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IMPACT OF BEECH PARTICLE SIZE ON COMPACTION RATIO OF THE SURFACE LAYER

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ABSTRACT

The purpose of this investigation was to determine the impact of beech (*Fagus sylvatica,* L.) particle size on the compaction ratio of the surface layer of three layer particleboard. For this purpose five different fractions of beech particles thicknesses between 0,17 to 0,97 mm were used. The size of particles used was altered in surface layer only. Particles were blended with UF adhesive. Surface layer compaction ratio was calculated with regard to the surface layer density before and after pressing. It was determined that the surface layer compaction ratio increases with decreasing particle size used, in the thickness range from 0,17 to 0,97 mm.

KEY WORDS: compaction ratio, particle, beech, vertical density distribution

INTRODUCTION

Important indicators of particleboard quality are their mechanical and physical properties. To attain optimum board properties, some conditions such as shape and size of particles, type of adhesive used, gluing factor, share of individual layer, compaction ration etc, have to be fulfilled. For optimum contact between particles they had to be pressed together so that there are less free spaces.

Kollmann et al. (1974), Moslemi (1974) and Maloney (1977) determined that particleboard density and compaction ratio depends on board fulfilment. Higher fulfilment was determined when thinner particles were used, or wood species with lower density were used. Higher fulfilment was also determined when boards were compressed at higher specific pressure.

Niemz and Bauer (1991) and Niemz et al. (1992) have determined that density and compaction ratio depends on particle size and wood species used. Xu and Suchsland (1998) have also determined the same correlation.

Irle (2000) determined that particles in surface layer are compressed to higher compaction ratio that those in the core layer. He also determined that when particles are compressed to higher compaction ratio there is danger of cell wall collapse.

Presented research is focused on determination of surface layer compaction ratio of beech (*Fagus sylvatica,* L.) particles thickness from 0,17 to 0,97 mm. The aim of this research was to determine how surface layer compaction ratio of three layer particleboard is impacted by different particle size of beech particles.

MATERIAL AND METHODS

From fresh beech logs with moisture content 65±5 %, particles were produced in laboratory chipper. Particles were then dried to 10 % moisture content approximately and separated into five different size classes that are characteristic for surface layer (Tab. 1).

Tab. 1: Particle size classes, dimensions and specific surface area of beech particles

Particle size class	Thickness	Width	Length	Particle specific surface area
	mm	mm	mm	m^2/100 g
A	0,171	0,176	0,703	4,570
B	0,290	0,303	1,590	2,600
C	0,605	0,625	2,464	1,399
D	0,619	0,640	3,170	1,408
E	0,967	1,005	3,542	0,891

Before blending, particles were 16 hours dried at temperature 65±5° C to moisture content approximately 1 %. Particles were blended in laboratory blender.

The structure of board was altered in surface layer only, while the structure of core layer was equal for all boards. Four board for each particle size class dimensions 500×500 mm were produced.

Mat was pressed at temperature 180° C and specific pressure 3 N/mm^2 to nominal thickness 16 mm. Boards were then cooled and placed into climate at temperature 20±2° C and relative humidity 65±5 %.

For determination of compaction ratio influence on the bending strength of three layer particleboard surface layer density and surface layer compaction ratio were determined. As for surface layer density and as for surface layer compaction ratio, vertical density distribution data were analyzed. Vertical density distribution was determined by means of gamma rays (Medved, 2000). Surface layer compaction ratio (CR_{SL}) was calculated by equation:

$$CR_{SL}=\rho_{SL2}/\rho_{SL1} \quad (1)$$

where:

* ρ_{SL2} means surface layer density after pressing and
* ρ_{SL1} surface layer mat density before pressing.

RESULTS AND DISCUSION

For the determination of the surface layer compaction ratio data obtained with determination of vertical density distribution (Fig. 1).

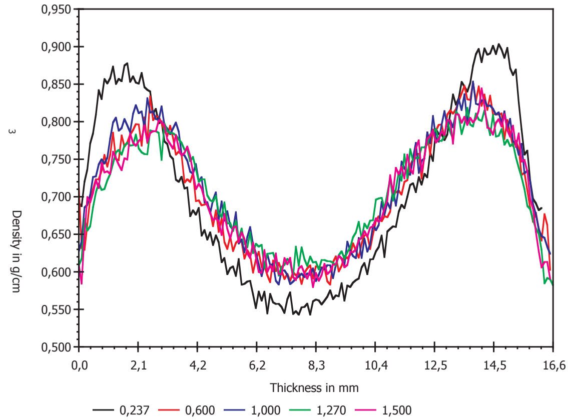

Fig. 1: Vertical density distribution of test boards with regard to the beech particles fraction

From Fig. 1 it can be seen that VDD and surface layer density depends on fraction size, where as surface layer density decreases with increasing size of the used particle size (fraction) (Fig. 2).

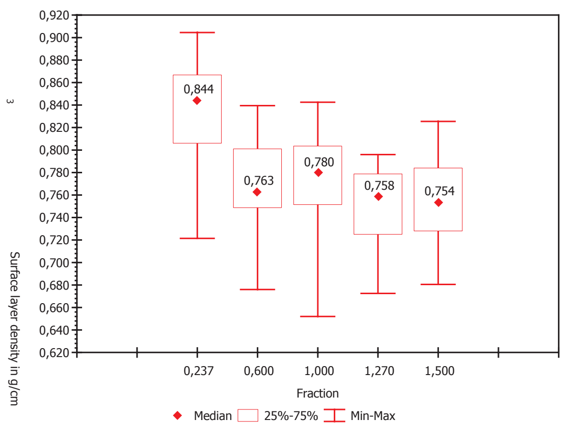

Fig. 2: Correlation between surface layer density and beech particles fraction

The surface layer density of three layer particleboard at fraction 0,237 is almost 0,850 g/cm^3, while is at other fractions almost 10 % lower.

It can be determined that surface layer compaction ratio depends mostly on the particle thickness used in surface layer (Fig. 3).

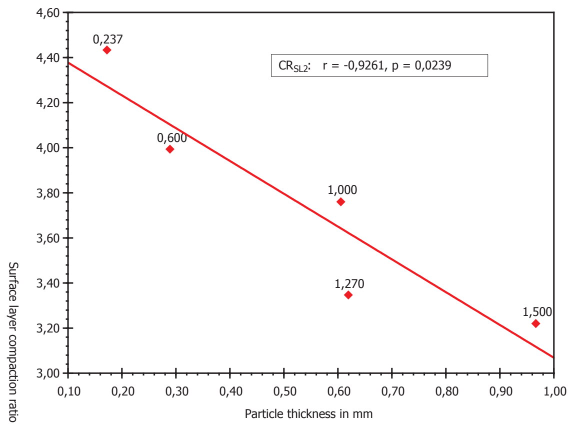

Fig. 3: Correlation between surface layer compaction ratio and beech particle thickness

The influence of particle size on the compaction ratio is the result of the fulfilment of the spaces between particles. The share and also the surface of those empty spaces are lower when smaller particles are used (Fig. 4 and Fig. 5).

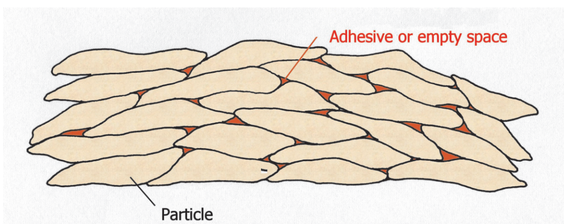

Fig. 4: Fulfilment at thinner particles

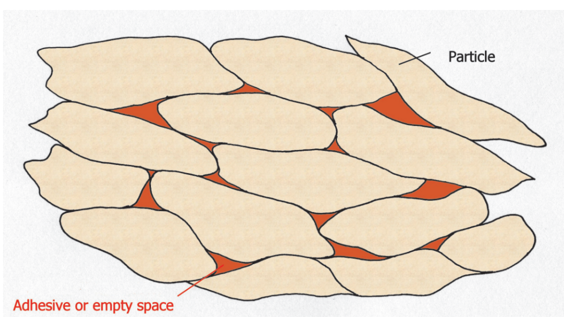

Fig. 5: Fulfilment at thicker particles

Fulfilment of spaces in particleboard is also the result of the number of particles of individual fraction. With increasing particle size the number of particles, at equal mass, decreases. If one fraction have more particles (numerically) then other fraction, than the one with more particles could be compressed to higher compaction ratio and also to higher density (Kollmann et al. 1974), Moslemi (1974a) and Maloney (1977).

Beside the compressibility of thinner particles and numerically superiority of thinner particles, the movement of particles to the next empty space must be considered (Hänsel et al. 1988). The particle movement is possible only in vertical direction. Particles, especially thinner one, move towards the section where optimal (maximal) density for this section is obtained. Thinner particles are, because of their smallness, more movable then thicker particles.

The compaction ratio and density of the particleboard is also influenced by the hydrothermal treatment during hot pressing. High temperature, around 180° C and the presence of moisture (moisture content of blended particles for surface layer is around 13 %), can induce softening of wood (Fengel and Wegner 1989). At the temperature over 100° C and at the presence of moisture formic and acetic acid extract from wood. Due to pH changes, caused by the presence of acid hardener and formic and acetic acid extraction, the degradation of hemicelluloses and in limited extent also the degradation of lignin is triggered, what leads to the softening of wood. Because the heat and steam easily penetrates into smaller particles the softening of those particles is more intense. Softer particles are therefore easily compressed to higher density.

The density of surface layer is, beside the size of the particles and the compression of surface layer, influenced also by the core layer. Because core layer is made from thicker and therefore less compressible particles it can induce additional pressure to more compressible surface layer (Fig. 6).

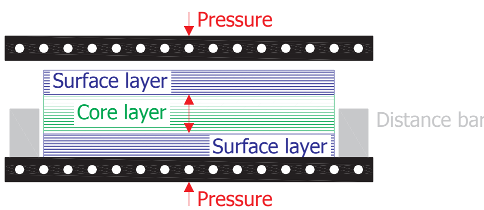

Fig. 6: Schematic layout of pressure action on surface layer

The additional compaction of surface layer also appears at press opening. Hänsel et al. (1988) and Schöberl (2000) have determined that with increasing difference between the thickness of particles used in surface and core layer, particleboard core layer thickness increases. Such behaviour is the effect of stress relaxation at press opening or springback effect. When the press opens, the tension stresses, especially in core layer are released. The relaxation of tension stresses in core layer firstly additionally compresses the surface layer and by that also decreases the thickness of surface layer, and secondly it influences (increases) the thickness of board. The relaxation of tension stresses in accordance to the mention authors increases with increasing core layer density.

CONCLUSIONS

It was determined that surface layer compaction ratio depends on the size of beech particles used. With increasing particle size or fraction used in surface layer the surface layer compaction ratio decreases. It was also determined that smaller particles are numerically more the bigger particles, hence there are less free spaces in layer and also the density of layer is higher.

The surface layer compaction ratio is also influence by the hydrothermal treatment of wood to which comes between hot pressing. The softening of wood is more efficient at smaller particles, because heat and steam penetrates faster to smaller that to bigger particles. Because smaller particles are more soften that bigger one, those particles can also be more compressed and also higher density of layer could be achieved.

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