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DEVELOPMENT OF MODIFICATION TECHNOLOGY OF WOOD RAW MATERIAL IN PRODUCTION OF SOLID BIOFUEL

Studies have shown that the mechanical properties of the pellets produced from hardwoods yield pellets traditionally used pine. In order to improve their original wood raw material modified by the addition of protein nature (albumin, casein, gelatin) and starch (potato starch and maize, starch syrup) by spraying through nozzles in the screw feeder directly before granulation. To increase the strength of pellets application proteinaceous adhesives has proved more effective than the starch paste. Albumin as presented in this particular interest. To carry out industrial testing technology was developed modifications of chopped wood with its use in the production of pellets.

The tests samples of modified wood pellets showed full compliance with them as a group 1 (in STB 2027). Humidity pellets was 10%, ash content – 0.7%, the wood dust abrasion – 0.8%; calorific value – 17,640 kJ/kg.

Key words: modification of the wood, technology of pellets, protein adhesive, starch adhesive, mechanical strength.

Introduction. At present as a result of the wide use of pine wood in wood processing industry waste wood is generated in the amount varying from 5 to 60% depending on the type of production. Some part of this waste is disposed on the enterprises, some part is removed and sold in the form of chipped wood or raw materials for the production of pulp and paper or boards or solid biofuel (pellets) [1]. At the same time taking into account the growing demand for pellets the problem of the deficiency of raw materials for their production arouse. It caused the necessity to use low-pr ice soft wood such as birch or alder that are fast-growing and characterized by relatively poor demand. That's why the goal of this research lies in the performance of works aimed at the exchange of expensive soft wood by cheaper and more accessible hard wood in the production of pellets.

Main part. In the laboratory conditions of the chair of chemical wood processing the samples of pellets from waste wood of birch and alder were obtained. The reference sample was produced of the traditional waste wood of pine. In order to receive the pellets of high quality the recommended ranges of humidity (8–11%), ash content (NMT 0.7%) and size of particles (0.5–1.0 mm) were maintained.

The tests of the samples of pellets were conducted in compliance with the methodology set in STB 2027: moisture test according to EN 14774-1:2009, ash content according to EN 14775:2009, density according to EN 15150:2005, bulk density according to EN 15103:2005, calorific capacity according to EN 14918:2005, mechanical strength according to EN 15210-1:2009 (based on the determination of wood dust content during abrasive wear) [2].

The conducted research at the comparison of the results of the use of pine wood and the mixed combination of alder and birch wood in ration of 1 : 1 demonstrated that the strength properties of the laboratory samples of pellets produced of hard wood are lower than those of traditional pine wood. In order to increase those properties the additive of protein origin (albumin, casein, gelatin) and containing starch (potato and corn starch, starch syrup) were introduced into the composition of wood raw materials. These substances can demonstrate glue properties and that determined their selection as a binder for pellets. Moreover, they are non-toxic, ecologically pure, they create the minimal quantity of hazardous gases after burning and do not alter the ash content of pellets due to their organic nature. Fig. 1 and 2 demonstrate the data on the effect of additive use on compression and bending resistance parameters of pellets.

As you can see from the characteristic curves, during the use of all the aforementioned additions with consumption of 0.5% the values of compression or bending resistance of pellets are growing along with the increase in consumption in the range from 0.1 to 0.5%. The most effective additives in this relation are albumin and gelatin.

The results for the determination of the parameter of wood dust contents during the abrasive wear of pellets (according to STB 2027) demonstrating their preservation of strength in the course of time on the condition of the use of additives with consumption of 0.5% are provided in Fig. 3.

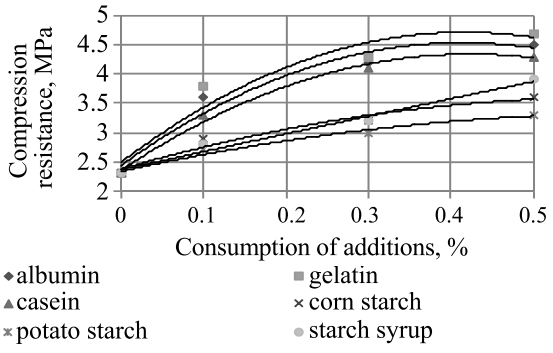

Fig. 1. Effect of additive use on compression resistance of pellets

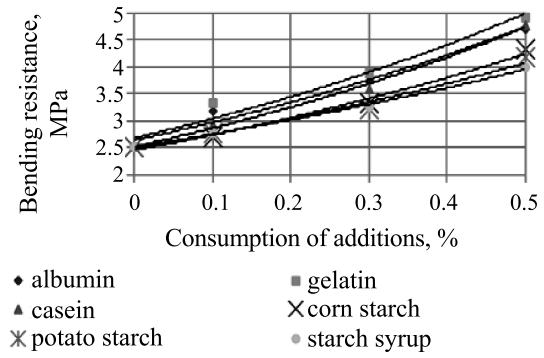

Fig. 2. Effect of additive use on bending resistance of pellets

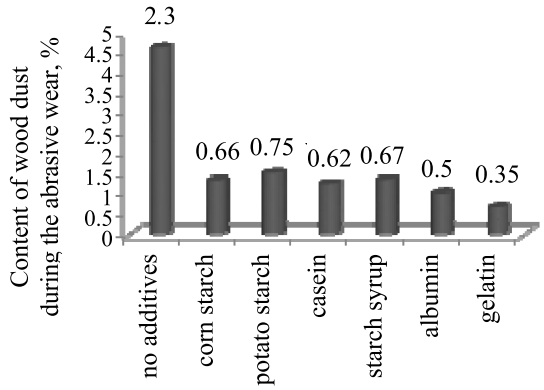

Fig. 3. Effect of additives on the contents of wood dust during the abrasive wear

According to STB 2027 the quantity of dust forming during the abrasive wear of pellets shall not exceed 0.8% for group 1. As you can see on Fig. 3 all the samples of pellets obtained by the use of additives with consumption of 0.5% conform to the requirements specified in the standard. The least quantity of dust fraction was forming during the tests of wood pellets treated with gelatin and albumin. The contents of dust fraction in comparison to the sample of pellets without additives reduced from 2.3 to 0.35 and 0.5% respectively. This allows us to make a conclusion that in order to increase the strength of pellets the use of protein glues is more effective than the use of starch paste. Albumin was of peculiar interest in this role. It is known [3] that it is a natural polymer formed from the residues of α-amino acids connected by peptide bonds. Peptide bond is characterized by conjugation of π-electron of nitrogen and oxygen, thus it acts as a partially double bond able to be disrupted in the process of chemical transformations with the creation of new functional groups. Amino acids that are the components of albumin, in their turn, contain great numbers of functional groups, such as carboxyl and amino groups that are prone to chemical interaction with the components of wood and being bound with such components they increase their reactive capacity, including polycondensation reactions. It is highly probable that these interactions played their role in the increase of the strength of pellets.

Taking into account the wide accessibility of albumin in order to conduct industrial tests the technology for modification of the milled wood with its subsequent use in the production of pellets was developed. The layout of the process of the production of pellets from waste wood in the form of saw dust with inclusion of albumin in its composition applied to the production line of State Enterprise “Belarustorg” is provided in Fig. 4.

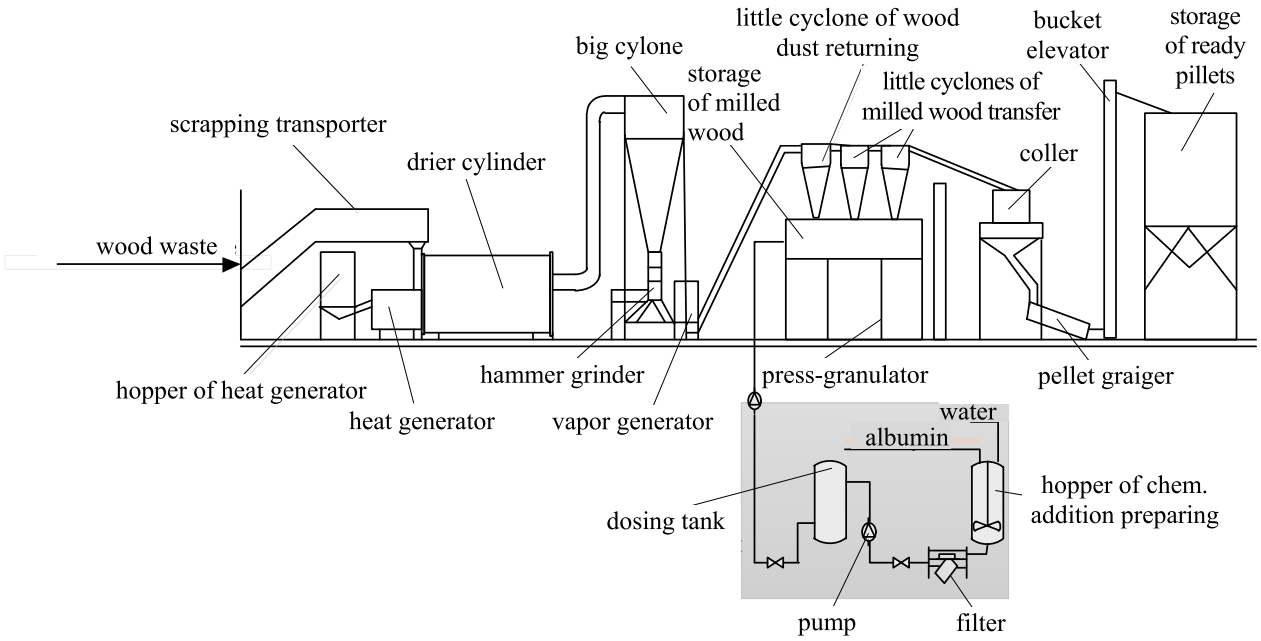

Fig. 4. Layout of the process of the production of pellets from waste wood and albumin

Quality parameters of pellets

Parameter	Requirements of STB 2027		Selected samples of pellets	
	group 1	group 2	prior to pilot batch	during pilot batch production
Humidity, %, NMT	10	12	6.1	5.5
Ash content, %, NMT	0.7	1.5	0.42	0.40
Density, kg/m^3	1,200 ± 200		1,275	1,295
Bulk density, kg/m^3	650 ± 150		600	650
Calorific capacity, kJ/kg, NMT	17,500		17,570	17,640
Wood dust content during abrasive wear, %, NMT	0.8	2.3	1.84	0.5

To obtain pellets according to the process layout provided in Fig. 4 wood waste was dried to humidity of 8–11% and transferred to the grinder where it was milled to the size of particles of 0.5–1.0 mm.

The solution of albumin was prepared through dissolving of powder albumin in water with the temperature of (30 ± 2)°C for 1.5 h in order to obtain 10% solution. Albumin solution was sprayed on the milled wood parts in inlet auger prior to granulation. Then the obtained wood mass was transferred to the pellet press. The formation of pellets was carried out by the means of intensive compression at the increased temperature of wood mass, so that its granules got cylindrical shape. The finished pellets were cooled by staying in the cooler and packed. We must add that technical changes of the production of pellets did not affect its technological parameters: granulation process was carried at the pressure of 5–10 MPa and temperature of 100–120°C. The volume of the pilot batch was 51 t. The pellets manufactured by the technology established on the production line of the branch of the State Enterprise "Belarustorg" for pine wood were taken as reference standard. The table below contains the values of the main quality parameters for group 1 and 2 according to STB 2027 and test results of the produced pellets.

As you can see from the table the pellets produced with the use of albumin have high calorific capacity and better parameters of strength and density in comparison with pine wood pellets (at the same values of humidity and ash content).

Conclusion. The technology for the modification of wood raw materials was prepared assuming the inclusion of the section for the preparation and addition of 10% albumin solution with consumption of 0.5% in the process of the production of pellets. The technology was tested in industrial conditions at the production line of State Enterprise "Belarustorg" and the pilot batch of pellets conforming to the quality requirements of group 1 according to STB 2027 was manufactured: humidity – 5.5%, ash content – 0.4%, wood dust content during abrasive wear – 0.5%, calorific capacity – 17,640 kJ/kg.

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