Fibre Chemistry, Vol. 41, No. 5, 2009

FABRICATION OF ORGANIC SYNTHETIC FIBRE PLATES USING SHORT-FIBRE TEXTILE WASTES

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UDC 677.08.02.16./.022

It was found that composite organic synthetic fibre plates (OSFP) containing short-fibre textile wastes have elevated physicomechanical properties. The wide introduction of new OSFP into production will solve the important problem of utilization of chemical wastes.

The use of wastes as secondary raw material is an important environmental and economic necessity. The development and introduction of energy-saving technologies and rational utilization of local resources and wastes are the most important mechanisms for ensuring the competitiveness of manufactured products and replacement of imports. Implementation of such technologies will reduce the specific consumption of materials for some types of products.

Processing of textile wastes consisting of chemical fibres is technologically somewhat complicated and expensive due to the necessity of creating special equipment. Most of these wastes go to landfills, creating a serious environmental problem. In particular, low-grade man-made fur fibre wastes are practically unsuitable for fabrication of textile products. Fibres from 0.5 to 25 mm in length not used in production are basically formed in a separate sector constituting 34% of the raw material used.

The Department of Spinning of Natural and Chemical Fibres has developed technology for processing short-fibre wastes into organic synthetic fibre plates (OSFP). Textile wastes are added to a mixture with wood fibre in the amount of 30 to 70% and the subsequent process of manufacturing the organic synthetic fibre plates takes place according to the usual technology for manufacturing wood-fibre plates.

Wood-fibre plates have low strength properties, very low bio- and chemical stability, and are not resistant to atmospheric factors. This limits the area of their application as construction and construction-finishing materials. In addition, they are comparatively expensive. The use of short-fibre wastes for production of OSFP would simplify and make the existing technology less expensive by reducing the components and is an example of the effective realization of textile industry wastes.

Both man-made fur clipping wastes — shearings (Nitron, Lavsan) and weaving wastes (Nitron, Capron, wool, polypropylene) are used in OSFP.

Manufacture of OSFP by the wet production method, which includes the following process operations, is recommended:

- preparation of raw material for production: preparation of wood pulp by grinding, grinding of textile wastes;
- mixing wood pulp with textile wastes and preparation of wood-polymer composite;
- preparation of adhesive compositions and gluing of wood-polymer paste;
- formation of wood-fibre carpet;
- hot extrusion;
- postextrusion treatment;
- pattern cutting and packaging.

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Vitebsk State Technological University, Belarus'. Translated from *Khimicheskie Volokna,* No. 5, pp. 52-55, September-October, 2009.

TABLE 1. Intervals and Levels of Variation of Factors

Factor	Notation	Coded values			Intervals of variation
		−1	0	1	
Proportion of textile wastes, %	$X_1 \rightarrow X$	30	50	70	20
Extrusion temperature, °C	$X_2 \rightarrow Y$	150	165	180	15

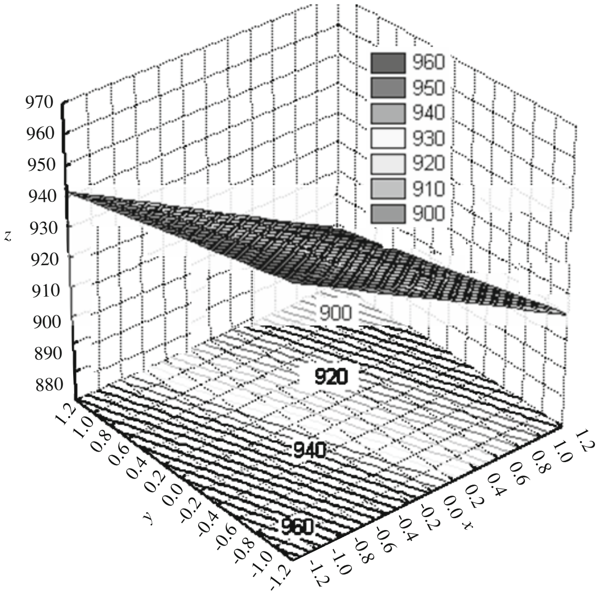

Fig. 1. Density of OSFP as a function of proportion of embedded fibre and extrusion temperature.

As we see, this method of processing textile chemical wastes is based on wood-fibre plate production technology that includes additional grinding. Implementation of this technology will allow expanding the assortment of construction materials with high physicomechanical indexes.

To determine the optimum composition of the mixture in production of OSFP, we investigated the dependence of the physicomechanical indexes of the OSFP on the textile waste content in the composite and the extrusion temperature [1]. The experiment, which included 9 experiments, was conducted with a Kono matrix design for a two-factor experiment. For constructing the experiment design, the conditions of conducting it, i.e., the levels of the factors and intervals of their variation, were determined in preliminary studies (Table 1). The fundamental indexes of the quality of the composite fibre-containing materials were used as the output parameters: density, bending strength, swelling.

Each experiment included 50 samples. The samples were tested and the average density, bending strength, and swelling values were determined. The results obtained were processed on a computer with Statistics for Windows software. As a result of processing the data, the values of the regression coefficients of polynomial models and the dependences of the quality indexes of the composite mixtures on the input factors were obtained. The significance of each coefficient and the adequacy of the model obtained were evaluated.

The results shown in Fig. 1 were obtained for the indexes of the density of the OSFP. In analyzing the regression model,

$$Z = 925.755\text{-}21.698X - 8.0094Y,$$

we can conclude that density (Z) is a function of both the proportion of embedded fibre wastes (X) and the extrusion temperature (Y). The significant negative coefficient for factor X indicates that the density of the OSFP tends to decrease to

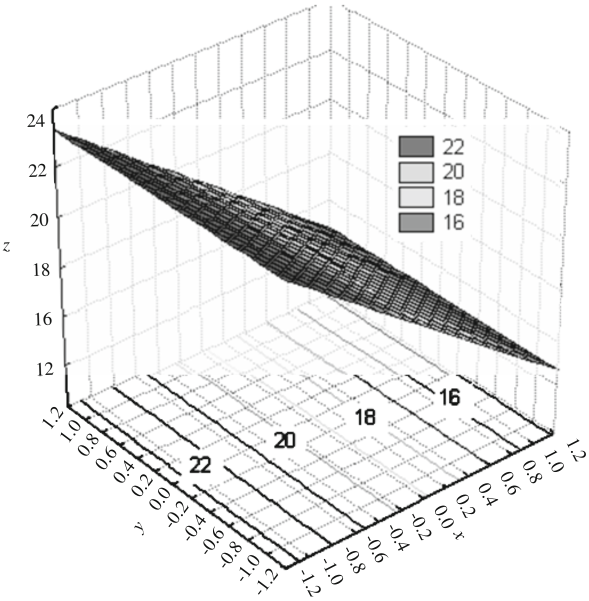

Fig. 2.

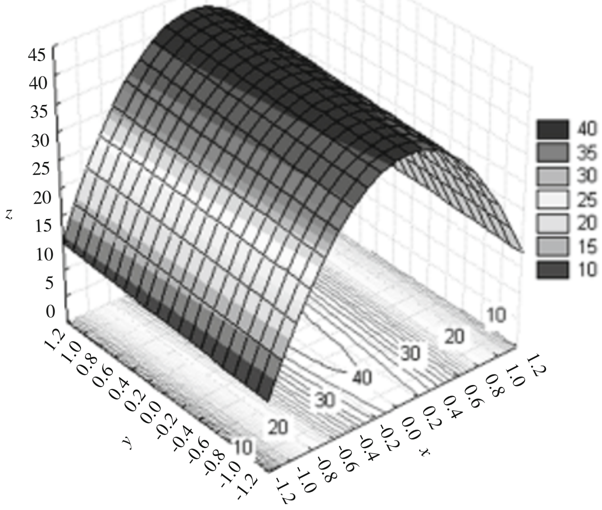

Fig. 3.

Fig. 2. Bending strength of OSFP as a function of proportion of embedded fibre and extrusion temperature.

Fig. 3. Swelling of OSFP as a function of proportion of embedded fibre and extrusion temperature.

a certain limit with an increase in the embedded fibre wastes. With an increase in embedded Nitron fibre wastes to a ratio of 35/65, the density increases because the finely disperse Nitron penetrates the gaps between the coarse wood substrate, which is reflected in the graph. However, in further substation of wood fibre by Nitron fibre wastes, new voids arise, and the density of the material decreases. The coefficient for factor *Y* is also significant and negative, indicating a tendency toward a decrease in the density with an increase in the extrusion temperature.

The results obtained for the bending strength index are shown in Fig. 2. Analyzing the regression model

$$Z = 19.1356 - 3.57X,$$

we note that the bending strength of the OSFP (*Z*) is only a function of the proportion of embedded Nitron fibre (*X*). The significant negative coefficient for factor *X* indicates that when the embedded Nitron fibre wastes are greater than 35%, there is a tendency for the bending strength to decrease to a certain level. For a 35/65 ratio of components, components of two types participate in the work in bending of the material and their strength is maximally utilized. When the embedded Nitron fibre wastes increase to 35%, the bending strength thus increases, which can also be seen in the graph.

The results in Fig. 3 were obtained for the swelling indexes of the material. Analyzing the regression model

$$Z = 40.7 + 1.96X - 0.96Y - 20.48X^2,$$

we can conclude that swelling (*Z*) is equally dependent on the proportion of embedded textile wastes (*X*) and the extrusion temperature *Y*. The coefficient for factor *X* is significant and positive, which indicates a tendency toward an increase in swelling to a certain limit with an increase in embedded Nitron fibre wastes, since wood and synthetic fibres increase the porosity of the OSFP when mixed. The increase in swelling with an increase in embedded wastes to a certain limit is reflected in the graph. When the extrusion temperature increases, the swelling decreases, since the proportion of melted fibres increases — the polymer fills the free pores of the material and does not pass moisture.

Mathematical models can thus be used to determine the character of the effect of each factor on the properties of materials and the optimum process parameters for manufacturing OSFP with assigned properties can be found with all of the

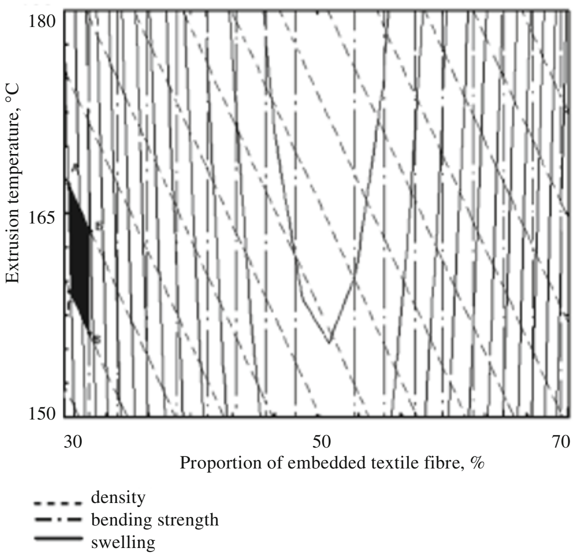

Fig. 4. Region of optimum values of OSFP formation parameters.

factors. The problem of finding the optimum parameters was solved with the graphic interpretations of the results of the experiment, i.e., by plotting the lines for equal levels of the optimization criteria in the coordinate axes of the independent factors (proportion of embedded fibre X and extrusion temperature Y — see Fig. 4).

The required quality of OSFP can be attained with a certain combination of the extrusion temperature and proportion of embedded textile fibres. To give the combined OSFP the best physicomechanical properties (density of 940-950 kg/m^3, bending strength of 20-22 MPa, swelling of 15%), an extrusion temperature of 165°C and proportion of embedded textile wastes of 35% are recommended.

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