Research physic–mechanical properties of composite materials on the base of peeled veneer and low density polyethylene

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Abstract. Use film of LDPE as thermoplastic binder for production of plywood is proposed. Results of physic-mechanical properties of plywood based on the LDPE film of different thicknesses in comparison with conventional thermosetting synthetic binder are presented.

1. Introduction
At the present time in the manufacture of plywood in Russia (material based on wood veneer sheets) are widely used synthetic thermosetting binders based on urea-formaldehyde (UFO) and phenol-formaldehyde (PFO) oligomers. Plywood based on it in its composition contains free formaldehyde, a toxic gas of the second class of danger, which is a carcinogen, mutagen, allergen.

According to the requirements of GOST 3916.1-96 content of free formaldehyde in the finished plywood should not exceed 8 mg per 100 g of absolutely dry mass of plywood. This requirement plywood, businesses can run, working on traditional formaldehyde binders. For some reducing toxicity of plywood enterprises use modifying additives, however, it is only partially solve the issue. Often use of additives leads to a decrease of physic-mechanical properties of the finished product or its appreciation. Therefore, modification of the environment has not fundamentally solved. A radical way to reduce the toxicity of plywood is the ability to use polyolefins, in particular polyethylene film as a binder for its production. Polyethylene, is the bulk polymer in the world, widely used for production of various packaging film and packages, which are already firmly established in our everyday life.

The United States first began to use thermoplastics as a binder for production of wood-plastic composite materials in the last century. Russia began to release new material only since 2007 [1].

Scientists from the Dresden Institute for wood processing in the early 1980s were obtained a thermoplastic veneer, however, «this interesting development is not received then development and remained almost unnoticed» [1]. In 2011, UPM introduced a new product – form plywood. «The basis of the new method is a special adhesive film that allows you to mold the plywood after manufacture» [2].

2. Methods of research
Studies concerning the possibility of using LDPE film as a binder for the production of thermoplastic plywood were carried out in this paper. Samples of thermoplastic three-layered plywood with different
thickness films of LDPE (10 to 200 µm) with the «shirt» and without it, as well as a control sample of plywood on the basis of the FFO with a consumption of 120 g/m² were manufactured and tested. Under the «shirt» means a film of LDPE, which is coated plywood with two sides directly in the hot pressing process. For the manufacture of the samples used peeled birch veneer with a nominal thickness of 1.5 mm for plywood production with existing enterprise NAO SVEZA Kostroma, Kostroma, Russia. Samples of plywood were conducted in the laboratory press, N100-400 in laboratory of the «KSU» at the following constant factors:
- nominal thickness of plywood 4 mm;
- duration of the press 6 min.;
- specific pressing pressure is 3.5 MPa;
- pressing temperature 180°C.

3. Results of research
Physic-mechanical properties of plywood were determined in accordance with the requirements of GOST 9624-2009, GOST 9621-72. The results are shown in table 1.

| Sample number | View binder film thickness | Ultimate strength in shearing adhesive layer in dry state, MPa | Ultimate strength in shearing adhesive layer after soaking during the day, MPa | Swelling at the thickness, % | Water absorption, wt. % |
|---------------|---------------------------|-------------------------------------------------------------|--------------------------------------------------------------------------------|---------------------------|--------------------------|
| 1             | Film of LDPE with a thickness of 200 µm with «shirt» | 2.74                                                        | 1.29                                                                           | 8.76                      | 27.87                    |
| 2             | Film of LDPE with a thickness of 100 µm with «shirt» | 2.43                                                        | 1.29                                                                           | 6.37                      | 40.30                    |
| 3             | Film of LDPE with a thickness of 20 µm with «shirt» | 0.36                                                        | 0.19                                                                           | 5.85                      | 57.47                    |
| 4             | Film of LDPE with a thickness of 10 µm with «shirt» | 0.09                                                        | 0.32                                                                           | 10.02                     | 62.68                    |
| 5             | Film of LDPE with a thickness of 200 µm             | 0.58                                                        | 0.24                                                                           | 7.28                      | 47.67                    |
| 6             | PFO control sample                                  | 4.32                                                        | 2.43                                                                           | 12.23                     | 52.16                    |

Influence of film thickness LDPE on mechanical properties of plywood is shown in Figures 1-4.
Figure 1. Effect of film thickness LDPE on the tensile strength of plywood for shearing on the adhesive layer in a dry form.

Figure 2. Effect of film thickness LDPE on the tensile strength of plywood in shear fracture in the adhesive layer after soaking.
Figure 3. Effect of film thickness LDPE on swelling of plywood thickness.

Figure 4. Effect of film thickness LDPE on water absorption of plywood.

4. Conclusion
Analysis of the obtained results allowed to draw following conclusions:
1. Shear on the adhesive layer dry and after soaking above the plywood based on the thermosetting binder is more than 1.5 times higher than that plywood on the basis of LDPE film with thickness of 200 and 100 µm (Figure 1,2).
2. Swelling of plywood on the basis of PFO for thickness higher than that of the thermoplastic plywood in any thickness film (Figure 3).
3. Water absorption of the thermoplastic plywood lower than traditional plywood, except plywood with a film thickness of LDPE 10 and 20 µm (Figure 4).

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