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Modeling Of Technological Process Of Wood-Composite Material Production Of Woodworking And Wood Chemical Complex Wastes

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Summary

At present the problem of forest reduction is very acute because a lack of attention to the waste utilization problem is paid by woodworking industries and timber enterprises. Woodworking enterprises generate shavings waste of natural pure wood, lignin waste is left at wood chemical complexes, while the number is calculated not by the hundreds of tons but millions ones. Besides the large areas of land are occupied with lignin, the roadside zones, air and territory adjoin the dumps [1,2] are contaminated, lignin ignites spontaneously during long-term storage.
It causes significant economic and ecological damage to the environment. In this article, the possibility of creating a new structural wood composite material as a complete substitute for natural wood, metals, expensive plastics, brick, concrete from the waste of woodworking and wood chemical complexe is proved (hydrolytic lignin) [3].

Keywords: wood-composite material (WCM), waste shavings of woodworking, hydrolytic lignin, quality indicators of WCM, production modes, multifactor experiment, mathematical model.

Introduction

The hydrolytic lignin is an amorphous powdery substance with a density of 1,25-1,45 g/cm3 from light-cream to dark brown color with a specific smell, possesses good sorption ability. Functional groups of lignin are found by nuclear magnetic resonances methods - and IK-spectroscopy [4-6]. These are metaxylene, hydroxyl phenolic and aliphatic, carbonyl, carboxyl. So, there are bases to assume the increasing in cohesive durability of a system if it contains such groups.

Wood composite material was created by technology:

Table 1 Technology of creation of wood composite material

External layer (layer of A)	Inside layer (layer of B)
- technical hydrolytic lignin (THL)	- shaving waste from roundup - shaving for an inside layer of wood-shaving plates

The ratio of layers And/B is accepted in accordance with the technology 40/60 [7].

The parameters of the pitch on the dry residue of the binder on the absolutely dry shaving:

- external layers of 14-15%
- inside layer of 12-14%

The research purpose:
The increasing of production efficiency of wood and composite materials [8-9] due to the fullest possible involvement of wastes of various woodworking enterprises and wood chemical complex.

Technique.
As a method of obtaining the mathematical description of production process of WCM, an active multifactor experiment is accepted. Technological mode of WCM production, main indicators of properties are the function of a response of such multifactor model. For creating of the mathematical model [10], checking of its adequacy and for an assessment of influence on process of each varied factor, the regression analysis is used. For obtaining the regression dependences the composite B-plan of the second order is used.

As output values the qualitative indicators of the finished product were accepted:

Y1 - strength of WCM at a bend (σ_{bend}), MPa;

Y2 - strength of WCM at stretching it is perpendicular to plate layer ($\tau_{stretching}$), MPa;

Y3 - strength of WCM at compression ($\tau_{compression}$), MPa;
Y4 - swelling of WCM on thickness for 24 h. (t), %.
Y5 - water absorption of WCM for 24 h. (Δw), %

The varied technology factors:
X1 - the content of shaving waste from roundup in an inside layer of WCM, %;
X2 - pressing temperature, 0C;
X3 - pressing duration, min.

The operated factors varied at the levels specified in table 2

Main part
Average results of output parameters of the multifactor experiment put for obtaining of the adequate mathematical description of technological process of WCM are reflected in a matrix of planning (table 3).

Table 2 The operated factors and levels of their variation

Name of a factor	Code mark	Lower level	Main level	Top level	Variation interval
1	2	3	4	5	6
The content of shaving from roundup as a part of wood-shaving composition of an inside layer of WCM, %	X_1	20	40	60	20
Pressing temperature, 0C.	X_2	140	155	170	15
Pressing duration, min.	X_3	4	6	8	2

Table 3 Matrix of planning and results of experiment of WCM production

experience No.	x_1		x_2		x_3		Y_1, σ_{bend}, MPa	Y_2, τ_{str}, MPa	Y_3, τ_{compr}, MPa	Y_4, t, %.	Y_5, Δ_w, %
		%		mass parts		min.					
1	-1	20	-1	140	-1	4	16,8	0,43	3,5	10,1	41,4
2	1	60	-1	140	-1	4	10,7	0,49	3,7	8,2	42,3
3	-1	20	1	170	-1	4	17,9	0,58	4,6	9,0	39,7
4	1	60	1	170	-1	4	11,7	0,65	4,8	7	40,6
5	-1	20	-1	140	1	8	18,6	0,4	3,2	10,7	42,5
6	1	60	-1	140	1	8	12,5	0,47	3,4	8,8	43,4
7	-1	20	1	170	1	8	19,6	0,56	4,3	9,6	40,8
8	1	60	1	170	1	8	13,5	0,63	4,5	7,7	41,7
9	-1	20	0	155	0	6	16,9	0,43	2,8	9,0	41,7
10	1	60	0	155	0	6	10,8	0,5	3,0	7,0	42,6
11	0	40	-1	140	0	6	15,3	0,41	2,7	8,2	44,6
12	0	40	1	170	0	6	16,3	0,57	3,7	7,0	42,9
13	0	40	0	155	-1	4	14,2	0,45	3,8	8,5	44,1
14	0	40	0	155	1	8	16	0,43	3,5	9,1	45,2

The mathematical description of dependence of WCM strength at a bend:

$$Y_1 = 14{,}8 - 3{,}06X_1 + 0{,}51X_2 + 0{,}89X_3 - 0{,}94X_1^2 + 1{,}01X_2^2 + 0{,}31X_3^2$$

when extending perpendicular to the plate layer:

$$Y_2 = 0{,}434 + 0{,}034X_1 + 0{,}079X_2 - 0{,}011X_3 + 0{,}031X_1^2 + 0{,}056X_2^2 +$$
$$+ 0{,}006X_3^2 + 0{,}00125X_1 \cdot X_2 + 0{,}00125X_1 \cdot X_3 + 0{,}0025X_2 \cdot X_3$$

when the compression on the edge:

$$Y_3 = 2{,}875 + 0{,}1X_1 + 0{,}54X_2 - 0{,}15X_3 + 0{,}025X_1^2 + 0{,}325X_2^2 +$$
$$+ 0{,}775X_3^2$$

swelling WCM thickness for 24 h:

$$Y_4 = 7{,}76 - 0{,}97X_1 - 0{,}57X_2 + 0{,}31X_3 + 0{,}245X_1^2 - 0{,}155X_2^2 + 1{,}045X_3^2$$

water absorption of WCM for 24 h:

$$Y_5 = 44{,}506 + 0{,}45X_1 - 0{,}85X_2 + 0{,}55X_3 - 2{,}343X_1^2 - 0{,}743X_2^2 + 0{,}157X_3^2$$

from the varied technological parameters is presented in the form of the normalized regression equations.

Dependences of WCM durability at a bend, when extending perpendicular to the plate layer, at the compression, swelling WCM thickness for 24 hours, water absorptions for 24 hours from the varied technology factors are presented in figure 1-5.

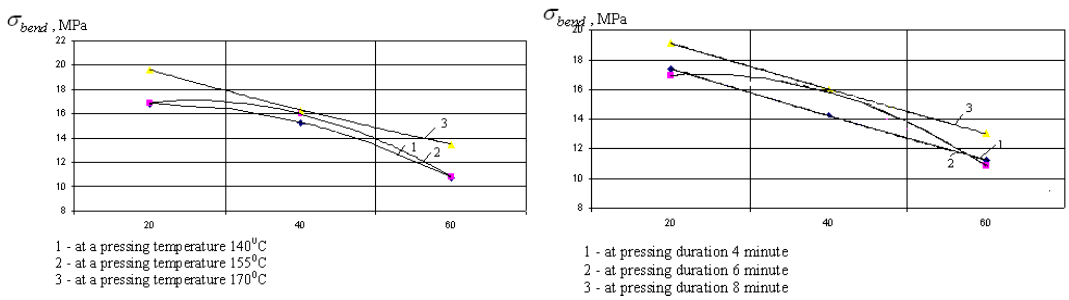

Figure 1 - Dependence of WCM strength at a bend on the content of shaving waste in B layer

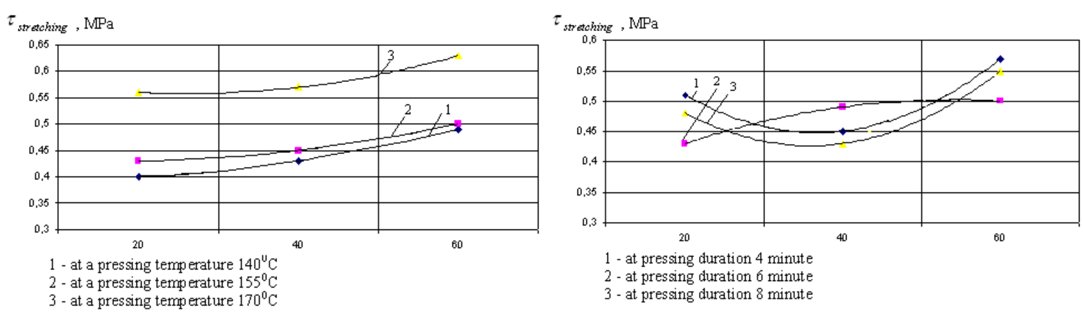

Figure 2 - Dependence of WCM strength when extending perpendicular to the plate layer on the content of shaving waste in B layer

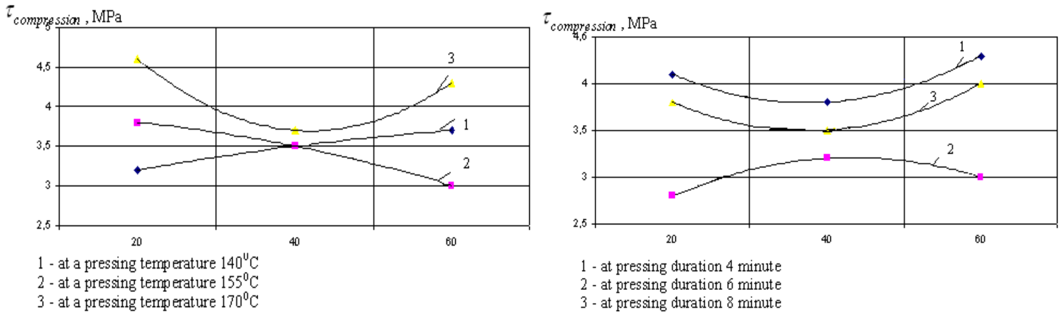

Figure 3 - Dependence of WCM strength when the compression on the edge on the content of shaving waste in B layer

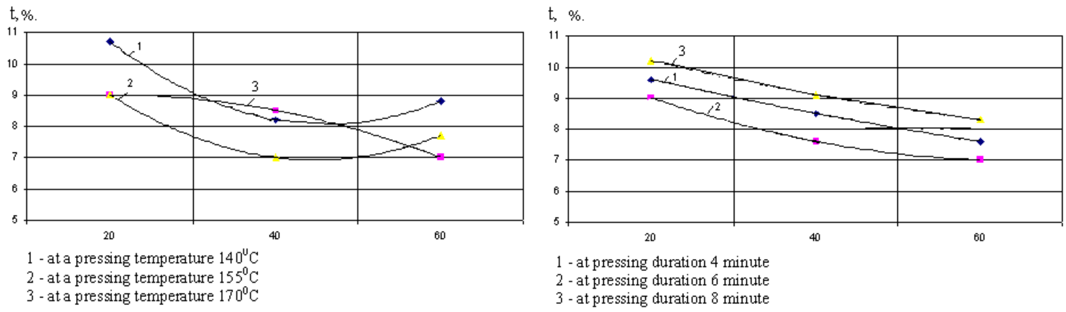

Figure 4 - Dependence of swelling WCM thickness for 24 h on the content of shaving waste in B layer

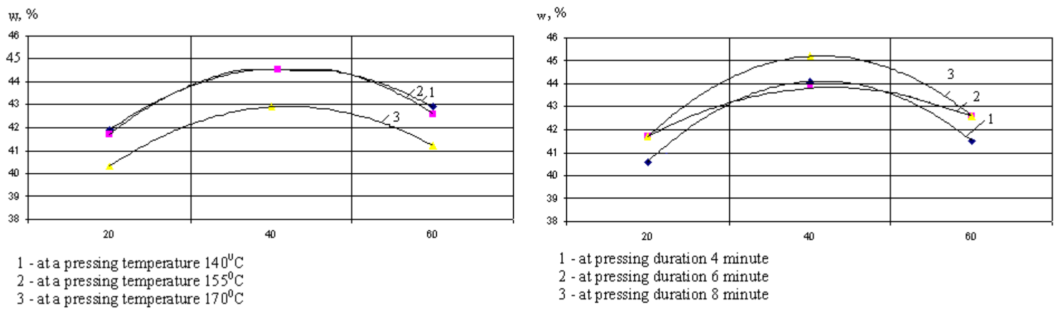

Figure 5 - Dependence of water absorption of WCM for 24 h from the content of shaving waste in the B-layer

Analyzing the received dependences, it is possible to note that WCM durability at a bend and when extending perpendicular to the plate layer, at compression increases, and swelling on thickness and water absorption for 24 hours decreases with pressing temperature increasing. The optimum temperature of pressing at which the durability of WCM will have the maximum value and water absorption will have the minimum value is 170 deg, and for swelling on thickness for 24 hours –

150 deg. The increasing of pressing duration positively influences on the indicators "strength at a bend and extending perpendicular to the plate layer", and for durability at compression, swelling on thickness and water absorption for 24 hours inverse relationship is observed. The optimum duration of pressing, at which swelling of WCM on thickness for 24 h. will have the minimum value 6 min., and water absorption for 24 hours – 4 min. The optimum content of shaving waste as a part of an inside layer of WCM providing the maximum durability at a bend is 20-40%, at extending perpendicular to the plate layer is 40-60%, the minimum swelling on thickness and water absorption for 24 hours is 40-60%.

Process of decreasing of water absorption is based on filling the pores of the plate, partial capillaries of wood and, as a result the decreasing in wettability, their walls, theoretical assumptions about higher cohesive strength of the system containing groups with high energy of interaction (-OH, - COOH). Water absorption of WCM when wetting proceeds with prevalence of forces of molecular interaction. The process of water absorption decreasing is based on filling of the pore of the plate, partial one of wood capillaries and, as a result decreasing in wettability of their walls. It is obviously, the creation of a continuous, monolithic external layer of WCM from a hydrolytic lignin interferes with penetration of water at the physical level. And also, existence in lignin of the groups with high energy of interaction increases the cohesive durability of system and interferes with water penetration at the chemical level too. Surfaces of a response of output sizes from the varied parameters are presented in figures 6-10

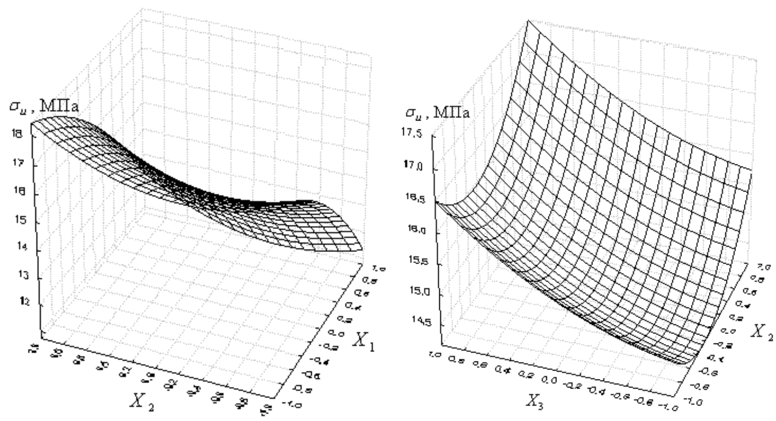

Figure 6 - Dependence of WCM durability at a bend from the varied factors

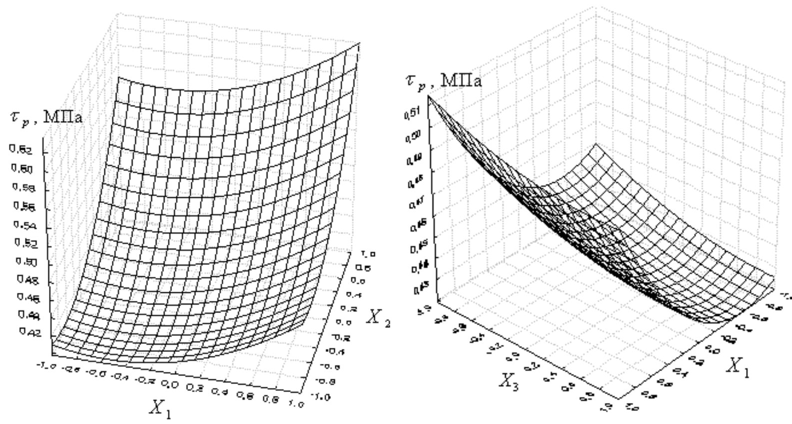

Figure 7 - Dependence of WCM durability when extending perpendicular to plate layer on the varied factors

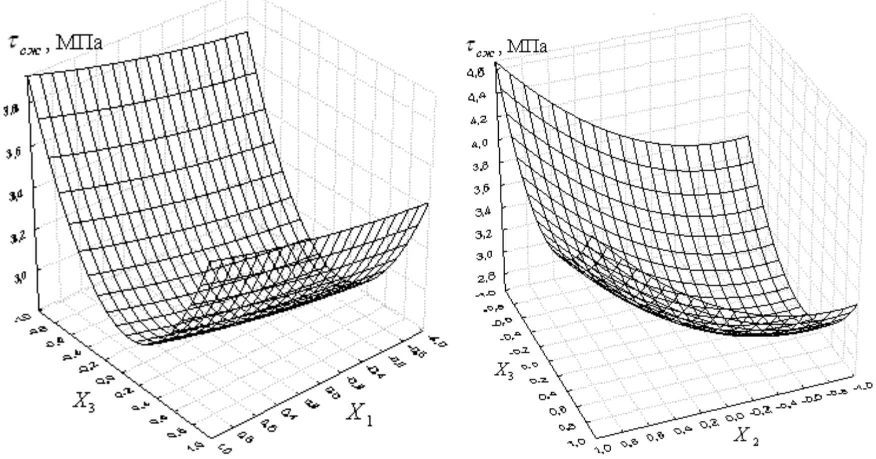

Figure 8 - Dependence of WCM durability of WCM at compression on the varied factors

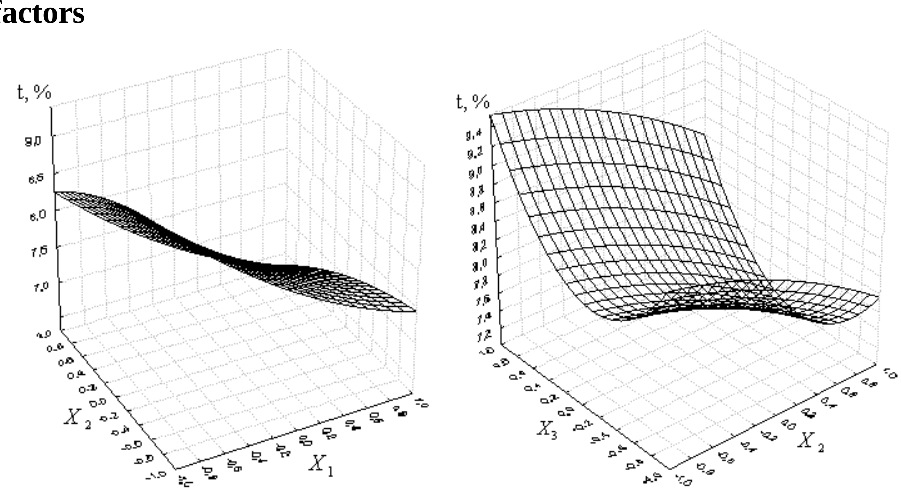

Figure 9 - Dependence of WCM swelling on thickness for 24 hours on the varied factors

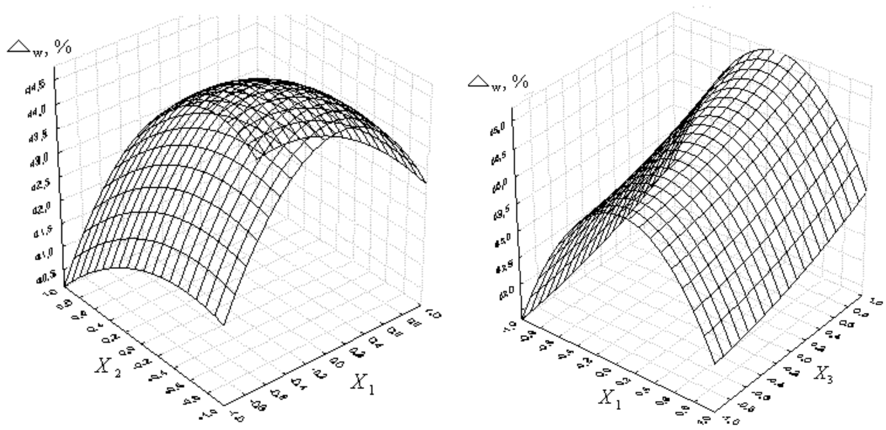

Figure 10 - Dependence of water absorption of WCM on the varied factors

Summary.

As a result of pilot studies the main theoretical prerequisites that creation of a continuous, monolithic external layer of WCM from TGL interferes with penetration of water at the physical and chemical levels are confirmed, and also the use of shaving waste allows to increase durability of plates because it has the rounded-off form. From the presented dependences it is possible to claim that each of the factors: the content of shaving waste, duration of pressing and temperature of pressing significantly influence on the output parameters. On the basis of a complex assessment of influence of the operated factors on the WCM physic-mechanical properties, the optimum parameters have been received:

- the composition of the shaving composition structure of the inner layer of WCM - 50% - standard shaving of B layer for WSP, fraction 7/2 and 50 of % - shaving waste.
- temperature of pressing of WCM: 170
- duration of pressing of WCM: 6 minutes.

The regression equations which are adequately describing influence of the studied technology factors on the mechanical and physical characteristics of WCM allowing to predict quality indicators of WCM and to define the optimum modes of their production with reliable degree of accuracy have been received.

Conclusions.

The results of the research conclusions can be drawn:

1. The use of THL in the composition WCM improves the physical properties WCM, it will allow them to be used in rooms with increases in humidity and possibly outdoors.
2. The developed WCM allows to utilize the waste of a wood chemical complex and woodworking industries in sufficient quantity.

3. The use of waste especially wood chemical complex one allows to improve the sustainability of the territories of Siberia, to reduce their fire risk.
4. Developed WCM is well processed by the standard cutting tool, it does not require the use of a high hardness tool.
5. The developed structure of WCM has higher mechanical properties compared to wood chipboards.

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