Scientific Papers. Series A. Agronomy, Vol. LXIV, No. 2, 2021
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

SUBSTANTIATION OF THE PARAMETERS OF THE COMBINE HEADER FEEDER CHAMBER CONVEYOR

Kuhmaz KUKHMAZOV[1], Alexey MACHNEV[2], Sergey GUBSKY[1]

[1]Penza State Agrarian University, 30 Botanicheskaya Street, 440014, Penza, Russia
[2]Moscow State University of Food Production, 11 Volokolamskoe Avenue, 125080, Moscow, Russia

Corresponding author email: kafedraemtp@mail.ru

Abstract

The materials of the article are devoted to an urgent problem - to reduce losses and crushing of grain by the threshing apparatus of a combine harvester by improving the design and substantiating the operating mode of the conveyor inclined chamber of the header. It describes the design of the proposed chain-slat conveyor for the feeder chamber of the combine harvester, the methodology and results of laboratory studies to substantiate its design parameters and operating mode. Laboratory studies were carried out on a developed experimental setup using the method of planning a multifactor experiment. As an optimization criterion, the degree of uniformity of the distribution of the stalk mass was taken when feeding it into the threshing apparatus of a combine harvester. As a result of laboratory studies, the optimal values of the following parameters were established: the pitch of the stamped strips of the conveyor of the header feeder chamber t_p = 307.2 mm; feeder chamber conveyor speed ϑ_tr = 3.5 m/s; working speed of the combine ϑ_k = 2.0 m/s.

***Key words**: grain harvester, header, inclined body, chain-slat conveyor, grain loss, crushing grain.*

INTRODUCTION

In the complex of works on grain production, the most important and stressful stage is harvesting. For harvesting grain crops, domestic industry and foreign firms produce a wide variety of grain harvesters. The technological process of the reaping parts of modern combine harvesters is not stable, which causes uneven supply of the stalk to the threshing apparatus, which in turn leads to frequent disruptions in the technological process (clogging, jamming of working bodies), a decrease in productivity, a deterioration in the quality of performance, an increase in energy consumption by reaping drive and threshing. The overall reliability of the combine is decreasing (Gubsky, 2018).

An important unit of the reaping part of the combine harvester, which ensures the spreading of the stalk mass coming from the spacer or the finger mechanism of the auger, and its uniform feeding into the threshing apparatus is the floating feeder chamber conveyor.

MATERIALS AND METHODS

It was found that with direct combining, the initial state of the stem mass entering the feeder chamber has a minimum in thickness in the middle of the stream and a maximum at the edges (Baizakova, 2012; Baizakova, 2013). To increase the coefficient of uniformity of the supply of the stem mass (increase the degree of leveling), leading to minimization of losses and grain crushing, we have proposed an improved design of the floating feeder conveyor.

The floating conveyor consists of a driving and driven shafts and a chain-slat conveyor. The chain-slat conveyor consists of four parallel sleeve-roller chains 1 (Figure 1) with a pitch of 38.4 mm, to which the fastening plates 3 are connected with rivets 3. Stamped metal strips are fixed to the plates 3 with the help of bolted connections 4 in a staggered manner 2. The length of the strips is 540 mm. The distance between the two middle chains is 443 mm, and the distance between the outermost and the nearest middle chain is 386 mm. The overhang of the outer end of the stamped metal strip relative to the middle of the extreme chain is 105 mm. At the outer ends of the two stamped strips of each extreme row, pins 5 are fixed, designed to exclude cases of clogging of the sidewalls of the inclined body with stem mass.

The total web width of the chain-slat conveyor is 1420 mm, and the length is 3379.2 mm.

The stamped strips 4 are fixed to the bushing-roller chains in three rows in a staggered manner. The distance between the planks of one row (pitch) is 307.2 mm, and between adjacent planks of the middle and outer rows - 153.6 mm. This arrangement of the strips allows to significantly improve the uniformity of the supply of the stem mass into the threshing apparatus of the combine (Kukhmazov, 2019).

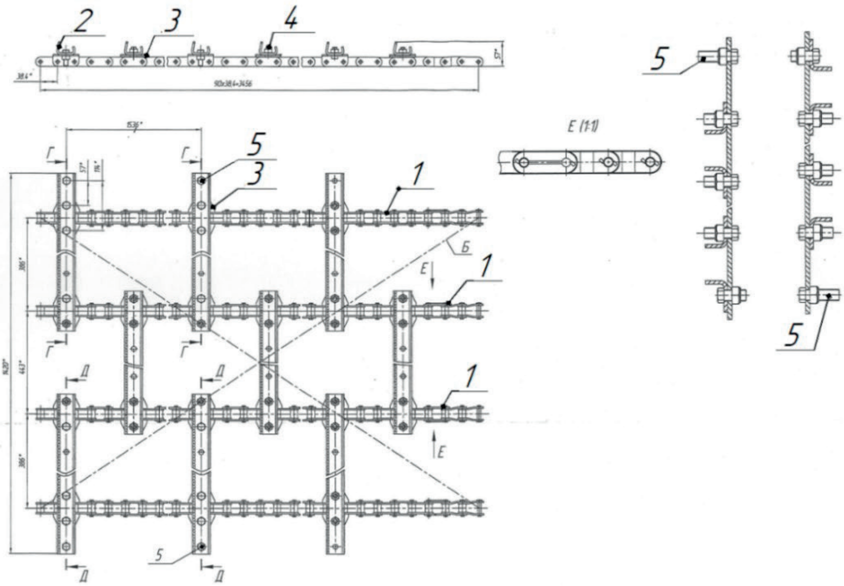

Figure 1. Chain-slat conveyor: 1 - conveyor chain; 2 - stamped bar; 3 - mounting plate; 4 - bolted connection; 5 - pin

To determine the optimal parameters and operating mode of the floating conveyor of the header incline chamber, a three-factor experiment was carried out on an experimental laboratory setup shown in Figure 2 (Gubsky, 2019).

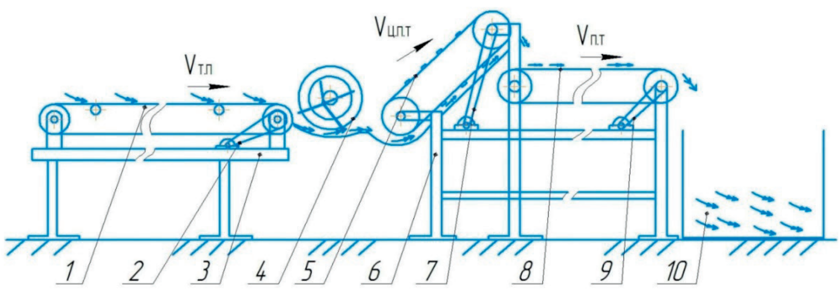

Figure 2. Laboratory setup: 1 - feed conveyor; 2 - feed conveyor drive mechanism; 3 - feed conveyor frame; 4 - auger with a finger mechanism; 5 - chain-slat conveyor; 6 - feeder chamber frame; 7 - drive mechanism; 8 - receiving conveyor; 9 - drive mechanism of the receiving conveyor; 10 - collection box

On the basis of a priori information, as well as on the basis of the research tasks, the most significant factors were identified that affect the uniformity of the supply of the stem mass to the threshing apparatus of a combine harvester. These factors and the levels of their variation are presented in Table 1.

Table 1 - Adjustable factors and levels of their variation

Adjustable factors: natural (coded)	Variation levels		
	-one	0	+1
X1 - speed of the chain-slat conveyor (υcpt)	2	3.5	five
X2 - distance between strips (step) (t, mm)	153.6	307.2	460.8
X3 - speed of the feeding conveyor (υt.p, m / s)	1.1	1.8	2.5

The degree of uniformity of the distribution of the stem mass was taken as an optimization criterion.

When determining the coefficient of distribution of the stem mass on the feeding conveyor 1 (Figure 2), a uniform roll 1 m long and 1.41 m wide was formed. The roll weight was 3.3 kg (in accordance with the results of previous studies). The roll of the stalk mass by the feeding conveyor 1 and the finger mechanism of the screw 4 was fed into the inclined chamber, then the chain-slat conveyor directed the roll to the receiving conveyor 8, where measurements were made. The stalk roll was divided into five equal portions along the width of the receiving conveyor (width of each portion 0.28 m) and weighed. Counting the average values of deviations of the masses made it possible to estimate the coefficient of uniformity of the distribution of the stem mass according to the formula (1):

$$\nu = \frac{m_{max} - m_{min}}{m_{max}}, \quad (1)$$

where: m max is the maximum portion weight, kg; m min is the minimum portion weight, kg.

RESULTS AND DISCUSSIONS

After processing the results of the three-factor experiment in the program "Statistica-6.0" obtained a mathematical model of the second order describing the dependence of the coefficient of uniformity of the distribution of the crop mass along the width of the receiving conveyor (width of the feeder chamber) on the speed of the chain-slat conveyor υts.p.t., the step of the slats of the chain-slat conveyor tp and the feed speed (the speed of the feeding conveyorυ etc.) in encoded form.

$$\nu = 98{,}68444 - 2{,}44000 \cdot x_1 + 1{,}52000 \cdot x_2 + 0{,}62000 \cdot x_3 - 155556 \cdot x_1^2 - -1{,}05556 \cdot x_2^2 - 1{,}65556 \cdot x_3^2 \quad (2)$$

The multiple correlation coefficient will be R = 0.95, the final remainder will be 5.22, a F-test = 0.96. Consequently, the resulting model adequately describes the results of the experiments.

To describe the response surface, a system of differential equations was compiled, which are the partial derivatives of equation 2 for each of the factors. Solving the differential equations, the coded values of the coordinates of the center of the response surface were found and two-dimensional sections were constructed, characterizing the dependence of the coefficient of uniformity of the distribution of the stem mass along the width on significant factors (Figures 3-5).

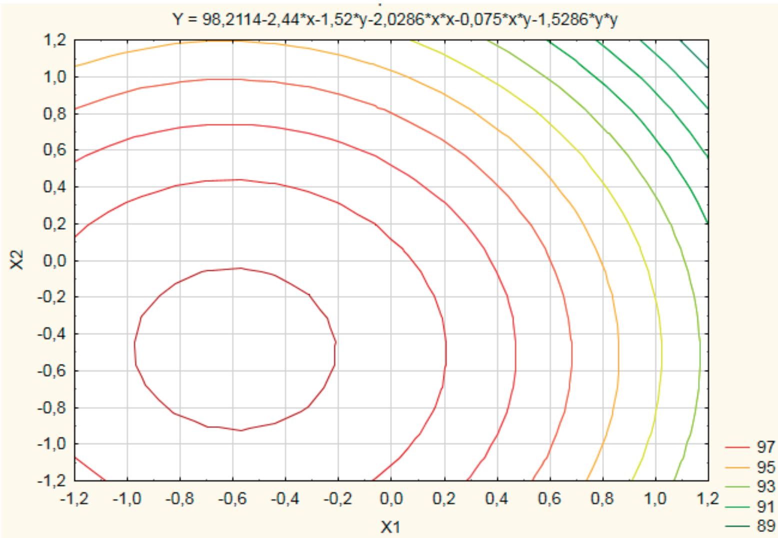

Figure 3. Two-dimensional cross-section of the response surface, characterizing the dependence of the coefficient of uniformity of the distribution of the stem mass along the width on the speed of the chain-plate conveyor Vts.p.tr. m/s, and the distance between the stamped strips t, mm

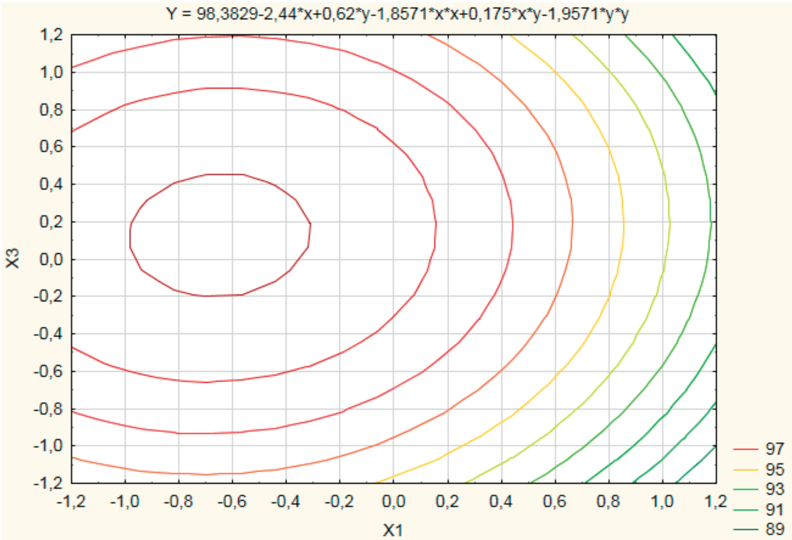

Figure 4. Two-dimensional section of the response surface, characterizing the dependence of the coefficient of uniformity of the distribution of the stem mass over width of the speed of the chain-plate conveyor Vts.p.tr. m/s, and the speed of the feeding conveyor Vp.tr., m/s

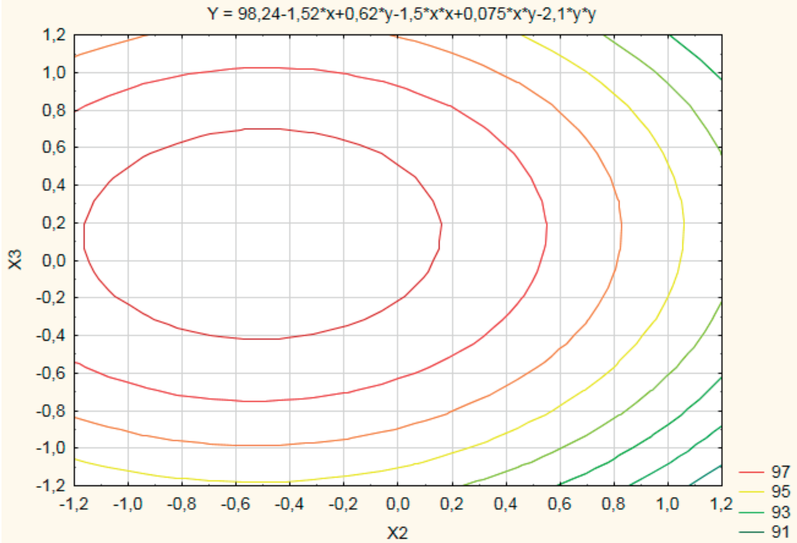

Figure 5. Two-dimensional cross-section of the response surface, characterizing the dependence of the coefficient of uniformity of the distribution of the stem mass along the width on the distance between the stamped strips t, mm and the speed of the feeding conveyor Vp.tr., m/s

CONCLUSIONS

Analyzing the graphic images of two-dimensional sections, it can be concluded that the optimal values of the factors under study are: the speed of the chain-slat conveyor υts.p.tr = 3.5 m/s; pitch of stamped stripstp = 307.2 mm; combine working speed (feed conveyor speed) υp.tr. = 2.0 m/s.

REFERENCES

Baizakova, Zh.S. (2012). Analysis of the movement of the grain mass in the inclined chamber under the influence of the working bodies of the accelerator. *Siberian Bulletin of Agricultural Science, Novosibirsk, 225*(2), 116–121.

Baizakova, Zh.S. (2013). Parameters of the device for normalizing the grain mass in the inclined chamber of the combine before threshing dry short-stemmed grain crops: Author's abstract. diss. Candidate of Engineering sciences.

Gubsky, S.E. (2018). Methods for determining the performance indicators of the combine harvester / S.E. Gubsky, A.V. Malyshev // Education, Science, Practice. An innovative aspect. Collection of materials of the International Scientific and Practical Conference dedicated to the 70th anniversary of the birth of Professor A.F. Blinokhvatova. Penza: MNITs MK-45-18. 71–73

Gubsky, S.E. (2019). Bench for testing the feeder chamber conveyors of the combine harvester / S.E. Gubsky, M.A. Alderbegov // Organizational and methodological aspects of improving the quality of educational activities and training students in programs of higher and secondary vocational education. Collection of articles of the All-Russian scientific-practical conference. Penza GAU. 63–67.

Kukhmazov, K.Z. (2019). Improvement of the design of the feeder chamber conveyor of the grain harvester header / K.Z. Kukhmazov, S.E. Gubsky, M.A. Alderbegov // The contribution of young scientists to the innovative development of the agro-industrial complex of Russia. Collection of articles of the All-Russian scientific-practical conference of young scientists. Volume II. 37–39.