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N. A. Sychova, PhD student, junior researcher (BSTU);
I. A. Khmyzov, PhD (Engineering), assistant professor (BSTU);
T. V. Solovyeva, D. Sc. (Engineering) professor (BSTU)

EFFECT OF COMPOSITION OF FUEL PELLETS ON THEIR QUALITY PARAMETERS

The present researches are aimed at studying the influence of composite pellets on their quality measures. To obtain experimental samples of pellets, we used the main tree species of wood, that is pine, alder and birch. Found that the pellets produced from hardwood inferior in mechanical strength of the pellets obtained from pine. Technological solution to this problem was to establish the optimal composition of the fuel pellets and chemical activation of hardwoods. The highest strength pellets are achieved with the use of starch. The laboratory results were tested in industrial applications through the issuance of an experimental batch of fuel pellets.

Introduction. Since ancient times mankind has used wood for heat and energy. However, the availability of other natural fuels, directly extracted from the bowels of the earth (oil, natural gas), their relative cheapness overshadowed the use of wood raw material as an energy source. Excessive spending of the natural wealth of traditional technologies in the twentieth century led to depletion and pollution. The possible threat of human-induced climate change, the negative impact of energy production and use on the environment and health of people make it necessary to search for clean, renewable sources of energy [1]. The developed countries see the way out of the potential energy and economic crisis in the use of renewable energy sources, which are practically inexhaustible. Structure of fuel-energy balance of the Republic of Belarus is presented in the Table 1 [2].

Table 1

Structure of the fuel and energy balance of the Republic of Belarus

Type of energy resource	Share, %
Natural gas	59
Light petroleum products	11.7
Fuel raw material	10.8
Transfer of electro-energy	3.8
Local kinds of fuel	12.4
Fuel oil	2.1

As it is seen from Table 1, in the structure of fuel and energy balance of the country 59% is natural gas. Therefore reduction of the share of natural gas and increase of the share of biofuels will be perspective.

Nowadays, more attention is paid to the wood biofuels. Due to the rapid development of markets for by-products of woodworking industry that encourages the development of one more branch of industry-processing of wood into fuel pellets. It is known that the production of fuel pellets made from waste wood is one of the promising directions in bioenergy. It should be noted that this is due to the low costs of fuel pellets, compared to other modern biofuels and simple technology of their production [3].

The purpose of this research is to study the influence of the composition of fuel pellets on physical-mechanical properties and calorific value.

Main part. For getting fuel pellets we used the tree species, that is pine [*Pinus silvestris* L.], alder [*Aihus glutinosa* (L) *Gaertn*] and birch [*Betula verrucosa Ehrh*], which are widely cultivated on the territory of the Republic of Belarus. It should be noted that under the current conditions of a deficit of raw materials and energy resources the use of deciduous timber for fuel production is of particular importance. Comparative analysis of fuel pellets in the main quality indicators according to the STB 2027 [4] obtained from traditionally used wood of pine and studied deciduous species of wood, are presented in Table 2.

Table 2

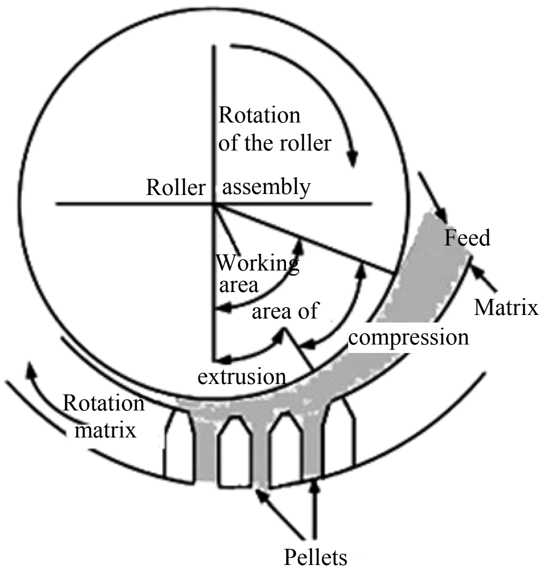
A comparative analysis of the quality of fuel pellets

The name of indicator	Wood species		
	pine	alder	birch
Moisture, %	8	9	10
Ash content, %	0.27	0.36	0.44
Density, kg/m^3	1,160	1,200	1,155
Wood dust (mechanical strength), %, not more	1.6	0.9	0.8
Pressure resistance limit, MPa	4.7	3.18	2.12
The lowest heat of burning, kJ/kg	17,540	17,490	17,630

Research had shown (Table 2) that the pellets made of hardwood (alder and birch) have a slightly reduced mechanical strength compared to that achieved when using the wood of a pine. Technological solution of this problem was the establishment of the optimal composition of fuel pellets and chemical activation of hardwood.

From a scientific point of view, the formation of fuel pellets occurs due to intensive compression of wood pulp, homogeneous on humidity and size of wood particles at elevated temperatures. The principle of pellet formation is shown in Fig. The formed pellets have a high temperature due to the friction. After being passed through the cylinders the warm material is divided into granules of specified length (usually 10–30 mm), i.e., the granules of the required form. Immediately after the stage of compression pellets are cooled and acquire the necessary strength, that making them suitable for storage and transportation.

Wood raw is a complex rheological system containing cellulose, lignin, hemicellulose and resinous substances [5]. It is established, that while heating there occurs destruction of these components with the formation of liquid plasticized phase, which spreads on a surface of wood fibers and provides them with adhesion interaction, wood pulp acquiring the desired shape. Chemical activation of hardwood aimed at increasing component reactivity of lignin-carbohydrated matrix, which as a result of the effects of temperature and pressure are plasticized and get the properties of the binder for high adhesion interaction of wood particles to each other.



Principle of formation of fuel pellets

In the laboratory of the Department of HFA researches were conducted for use albumin, casein, starch as a non-toxic organic additives, which act as a binder, not only affecting the rheological parameters of the composite while pressing on the matrix and improves the physical and mechanical parameters of fuel pellets.

Our studies showed that the binders of natural origin allow us to change rheological properties of processed wood particles i.e. make them more flexible and reduce the power consumption of a granulating process in general. The results of mechanical strength improvement of fuel pellets, derived from hardwood, are given in Table 3.

Table 3 shows that the highest values of the compressive strength of pellets are achieved with the use of starch. However, their strength is still somewhat lower than the mechanical strength of fuel pellets of pine wood.

Therefore, further research on the technology of fuel pellets was continued to establish the effect of consumption (contents of activated hardwood birch and alder, consumption of starch) and operating condition parameters (temperature of pressing), which will ensure a consistently high quality of fuel pellets.

Table 3

Physical-mechanical parameters of quality fuel pellets depending on the type of organic additives

Wood species	Type of organic additive	Consumption, %	Compression strength limit, MPa	Ash content, %
Pine	–	–	4.7	0.32
Alder	Albumin	0.1	3.22	0.41
		0.5	3.31	0.45
Birch	Albumin	0.1	2.92	0.42
		0.5	3.17	0.48
Alder	Casein	0.1	3.19	0.37
		0.5	3.26	0.39
Birch	Casein	0.1	2.91	0.34
		0.5	3.08	0.37
Alder	Starch	0.1	4.37	0.21
		0.5	4.59	0.25
Birch	Starch	0.1	4.31	0.23
		0.5	4.55	0.26

To determine the optimal parameters of the process for the production of fuel pellets we used mathematical planning of the experiment with the implementation of the plan Kono [6]. As independent controlled variables there were selected active factors, which varied in the range of values: the content of activated hardwood birch and alder was 20, 30, 40%; starch consumption was 0.1, 0.3, 0.5%; the pressing temperature was 100, 110, 120°C. Indexes of the compressive strength limit and calorific value were determined to obtain samples of fuel pellets.

Optimal consumption and operating condition parameters and corresponding to these parameters indicators of fuel pellets quality were found by calculation of the generalized optimization criterion i.e. W=0.88. It was found that the optimal parameters of the process for fuel pellets production are the following: pressing temperature is 111°C; consumption of starch is 0.47%; the share of hardwood is 30%. At these parameters the following values of quality indicators of fuel pellets are achieved: compressive strength is 4.6 MPa; calorific value is17,958 kJ/kg.

The results of the conducted researches inspired us to continue our studies under industrial conditions. Thus, the production line of state enterprise “Belarustorg” have tested the technology for the production of fuel pellets from activated starch hardwood (in a ratio of 30% broadleaf and 70% softwood) by the issue of the pilot batch.

Conclusion. The influence of the composition of fuel pellets on the basic quality indicators has been studied. With the help of mathematical experiment planning and a compromise solution to the optimization problem we have established optimal parameters for the process for fuel pellet production. The results of laboratory researches were tested under industrial conditions by producing of a pilot lot of fuel pellets.

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