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EFFECT OF VENEER DRYING TEMPERATURE ON THERMAL CONDUCTIVITY OF VENEER SHEETS

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Abstract
High quality panel manufacturing has been achieved with a good bonding under the optimum pressure conditions depending on adhesive type in wood based panel products like plywood. Thermal conductivity is a very important parameter for determining optimum pressing time. The thermal conductivity values depending on wood species and adhesive types are varied in literature. In this study, it was researched the effect of veneer drying temperature on thermal conductivity of veneer sheets. For this purpose, 2-mm-thick rotary-cut veneers obtained from alder (Alnus glutinosa barbata), Scots pine (Pinus sylvestris L.), spruce (Picea orientalis L.) and tetra (Tetraberliniana bifoliolata) logs were used as materials. After rotary cutting, veneer sheets were classified into four groups and dried at 90, 110, 130, and 160^{o}C temperatures. The thermal conductivity of veneer sheets were determined according to ASTM C 518 & ISO 8301. According to the results from the study, the highest thermal conductivity values were obtained for 110°C drying temperature and the thermal conductivity values decreased with increasing veneer drying temperature above 110°C. The veneer sheets obtained from alder and tetra logs exhibited the highest thermal conductivity values when compared to other wood species.

Key words: *veneer drying temperature; thermal conductivity; alder; pine; spruce; tetra.*

INTRODUCTION

In facing the global warming trend, there is a dire need for more effective measures to sustain comfortable temperatures in living environments. To sustain an indoor temperature that is independent of outdoor temperature fluctuations, materials need to be developed that have superior thermal insulation abilities (Kawasaki and Kawai 2006). Wood has been intensively used as residential construction material due to its natural beauty and great properties, such as high specific strength, thermal insulation, and ease of handling and processing (Kilic et al. 2006). For example, wood's low thermal conductivity and good strength make it of special interest for building construction, refrigeration, automobile applications, and cooperage, among others (Gu and Zink-Sharp 2005; Sahin Kol and Altun 2009).

Thermal conductivity is a very important parameter in determining heat transfer rate and is required for development of drying models and in industrial operations such as adhesive cure rate (Sahin Kol and Altun 2009). Information on the thermal conductivity of wood and its relationship to other wood properties is of interest from the standpoint of thermal insulation, drying, plastizing, preservation, gluing of wood, and where heat resistance of wood is a major consideration in its application (Sanyal et al. 1991; Zhang and Datta 2004; Hansson and Antti 2008).

In literature, it was stated that thermal conductivity was influenced by thickness of composite materials, density, moisture content, ratio of early and late wood, temperature, and flow direction of heat (Suleiman et al. 1999; Bader et al. 2007; Sonderegger and Niemz 2009).

Wood thermal properties is important when simulation and optimization of processes such as air-conditioning in timber buildings, heating of logs, and drying of timbers, veneers, chips, and fibers are attempted (Avramidis and Iliadis 2005). Veneer drying is an important stage in the manufacturing of wood-based panel products such as plywood and laminated veneer lumber (LVL). The veneer drying temperature has an effect on both physical and mechanical properties of plywood (Aydin and Colakoglu 2005).

OBJECTIVE

The main objective of the present research was to determine the effects of veneer drying temperature on thermal conductivity of veneer sheets. For this purpose, veneer sheets obtain from four different wood species and four different veneer drying temperatures were studied.

MATERIAL, METHOD, EQUIPMENT

Alder (*Alnus glutinosa* subsp. *barbata*), scots pine (*Pinus silvestris*), spruce (*Picea orientalis* L.) and tetra (*Tetraberliniana bifoliolata*) veneers having 2mm thickness obtained by rotary cutting at laboratory conditions were used in the study. Scots pine, spruce and tetra logs were steamed for 12h before cutting. On the other hand, fresh alder logs were used in veneer manufacturing without steaming. Rotary cut veneer sheets with 50cm by 50cm dimensions and 2mm thickness were obtained from logs. A rotary type peeler with a maximum horizontal holding capacity of 80cm was used for veneer manufacturing. While the vertical opening was adjusted as 0.5mm, the horizontal opening between knife and nose bar was 85% of the veneer thickness in the rotary peeling process. Veneers were classified into four groups after peeling process and they were dried at 90, 110, 130, and 160^{o}C temperatures. Each veneer sheet was dried to 6–8% moisture content by using a veneer dryer.

The thermal conductivity of the veneer sheets were determined according to ASTM C 518 & ISO 8301 (2004). Sample size required is 300x300x2mm. Two specimens were used for each test group. The Lasercomp Fox-314 Heat Flow Meter shown in Fig. 1 was used for the determination of thermal conductivity. The top and lower layers of it was set for 20°C and 40°C for all specimens, respectively. The veneer temperature during the measurement of the thermal conductivity was maintained to these constant temperatures. In addition to thermal conductivity measurements, the density of veneer sheets were evaluated according to EN 323 (1993) standard.

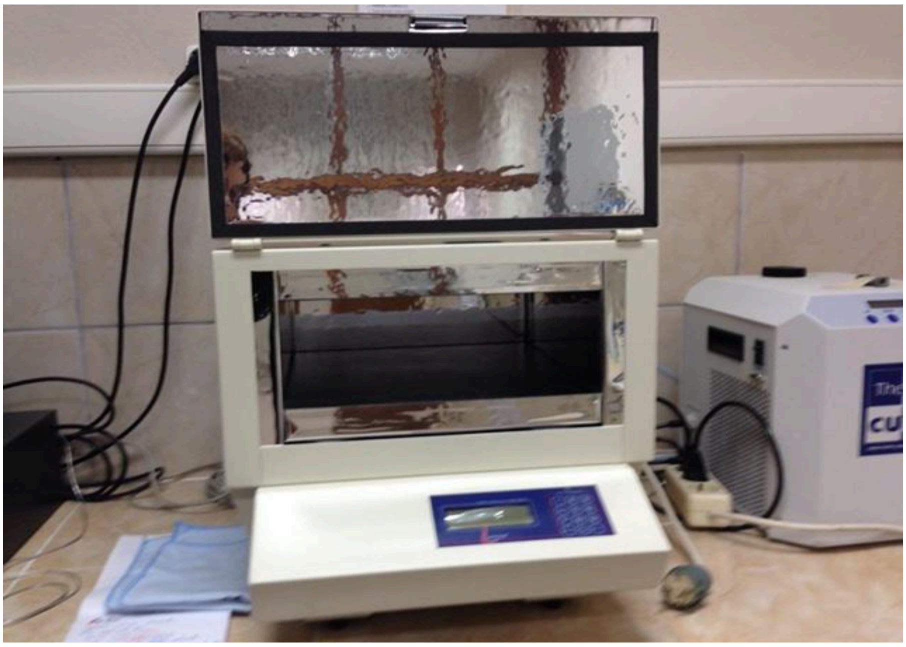

Fig. 1.
Lasercomp Fox-314 heat flow meter

RESULTS AND DISCUSSION

The thermal conductivity mean values of veneer sheets according to the veneer drying temperature were shown in Fig. 2.

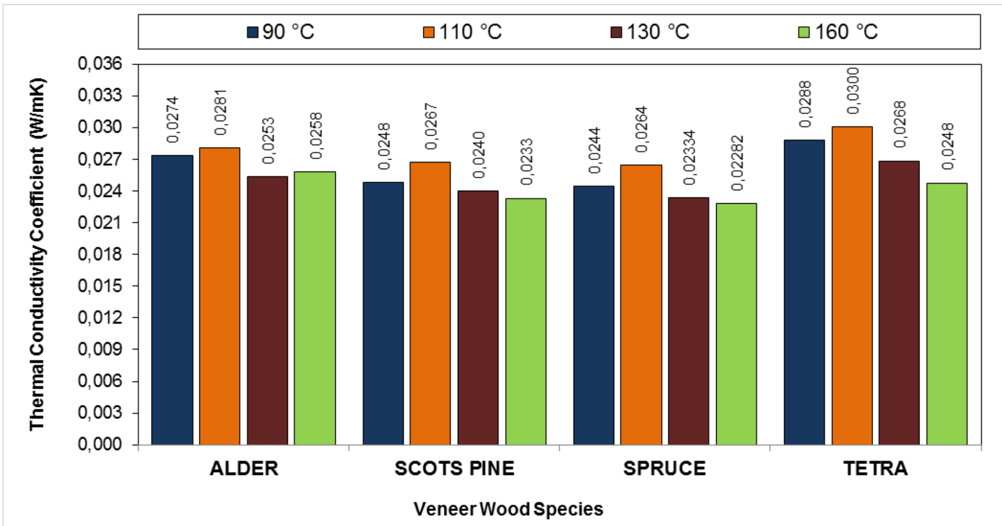

Fig. 2.
Effect of of veneer drying temperature on thermal conductivity of veneer sheets

As can be seen from Fig. 2, the highest thermal conductivity values were obtained for 110°C veneer drying temperature. As the veneer drying temperature incereased from 90°C to 110°C, thermal conductivity values also incereased. However, decreased thermal conductivity values were obtained for 130°C and 160°C when compared to 90°C and 110°C veneer drying temperature. In literature, the effect of the temperature on thermal conductivity of wood varied. Zhou et al. (2013) indicated for the MDF panels that thermal conductivity incereased wth the temperature up to 50°C and then decreased with increasing temperature in the range of 50°C to 100°C. On the other hand, it was stated that thermal conductivity of wood increases as temperature of the wood increases (Counturier et al. 1996; Sahin Kol and Altun 2009). Tenwolde et al. (1988) also reported that the conductivity increased approximately 10 percent for every 50°C increase in temperature. The density of air filling the voids in the wood decreases as temperature increases, and this causes lower heat conduction through the voids (Suleiman et al 1999). This case in literature can explain that thermal conductivity decreased with drying temperature increase above 110°C.

The density of wood ia another important factor affecting thermal conductivity. Therefore, the density values of veneer samples were determined and the results were presented in Table 1.

Table 1

The density values according to the veneer wood species

Veneer Wood Species	**Density (g/cm^3)**
Spruce	0,47
Scots Pine	0,52
Tetra	0,59
Alder	0,60

As can be seen from Fig. 2, the highest thermal conductivity values were determined for the veneer sheets obtained from alder and tetra logs. This can be attributed to higher density values of alder and tetra when compared to spruce and scots pine (Table 1). It was stated that the thermal conductivity of wood-based composites, as for wood, are strongly dependent on density and thermal conductivity of wood increases as density of the wood increases (Kamke and Zylkowski 1989; Kol and Altun 2009).

CONCLUSIONS

It can be concluded from this study that the highest thermal conductivity values were obtained for 110°C drying temperature and the thermal conductivity values decreased with increasing veneer drying temperature above 110°C. The lowest thermal conductivity values were determined for 160°C veneer drying temperature. Among the veneer wood species, the highest thermal conductivity values were measured for the veneer sheets obtained from alder and tetra logs while the lowest thermal conductivity values were obtained from spruce veneers. The veneer sheets obtained from alder and tetra logs gave the highest values in the all groups due to high density of them.

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