STUDY ON POSSIBILITY FOR THE UTILIZATION OF TECHNICAL, HYDROLYSIS, LIGNIN IN COMPOSITION OF MEDIUM DENSITY FIBERBOARD

Nikola Yotov[1], Viktor Savov[2], Stoyko Petrin[1], Ivo Valchev[1], Viktor Karatotev[2]
[1]University of Chemical Technology and Metallurgy, Sofia, Bulgaria
[2]University of Forestry, Sofia, Bulgaria
e-mail: niko_yotov@abv.bg, victor_savov@abv.bg, stoiko_petrin@abv.bg, ivoval@uctm.edu, iguurrr@abv.bg

ABSTRACT

In the present report is presented a study on the possibility for utilization of hydrolysis lignin in the composition of Medium Density Fiberboard. For the purpose of the study in laboratory conditions were produced boards with five percentages technical lignin in their composition and different quantity of phenol-formaldehyde resin. The main physical and mechanical properties of boards were determined, and they have been compared with those of boards without technical lignin. It is compared the visual appearance of MDF with and without technical lignin. On that base was accomplished an analysis of the results with proper conclusions.

Key words: : Medium Density Fiberboard, technical, hydrolysis, lignin, Phenol-formaldehyde resin.

INTRODUCTION

The production of fiberboard is the second highest of all wood base panels and it is biggest than this of particleboards (FAO). This is due to the presence of cohesion bonds in fiberboard, which is why they have nearly two and a half to three times better properties than particleboards. An additional factor in increasing production and consumption of Medium Density Fiberboard (MDF) are innovations in technology in their production in the last decade. However, it is still a relevant question for emissions in the panels as a result of the presence of free formaldehyde. It should also be noted that the higher value of fiberboard compared with particleboard mainly due to the energy intensive process of pulp production. This determines the relevance of studies on the possibility of reducing content of synthetic resins in the boards through the use of products where there are no harmful emissions and studies related to the possibility of recovery of waste from other wood processing industries in the composition of the boards. Lignin is the second by the mass chemical component of wood. According to some authors lignin functions as a binder and affects the physical and mechanical properties of fiberboard. It is essential in the thermal or chemical pulping and pressing of the boards (Euring, M. et al.).

There are studies which have successfully produced MDF without the involvement of synthetic resins and as a binder has been used an enzymatic lignin (Zouh, X.). A team of researchers from China have produced fiberboard with 10% enzymatic hydrolysis lignin activated at a temperature of pressing 210º C and a press cycle time of 60 s.mm-1 of board thickness. In order to assist glass transition of lignin the water content of pulp mass was with relatively high levels from 10 to 18%. Those boards were with physical and mechanical properties that approach the required by standard and are completely non-toxic, as they are made of biological, natural components.

There have been others successful studies for production MDF with enzyme lignin. In some, however, the amount of used lignin is 30% (Mancera, C. et al.), and in others the boards have a very high density – 1300 kg.m-3 (Nasir, M. et al.). The amount of used lignin is also very high, respectivley 20 and 30%.

Other mager interest in that area present the studies form production of MDF with natural binders obtained as residual products from chemical wood technologies (Radosavljevic, Lj. et al.; Tupciauskas, R. et al.).

These studies are still at the stage of laboratory research.

Technical lignin is a waste product in multiple industries related to chemical processing of wood. In Bulgaria there are significant stocks around 350 000 t waste, technical lignin (Petrin, St).

The presented determines the actuality of study on the possibility of utilization of technical, hydrolysis, lignin composition of MDF.

1. MATERIALS AND METHODS

In order to establish the possibility for utilization of hydrolysis lignin in composition of MDF was selected an amount of lignin to be 5% and for improvement of strength and waterproof properties of the boards it is used phenol-formaldehyde resin. By the published data it is found that the applied quantities of phenol-formaldehyde resin, depending on the purpose of MDF, are from 6 to 10%. Therefore, in this range of variation of the content of the resin was studied the influence of the addition of 5% technical lignin. The levels of resin content were 10, 9, 8, 7 and 6%. For each level were produced MDF with and without technical lignin.

For the production of laboratory MDF was used wood mass produced by the thermo-mechanical method "Asplund". The mass was from beech and cerris in the ratio 2:1. The water content of mass was 11% at bulk density of 32 kg.m-3 and pulp freeness of 11 ShR° (21 Ds).

It was used technical hydrolysis lignin composed of: cellulose – 14.2%; lignin-71.3%; ash-14.5%. The process technology is based on a high temperature, dilute sulfuric acid and hydrolysis of the shavings and wood of conifers to sugars, which are further subjected to the production of yeast for feed. The lignin was added as dry substance.

The resin was added by a laboratory blender (820 rpm) and for hot pressing it is used laboratory press type PMS ST 100, Italy.

The temperature of the hot pressing was 190° C at a cycle time of 1 min.mm-1 of board thickness. The cycle for hot-pressing was as follows: first stage pressure – 3 MPa and duration 90 s; a second stage: pressure - 1.8 MPa and duration 90s; third stage at a pressure of – 0.6 MPa and duration 160 s; fourth stage: pressure – 1.3 MPa and duration 90 s.

MDF properties was determined by the methods set by EN standards. To determine the mechanical properties of the boards will was used universal testing machine Zwick / Roell Z010.

To determine a given property for every board was used 8 test pieces and the results was processed by the methods of variation statistics.

2. ANALYSIS AND DISCUSSION

The summarized results for the change in physical and mechanical properties of MDF resulting from variations in the levels of the factors are presented in Table 1.

Figure 1 shows the resulting for MDF properties in different content of phenol-formaldehyde resin and technical lignin. The numbering of the boards is consistent with experimental matrix. Boards 2, 4, 6, 8 and 10 with 5% content of technical lignin.

In comparative characteristic outlook of the boards worsening of appearance, dark spots on the surface of the boards are observed with the addition of lignin.

Table 1: Change in value of MDF properties as a result of change of lignin content and content of phenol-formaldehyde resin

№	Content of lignin [%]	Content of phenol-formaldehyde resin, [%]	Density ρ [kg.m^{-3}]	Bending strength *fm* [N.mm^{-2}]	Water absorption *A* [%]	Swelling in thicknesses G_t [%]
1	0	10	728	29.42	68.96	19.74
2	5	10	726	23.35	101.64	27.93
3	0	9	732	27.91	69.13	20.31
4	5	9	720	22.63	103.15	28.65
5	0	8	714	26.88	84.38	22.95
6	5	8	711	20.69	105.15	29.56
7	0	7	730	22.43	85.37	22.01
8	5	7	731	19.23	107.79	30.32
9	0	6	725	22.72	90.52	26.46
10	5	6	728	17.70	115.69	34.86

This may be due to an increased ash content of technical lignin. However, the defect is visible and can be removed by surface finishing of the boards.

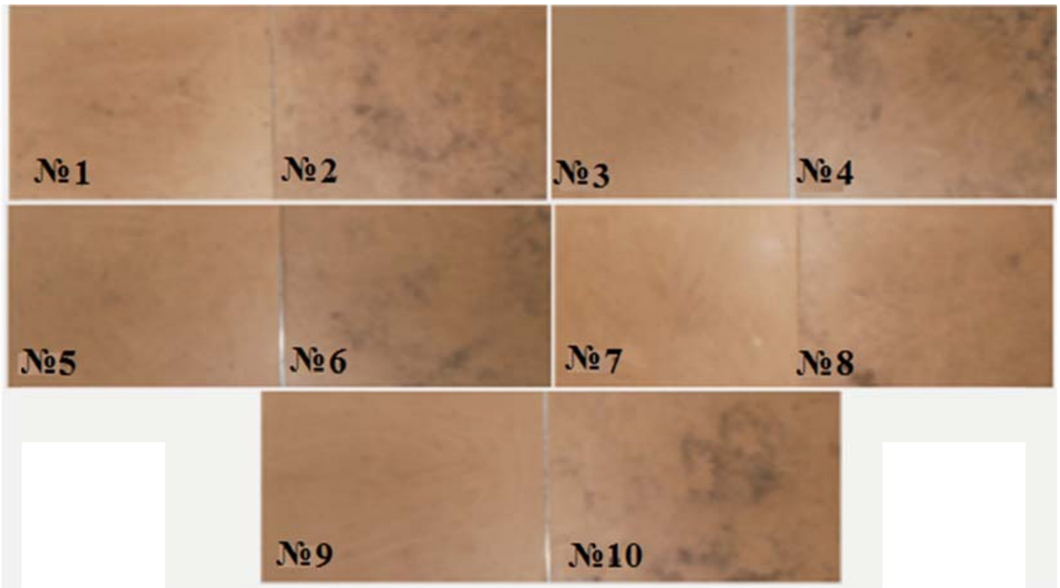

Figure 1: Appearance on MDF, with different content of phenol-formaldehyde resin and technical lignin

2.1. Analysis of the results for water absorption and swelling in thicknesses of MDF

Water adsorption of MDF varied from 69 to 116%. The graphical interpretation of the results for different content of binder and technical lignin is presented in Figure 2.

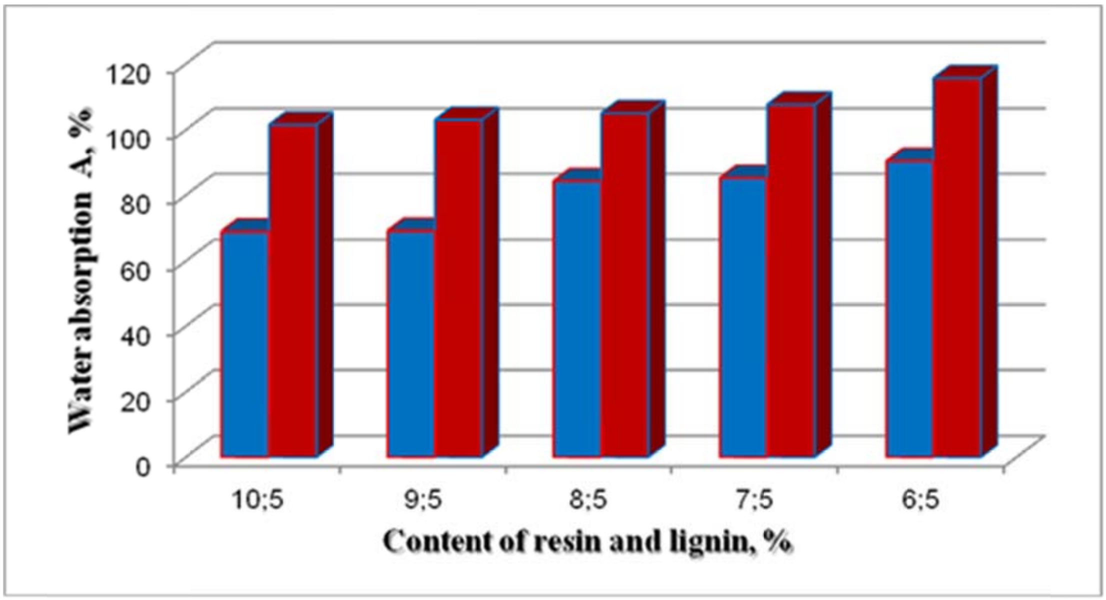

Figure 2: Amendment of water absorption of MDF with different amount of phenol-formaldehyde resin and technical lignin

Worst properties have MDF with six percent and five percent phenol-formaldehyde technical lignin. Best are the properties of MDFs by 10% phenol-formaldehyde and without the participation of technical lignin.

The average indicator deteriorates, the water absorption increases, by 120 to 150% when adding 5% of a lignin in the composition of the plates.

The results of swelling in thickness of the MDF in a different part of the phenol-formaldehyde resin and the technical lignin are presented in Fig. 3.

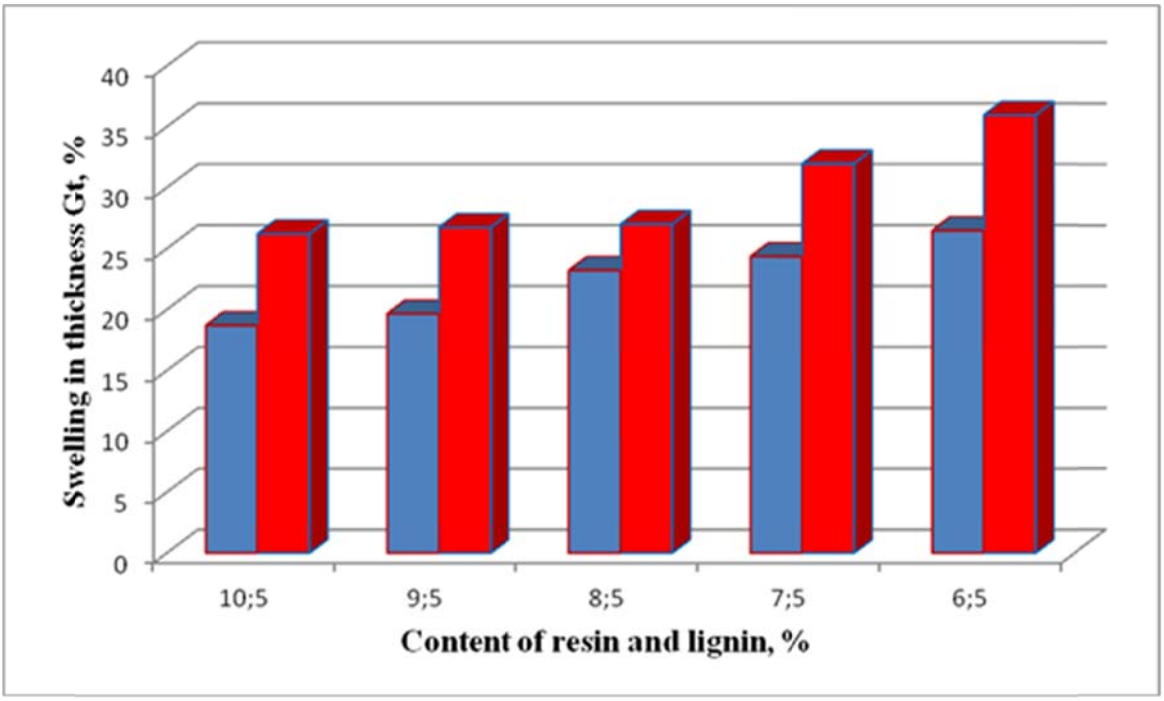

Figure 3: Amendment of swelling in thickness of MDF with different amount of phenol-formaldehyde resin and technical lignin

With the addition of technical lignin, the composition of MDF, at all levels tested on the content of the relevant nature substance is observed a deterioration of the properties. The average deterioration, i.e. the increase of swelling in thickness is 130 to 170%. However, with the exception of MDF with 6% and 7% phenol-formaldehyde resin and 5% lignin, all the other boards meet standard requirements for use in a dry environment.

The deterioration of MDF properties indicates that the hygroscopic technical lignin is not connected to any significant extent with the fibrous elements in the composition of the boards and acts as filler. This can be explained by the increased ash content of technical lignin, insufficient duration of treatment in thermal treatment or insufficient amount of lignin. In higher percentage of technical lignin composition of MDF would increase the contact area and at least partially would bridge the impact of the ash. Another method for linking of lignin with the fibrous elements is to increase the temperature and duration of the hot-pressing treatment. In this case should take into account the negative impact on synthetic binders.

2.2. Analysis of results for bending strength of MDF

When the studied values amend the content of phenol-formaldehyde resin and hydrolysis lignin strength in bending MDF varied from 17.7 to 29.4 N.mm^{-2}. The highest bending strength was observed in MDF with 10% phenol-formaldehyde resin and 0% lignin, and at least at the MDF by 6% and 5% technical lignin Fig.4. The analysis of the values of this properties leads to the conclusion that technical lignin acts as a filler of pulp mass. Under the conditions of the experiment, it is not activated and acts as a bond.

Despite the deterioration in the research property data indicates that the MDF with a 10% phenol-formaldehyde resin and 5% respectively lignin qualify for MDF for general purpose and use in a dry environment. Therefore, in the content of at least 10% of a phenol-formaldehyde resin, technical lignin can be used in a content of 5% as a substitute for expensive for manufacturing pulp mass.

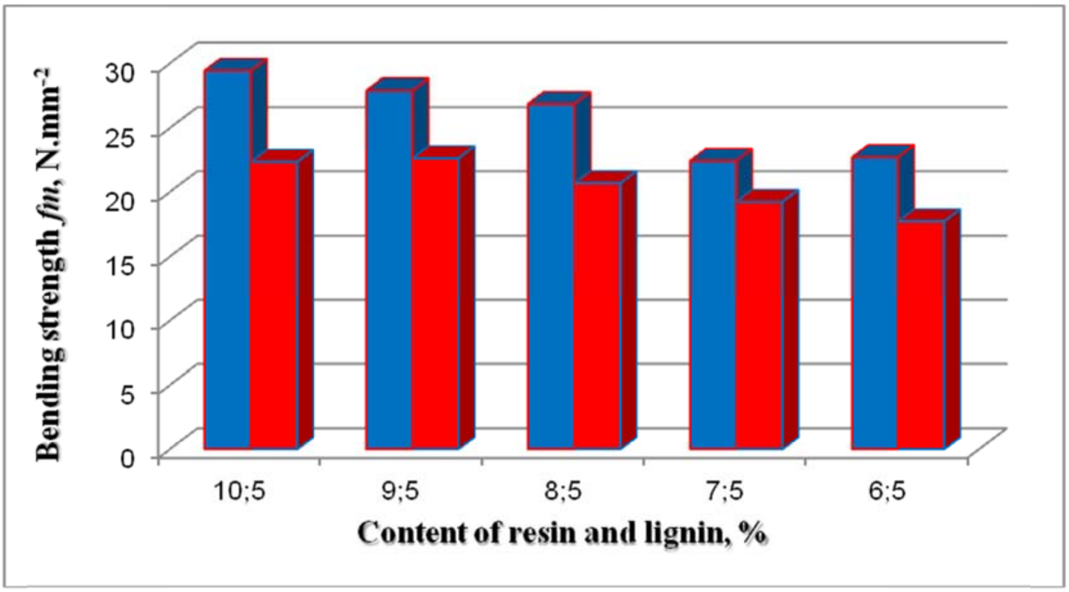

Figure 4: Amendment of bending strength of MDF with different amount of phenol-formaldehyde resin and technical lignin

3. CONCLUSIONS

As a result of the studies on the possibility for utilization of technical (hydrolysis) lignin in the composition of MDF, can be drawn the following conclusions:

1. At experiment conditions, the temperature of hot pressing of 190º C and duration of pressing 1 min.mm^{-1} on the thickness of the board, hydrolysis lignin is not activated, it does not act as a bond but as a filler of pulp mass;
2. In the function of the filler hydrolysis lignin deteriorates the appearance of the boards;
3. Water absorption and swelling in thickness of the MDF worsen with the addition of 5% hydrolysis lignin. However, all MDF with lignin, except that 6% phenol-formaldehyde resin, satisfy the standardized requirements in terms of swelling in thickness;
4. The bending strength deteriorates with the addition of hydrolysis lignin, but at 10% or more part of the phenol-formaldehyde resin may be added up to 5% lignin;
5. When this balancing with standardized requirements for swelling in thickness and bending strength of MDF with an average density is found that it is possible addition of 5% technical, hydrolysis lignin, wherein content of the phenol-formaldehyde resin of ten percent or more, as a substitute for energy-intensive production of pulp mass.
6. In subsequent studies should be examined the impact of the hydrolysis lignin content at more than 5% in the composition of the boards, and the possibility of its activation by the addition of different reagents.

REFFERENCES

MANCERA, C., MANSOURI, N., VILASECA, F., FERRANDO, F., SALVADO, J. 2011. The effect of lignin as a natural adhesive on the physic-mechanical properties vitis vinefera fiberboards. Bio-resources 6 (3) pp. 2851–2860.

EURING, M, RÜHL, M, RITTER, N, KHARAZIPOUR, A. 2011. Laccase mediator systems for eco-friendly production of medium-density fiberboard (MDF) on a pilot scale: Physicochemical analysis of the reaction mechanism. Biotechnology Journal 6(10):1253–61.

NASIR, M., GUPTA, A., BEG, M., CHUA, GK., KUMAR, A. 2014. Physical and mechanical properties of Medium Density Fiberboard using soy-lignin adhesives. Journal of tropical forest science (1) pp. 41–49.

RADOSAVLJEVIC, L.; PECENKA, R.; FÜRLL, CH. 2008. Natural Binders for Fibreboard Made of Hemp. International Conference on Flax and Other Bast Plants. pp.70–74.

PETRIN, ST.; VALCHEV, I., NENKOVA, S., RADOYKOVA, T. 2013. Utilization of waste hydrolysis lignin from the Razlog area. University of Chemical Technology and Metallurgy, Sofia.

RAMUNAS TUPCIAUSKAS, JANIS GRAVITIS, JANIS ABOLINS, TARJA TAMMINEN. 2017. Utilization of lignin powder for manufacturing self-binding HDF. Holzforschung 71 (7).

ZOUH, X., TAN, L., ZHANG, W., CHENLONG, LV., ZHENG, F., ZHANG, R., DU, G., TANG., B., LIU, XU. 2011. Enzymatic hydrolysis lignin derived from corn stoves as an instant binder from bio-composites: effect of fiber moisture content and pressing temperature on board's properties. Bio-resources 6 (1) pp. 253–264.

EN 310:1999. Wood-based panels – Determination of modulus of elasticity in bending and of bending strength.

EN 316:2009. Wood fibreboards – Definition, classification and symbols.

EN 317:1998. Particleboards and fibreboards – Determination of swelling in thickness after immersion in water.

EN 322:1998. Wood-based panels – Determination of moisture content.

EN 323:2000. Wood-based panels – Determination of density.

http://www.fao.org/forestry/statistics/.

UNIVERSITY OF FORESTRY

FACULTY OF FOREST INDUSTRY

INNOVATION IN WOODWORKING INDUSTRY AND ENGINEERING DESIGN

2/2017

INNO vol. VI Sofia

ISSN 1314-6149
e-ISSN 2367-6663

INNOVATION IN WOODWORKING INDUSTRY AND ENGINEERING DESIGN, 2/2017 (12): 3–4

CONTENTS