NEW WORKING ELEMENT OF STRIPPER HEADER "OZON"
/
НОВЫЙ РАБОЧИЙ ОРГАН ОЧЕСЫВАЮЩЕЙ ЖАТКИ «ОЗОН»

Prof. PhD. Eng.Sc. Aldoshin N.V.[1)], Prof. PhD. Eng.Sc. Kravchenko I.N.[1)], Prof. PhD. Eng.Sc. Kuznetsov Y.A.*[2)], Prof. PhD. Phil.Sc. Kalashnikova L.V.[3)], Assoc. Prof. D.Eng.Sc. Korneev V.M.[1)]

[1)]Russian State Agrarian University – Moscow Agricultural Academy named after K.A. Timiryazev, Moscow / Russia;
[2)]Orel State Agrarian University named after N.V. Parakhin / Russia;
[3)]Orel State University named after I.S. Turgenev / Russia
Tel: +79208289219; E-mail: kentury@rambler.ru.

Keywords: *combine harvester, stripper header, construction, beater, fingers, tines*

ABSTRACT

New construction of working elements of combine harvester stripper header is suggested. The essence of technical solution consists in the construction alteration of stripper header fingers at the account of tine technological gap increase. The recommendations on the choice of rational kinematic operation mode of combine harvester header are developed. The improved construction allows increasing combine harvester stripping efficiency and decreasing grain material losses to 5% at harvesting.

РЕЗЮМЕ

Предложена новая конструкция рабочих органов комбайновых очесывающих жаток. Суть технического решения заключается в изменении устройства гребенок очесывающих барабанов, за счет увеличения технологического зазора между зубцами. Разработаны рекомендации по выбору рационального кинематического режима работы комбайновой жатки. Усовершенствованная конструкция позволяет повысить эффективность комбайнового очеса и снизить при уборке до 5 % потери зернового материала.

INTRODUCTION

Now there are questions of great importance regarding the construction development of stripping harvesting part of grain combine harvesters in many countries. A considerable amount of research papers is related to the investigations in the areas of grain harvesting optimization and combines header modernization *(Chegini G. and Mirnezami S.V., 2016; Henry W.B. et al, 2008; Ince A. et al, 2011).*

In the structure of grain production, grain legumes occupy a significant place *(Stagnari F. et al, 2017; Zotikov V.I., 2017).* In the world agricultural farming, leguminous crops occupy about 13% of grain crops. In the Russian Federation, the share of these crops in the structure is less than 1%. Leguminous are the source of plant protein. Increase of their sowing area allows solving the problem of fodder shortage. Leguminous in the Russian Federation are cultivated on areas of 1300…2000 thous. ha *(Sergeeva V.A. et al, 2016).*

At the present time, on the country territory white lupine sowings are expanded wider. This crop peculiarities require the reasoned recommendations on carrying out all kinds of different mechanized works and particularly harvesting *(Aldoshin N., (2016); Zotikov V.I., 2017).*

In this respect, the experimental researches of white lupine harvesting process with usage of stripper headers are of particular interest.

Stripper headers operate steadily in large range of harvested crops humidity. The maximum humidity level is limited to biological grain ripening, and that is why stripper headers provide good harvesting results even at 30% crop humidity. The minimum humidity level is limited with equilibrium humidity of grain storage, which is 12-15% *(Aladyev N.A., 2015; Sergeeva V.A. et al, 2016).*

It should be emphasized that the applied stripper headers are divided into mounted and trailed, which differ in terms of stripping equipment, working elements, method of stripping products harvesting. Herewith, the machines are produced with or without the plant supplying equipment, that feeds the stripping zone *(Ince A. et al, 2011; Mkrtchyan S.R. et al, 2013; Mosyakov M.A., 2016).*

On the Russian market the stripper headers of trademarks "Ozon" (Russia), "Slavyanka" (Ukraine), and also "Shelbourne" (Great Britain) are the best known.

The main difference of all presented models is in number of stripping rotors (beaters), but the headers operation principle is the same.

OJSC "Penzmash" (Russia) produces mounted stripper headers of type "OZON". Header "Ozon" is designed to harvest grain crops and grass seeds with direct combining by grain stripping and feeding stripping mass into combine harvester. The technological process of header operation is presented in fig. 1.

On average, the grain mass harvested from one field area unit with a conventional header consists of one mass part of grain and one-and-a-half part of straw. Grain mass harvested by stripper header from the same field area unit on an average consists of one mass part of grain and just a quarter of mass part of straw. Thus, the decrease of grain mass fed to combine harvester in half at the expense of reduction of straw amount in grain heap, results in combine threshing drum operation in underload mode. The reserve in threshing drum capacity appears. This enhances the speed of combine harvester movement. At harvesting, the usage of stripper headers enables combine harvester to move in 1.5-2 times faster *(Aldoshin N., 2016).*

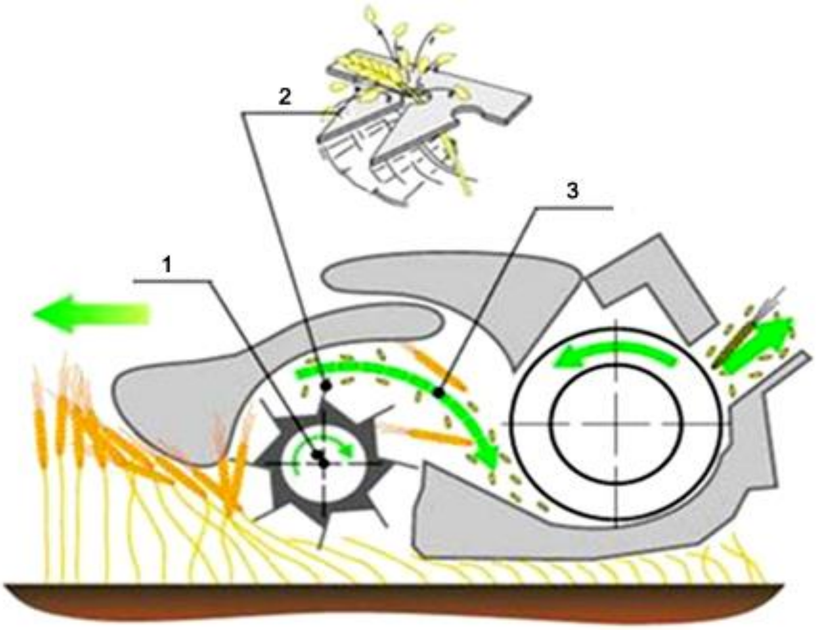

Fig. 1 - Technological process of stripper header "OZON" operation
1 – stripping rotors; 2 – stripping tines; 3 – grain and turned away grain heads

Stripper headers operate steadily in a large range of harvested crops humidity. The upper humidity limit is limited only by biological ripeness of grain and that is why stripper headers are able to harvest grains with good results, even at 30% crop humidity. The lower humidity limit depends on the equilibrium humidity of grain storage, which is 12-15%. At lower humidity the fixation of grain in head grows weak. Some extra grain losses appear at mechanical impact of header on plant stand. However, due to the 3-5 days earlier start of harvesting the total duration of stripper header usage in harvesting time is longer in comparison with the usage of conventional headers *(Aldoshin N., 2016; Mkrtchyan S.R. et al, 2013; Mosyakov M.A., 2016).*

It should be pointed out, that it is impossible to confuse biological plant humidity with surface moisture from rain or dew. In this case, the connection of root system and soil grows weak and at stripping, some plants can be pulled out with roots. Thus, after rain, soil should get dry but anyway harvesting can be started by 2-3 - hours earlier than with conventional header.

Stripping operating principle provides that qualitative plant threshing (stripping) is done in the open space. In this case, the grains (seeds) separated after stripping do not affect plant stand and move in the open space into the intended direction. Thus, the losses of the stripped grains are minimal. Such stripping levels are possible only in the case when plant inflorescences are compact and are located at the end of the stem top, i.e. in the area close to the open space. The cereals and headings crops, such as wheat, barley, rye, oat, triticale, rice, sorgo, flax and others correspond to these requirements first (fig. 2).

If plant inflorescences are located along the whole stem (leguminous crops) or they are located incompact (rape), grains being separated after stripping from lower stem part, affect plant stand at flight and can considerably deviate from the intended direction. It results in significant grain losses (fig. 3) *(Aldoshin N.V., 2016).*

The purpose of our investigation was estimation of utilization possibility and operation quality of stripper header "Ozon" at harvesting white lupine of "Dega" variety.

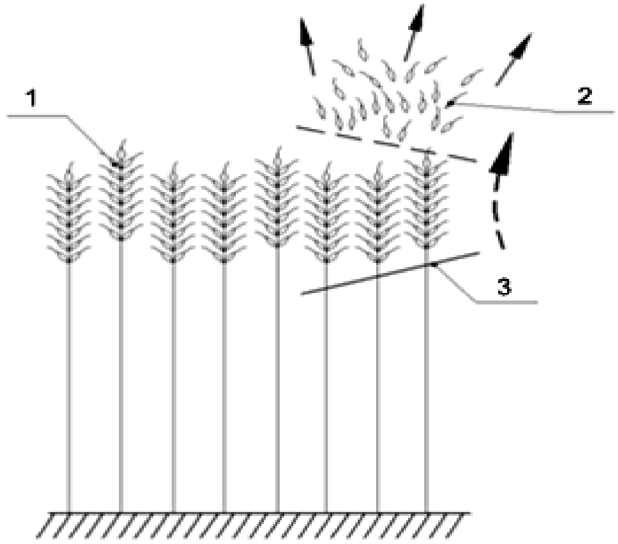

Fig. 2 - Scheme of stripping of cereals and headings crops
1 – inflorescences; 2 – stripped grains; 3 – finger

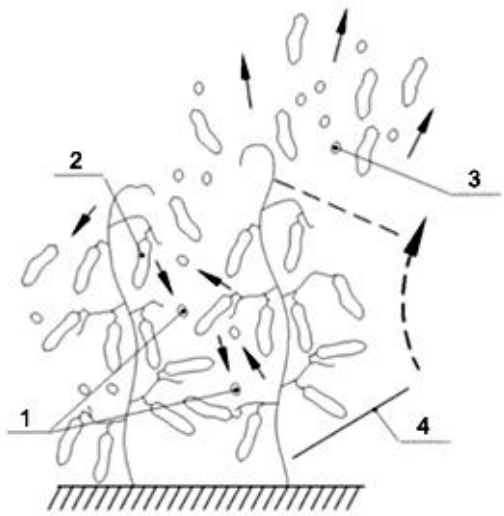

Fig. 3 - Scheme of leguminous crops stripping
1 – grains flying incorrectly; 2 – beans; 3 – stripped grains; 4 – finger

MATERIALS AND METHODS

White lupine "Dega" beans are located mostly in one upper layer. This allows using ultimately the technology of stripping at its harvesting *(Mosyakov M.A., 2016; Sergeeva V.A. et al, 2016).* Nevertheless, for harvesting leguminous crops with rather large bean size the stripper header of type "Ozon" in the conventional design has sufficiently small spacing between tines of the beater stripping fingers. In this case, bigger beans of white lupine do not fit in spacing between finger tines and the stripping process runs inefficiently. Therefore, to harvest white lupine sowings, we use modernized fingers with large spacing between tines *(Lukomets V.V. et al, 2016)* together with conventional ones. Different variants of stripping fingers are shown in figure 4.

Finger of stripper beater performs plane-parallel motion relative to ground surface composed from combine harvester forward speed and beater rotating motion. Each point of stripper beater in this case travels along a cycloid. In this regard, the stripping efficiency will depend on correlation of combine harvester forward speed and linear speed of stripper beater finger, determined with angular speed of beater and its geometrical dimensions, i.e. kinematic parameter λ.

The formula to determine kinematic parameter λ appears as follows:

$$\lambda = \frac{V_n}{V_p} = \frac{\omega r}{V_p} = \frac{\pi n r}{30 V_p}, \quad (1)$$

where:

V_n – linear speed of stripper beater finger, [m/s];
V_p – operation speed of combine harvester, [m/s];
ω – angular speed of stripper beater, [s^{-1}];
r – beater radius, [m];
n – beater rotational frequency, [min^{-1}].

The stripper beater drive provides three angular speeds: 485, 580 and 662 min^{-1}.

Fig. 4 - Stripping fingers of the "OZON" header (Russia):
left – conventional; right – modernized with large spacing between tines

RESULTS

According to testing data (fig. 5-8), efficient operation of stripper header at white lupine harvesting can be realized at the following correlations of combine harvester operation speeds and stripper beater rotation frequency:

a) at a stripper beater rotation frequency of 485 min^{-1} the operation speeds of combine harvester should be ≤ 4.3 km/h;

b) at a stripper beater rotation frequency of 580 min^{-1} the operation speeds of combine harvester should be ≤ 5.3 km/h;

c) at a stripper beater rotation frequency of 662 min^{-1} the operation speeds of combine harvester should be ≤ 6.0 km/h.

This limits the combine harvester operation at rather high operation speeds. According to the energy data it can be considered as the advantage over crop harvesting by the conventional method with the threshing of all straw-grain mass. In this regard, in the header design, it is reasonable to provide the possibility of further increase the rotation speed of the stripper beater.

From figure 5 follows that reduction of white lupine losses due to incomplete stripping decreases with reduction of plant mass supply for every finger, i.e. increase of linear speed of the stripping beater fingers in relation to combine harvester forward speed.

According to dependency, presented in figure 6, it follows that with the decrease of mass supply for every finger, shatter losses increase. It is the result of the construction fault of conventional stripping finger of beater for harvesting leguminous crops, particularly white lupine. Because of too small spacing between conventional finger tines, the sufficiently big beans of white lupine cannot get through the space between tines. In this case, in a greater degree the wearing out of legumes takes place and, as a result, great shatter losses occur. Since kinematic parameter increases, mainly because of the increase of the stripper beater rotation speed in relation to the combine harvester speed, the "effect" of legumes wearing out increases and shatter losses grow.

According to the data in figure 5, the results presented in figure 7 demonstrate that reduction of white lupine losses, because of incomplete stripping with the modernized header, is reducing with respect to the reduction of plant mass supply for every finger. There is the increase of linear speed of the stripper beater fingers in relation to forward speed of the combine harvester.

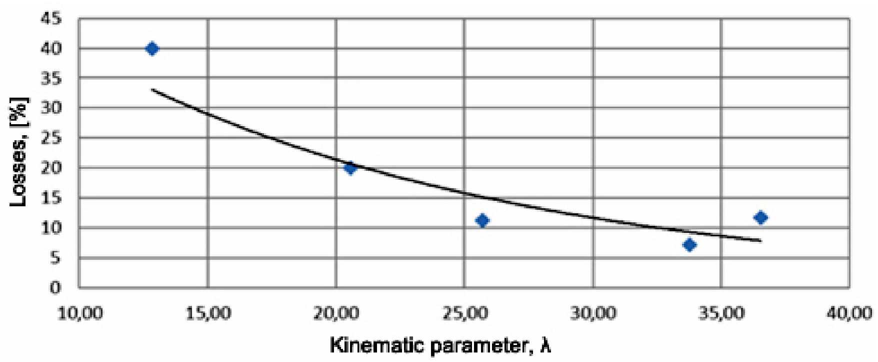

Fig. 5 - Dependence of white lupine losses due to incomplete stripping on λ, when using conventional design of stripper header fingers

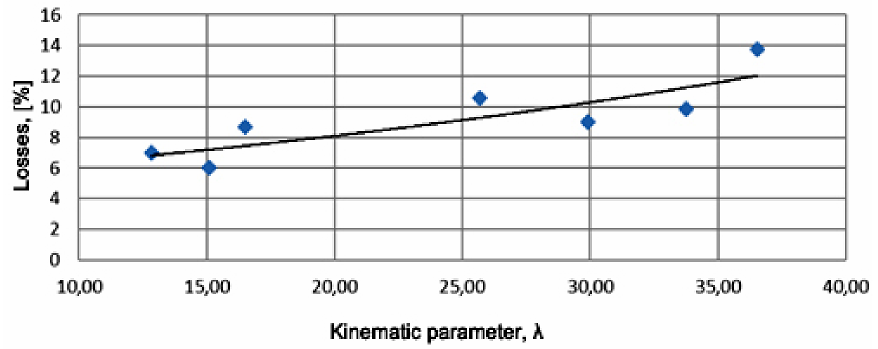

Fig. 6 - Dependence of white lupine shatter losses on λ, when using conventional design of stripper header fingers

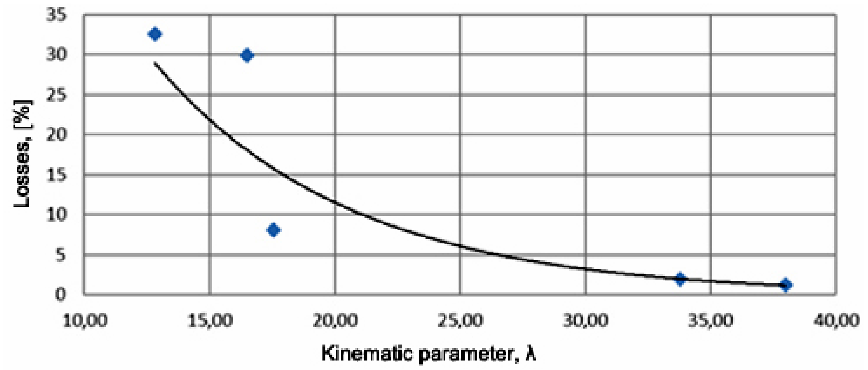

Fig. 7 - Dependence of white lupine losses due to incomplete stripping on λ, when using modernized fingers of the stripper header

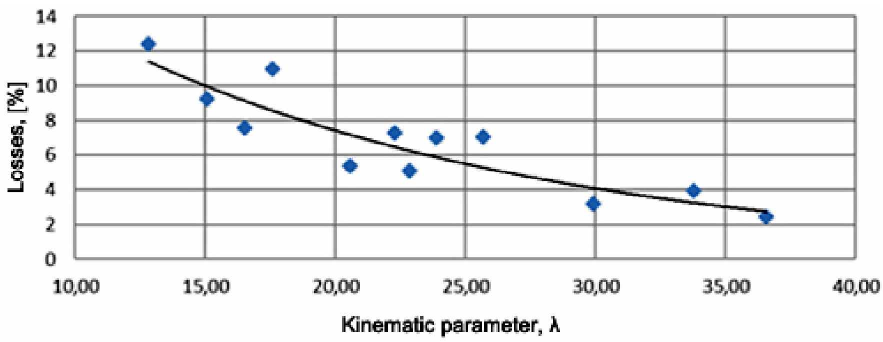

Fig. 8 - Dependence of white lupine shatter losses on λ, when using modernized fingers of the stripper header

The dependence presented in figure 6 demonstrates that the utilization of the modernized stripping fingers allows changing the white lupine grain losses behaviour due to the mass supply for every finger (kinematic parameter increase). Modification of the stripping finger construction due to the increase of the tines spacing provides more efficient stripping of white lupine.

According to the data presented in figures 7 and 8, it is possible to stress that utilization of the modernized fingers of the stripper beater can provide decrease of total losses of white lupine grain from incomplete stripping and loose grain up to 5% and lower. Herewith the operation speed of the combine harvester does not exceed 4.0 km/h at the stripper beater rotation frequency of 662 min^{-1}; 3.6 km/h – at 580 min^{-1}; 3.0 km/h – at 485 min^{-1}.

CONCLUSIONS

The "Ozon" stripper header of the OJSC "Penzmash" (Russia) production can be successfully utilized at harvesting white lupine of the "Dega" variety. In this regard, we recommend using the modernized fingers of the stripper beater with the increased spacing between tines. Herewith total losses of white lupine grain from incomplete stripping and loose grain can be up to 5% and lower.

The existing rotation speeds of the stripper header do not allow harvesting at combine harvester speeds of more than 6.0 km/h. To increase operation speeds of the combine harvester is necessary to foresee the possibility of rotation speed growth of the stripper header beater.

REFERENCES

[1] Aladyev N.A., (2015), Influence of tool-point velocity on grain damage of white lupine (Влияние скорости рабочих органов на повреждение зерна белого люпина), *Innovations in agriculture (Инновации в сельском хозяйстве),* Issue number 4 (14), pp. 97-102, Moscow/Russia;

[2] Aldoshin N., (2016), Methods of harvesting of mixed crops. (Методы уборки смешанных культур), *Proceeding of 6th International Conference on Trends in Agricultural Engineering 2016*, *Part 1, Czech University of Life Sciences Prague, Faculty of Engineering*, pp. 26-32, Prague/ Czech Republic;

[3] Chegini G., Mirnezami S.V., (2016), Experimental comparison of combine performance with two harvesting methods: Stripper header and conventional header, *Agricultural Engineering International: GIGR Journal*, Vol. 18, Issue 1, ISSN:1682-1130, pp. 192-200, Beijing/China;

[4] Henry W.B., Nielsen D.C., Vigil M.V., Calderon F.J., West M.S., (2008), Proso millet yield and residue mass following direct harvest with a stripper-header, *Agronomy journal*, Vol. 100, Issue 3, ISSN:0002-1962, pp. 580-584, Madison/USA;

[5] Ince A., Say M.S., Kara O., Bilgili E., (2011), Comparing of Different Harvesting Systems in Wheat Harvesting, *Tarim Makinalari Bilimi Dergisi (Journal of Agricultural Machinery Science)*, Vol. 7, Issue 1, ISSN:1306-0007, pp. 89-93, Alsancak-Izmir/Turkey;

[6] Lukomets V.V., Aldoshin N.V., Zolotov A.A., (2016*), Stripper beater.* Russia, Patent RU, No. 164619, МПК A01D 41/08;

[7] Mkrtchyan S.R., Ignatov V.D., Zhalnin E.V., Struzhkin N.I., (2013), Stripper headers: state and development perspectives (Очесывающие жатки: состояние и перспективы развития), *Agricultural Machinery and Technologies (Сельскохозяйственные машины и технологии),* Issue 4, ISSN:2073-7599, pp. 18-21, Moscow/Russia;

[8] Mosyakov M.A., (2016), Comparative evaluation of combine harvesters for white lupine harvesting (Сравнительная оценка комбайнов для уборки белого люпина), *Horticulture and berry culture of Russia (Плодоводство и ягодоводство России),* Vol. XXXXVI, pp. 246-250, Moscow/Russia;

[9] Sergeeva V.A., Nuravyev A.A., Naumkin V.N., (2016), Agricultural methods of obtaining high yield of white lupine (Агротехнические приемы получения высокого урожая люпина белого), *Agrarian science (Аграрная наука),* Issue 7, ISSN:0869-8115, pp. 4-7, Moscow/Russia;

[10] Stagnari F., Maggio A., Galieni A., Pisante M., (2017), Multiple benefits of legumes for agriculture sustainability: an overview, *Chemical and Biological Technologies in Agriculture*, Vol. 4:2, Issue 1, ISSN:2196-5641 (Online), Heidelberg: Springer/Germany;

[11] Zotikov V.I., (2017), Leguminous and cereal crops – acute direction of production quality growth (Зернобобовые и крупяные культуры – актуальное направление повышения качества), *Leguminous and cereal crops (Зернобобовые и крупяные культуры),* Issue 3(23), ISSN:2309-348X, pp. 23-28, Orel/Russia.