EUROPEAN MECHANICAL SCIENCE
e-ISSN: 2587-1110

Research Paper

Influence of Pressing Time on Physical and Mechanical Properties of Particleboards Made From Scots Pine (*Pinus sylvestris* L.)

Miglena Valyova[1*], Daniel Koynov[2]

[1]University of Forestry - Sofia, Faculty of Ecology and Landscape Architecture, Department of Plant Pathology and Chemistry, 1797 Sofia, Bulgaria
[2]University of Forestry - Sofia, Faculty of Forest Industry, Department of Mechanical Technology of Wood, 1797 Sofia, Bulgaria

Abstract

This study presents the results of investigations on some physical and mechanical properties of one-layer particleboards made from Scots pine (*Pinus sylvestris* L.). The size and the ratio of the using particles were: 0.5-1 mm- 20 %, 1-3 mm- 60 % and 3-5 mm-20 %, respectively. Urea-formaldehyde resin was used as a binder. The effect of different pressing time- 15, 30, 60 and 90 s.mm^{-1} on the some properties, such as: density, moisture content, water absorption, thickness swelling and bending strength according to appropriate standards was evaluated. The best results were observed at pressing time of 90 s.mm^{-1}. The particleboards obtained under these conditions can be used in the furniture industry.

Keywords: particleboards, urea-formaldehyde resin (UF), physical properties, pressing time

1. INTRODUCTION

Particleboards (PB) are pressed panels made out of wood particles or other lignocellulosic materials and an adhesive under pressure [1]. They possess a number of valuable properties, such as: high density, high durability, abrasion resistance, high surface hardness etc. [2; 3]. Particleboards are widely used throughout the world in the production of home and office furniture, house construction, as well as interior design elements, flooring systems, etc. [4; 5].

The forestry industry generates a considerable amount of waste, such as bark, off-cuts, slabs, rejects, etc. Many of these are small size wastes, for example sawdust and shavings obtained in the processing of solid wood materials [6]. The release of waste is a serious problem and its incorrect solving leads to an irrational utilization of the wood. On the other hand, conditions for environmental pollution are created [7; 8; 9]. In recent years, wood waste has a great application as a raw material for combustion, as well as in the production of pellets, briquettes, etc. [10].

Furthermore, the consumption of wood and products made from wood has been rapidly increasing year by year. This requires searching for more rational methods for utilization [11; 12].

There are various technological processes for the production of shredded wood composites. In addition, the assortment of manufactured products covers more than 100 types of panels and volume pressed products with different operational properties [13; 14].

The qualitative indicators of the different types of boards are regulated by the relevant standard requirements. The quality of the manufacturing particleboards depends on the influence of many factors, such as: particle density, particle size, pressing time, press temperature, type of adhesive etc. [15; 16; 17]. In this regard, the physical and mechanical properties of the boards can be improved by regulation of these factors [18; 19; 20; 21]. The objective of this research was to evaluate the effect of pressing time on some physical and mechanical properties of particleboards made from softwood.

2. MATERIAL AND METHODS

For the production of panels, particles from softwood (*Pinus sylvestris* L.) were used. The size of particles in the mixture was 0.5-1 mm- 20 %; 1-3 mm- 60 % and 3-5 mm-20 %, respectively. The target dimensions of the experimental one-layer particleboards were 500×500×8 mm. Commercial urea-formaldehyde (UF) resin (type UFR 1;"Neochim" PLC Dimitrovgrad) with solid content 70 % and hardener- 1 % ammonium chloride was used as an adhesive. The amount of the applied resin was 20 % in relation to the mixture.

After mixing of raw materials, particleboards were manu-

* Corresponding authour
Email: mvalyova@abv.bg

European Mechanical Science (2020), 4(2): 78-81
doi: https://doi.org/10.26701/ems.532796
Received: February 26, 2019, Revised: March 10, 2020
Accepted: March 17, 2020, Published: April 29, 2020

factured by pressing at temperature of 150°C, pressure of 2 MPa and pressing time of 15, 30, 60, 90 s/mm^{-1}. Four experimental boards were produced for each pressing time. Boards were conditioned at 20°C and 65 % relative humidity for five days prior to testing the following physical and mechanical properties: density, moisture content, water absorption, thickness swelling and bending strength.

The measurement of the density of the particleboards were made in accordance with BDS EN 323:2001 [22] using equation 1:

$$\rho = \frac{m}{V}, \text{ kg.m}^{-3}, \quad (1)$$

where: m is the mass of the test sample (kg); V is the volume of the test sample (m^3).

The dimensions of the test specimens for determination of density, moisture content, water absorption and thickness swelling were 50×50×8 mm.

The moisture content of the experimental particleboards was evaluated according to BDS EN 326-1:2001 [23]. It was calculated using equation 2:

$$H = \frac{m_H - m_0}{m_0}.100,\%, \quad (2)$$

where: $m_н$ is the initial mass of the test sample (g), m_0 is the mass of the test sample after drying (g).

The water absorption of the particleboards was measured in accordance with BDS EN 317:1993 (equation 3) [24]:

$$\Delta_W = \frac{m_2 - m_1}{m_1}.100\,, \% \quad (3)$$

where: m_1 is the mass of the test sample before immersion in water (g), m_2 is the mass of the test sample after immersion in water (g).

The thickness swelling was determined in accordance with BDS EN 317:1993, using the following equation:

$$G_t = \frac{t_2 - t_1}{t_1}.100\,, \% \quad (4)$$

where: t_1 is the thickness of the test sample before immersion in water (mm), t_2 is the thickness of the test sample after immersion in water (mm).

The bending strength test was carried out according to BDS EN 310:1999 [25]. Eight specimens for each pressing time with dimensions 200×50×8 mm were prepared. The calculations were based on the equation 5:

$$f_m = \frac{3F_{\max}.l_1}{2bt^2}, \text{ N.mm}^{-2} \quad (5)$$

where: F_{max} is the failure load (N), l_1 is the distance between the centers of the supports (mm), b is the width of the test sample (mm), t is the thickness of the test sample (mm).

The results were calculated based on statistical methods and the following parameters were determined: average arithmetical values ($\overline{X}$), average quadratic diversion (S_x), average error (m_x) and index of accuracy (p_x).

3. RESULTS AND DISCUSSION

The effect of pressing time on the density is shown in Fig. 1. According to data, the increasing of pressing time leads to increase the density of particleboards. The values obtained ranged from 672 to 953 kg.m^{-3}.

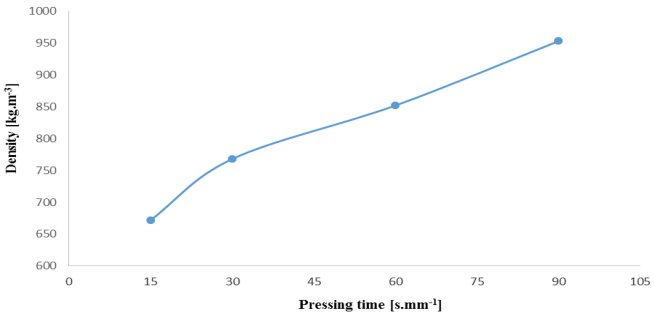

Figure 1. Density of particleboards depending on the pressing time

The highest density (953 kg.m^{-3}) was obtained at samples with a pressing time of 90 s.mm^{-1}. The density has a significant effect on the other properties of particleboards. The increase of pressing time leads to an increase in the density of the pressed panels. This is due to the compaction of the wood under pressure and temperature, especially the facial layers that are in contact with the hot press.

The results from determining the moisture content of the experimentally obtained panels are given in Fig. 2. This indicator progressively increases with an increase in the pressing time- from 6.90% (at 15 s.mm^{-1}) to 7.60% (at 90 s.mm^{-1}). In this assay, the moisture content of the source wood was 7.75% and that of the particleboards was 7.65%, respectively.

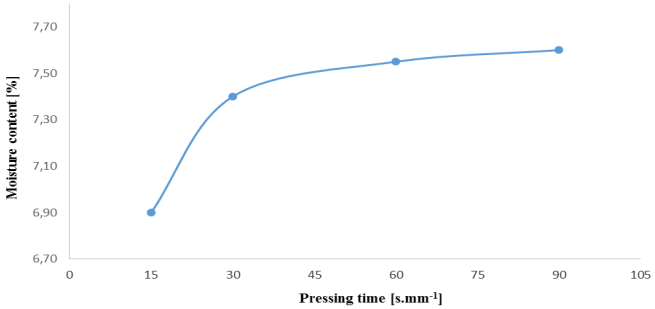

Figure 2. Moisture content of particleboards depending on pressing time

Table 1 summarizes the obtained results of water absorption depending on pressing time. As can be seen from data, the particleboards obtained at pressing time of 60 s.mm^{-1} had greater water absorption in comparison to these obtained at pressing time of 90 s.mm^{-1}. The latter had about fifteen times lower values and they possess better water resistance.

Table 1. Water absorption of particleboards depending on the pressing time

Pressing time (s.mm^{-1})	$\overline{X}$ (%)	S_x (%)	m_x (%)	p_x (%)	n
60	77.66	0.64	0.20	0.26	32
90	5.34	0.18	0.06	1.07	32

*n- number of samples

The samples obtained at pressing time of 15 and 30 s.mm^{-1} did not show any water resistance because of their destruction. Similar results were established also for thickness swelling. At pressing times of 15 and 30 s.mm^{-1}, the wood particles do not compress enough. In general, the time is insufficient for their compaction and adhesion. For this reason, the obtained panels were destroyed at removing from the press. This in turn led to the inability to determine their water resistance.

The average values at investigation of thickness swelling are given in Table 2. It includes data from evaluation of particleboards at pressing time of 60 and 90 s.mm^{-1}, respectively. A better value showed panels with a pressing time of 90 s.mm^{-1}.

Table 2. Effect of pressing time on the thickness swelling of particleboards

Pressing time (s.mm^{-1})	$\overline{X}$ (%)	S_x (%)	m_x (%)	p_x (%)	n
60	60.06	3.29	1.04	1.73	32
90	4.95	0.31	0.098	1.97	32

*n- number of samples

The effects of pressing time on the bending strength of particleboards are shown in Fig. 3.

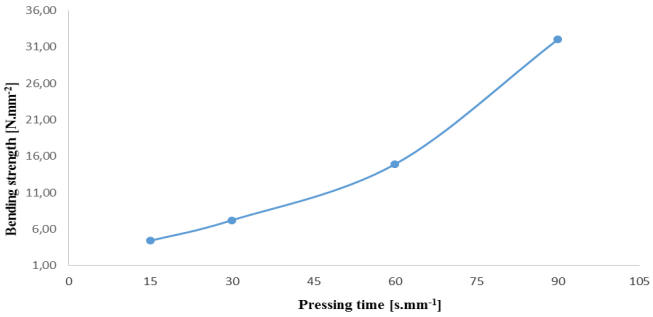

Figure 3. Bending strength of particleboards depending on pressing time

The bending strength of boards increases from 4.41 to 32.06 N.mm^{-2} or about 7 times with an increase in the pressing time from 15 to 90 s.mm^{-1}. The bending strength of panels obtained at pressing time of 90 s.mm^{-1} was about four times better than these obtained at pressing time of 30 s.mm^{-1}. The highest value was found at pressing time of 60 (14.91 N.mm^{-2}) and 90 s.mm^{-1} (32.06 N.mm^{-2}), respectively.

The bending strength increased with increase in the density of the wood due to the pressure and temperature during the pressing. The tree species with higher density are characterized with greater bending strength. The latter property affects the production of the wood based panel products.

4. CONCLUSIONS

In this research some physical and mechanical properties of one layer particleboards produced from Scots pine were determined according to the standards. The following conclusions can be drawn from the obtained results presented above:

1. The greatest density was established for particleboards at pressing time 90 s.mm^{-1}.

2. For just one parameter, bending strength, one highest value was obtained at pressing time 90 s.mm^{-1}.

Therefore, these panels can be used as a construction material in the furniture industry.

3. The lowest values for physical properties water absorption and thickness swelling at pressing time of 90 s.mm^{-1} were determined. For this reason, these panels are characterized by the best water resistance.

5. REFERENCES

[1] Sellers, T. (2000). Growing markets for engineered products spurs research. Wood Technology, 127 (3): 40–43.

[2] Taş, H. H., Sevinçli, Y. (2015). Properties of Particleboard Produced from Red Pine (Pinus brutia) Chips and Lavender Stems. BioResources, 10(4). doi:10.15376/biores.10.4.7865-7876

[3] Maloney, T. M. (1993). Modern particleboard and dry process fiberboard manufacturing. Miller Freeman Publ, San Francisco.

[4] Wang, D., Sun, X. S. (2002). Low density particleboard from wheat straw and corn pith. Industrial Crops and Products, 15 (1): 43-50. doi: 10.1016/S0926-6690(01)00094-2.

[5] Kord, B., Roohani, M., Kord, B. (2015). Characterization and utilization of reed stem as alignocellulosic resource for particleboard production. Maderas. Ciencia y tecnología, 17 (3): 517-524. doi: 10.4067/S0718-221X2015005000046.

[6] Valarelli, I., Battistelle, R., Bueno, M., Bezerra, B., Campos, C., Alves, M. (2014). Physical and mechanical properties of particleboard bamboo waste bonded with urea formaldehyde and castor oil based adhesive. Revista Matéria, 19 (1): 1-6. doi: 10.1590/S1517-70762014000100002.

[7] Merrild, H., Christensen, T. H. (2009). Recycling of wood for particle board production: accounting of greenhouse gases and global warming contributions. Waste Management & Research, 27 (8): 781-788. doi: 10.1177/0734242X09349418.

[8] Ganne-Chédeville, C., Diederichs, S. (2015). Potential Environmental Benefits of Ultralight Particleboards with Biobased Foam Cores. International Journal of Polymer Science, 2015: 1–14. doi:10.1155/2015/383279

[9] Németh, G. (2009). Handling and recycling of waste in wood industry, Ph.D. Thesis, University of West Hungary.

[10] Kamikawa, D., Kuroda, K., Inoue, M., Kubo, S., Yoshida, T. (2009). Evaluation of combustion properties of wood pellets using a cone calorimeter. Journal of Wood Science, 55 (6): 453–457. doi: 10.1007/s10086-009-1061-1.

[11] Melo, R. R., Stangerlin, D. M., Santana, R. R. C., Pedrosa, T. D. (2014). Physical and mechanical properties of particleboard manufactured from wood, bamboo and rice husk. Materials Research, 17 (3): 682-686. doi: 10.1590/S1516-14392014005000052.

[12] Palo, M., Uusivuori, J. (2012). World forests, society and environment. Springer Science & Business Media.

[13] Skog, K., Ince, P., Dietzman, D., Ingram, C. (1995). Wood products technology trends. Changing the face of forestry. Journal of Forestry, 93 (12): 30-33.

[14] Tabarsa, T., Khanjanzadeh, H., Pirayesh, H. (2011). Key Engineering Materials, 471-472: 62-66. doi: 10.4028/www.scientific.net/KEM.471-472.62.

[15] Antonovic, A., Jambrekovic, V., Kljak, J., Spanic, N., Medved, S. (2010). Influence of urea-formaldehyde resin modification with liquefied wood on particleboard properties. Drvna Industrija, 61 (1): 5-14.

[16] Oliveira, S. L., Mendes, R. F., Mendes, L. M., Freire, T. P. (2016). Particleboard panels made from sugarcane bagasse: characterization for use in the furniture industry. Materials Research, 19 (4): 914-922. doi: 10.1590/1980-5373-MR-2015-0211.

[17] Savov, V. (2014). Effect of temperature and duration of hot-pressing on main properties of light MDF. Woodworking industry and furniture manufacturing, 1: 34-39, Sofia. ISSN 1311-4972.

[18] Muruganandam, L., Ranjitha, J., Harshavardhan, A. (2016). A review report on physical and mechanical properties of particle boards from organic waste. International Journal of ChemTech Research, 9 (1): 64-72, ISSN: 0974-4290.

[19] Candan, Z., Akbulut, T. (2015). Physical and mechanical properties of nanoreinforced particleboards composites. Maderas Ciencia y Tecnología, 17 (2): 319 – 334. doi: 10.4067/S0718-221X2015005000030.

[20] Batiancela, M. A., Acda, M. N., Cabangon, R. J. (2014). Particleboard from waste tea leaves and wood particles. Journal of Composite Materials, 48 (8): 911-916. doi: 10.1177/0021998313480196.

[21] Taghiyari, H. R., Rangavar, H., Bibalan, O. F. (2011). Effect of nano-silver on reduction of hot pressing time and improvement in physical and mechanical properties of particleboard. BioResources, 6 (4): 4067-4075.

[22] BDS EN 323: 2001 "Wood-based panels - Determination of density".

[23] BDS EN 326-1: 2001 "Wood-based panels - Sampling, cutting and inspection - Part 1: Sampling and cutting of test pieces and expression of test results".

[24] BDS EN 317:1993 "Particleboards and fibreboards. Determination of swelling in thickness after immersion in water".

[25] BDS EN 310:1999 "Wood-based panels - Determination of modulus of elasticity in bending and of bending strength".