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Effect of sawdust volume on mechanical properties of composite material*

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Влияние объема древесных опилок на механические свойства композитного материала***

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Introduction. Generation of composite materials with addition of sawdust is considered. The wood component of the composites is treated with water to enhance the surface roughness. This increases the contact area resulting in intensifying the sawdust – polymer fibers interaction. The work objective is to study the possibility of strengthening composites obtained from sawdust.
Materials and Methods. Samples are made of composite materials based on the unsaturated polyester resins, reinforced with wood chips. Water treatment was carried out at room temperature for 2, 4, 6 and 8 days. Then the samples were tested for bending and compression.
Research Results. As a result of testing the samples, changes in their mechanical properties were recorded. It is determined how the bending and compression resistance depends on the water treatment time. Graphs that reflect these dependences are constructed.
Discussion and Conclusions. After water treatment, the composites reinforced with sawdust show a higher resistance to bending. This is due to the increased roughness of the sawdust surface and, as a consequence, to the extension of the surface area adhesion with the composite base. Besides, the water treatment enhances the specimen resistance under compression. The samples created on the basis of large sawdust come into particular prominence. This is due to the formation of holes on the sawdust surface which also enhances the adhesion between them and the composite polymer base.

Keywords: wood fibers, sawdust, polymer, composite material.

Введение. Рассматриваются вопросы создания композиционных материалов с добавлением древесных опилок. Древесная составляющая композитов обрабатывается водой для усиления шероховатости поверхности. Это увеличивает площадь контакта, вследствие чего усиливается взаимодействие между опилками и волокнами полимера. Цель исследования — изучение возможности упрочнения композиционных материалов, полученных из опилок.
Материалы и методы. Образцы изготовлены из композитных материалов на основе ненасыщенных полиэфирных смол, армированных древесной стружкой. Обработка водой проводилась при комнатной температуре в течение 2, 4, 6 и 8 дней. Затем образцы проходили испытания на изгиб и сжатие.
Результаты исследования. В результате испытаний образцов зафиксированы изменения их механических свойств. Определено, каким образом сопротивления изгибу и прочности при сжатии зависят от времени обработки водой. Построены графики, отражающие указанные зависимости.
Обсуждение и заключения. После обработки водой композиты, армированные древесными опилками, демонстрируют более высокую стойкость при изгибе. Это объясняется усилением шероховатости поверхности опилок и, как следствие, увеличением поверхности сцепления с композитной основой. Кроме того, обработка водой повышает стойкость образцов при сжатии. Особенно заметно упрочняются образцы, созданные на основе крупных опилок. Это объясняется образованием углублений на поверхности древесных опилок, что также усиливает адгезию между ними и полимерной основой композита.

Ключевые слова: древесные волокна, опилки, полимер, композитный материал.

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Introduction. Composite materials based on polymers reinforced with various impurities are widely used in modern production practice. Major advantages of wood impurities (sawdust, chips) are their economic cost and availability [1, 2].

To determine ratios of the sawdust wood fibers, a vibrating unit with a nest of sieves was used. In the end, three volumes of sawdust (5 mm^3, 25 mm^3, 120 mm^3) were selected [2, 3, 4]. Through the experiments, the samples were subjected to three types of load (pressure, shear, and bending) to determine the effect of the sawdust volume on the strength characteristics of the composite materials.

In 2001, samples with wood filler were subjected to the tests, the purpose of which was to determine the quality of adhesion between fibers and binder. The results suggest that reinforcement with wood fibers increases the material [3].

In 2002, during the experiments, wood and wood fiber was chemically treated using MAPP (maleated polypropylene). It was found that these samples have higher tensile and flexural strength [5].

In 2006, tests were conducted on the surface treatment of NaOH and CICH2COOH wood. The experiments have shown that such an effect enables to obtain high values of tensile strength [6].

Within the framework of this study, it is planned to demonstrate the practicability of the chemical treatment to improve the properties of the composite materials.

Materials and Methods. Wood sawdust (5 mm^3, 25 mm^3, 120 mm^3) [1] was treated by water at room temperature for 2, 4, 6 and 8 days.

100 g of sawdust was placed in a plastic container covered with 1 liter of water and left for 2, 4, 6 and 8 days. Then the water was drained, and the mass was covered with distilled water for an hour. After that, the sawdust was removed and dried in the oven for 24 hours at 110 ° C. Further on, all tests were also conducted at room temperature.

Research Results.

Metering of weight loss of processed sawdust

10 g of sawdust of different volumes (5 mm^3, 25 mm^3, 120 mm^3) treated by the method described above were used. After processing, the samples were examined under an optical microscope.

In this case, the weight loss of sawdust is equal to the weight difference before and after processing. The weight loss ratio is calculated as follows:

$$\frac{W_0 - W_1}{W_1} = W\%,$$

where W_0 is the weight of the fiber sample before processing (g); W_1 is the weight of the fiber sample after treatment (g); W% is percentage of the weight loss (Fig. 1).

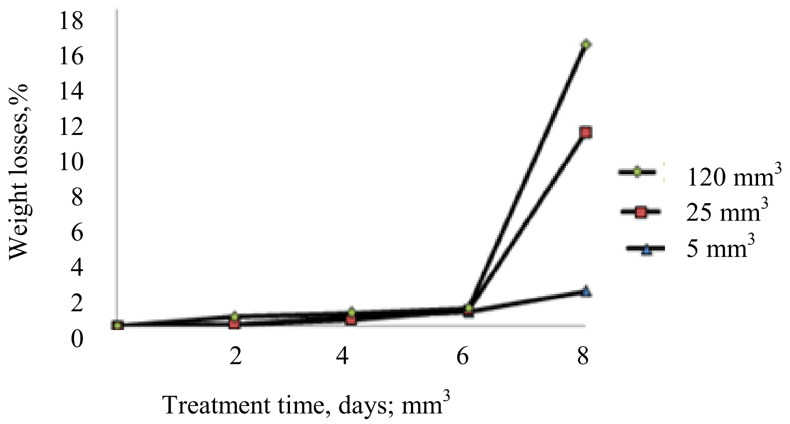

Fig. 1. Dependence of sawdust weight loss on time of treatment by water

The graph shows that 120 mm^3 sawdust does not lose much more weight than 25 mm^3 sawdust (the difference is about 4%). If we compare sawdust of 5 mm^3 and of 120 mm^3, the weight loss of the latter is 8 times higher. At this, in all samples, weight loss depends directly on the treatment time (the longer the test, the less weight). On exposure to water for long, some solubles go into the liquid, so, after washing and drying, the material weighs less.

In the succeeding experiments, three composite samples were considered. For that, sawdust of various volumes (5 mm^3, 25 mm^3, 120 mm^3) was impregnated with 10% polyurethane ether and mixed well. Then, a hardener was added, and the mixture was poured into dies. Polyester was 90% of the total mass of the sample.

Bending test of composites

For the tests, samples of the composite material of 8 × 15 × 160 mm according to ASTM D 790 [7, 8] were prepared.

Resistance to bending was measured at three points. Fig. 2 shows samples of the composite material reinforced with sawdust before the bending test.

Fig. 2. Samples of composite material reinforced with sawdust before bending test

Resistance of the specimen to bending (MPa) is determined by the formula:

$$\sigma_{изг} = \frac{3 \cdot P \cdot L}{2 \cdot B \cdot t^2},$$

where P is load force (H), L is the sample length (mm), B is the sample width (mm), t is the sample height (mm).

Compression test of composites

For the tests, samples of the composite material of Ø12.7 × 25.4 mm were prepared. Resistance was measured under the compressed condition. The load was applied until a rupture occurred.

Samples of the composites reinforced with sawdust and prepared for testing are shown in Fig. 3. Resistance to compression (MPa) is determined by the formula [9]:

$$\sigma_{сж} = \frac{P}{F},$$

where P is compression force (H), F is c/s area (mm^2).

Fig. 3. Samples of composites reinforced with sawdust before compression test

Bending test results

Fig. 4 shows that samples made of 5 mm^3 sawdust are more resistant to bending.

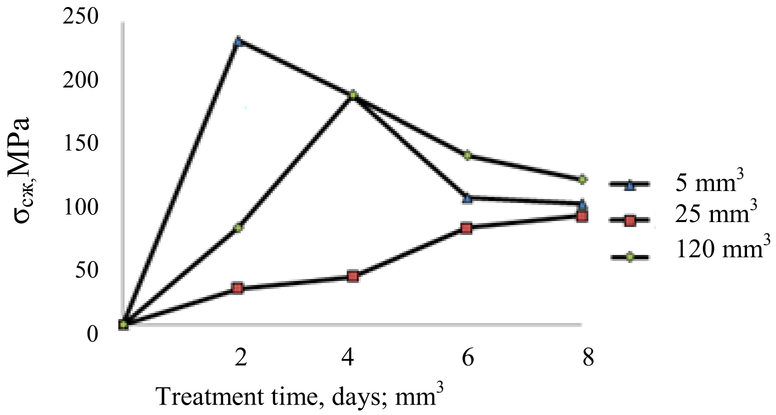

Fig. 4. Change in resistance to bending against specimen treatment time

Maximum bending resistance (230.88 MPa) was shown by the sample with 5 mm^3 sawdust after treatment for two days. The sample of 25 mm^3 exhibited maximum bending resistance (98.6 MPa) after the eight-day treatment. The sample of 120 mm^3 exhibited maximum bending resistance (194.55 MPa) after the four-day treatment.

The increase in bending resistance in this case is explained as follows. Under the treatment with water, the roughness of the sawdust surface increases, and the area of interaction with the base expands. Thus, the adhesion between sawdust and polyester is strengthened and, as a consequence, the strength of the samples increases under bending.

Compression test results

The samples from sawdust of 5 mm^3 are weaker in compression (compared to the samples of sawdust of 25 mm^3 and 120 mm$^{3)}$ (Fig. 5).

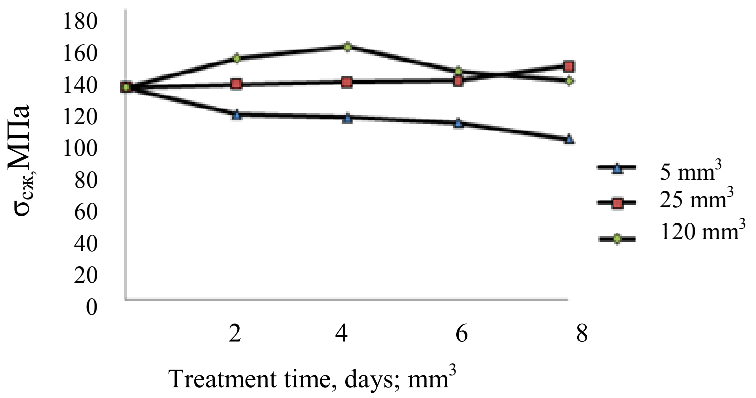

Fig. 5. Change in compression resistance depending on specimen treatment time

The peak value of compression strength (156.67 MPa) is shown by the samples with 120 mm^3 sawdust treated within four days. This is due to the fact that under the water treatment, holes appear on the surface of larger wood sawdust. This leads to the increased adhesion between the sawdust and the basic polymer, and enhances the compression resistance of the composite.

Discussion and Conclusions. Testing of the composite samples reinforced with wood sawdust and treated with water allows for the following conclusions.

1. Samples of 120 mm^3 sawdust lose more weight than samples of sawdust of 5 mm^3 and 25 mm^3.
2. Sample weight loss depends directly on the water treatment time.
3. Under treating samples with water, the first sharp increase in bending resistance is observed for two days.

4. Maximum bending resistance (230.88 MPa) was shown by the sample with 5 mm^3 sawdust.

5. Maximum compressive strength (156.67 MPa) was performed by the sample with 120 mm^3 sawdust.

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