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INCREASE IN SOME QUALITY INDICATORS OF PARTICLEBOARDS BY OPTIMIZING SURFACE LAYERS – PART I

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Abstract

The effect of particle size, binder content in surface layers and surface/core layer ratio on bending strength, modulus of elasticity in bending and internal bond of particleboards is investigated in the paper.
The results show the positive effect of particle size and binder content on the investigated indicators, while the effect of the percentage of surface layers is more weakly expressed.

Key words: *particleboards, quality, planned experiment, effect of factors.*

INTRODUCTION

Competition, market requirements and striving for increasing the market share necessitate that particleboard (PB) factories manufacture and offer boards differing in type and purpose.

The main differences in the requirements of mechanical indices for the individual types of PBs are related to the bending strength and modulus of elasticity in bending (EN 312:2010). At the same time, it has been established that this properties mainly depend on the properties of surface layers, PB density, coefficient of compression, particle size and slenderness ratio, binder amount, temperature and duration of hot pressing, etc. (Yosifov, N., 1989; Todorov, T., 1980; Arabi, M. et al., 2011; Maloney, T. M., 1970, etc.).

The manufacture conditions and raw materials used at present differ from those in the investigations performed up to now, in which particles of hard tree species have been used (Yosifov, N., 1989; Todorov, T., 1980; Bodig, J., Jayne, B. A., 1982). At present, particles of soft hardwood or softwood species are mostly used. Phenol-formaldehyde and isocyanate glues have been used, while in manufacture the binders used are based on urea-formaldehyde resins (Barnes, D., 2001). Temperatures of 160-170 °C in previous investigations are lower than the 190-200 °C used today (Todorov, T., 1980).

Taking into account these considerations, the aim of this paper is the investigation of the effect of size of sieve through which the particles for surface layer (i.e. particle size) have passed, binder amount in surface layer (SL), and surface/core layer ratio on the mechanical indices of PBs. To attain the above aim, a planned experiment has been conducted.

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MATERIALS AND METHODS

Industrially obtained particles for core layer to the softwood/hard hardwood ratio of 70/30% have been used. The particles used for surface layer have a size corresponding to fractions 3/2; 2/1; 1/0, and for the core layer – to fraction 4/0.5 mm. The particles have been dried to 3.5% moisture content. The binder is urea-formaldehyde (UF) resin, with jellying time of 45-50 s and 8% participation in the core layer. 2.2% and 0.7% ammonium sulphate has been added to the resin in the role of hardener, respectively for core and surface layer. The manually formed mat has been subjected after cold pressing to hot pressing at panel temperature of 195 °C, maximum pressure of 2.8 MPa for 240 s.

As the variables participating in the FL/CL ratio are interdependent ones, a combined D-optimum plan containing several experiments more than the number of the coefficients of the model has been used. The plan of the experiment (Table 1) has been generated by means of the QStatLab software programme.

Table 1. Generated D-optimum plan of the experiment

	Resin in SL, %	Size of sieve, mm	CL, %	SL, %
	X1	X2	X3	X4
1	8	1	80	20
2	14	1	80	20
3	8	3	80	20
4	14	3	80	20
5	11	1	60	40
6	8	2	60	40
7	11	2	80	20
8	11	3	60	40
9	14	2	60	40
10	14	3	70	30
11	11	2	70	30
12	8	3	70	30
13	14	1	60	40
14	8	1	60	40
15	8	3	60	40

PBs with a density of 680 kg/m^3 and dimensions 500/500/16 mm have been obtained under laboratory conditions according to the plan of the experiment so set. After conditioning for one week at a temperature of 22 °C and relative humidity of 65%, test pieces necessary for testing and determination of the following quality indicators: bending strength (MOR) – 16 pcs. (pursuant to EN 310:1999); modulus of elasticity in bending (MOE) – 8 pcs. (pursuant to EN 310:1999); tensile strength perpendicular to the plane of the board (internal bond – IB) – 10 pcs. (pursuant to EN 319:2002), have been cut from the boards.

The minimum densities in the middle layer have been also determined by means of X-ray scanning.

RESULTS AND DISCUSSION

The results have been processed by means of the QStatLab software programme.

Complex dependence between bending strength, particle size and resin amount in surface layers is presented in Fig. 1. It is clearly seen that the particle size affects the bending strength to a greater extent than the binder amount. The increase of the particle size leads to increase of bending strength. In the case of particles with size greater than 2.5 mm, the bending strength decreases. The reason for this is probably the worse (more difficult) contacts between greater particles. With the increase of the resin amount, higher values

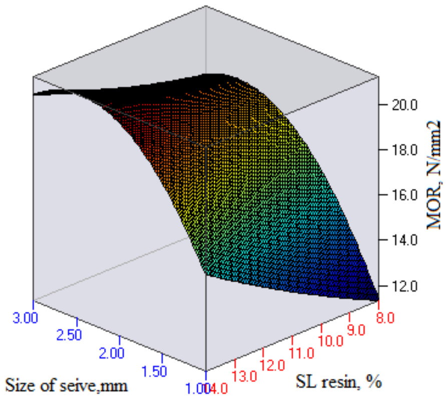

Fig. 1. Variation of bending strength at surface/core layer ratio of 30/70% depending on size of sieve and resin content in surface layer

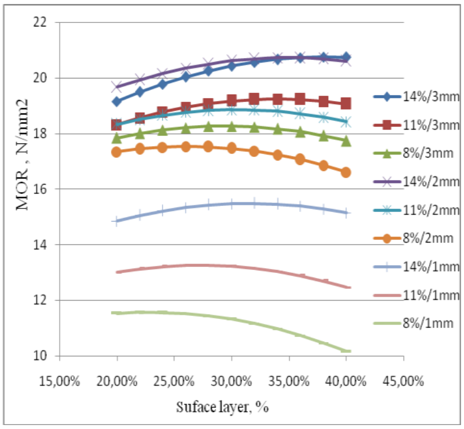

Fig. 2. Effect of factors investigated on bending strength (the graph has been obtained on the basis of data from the experiment and equation worked out)

of bending strength are also obtained. In the case of smaller particles, the effect of the binder amount is more strongly expressed. This is due to the circumstance that they have greater specific surface and in case of smaller binder amount there is insufficiently good glueing. An essential peculiarity is the poorly expressed effect of the amount of SL on the bending strength (Fig. 2). This, probably, is due to the fact that the lower surface layer subjected to tension takes the load, and its destruction leads to fast increase of the destroyed area, i.e. the participation of the internal layers in case of bending load is small. In case of particles with 1 mm size and binder amount of 8% and 11%, the increase of the percentage of SL leads to decrease of the bending strength. In case of particles with 2 mm and 3 mm size and binder amount of 14%, the increase of the percentage of SL increases the bending strength by 5-10% and it reaches values above 20 N/mm^2.

The modulus of elasticity in bending (Fig. 3), similarly to the bending strength, increases with the increase of the particle size and the binder amount in the surface layers. Again at the end of the range of variation of the particle size, decrease of the modulus of elasticity in bending is observed. The effect of the binder amount on the modulus of elasticity in bending is more strongly expressed. The increase of the percentage of the surface layer

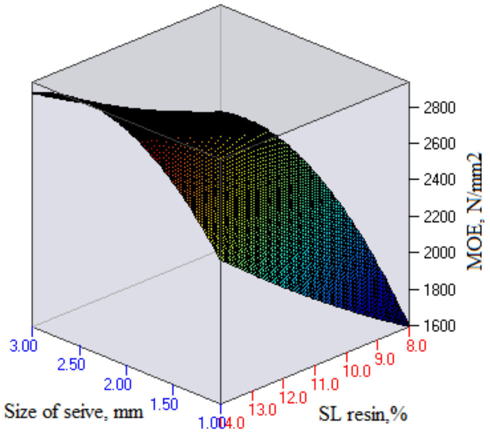

Fig. 3. Variation of modulus of elasticity in bending at surface/core layer ratio of 30/70% depending on size of sieve and resin content in surface layer

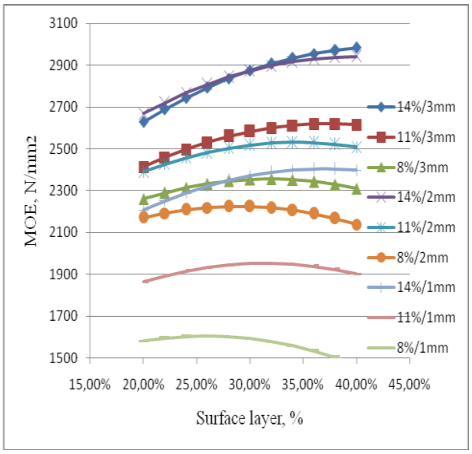

Fig. 4. Effect of factors investigated on modulus of elasticity in bending (the graph has been obtained on the basis of data from the experiment and equation worked out)

affects most strongly the modulus of elasticity in bending in combination with higher binder content, which is seen in Fig. 4. In case of binder amount of 8%, the percentage effect of SL is minimum. With the increase of the percentage of SL, the total binder amount in the board also increases, which also presupposes higher values of bending strength and modulus of elasticity in bending.

The tensile strength perpendicular to the plane of the board (IB) depends on the properties of the PB core layer (Fig. 5). Although the factors in the experiment apply to the surface layers, they also affect the core layer (Fig. 5). The factor particle size in surface layer affects indirectly the tensile strength perpendicular to the plane of the board because with the increase of the particle size, the density in the central zones of the core layer also increases (Fig. 6). The tensile strength perpendicular to the plane of the board is related to the density in the core layer (Fig. 7). The increase of the percentage of surface layer increases the internal bond in case of use of particles that have passed through sieves with mesh 1 and 2 mm (Fig. 8).

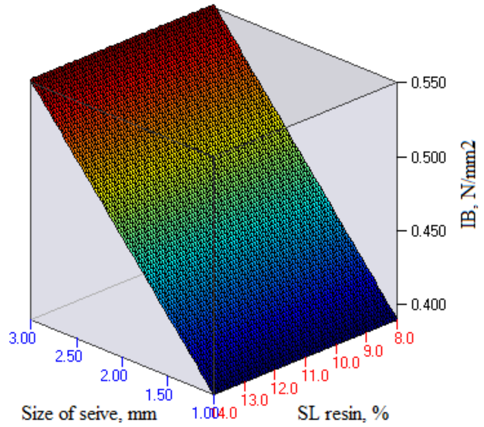

Fig. 5. Variation of internal bond at surface/core layer ratio of 30/70% depending on size of sieve and resin content in surface layer

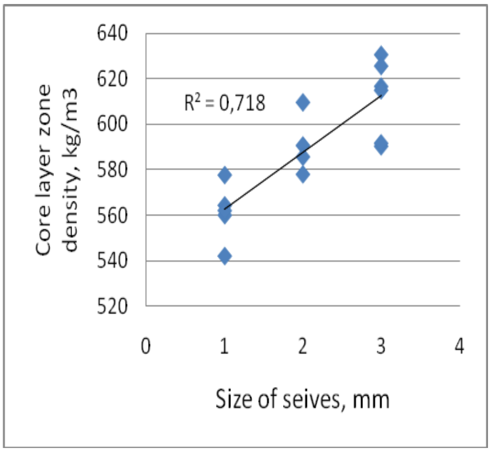

Fig. 6. Correlation between sieve mesh and minimum density of PBs

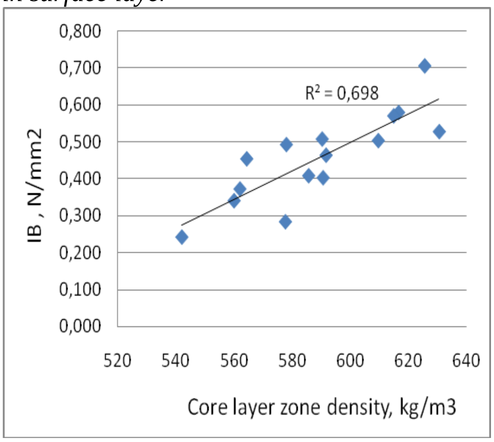

Fig. 7. Correlation between minimum density of PBs and internal bond

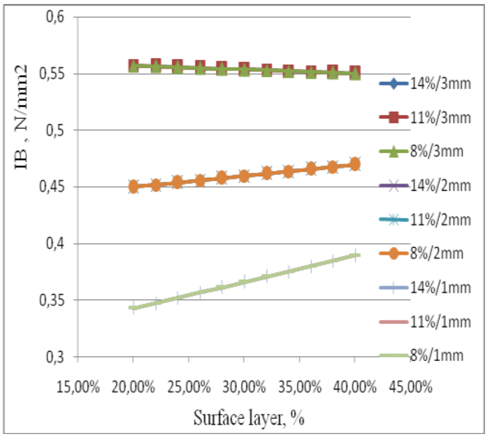

Fig. 8. Effect of factors investigated on internal bond (the graph has been obtained on the basis of data from the experiment and equation worked out)

CONCLUSION

On the basis of the data from the experiments conducted and the analysis of the results obtained, it may be summarised that:

- the increase of the particle size and binder amount in surface layers leads to increase of the values of bending strength and modulus of elasticity in bending by more than 50%;
- the increase of the particle size in surface layer affects indirectly the tensile strength perpendicular to the plane of the board, by increasing the compression in the middle layer;
- the effect of the percentage of surface layer on the mechanical properties of the boards is relatively weak, with increase of the bending strength and modulus of elasticity in bending being observed with the increase of the participation of the surface layers and at 14% binder.

The inferences made warrant drawing the following conclusion: the decrease of the binder amount may be compensated with increase of particle size, in the course of which retention of the values of bending strength, modulus of elasticity in bending and tensile strength perpendicular to the plane of the board is attained and thus reduction of production costs is attained.

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