КРАТКИЕ СООБЩЕНИЯ И ОБМЕН ОПЫТОМ

Original article
УДК 674.815
DOI: 10.37482/0536-1036-2024-4-177-184

Surface Treatment of Fiberboard Wood Pulp Mat with Dispersed Water (by the Example of Arian Sina MDF Company)

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Received on August 7, 2023 / Approved after reviewing on November 10, 2023 / Accepted on November 12, 2023

Abstract. This research focuses on the effect of mat water spraying on the production yield and the quality of medium density fiberboard (MDF) on an industrial scale at Arian Sina MDF Company. A total of 180 raw medium density fiberboard panels, each with dimensions of 3.66×1.83×0.016 m, manufactured by the company in 2018, have been used as the experimental samples. These samples have been produced under various conditions, including 3 different groups: 1 – without mat water spraying; 2 and 3 – with mat water spraying using 40 and 50 g/m² of water, correspondingly. Other parameters have included a constant adhesive content (10 % of dry fiber content), a fixed mat moisture content (7 %), and the use of poplar species (70 %) and *Eucalyptus camaldulensis* (30 %). Additionally, a hardener (at 0.8 % of the dry weight of glue) has been applied. The results have demonstrated that water spraying onto both sides of the mat increases the strength properties and improves the production yield. This enhancement is attributed to the reduced time required for transferring heat from the press plates to the core layer of the mat. Furthermore, X-ray vertical profile density analysis has indicated that water spraying onto the mat surface also increases the surface and core layer density of the panels.
Keywords: mat water spraying, medium density fiberboard, vertical profile density, sanding machine
Acknowledgements: We thank Mr. Ali Saeedi, chairman of the board of the Arian Saeed Industrial Group, for financial and spiritual support.

For citation: Moazami V., Esbouei A.Ya., Hatefnia H. Surface Treatment of Fiberboard Wood Pulp Mat with Dispersed Water (by the Example of Arian Sina MDF Company). *Lesnoy Zhurnal* = Russian Forestry Journal, 2024, no. 4, pp. 177–184. (In Russ.). https://doi.org/10.37482/0536-1036-2024-4-177-184

Научная статья

Поверхностная обработка диспергированной водой ковра древесной массы волокнистой плиты (на примере компании «Arian Sina MDF Company»)

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Поступила в редакцию 07.08.23 / Одобрена после рецензирования 10.11.23 / Принята к печати 12.11.23

Аннотация. Исследование посвящено влиянию увлажнения древесного волокна на выход и качество древесноволокнистых плит средней плотности (МДФ) в промышленных масштабах на примере компании «Arian Sina MDF». Экспериментальными образцами послужили 180 необработанных панелей древесноволокнистых плит средней плотности размером 3,66×1,83×0,016 м каждая, изготовленных предприятием в 2018 г. Образцы были разделены на 3 группы по условиям производства: 1 – без увлажнения; 2 и 3 – с увлажнением 40 и 50 г/м² воды соответственно. Другие параметры включали постоянное содержание клея (10 % от массы сухого волокна), фиксированную влажность древесного волокна (7 %), а также применение при производстве плит тополя (70 %) и эвкалипта камальдульского (30 %) и отвердителя (0,8 % от сухой массы клея). Результаты показали, что увлажнение древесного волокна с двух сторон повышает прочностные характеристики и выход продукции. Это объясняется сокращением времени, необходимого для передачи тепла от прессовальных плит к среднему слою волокна. Кроме того, рентгеновский анализ плотности вертикального профиля плит также выявил, что увлажнение поверхности древесного волокна увеличивает поверхностную и внутреннюю плотность плит.

Ключевые слова: увлажнение древесного волокна, древесноволокнистая плита средней плотности, плотность древесной массы, шлифовальная машина
Благодарности: Авторы статьи выражают благодарность г-ну Али Саеди, председателю правления промышленной группы «Arian Saeed Industrial Group», за финансовую и моральную поддержку в ходе исследования.

Для цитирования: Moazami V., Esbouei A.Ya., Hatefnia H. Surface Treatment of Fiberboard Wood Pulp Mat with Dispersed Water (by the Example of Arian Sina MDF Company) // Изв. вузов. Лесн. журн. 2024. № 4. С. 177–184. https://doi.org/10.37482/0536-1036-2024-4-177-184

Introduction

Medium density fiberboard (MDF) is one of the most favorite wood composites which has been greatly welcomed during recent years. Based on the FAO (Food and Agriculture Organization of the United Nations) statistics, MDF, as a product with high applicability, has gained a considerable market share in wood industry and its demand is growingly increasing for construction, furniture and internal decoration [10]. Increasing the production yield in order to reduce the manufacturing cost via elevating the product quality has been one of the great concerns of the key players in this industry. Heating energy is one of the most important factors in wood-based panel industries. During the press process, heating energy is transformed to the core layer of the mat through its contact with hot press plates. Rapid and sufficient heat transfer to the core layer is the prerequisite to polymerization and effective bond formation between the fibers.

Heating facilitates the complete curing of thermoset resin due to accelerating its polymerization. Furthermore, heating through advancing the stress relief mechanism or reducing the fiber strength, affects the mat compression process. Pressure gradient resulted from temperature increase directs the moisture content within the mat toward the void volumes, which finally finds its way to exit. During the press operation, three processes, including simultaneous transformation of mass and heat, stress relief or reducing fiber strength and resin polymerization, happen at the same time. If the press cycle is shorter than needed and hence the press time is less than enough, either the panel surface is blistered or the layers are separated, which all result from the incomplete resin curing or the steam overpressure within the mat [6]. Heat is transferred within the panel by usual heat transfer (emission) and also by flowing the steam toward the core layer of the panel.

As the temperature changes through the mat thickness, the compression rate changes and subsequently there will be a density gradient all along the panel thickness. Achieving a moisture gradient is possible by spraying some water onto the mat surface. The optimum water consumption depends on the fiber shape and mat moisture content. Two-sided water spraying (spraying on both sides of the mat) is crucial to avoid the panel deformation [5]. Wong et al. have studied the panel density profile and its effects on the panel characteristics. According to the results of their studies, the effect of the rate of press closing, pressure, moisture distribution and the way that the panel is pressed on the density of the surface layers is more than that of the core layers [9].

Surface quality is one of the functional characteristics of MDF and under different conditions of relative humidity, low surface quality not only reduces the quality of coating and surface finishing but also increases the necessity of sanding before surface finishing and hence enhances the overall cost [8]. In order to increase both the surface quality of wood composites and their functional properties, there are different solutions, and mat water spraying is one of them.

The high applicability potentials of MDF panels has motivated the key industrialists to increase their production yield in order to decline the costs besides promoting the quality to get the national and international markets. Due to the lack of academic data on the benefits of mat water spraying, the main objective of this research is focusing on the effect of mat water spraying on the yield and the quality of MDF on an industrial scale at Arian Sina Company.

Research Objects and Methods

180 MDF panels with the dimensions of 3.66×1.83×0.016 m have been produced in Arian Sina Company, divided into 3 groups by manufacturing conditions: 1 – with no mat water spraying; 2 and 3 – with mat sprayed with 40 and 50 g/m² of water.

Urea-formaldehyde resin with a solid content of 60 % and molar ratio of (U:F) 1:1.1 has been used at 10 % of dry fiber content.

The moisture content of the mat before hot pressing has been set to 9 % O.D. (Oven Dry). The use of poplar species (70 %) and *Eucalyptus camaldulensis* (30 %), hardener (0.8 % of the dry weight of glue) and other parameters have been established. In order to prevent panel deformation, mat water spraying has been performed on both sides of the panel. The water has been sprayed on the forming belt before the formation of the mat, and after that it has been sprayed on its surface. The mat has been pressed for 180 s at 190 °C and a maximum press pressure of 35 kg/cm².

In order to analyze the temperature of the core layer of MDF panels a thermocouple Testo 925 with the measurement range of –50 to 1000 °C and the precision of ± 1, has been used.

When acquiring the equilibrium moisture content, testing samples have been cut according to EN 622-5 (EN 1998), EN 310 (EN 1996) and EN 319 (EN 1996) for internal bond (IB), and subsequently loaded by the IMAL (IB 600) mechanical tester at Arian Saeed Industrial Group. To determine the vertical density profile, a Sicoscan has been utilized [2–4].

Results and Discussion

Vertical profile densities (fig. 1) show that the water sprayed panels have had a higher peak density. So the panels manufactured with 50 g/m² water sprayed have shown an increase of 17.1 and 6.6 % in peak density compared to that of the non-sprayed panels and those sprayed with 40 g/m² of water, respectively. The panels which were sprayed with 50 g/m² of water have shown an increase of 13.97 % in MOR compared to that of the non-sprayed panels. For the panels sprayed with 40 g/m² of water, this increase has been 9.7 % compared to that of the panels not sprayed with water.

In addition, the results have shown that mat water spraying increases the panel core layer density, as the panels sprayed with 50 and 40 g/m² water have shown 11.45 and 2.65 % increase in core layer density, respectively, compared to that of the panels not sprayed with water.

As can be seen in table, mat water spraying increases the mechanical strength of the treated panels, so that the panels sprayed with 50 g/m² of water have had an increase of about 17.3 % in IB compared to that of the non-sprayed panels. For the panels sprayed with 40 g/m², this increase in IB has been 8.1 % compared to that of the non-sprayed panels.

The effect of mat water spraying on the characteristics of MDF panels manufactured under the same conditions

Mat spray rate, g/m²	Surface layer density, kg/m³		Core layer density, kg/m³	IB, N/mm²	MOR, N/mm²	MOE, N/mm²
50	1127	1127	633	0.75	25.28	2450
40	1041	1073	583	0.67	24.33	2341
0	960	965	568	0.62	22.18	2302

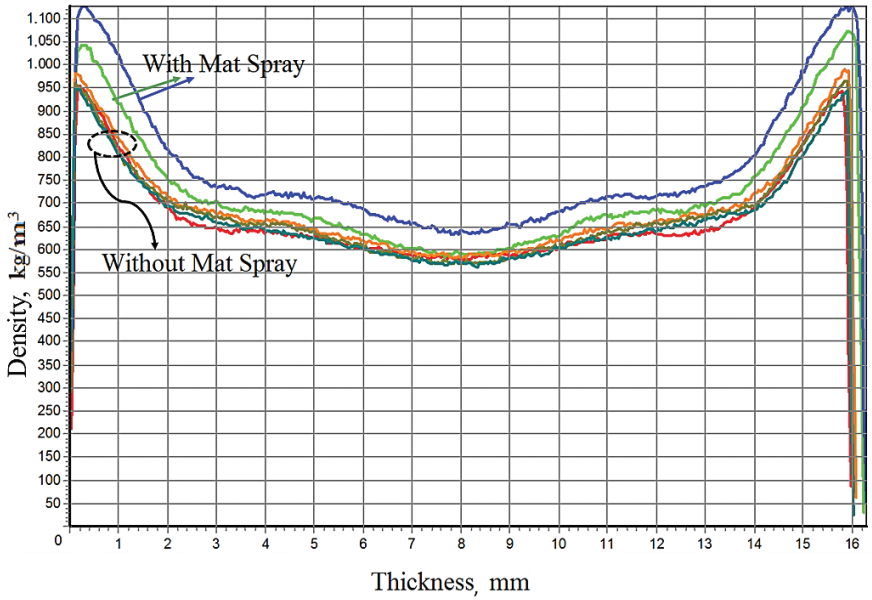

Fig. 1. The vertical density profile of the panels produced with and without mat water spraying

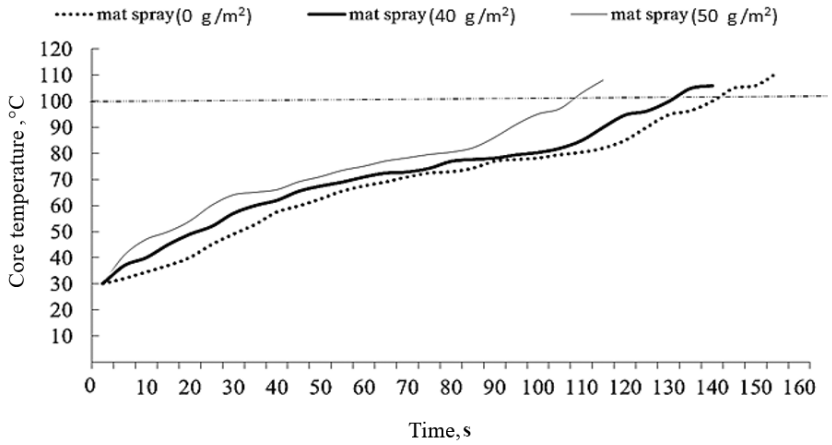

Fig. 2. The effect of mat water spraying onto the core layer temperature

As is shown in fig. 2, after spraying the mat with 0, 40 and 50 g/m^2 of water, it has taken 140, 130 and 108 s for the core layer of water-sprayed panels to reach the target temperature of 100 °C, respectively. Increasing the amount of water sprayed onto the mat surface from 0 to 50 g/m^2, has reduced the time required for the core layer to reach the temperature of 100 °C by 29.63 %. The higher the moisture content resulted from water spraying within both surface layers of the mat, the higher the mechanical strength characteristics in the final product has been [7]. Mat water spraying, especially at the amount of 50 g/m^2, accelerates the heat transfer from the press plates to the core layer of the panel, improves the curing of resin and hence promotes IB in the final product. The moisture which comes from water sprayed onto the mat softens the fibers and increases their flexibility which enhances the initial pressure and subsequently the density of surface layers that

altogether promote the bending strength [1]. The core layer density independently affects the internal bond. The higher the core density, the higher the internal bond of the panel is [6]. In addition, as thermocouples have shown, water spraying facilitates the heat transfer. Furthermore, water spraying not only improves the panel quality, but also reduces the manufacturing costs by enhancing the process productivity (yield).

In order to precisely determine panel thickness, to achieve a smooth and homogenous surface, to remove the loose surface layers, as well as to obtain a higher density surface layers and hence a higher MOR, it is crucial to sand the surface of the panels. The results of vertical profile density measurement (fig. 3) have shown that mat water spraying reduces the thickness of the loose surface layer by 0.7 mm. The density of the surface layers is relatively low, which is removed through the sanding process and as a result improves the panel's strength.

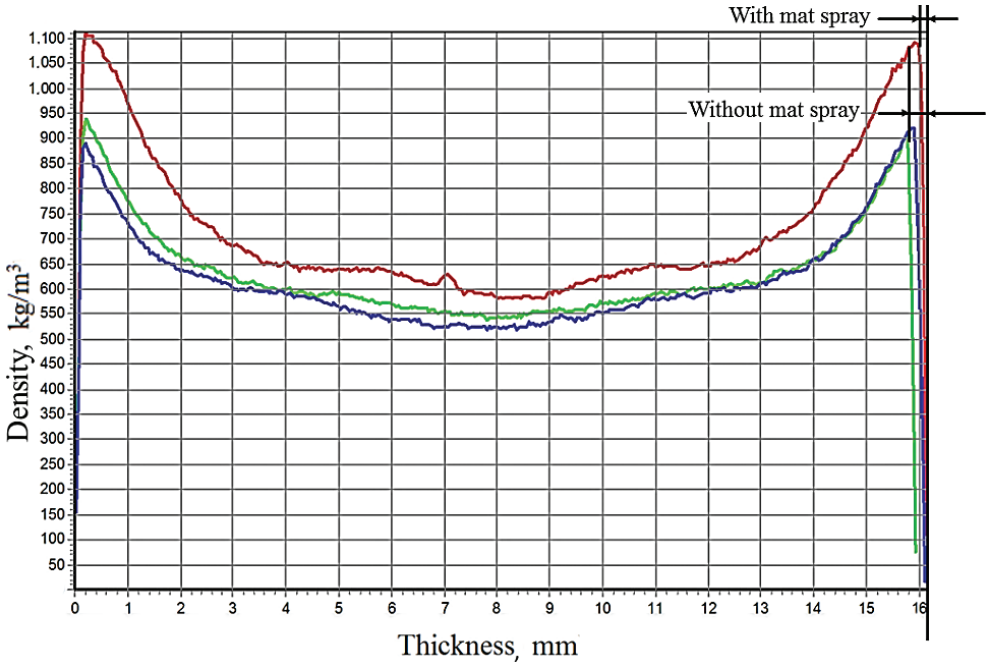

Fig. 3. The effect of mat spraying on the loose surface structure

The amount of this loose and low density layer to be removed by sanding machines, is determined considering the vertical density profile of the panels. Since water spraying reduces the dust produced in each panel with the dimensions of 0.016×1.83×3.66 m by 2 kg, it can be concluded that the spraying treatment reduces the manufacturing cost in both terms of sanding machine work and raw materials cost.

Conclusions

Considering the importance of production yield while maintaining the panel quality, in this research we have investigated the effect of mat spraying on the production yield and quality of MDF on an industrial scale. After water spraying

onto the mat surface, determining the core layer temperature and strength properties of the products, the following results have been obtained. It is worth noting that based on the results obtained in the research performed at Arian Sina company, increasing the amount of water sprayed onto the mat to higher than 50 g/m^2 is not recommended, since it leads to the reduction of panel strength properties and increases the waste production. This could be related to the steam augmentation in the core layer and its low possibility to be discharged.

1) Mat spraying has a considerable effect on the panel mechanical properties;

2) Mat spraying increases the peak and core layer density of the panels;

3) Increasing the amount of water sprayed onto the mat from 0 to 50 g/m^2, reduces the time required by the core layer to reach the target temperature of 100 °C by 29.63 %;

4) Mat water spraying reduces the thickness of the surface layer which is required to be removed in a sanding machine and thus diminishes the dust produced while sanding the panel with the dimensions of 0.016×1.83×3.66 m by 2 kg per panel;

5) Mat water spraying accelerates the heat transfer from the press plates to the core layer.

It is predicted that the higher surface density resulted from water spraying allows the utilization of the lower grammage veneer layers.

Since the strength properties, especially the internal bond, increase, a 5 % saving in resin consumption is expected.

The research has been carried out in the Multidaylight press and the results may vary in continuous presses.

REFERENCES

1. Cai Z., Muehl J., Winandy J. Effects of Pressing Schedule on Formation of Vertical Density Profile for MDF Panels. *40th International Wood Composites Symposium Proceedings* (*Seatle, Washington; April 11–12, 2006*). Washington, Pullman, Washigton State University, 2006. 11 p.

2. *European Standard EN 310. Wood Based Panels, Determination of Modulus of Elasticity Inbending and Bending Strength*. Brussels, European Standardization Committee, 1996.8 p.

3. *European Standard EN 319. Wood Based Panels, Determination of Tensile Strength Perpendicular to Plane of the Panel*. Brussels, European Standardization Committee, 1996. 7 p.

4. *European Standard EN 622-5. "Fiberpanel-Specifications-Part 5. Requirements for Dry Process Panel (MDF), TES.* Brussels, European Standardization Committee, 1998. 12 p.

5. Maloney T.M. *Modern Particlepanel & Dry-Process Fibrepanel Manufacturing*. San Francisco, Miller Freeman Publ., 1977. 672 p.

6. Moazami V., Afsoni F., Dadashi S., Dadashi E. Evaluation the Mechanical Properties of Medium Density Fiber Panel of Domestic Production and Imported with Help of Vertical Density Profile, Infrared Rays, Spectroscopy and Imagine Analyses (Case Study of Arian Sina Co). *Iranian Journal of Wood and Paper Science Research*, 2017, vol. 32, iss. 1, pp. 145–156. https://doi.org/10.22092/ijwpr.2017.107595

7. Nemli G., Aydın I., Zekoviç E. Evaluation of Some of the Properties of Particlepanel as Function of Manufacturing Parameters. *Materials & Design*, 2007, vol. 28, iss. 4, pp. 1169–1176. https://doi.org/10.1016/j.matdes.2006.01.015

8. Ozdemir T., Hiziroglu S., Malkocoglu A. Influence of Relative Humidity on Surface Quality and Adhesion Strength of Coated Medium Density Fiberpanel (MDF)

Panels. *Materials & Design*, 2009, vol. 30, iss. 7, pp. 2543–2546. https://doi.org/10.1016/j.matdes.2008.09.036

9. Wong E.D., Zhang M., Han G., Kawai S., Wang Q. Formation of the Density Profile and its Effects on the Properties of Fiberpanel. *Journal of Wood Science*, 2000, vol. 46, pp. 202–209. https://doi.org/10.1007/BF00776450

10. Zheng Y., Pan Z., Zhang R., Jenkins B.M., Blunk S. Properties of Medium-Density Particlepanel from Saline Athel Wood. *Industrial Crops and Products*, 2006, vol. 23, iss. 3, pp. 318–326. https://doi.org/10.1016/j.indcrop.2005.09.003

Конфликт интересов: Авторы заявляют об отсутствии конфликта интересов
Conflict of interest: The authors declare that there is no conflict of interest

Вклад авторов: Все авторы в равной доле участвовали в написании статьи
Authors' Contribution: All authors contributed equally to the writing of the article