Use of Alternative Types of Fuel for Grain Drying

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1 Introduction

The largest energy expenses of after-gathering processing of corn, sunflower, and soybean grain are spent for drying [1].

Every year prices for the traditional types of fuel (natural gas, diesel fuel, mazout, coal) are rising, and therefore, it is reasonable to use alternative types of fuel in the process of grain drying. The most widespread types of them are organic waste from cultivation and processing of agricultural crops (straw, grain cleaning waste, sunflower husk), as well as wood (logs, wood shaving, fuel chips, granules) [2, 3].

2 Analysis of Reference Sources Data and Problem Statement

It is better to use the straw left on the field as organic fertilizer, and the intensity of its combustion in bales is difficult to control. The most primitive technology of burning one-meter-long logs (Brazilian driers Kepler Weber [4]) requires considerable labor costs. Significant disadvantage of using this type of fuel is its high humidity which is difficult to remove. Thus, one-meter-long logs by air-and-sun drying for several months are mostly above 30% in humidity [5, 6].

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Wood for accelerating its drying is crushed on fuel chips up to 30 mm. The latter can be received by branches cutting of fruit and forest plantations remained after preventive pruning. Screw, belt, scraper conveyors, and grain cores are suitable for their transportation. Fuel chips are dried in drum driers [7].

Granulation of biofuel increases its friableness and caloric content and reduces transportation costs. Heat generators for combustion of crushed fuel are equipped with mechanized loading systems [8].

Products of biofuel combustion with high content of ash substances are given to the grain mass in the driers of Brazilian technology; in addition, grain absorbs the smell of smoke. Driers with a heat exchanger are deprived of this lack. Air temperature does not exceed 120 °C at the outlet that positively affects the quality of grain, but it can reduce the productivity of grain driers designed for higher temperatures of the drying agent. It is difficult to keep a stable temperature of the drying agent operating under such grain driers, especially when burning of nonuniformity in caloric content and fuel humidity (grain cleaning waste, fuel chips) [9].

Technical and economic grounds, technological scheme and working projects of a heat generator for combustion of fuel chips, pellets, and a small amount of waste of wood processing industry (with knots and nails that cannot be crushed to chips) were developed. It is necessary to increase the power of a heat generator and fuel consumption by almost twice in case of using heat exchanger. Effective operation of a heat exchanger is possible only by highly skilled, disciplined personnel together with engineering solutions—automation of the combustion process, protection against electricity irregularity, etc.

Construction project provides purification of flue gases in cyclones and verification of safety indicators of soybean seeds for remains of incomplete combustion substances: dioxins, heavy metals, polycyclic aromatic hydrocarbons (benzopyrene, etc.).

3 Research Objectives and Tasks

Purpose and objectives of the study consist in finding optimal types of alternative fuel and machines for their preparation for combustion in a heat generator of a grain drier—DSP-32*2 M.

4 Research Materials and Methods

Our study was conducted on the basis of "Vidrodzhennia" LLC of Hromada village of Liubar district, Zhytomyr region.

The study determined: productivity of log splitters by dividing the volume of wood delivered by one car (indicated in the consignment note) for the time necessary for its processing; chipping machines by marking the time required to fill the operational

Table 1 Basic technical and technological indexes of the machines for wood splitting

Indicator	KG(КГ)-1000	KM(КМ)-2000
Maximum tree length (mm)	1000	2000
Maximum tree diameter (mm)	700	1000
Actual maximum diameter (mm)	300	500
Maximum productivity (m^3/h)	2–9	9–20
Actual productivity (m^3/h)	1	3
Number of blades (pieces)	2	1
Engine power (kW)	11	22
Weight (kg)	310	1000

bunker with volume of 6 m^3; mass fraction of a large fraction of fuel chips by weighing of manually selected chips in the process of reloading from the operational (volume of 64 m^3) into the accumulation bin of a heat generator. Such repetition was done three times.

5 Results and Their Discussion

It is necessary to split that wood which has a larger diameter than maximum permissible size of a chopping machine. You should have a hydraulic log splitter KG(КГ)-1000 together with a chopping machine PL(ПЛ)-160. We designed a mechanical log splitter KM(KM)-2000 for a chopping machine MRNP(МРНП)-30 (Table 1).

It was established that the actual maximum diameter of wood for both machines was lower than in the passport because there was wood of non-rectilinear form for combustion, with a large number of branches of fibrous structure. However, excess of load resulted in carriage bending of overheating of hydraulic fluid (KG(КГ)-1000) or chain breaking (KM(KM)-2000), and lack of mechanical supply significantly reduced the productivity of a log splitter (KM(KM)-2000) to 3 m^3/h.

Optimal modes of chopping machines operation expected the use of wet wood, drying and storing of fuel chips. Using such scheme requires additional operations for transporting fuel chips to storehouses for their keeping. We chose the following scheme for this purpose which includes: air-and-sun drying of wood, its transportation, chopping, and burning. Blades of chopping machines were sharpened on the TChN(ТЧН) 21–5 bench; angle for blades sharpening was chosen according to the wood moisture content.

Wood chopping was performed using a stationary chopping machine MRNP (МРНП)-30 and a mobile machine—PL(ПЛ)-160. The drive of a chopping machine PL(ПЛ)-160 could be carried out both from the electric motor and from the power shaft of capacity takeoff of a tractor of MTZ(МТЗ)-82 class. The latter option allowed chopping the crowns of trees directly in the forest (Table 2).

Table 2 Basic technical indexes of chopping machines PL(ПЛ)-160 and MRNP(МРНП)-30

Indicator	PL(ПЛ)-160	MRNP(МРНП)-30
Maximum tree diameter (mm)	160	250
Maximum productivity (m^3/h)	9	30
Number of blades (pieces)	3	16
Engine power (kW)	30	90
Wood supply	Hydraulic	Gravitation
Weight (kg)	860	5750
Actual productivity (m^3/h)	3	21

Supply of fuel chips to the heat generator was carried out by screw conveyors, and therefore, one of the important indicators in the work of chopping machines was mass fraction of chips that could not be given by a screw (length—more than 100 mm; thickness—more than 20 mm).

Chopping machine PL(ПЛ)-160 is completed with an electric motor with a power of 30 kW by the factory manufacturer that is much less than the power of a tractor engine of MTZ(МТЗ)-82 class. Studies showed that the use of electric drive lowered actual productivity of a chopping machine to 3 m^3/h. Problems with exceeding the temperature of hydraulic fluid also caused forced stops. The lack of mechanized wood supply to the chopping machine MRNP(МРНП)-30 was the main reason for reducing the actual productivity to 21 m^3/h.

Chopping machine MRNP(МРНП)-30 is located below the shop floor which makes gravitation wood supply easier. Chips were given into a bunker of fuel receiving from vehicles with centrifugal force, for example, from a mobile chopping machine PL(ПЛ)-160. Contents of the bunker were unloaded onto the belt conveyor. Scraper conveyor was used to lift fuel chips into a storage bunker. Fuel chips were given to the heat generator TPG(ТПГ)-5 (project of Martsun O. M., Skoblenko V. P., Yaroshenko V. V., Tkachenko G. V.) with the help of four screw conveyors.

It is found that qualitative combustion of fuel on a sloping grate grid was carried out by the linear size of chips within the limits: width and height—10 to 25 mm; length—25 to 100 mm. Fuel pieces of smaller size fell through the holes in a grate grid, and they damaged it with high temperatures burning under a grid. Pieces with a high surface area and low weight were raised by air flow, did not have time to burn in the fuel spray zone. and increased the amount of sparks and products of incomplete combustion in flue gases.

It was revealed that a large fraction of fuel was difficult to transport with screws, and the duration of its drying on the sloping part of a grate grid was longer. A large fraction had a smaller total surface area; therefore, the intensity of the oxidation process was slowing down. The mass fraction of a large fraction of chips is shown in Fig. 1.

In 2017, about 40 thousand tons of soy to 8% of humidity [10, 11] without the use of natural gas was dried at the enterprise. A gas burner with minimum fuel

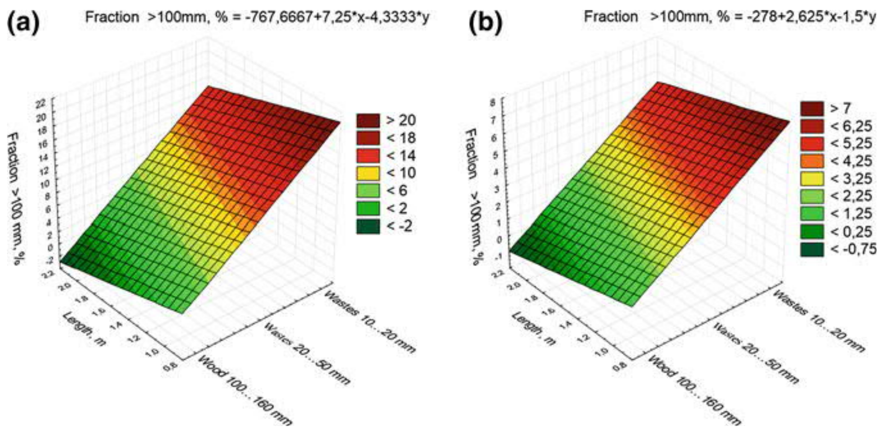

Fig. 1 Mass fraction of chips with a length of more than 100 mm under processing of wood and wastes from woodworking with the length of 1 and 2 m by chopping machines **a** ПЛ(ПЛ)-160 and **b** МРНП(МРНП)-30

consumption was turned on at night only for drying individual batches with a seed moisture content of more than 25%. Technical documentation for building the second stage of an elevator with grain drier with a capacity of 100 t/h on alternative types of fuel was developed on the accumulation of ascorbic acid in black currant fruits.

6 Conclusions

1. Actual productivity of a log splitter KG(КГ)-1000 and chopping machine PL(ПЛ)-160 was lower than passport index under the conditions of uninterrupted operation at a large enterprise of 1 and 3 m^3/h, respectively.
2. Lack of mechanized supply of raw materials reduced actual productivity of a log splitter KG(КГ)-2000 to 3 m^3/h and a chopping machine MRNP(МРНП)-30 to 21m^3/h.
3. Greatest output of a large fraction of fuel chips (20%) was observed under use of a chopping machine MRNP(МРНП)-30.
4. Output of a large fraction of fuel chips was observed by processing of raw materials in the length of 1 m by 60–100% higher than by 2 m in length.

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