 151 | 138.8 | 212.72 | 1000 |

The total length of all cells $\sum \ell$ is equal to the width of the drum B = 1000 mm.

The length values $\ell_i$ are plotted on the abscissa and correspond to the i-th cells of the drum length (L).

Using the given tabular values for each of the moisture content of the grain mass, approximate functions f (x) were obtained. Each graph shown in Fig. 2 is described by a mathematical model of the dependence of the drum length (L) on its width (B).

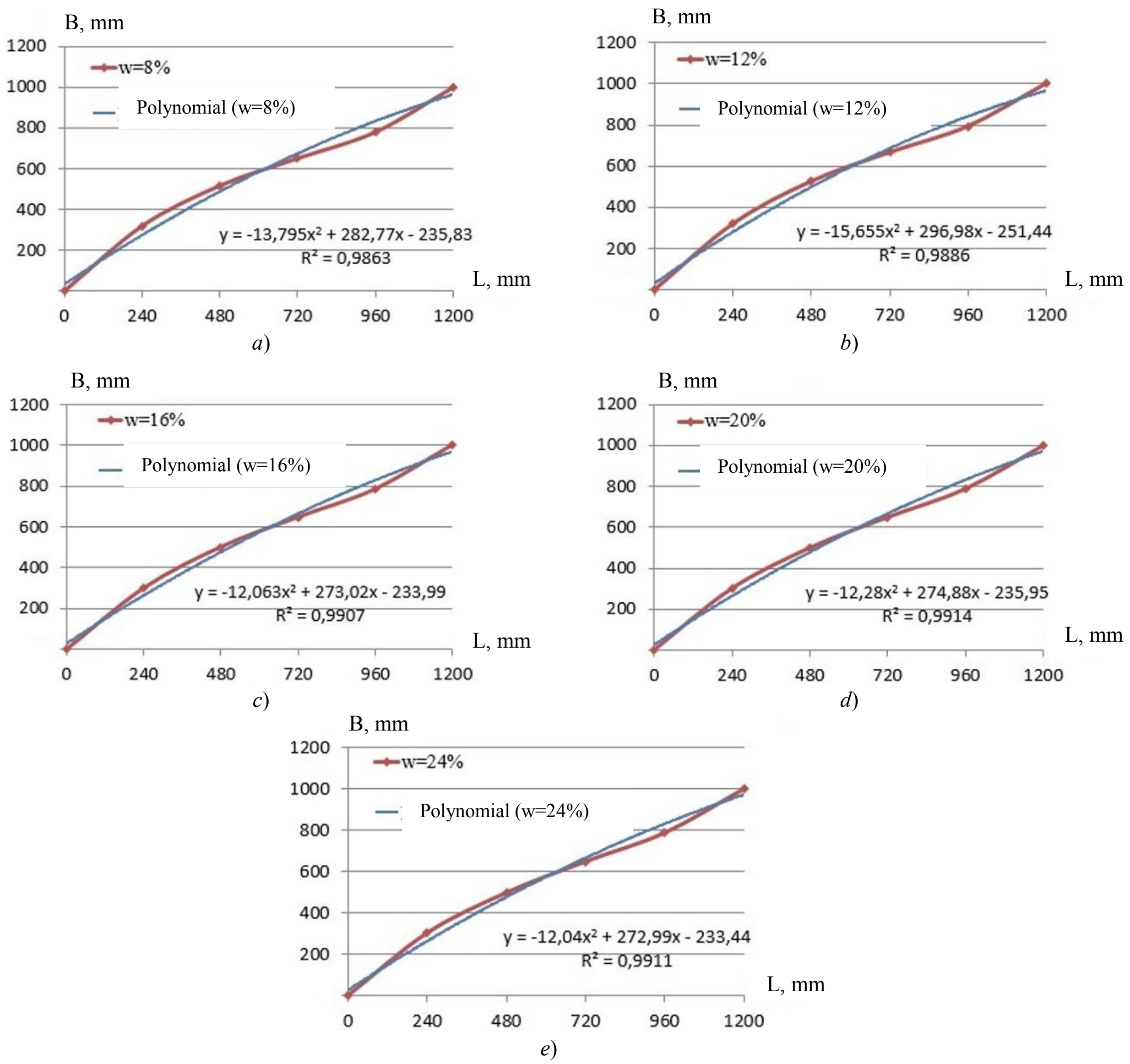


Fig. 2. Cut profiles depending on the moisture content of the grain mass: *a*) 8%; *b*) 12%; *c*) 16%; *d*) 20%; *e*) 24%

Fig. 2 shows the identity of the graphs. Consequently, it is possible to construct an averaged cut profile for a full moisture range of the processed grain mass. For this purpose, the length values of each cell are summed up and divided by the total number of humidity indices. By analogy with the previous graphs, an average cut profile is plotted (Fig. 3).

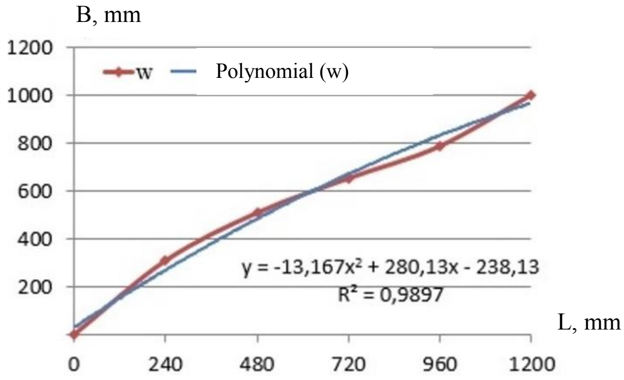


Fig. 3. Average cut profile for the treated plant mass with moisture of 8%, 12%, 16%, 20% and 24%

The data from Fig. 3 are compared to the earlier obtained averaged cut profile due to the second feed (Fig. 4).

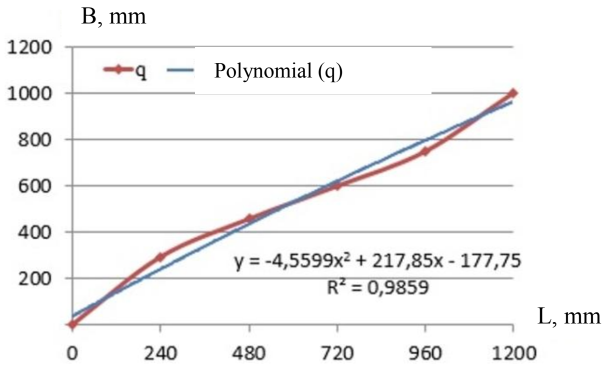


Fig. 4. Average cut profile for the treated plant mass depending on the second feed

**Discussion and Conclusions**

1. Fig. 2 shows that when the moisture content of the treated plant mass is changed, the curves of the cut profile are identical along the total length of the drum.

2. The confidence coefficient of the approximation $R^2$ shows the degree of compliance of the trend model with the initial data. The confidence coefficient is close to 1 which indicates the accuracy of the model.

3. The identity of the average cut profiles depends obviously on the moisture content of the plant mass (Fig. 3) and on the second feed (Fig. 4).

**References**

1. Krasnoshchekov, N.V. Innovative development of agricultural production in Russia. Moscow: Rosinformagrotekh, 2009, 388 p.

2. Maslov, G.G. Russian grain is not in high demand on the world market. Chief Agronomist, 2009, no. 11, p. 6.

3. Lipovsky, M.I. Rotary combine harvester quality improving. Agricultural machinery and technology, 2014, no. 2, p. 43.

4. Maslov, G.G., Palapin, A.V., Rinas, N.A. Grain crops complex harvesting perspectives: monograph. Krasnodar: Kuban State Agrarian University, 2014, 87 p.

5. Tarasenko, B.F., et al. Zernouborochnaya ochesyvayushchaya mashina : patent 2305395 Ros. Federatsiya: A01D 41/08 [Combine harvesting machine.] RF Patent no. 2305395, 2007 (in Russian).

6. Antypas, I.-R., Dyachenko, A.G., Savostina, T.P. Issledovanie protsessa obmolota tangentsial'no-aksial'nym separiruyushchim ustroystvom v zavisimosti ot raspredeleniya zernovoy massy po zonam. [Research of the threshing process with tangential-axial breaking unit in independence of grain mass zone division.] Science Review, 2016, no. 23, pp. 87–91 (in Russian).

7. Antypas, I.-R., Savostina, T.P. Vliyanie sekundnoy podachi na protsess obmolota tangentsial'no-aksial'nym molotil'no-separiruyushchim ustroystvom. [Impact of second feed for the threshing process of tangential-axial breaking unit.] Science Review, 2017, no. 3, pp. 47–51 (in Russian).

8. Antypas, I.-R., Savostina, T.P., Saed, B.I. Vliyanie parametrov molotil'no-separiruyushchego ustroystva na obmolot. [Effect of threshing-separating device parameters on threshing.] Vestnik of DSTU, 2017, vol. 17, no. 2 (89), pp. 108–115 (in Russian).

9. Antypas, I.-R., Savostina, T.P. Modelirovanie profilya sreza transportiruyushchego ustroystva. [Modeling a cut profile of a conveying device.] Sostoyanie i perspektivy razvitiya sel'skokhozyaystvennogo mashinostroeniya: sb. st. 11-y mezhdunar. nauch.-prakt. konf. v ramkakh 21-y mezhdunar. agroprom. vystavki «Interagromash-2018» [State and prospects of agricultural machinery development: Proc. 11th Int. Sci.-Pract. Conf. within framework of the 21st Int. Agroindustrial Exhibition "Interagromash-2018"] 2018, pp. 40–42 (in Russian).

10. Lapen, D.-R., et al. Combination cone penetration resistance/water content instrumentation to evaluate cone penetration-water content relationships in tillage research. Soil & Tillage Research, 2003, no. 58, pp. 193–206.

11. Salloum, W., Bahlawan, H. Design of Penetrometer Cone for Measuring Soil Penetration Resistance and Determine Soil Porosity. Research Journal of Aleppo University, 2009, no. 76, pp. 40–57.

12. Dyachenko, A.G., Savostina, T.P. Vliyanie vlazhnosti obmolachivaemogo materiala na protsess obmolota [Effect of threshed material moisture on threshing process] Innovatsionnye tekhnologii v nauke i obrazovanii (ITNO-2017): mat-ly V Mezhdunar. nauch.-prakt. konf. [Innovative technologies in Science and Education (ITNO-2017): proc. V Int. Sci.-Pract. Conf.] Rostov-on-Don: DSTU-Print, 2017, pp. 88–91 (in Russian).

13. Savostina, T.P., Dyachenko, A.G. Profil' sreza transportiruyushchego ustroystva ot velichiny podachi khlebnoy massy. [Cut profile of conveying device on the value of bread mass supply.] Sostoyanie i perspektivy razvitiya sel'skokhozyaystvennogo mashinostroeniya: sb. st. 11-y mezhdunar. nauch.-prakt. konf. v ramkakh 21-y mezhdunar. agroprom. vystavki «Interagromash-2018» [State and prospects of agricultural machinery development: Proc. 11th Int. Sci.-Pract. Conf. within framework of the 21st Int. Agroindustrial Exhibition "Interagromash-2018"] Rostov-on-Don: DSTU-Print, 2018, pp. 44–46 (in Russian).

14. Savostina, T.P., Saed, B.I. Optimizatsiya profilya sreza transportiruyushchego ustroystva ot velichiny sekundnoy podachi. [Optimization of transporter cut profile on the second supply value.] Vestnik of DSTU, 2017, vol. 17, no. 4 (91), pp. 44–49 (in Russian).

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