

PAPER • OPEN ACCESS

Innovative technology for processing flax straw on block-modular mobile units in agricultural organizations

To cite this article: A G Nikiforov *et al* 2022 *IOP Conf. Ser.: Earth Environ. Sci.* **1045** 012075

View the [article online](#) for updates and enhancements.



*Benefit from connecting
with your community*

ECS Membership = Connection

ECS membership connects you to the electrochemical community:

- Facilitate your research and discovery through ECS meetings which convene scientists from around the world;
- Access professional support through your lifetime career;
- Open up mentorship opportunities across the stages of your career;
- Build relationships that nurture partnership, teamwork—and success!

Join ECS! Visit electrochem.org/join



Innovative technology for processing flax straw on block-modular mobile units in agricultural organizations

A G Nikiforov¹, V N Gerasimov¹, V M Novitsky², Yu V Startseva³, F J Boboev⁴ and T P Baranovskaya⁵

¹ Smolensk State Agricultural Academy, 10/2, st. Bolshaya Sovetskaya, Smolensk, 214000, Russia

² Vitebsk Interdistrict Repair Company, 12, st. Sivakova, Vitebsk, 210013, Belarus

³ Russian Technological University MIREA, 78, Vernadsky avenue, Moscow, 119454, Russia

⁴ Tajik National University, 17, Rudaki Avenue, Dushanbe, 734025, Republic of Tajikistan

⁵ Federal State Budgetary Educational Institution of Higher Education “Kuban State Agrarian University named after I. T. Trubilin”, 13, Kalinina, Krasnodar, 350044, Russian Federation

E-mail: nikiforof@mail.ru

Abstract. The article considers the possibilities of increasing the profitability of flax production during the primary processing of trusts directly in the flax-sowing economy using innovative technology. A substantiated layout design of a mobile block-modular unit for processing flax straw into a single-type short fiber in a field mill and a hospital is presented. The description of the structure is given.

1. Introduction

An analysis of the development of the domestic flax industry over the past decades shows that from 1990 to 2016, the flax sown area in the country decreased from 418.0 thousand hectares to 48.5 thousand hectares, that is, by 88.4%.

However, by 2020, flax sown areas in the country have increased to 53 thousand hectares.

Fiber flax producers in the Smolensk region also managed to stop the decline in its production and stabilize work on the restoration of sown areas. The Smolensk region was one of the first in the country to start developing the flax industry as part of the implementation of the State Program for the Development of Agriculture and the Regulation of Agricultural Products, Raw Materials and Food Markets, approved by Decree of the Government of the Russian Federation No. 446 dated 14.07.2007. development of the industry over 730 million rubles. investment.

At present, the linen industry of the Smolensk region is represented by 16 flax-sowing enterprises.

In our country, the bulk of the trusts are processed into fiber at flax mills. At the same time, about 10% of the fibers are produced at the scutching and scutching stations directly on the farms.

From each hectare, on average, flax growers, if the requirements of the technology are met, receive 2.5 - 3.5 tons of flax straw. With an average purchase price of 4 thousand rubles. per ton of trust, each hectare can yield 10-14 thousand rubles income.



However, during the primary processing of trusts directly on the farm, you can get 12 - 15 centners of fiber per hectare. With an average market value of a ton of fiber of 45 thousand rubles. the economy will receive more than 60 thousand rubles. from one hectare.

The difference in the cost of sold products of primary processed trusts and trusts sold as the final product will be more than 400%, and this is without taking into account the savings in resources for transporting flax straw to a flax mill remote from the farm.

This income can remain on the farm, provided that the processing of the trust is organized at the place of production. That is why investing in the introduction of innovative technical support in the technology for producing flax fiber directly on farms can be extremely profitable.

At present, the trust is processed mainly by farms located at considerable distances from flax mills. When organizing the primary processing of flax on farms, it is necessary to build a scutching and scutching station, which requires significant financial investments, which, as a rule, is not economically feasible given the small sown areas of flax and the seasonal nature of processing [3].

2. Materials and methods

In the process of developing an innovative technology for processing flax straw and designing a mobile unit, calculation methods and design solutions for the arrangement of elements of existing stationary processing lines were analyzed [1-5]. This made it possible to create a unified computational design algorithm and determine the optimal set of elements of the complex.

The design of the main element of the mobile unit (cutting-separating turbine unit) has no analogues, which required the development of an original method for calculating and designing this element.

In the process of developing the design of the cutting-separating turbine unit, it was noted that the device is to a certain extent similar to the design of the centrifugal fan stage. A special theoretical study based on the analysis of the flat axial flow of the fire-fibrous air mixture in the flow part of the impeller of the turbine unit made it possible to determine the pressure characteristic and calculate the hydraulic characteristic of the pneumotransport network. This made it possible to calculate the operating point of the inlet part of the pneumatic transport system and the turbine unit by calculation. The calculated flow rate of the bone-fiber mixture was 18 m/s, which exceeds the speed of solid particles in the mixture and, accordingly, ensures the reliable movement of the mixture in the initial part of the pneumatic transport system without the formation of congestion and deposits. This computational analysis made it possible to abandon the installation of a special blower at the inlet section, which significantly reduces the energy costs for processing linen stock and, accordingly, the cost of production [1; 6-9].

The results of theoretical studies were verified by experimental tests of the cutting-separating turbine unit.

Experimental tests of the cutting-separating unit were carried out in accordance with the cooperation agreement between the Smolensk State Agricultural Academy and JSC "Vitebsk Interdistrict Repair Enterprise". The studies were carried out in accordance with the methodology GOST 17.2.4.06-90 "Methods for determining the speed and flow rate of gas and dust flows from stationary sources of pollution."

A schematic representation of the test stand is shown in figure 1.

This turbine unit consists of a suction pipe 1, a cutting-separating impeller with a collection chamber (volute) 2, a vertical discharge pipe of the pneumatic transport system 3, an impeller drive shaft 4. Flax straw enters the cutting-separating impeller through the suction pipe, where mechanical separating the fibers from the wood of the stems and grinding the wood itself and mixing the bone-fiber mixture with air. The impeller moves the bone fluff mass further along the collection chamber and air ducts of the pneumatic conveying system.

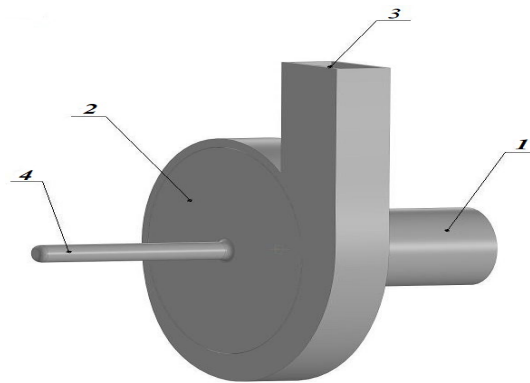


Figure 1. General view of the cutting-separating turbine unit.

Measurements of gas-dynamic parameters (Pitot tubes of full and static head) were made on the suction pipeline 1 and on the discharge pipe 2.

3. Results

At the Department of Mechanization of the Smolensk State Agricultural Academy, an innovative technology and design of a mobile universal block-modular unit for the primary processing of trust at a field camp or in stationary conditions of the economy has been developed (figure 2).

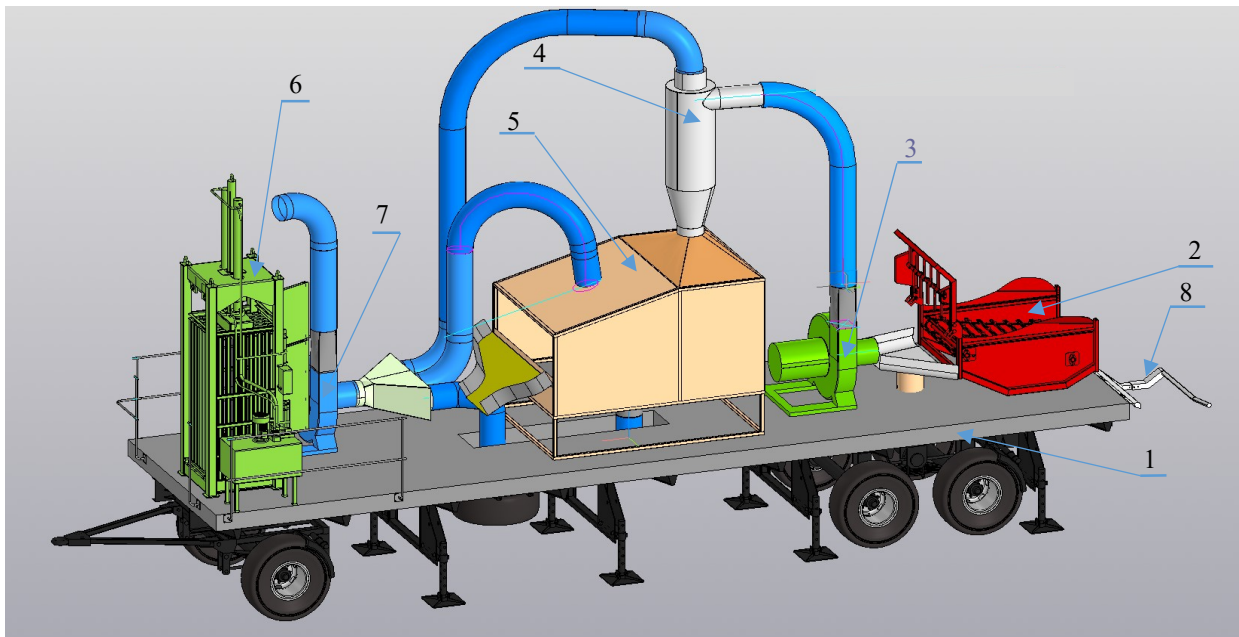


Figure 2. Block-modular mobile unit BMA-1: 1 - mobile platform; 2 - roll unwinder; 3 - cutting-separating unit; 4 - cyclone; 5 - shaking machine; 6 - press; 7 - fan; 8 - roll loader.

The entire mechanical system is located on a movable trailer chassis, which is moved by an autonomous traction means. The unit receiving the straw from the roll unwinder performs the functions of preparing and disintegrating, de-spitting the trust, as well as the function of post-cleaning on a shaker to simultaneously remove the fire and staple the fiber without cutting and achieve an average fiber length of more than 70 mm.

The BMA-1 unit consists of a mobile platform on which are mounted: dosing device; a device for breaking the bond between fiber and wood stems; a device for separating fiber and fires; device for

post-treatment of fiber; an aerodynamic system for transporting technological material, a control system for mechanisms and a press for packaging the finished material.

The mobile platform 1 is a three-dimensional structure welded from steel profiles, resting on the chassis and forming the main frame of the unit.

The dosing apparatus 2 consists of a decoiler for bales with a guide table.

The device for separating the fiber from the fire 3 is a welded body ("snail"), inside which is placed the impeller and mounted power elements that impact the mass of flax. The impeller is mounted in a bearing support mounted outside the housing.

The device for separating fiber and fire 4 is fixed on the air duct of the aerodynamic transport system and consists of a body with an inlet and an outlet window of a special configuration that separates the technological product based on physical and mechanical properties. The mechanism for installing the device when transferred to the transport position allows you to fold the protruding elements beyond the height dimensions and frame dimensions.

The aerodynamic system for transporting a technological product is a system of air ducts connecting the fan and units into a single technological chain.

The principle of operation of the BMA-1 unit. When the machine is working in the field, the trust packed in rolls is delivered by a vehicle and sent to the roll unwinder. The dosing device directs the straw tape into the intake suction funnel with a confuser and then through the suction air duct enters the device for separating the fiber from the fire (cutting-separating turbine unit) (figure 2). After the disintegrator, the bonfire mass after the disintegrator is fed through the air duct into the device for separating the bonfire from the fiber, consisting of a cyclone unloader and a shaker. In this device, the fiber is separated from the fire, based on physical and mechanical properties. Next, the fiber is collected in a pressing device, and the fire, blown by the air flow, is removed outside the site.

4. Discussion

Experimental studies were carried out on a cutting-separating unit manufactured by JSC "Vitebsk Interdistrict Repair Enterprise" by order of a flax processing enterprise. This determined the instrument installation scheme and the methodology for conducting experimental studies.

By conducting experiments and processing measurement results:

1. The results of the experiment confirmed the conclusions of theoretical developments.
2. Diagrams of the air flow rates and the bone-fiber air mixture in the suction and pressure nozzles of the unit were obtained at various flow rates. This allows you to determine the productivity of the combine in the process of designing new optimal designs and to establish the optimal operating modes of its operation.
3. It has been established that the speed of the fibrous air flow exceeds the speed of the fibrous substances, which ensures reliable transport of substances within the initial section of the pneumatic transport system.
4. The pressure characteristic of the cutting-separating unit has been obtained, which makes it possible to design the pneumatic transport system of a mobile block-modular flax harvester.
5. The presence of a pressure characteristic makes it possible to determine the operating point of the unit as the intersection of the pressure characteristic of the unit and the characteristics of the network, and to determine the reliability of the movement of the bone-fiber mixture in the first part of the pneumotransport system of the combine without the formation of stagnant zones.
6. The pressure characteristic of the pneumatic transport network can be calculated according to the method proposed in this paper, and depends on the design of the network connecting the cutting-separating unit and the units following it (cyclone and shaker).
7. When completing a block-modular flax harvester, the calculation of the operating point makes it possible to decide whether it is necessary to install an additional fan at the suction or discharge or do without it, using only the discharge properties of the cutting separating unit. The latter depends on the planned performance and the accepted design of the pneumatic transport system.

5. Conclusion

The proposed technology and the developed design of a mobile block-modular unit for processing flax straw allows you to have the following advantages:

- The unit can operate in stationary conditions as close as possible to the place of production of trust. This makes it possible to reduce production costs for transportation costs associated with the need to move large volumes of trust to the place of its processing, which, as a rule, is located outside the farm at a considerable distance;
- Mobility of use allows to operate the unit all year round;
- After delivery of the block-modular unit to the flax processing site, the traction facility is sent to perform other operations not related to flax production.
- The use of an electric drive in stationary conditions will significantly reduce the energy costs of production;
- There is an opportunity to increase the employment of the rural population in the autumn-winter period and to receive a significant additional income from the sale of flax fiber produced in stationary conditions;
- Possibility during the operation of the debonding unit to simultaneously perform the functions of stapling the fiber with the achievement of its average length of more than 70 mm, which makes it possible to obtain fiber with the required parameters of technological quality.

References

- [1] Nikiforov A G, Kuchumov A V, Terentyev S E, Gerasimov V N and Rekovets A V 2021 Methodology for designing the pressure characteristics of the cutting-separating unit of the flax harvester. *International scientific and practical conference "Ensuring sustainable development in the context of agriculture, green energy, ecology and earth science" Mechanization. engineering. technology.innovation and digital technologies in agriculture* **723**
- [2] Nikiforov A G, Gerasimov V N, Rekovets A V, Rudakov N A and Matychenkov E V 2020 The method for designing of the cutting-separating unit of the flax harvester. *Collection of materials of the international scientific conference "Digital technology – the basis of development of agro-industrial complex* **1** 316-322
- [3] Sidorov A, Abdullozoda R, Sadullozoda S, Saifiddinzoda O and Abdullozoda I 2021 Method for determining the state of an grounding device. *IOP Conference Series: Earth and Environmental Science* **808** 012005
- [4] Saidaliev Sh S and Valeev R G 2016 The simulation of neutralling system in Matlab/Simulink environment for research conditions electrical safety. *2nd International Conference on Industrial Engineering, Applications and Manufacturing* 7911693
- [5] Ermakova A M 2021 The main directions of development of the fuel and energy complex at the regional level. *IOP Conference Series: Earth and Environmental Science* **808(1)** 012048
- [6] Nosov V V, Vorob'eva D A, Udovik E E, Zhenzhebir V N, Morkovkin D E and Gibadullin A A 2022 Indemnities to Russian farmers for losses due to extreme weather event losses: the challenges and opportunities. *Agronomy Research* **20(2)** 357-370
- [7] Firsova A, Balash O and Nosov V 2014 Sustainability of economic system in the chaos. *Springer Proceedings in Complexity* 299-304
- [8] Terentyev S E, Gnezdova J V and Semchenkova S V 2020 Features of Machine-Technological Stations Organization in the System of Agro-Industrial Production. *IOP Conference Series: Earth and Environmental Science* **459(6)** 062060
- [9] Gruzina Y, Firsova I and Strielkowski W 2021 Dynamics of human capital development in economic development cycles. *Economies* **9(2)** 67