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Current and Future Trends of Thermo-Hydro-Mechanical Modification of Wood Opportunities for new markets?

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Softwood strand-boards manufacturing without adhesive using linear friction welding technology

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Linear friction welding process consists basically in the melting and flowing of amorphous wood interconnecting material by friction between wood surfaces induced by mechanical vibrations at high contact pressure. This causes a partial detachment of wood cells and fibers and the formation of an entanglement network drowned in a matrix of melted material which then solidifies, thus forming a wood cell/fiber entanglement network composite with a polymer matrix derived from lignin and hemicellulose able to join solid wood specimens (Gfeller et al. 2003).

The possibility of producing softwood strand-boards without use of adhesives by this technology was investigated. Spruce (*Picea abies*) OSB strands for surface layers were used at relative moisture contents within 5.4 and 12.0%. Welding tests were carried out on a Branson M-DT24L linear vibration welding machine of the AHB-BFH facility.

Different custom-made tools were developed for an efficient transmission of the vibrations from the welding machine to the softwood strands (welding tools). Major problem was the adhesion of the wood strands to the welding tools, which required a strong cleaning effort after each welding cycle. The best solution resulted in an expanded iron grid fixed over an anti-sticking graphite layer. Usage of graphite powders charged lubricants and bakery release paper sheets interposed between the iron grid and the wood strands were also helpful to avoid almost completely wood particles sticking with welding tools.

Manufacturing of softwoods strand-boards within 5.5 and 8.5 mm in thickness and 0.125 m² in surface was performed in two principal steps: friction welding of approximately 300 g of wood strands in thin panels of about 2 mm in thickness (layer welding), and sequential friction welding of four previously produced thin panels to produce the final boards (panel welding).

Identification of suitable vibration amplitude (A), friction pressure and time (FP, FT), welding pressure and time (WP, WT), holding pressure and time (HP, HT) was performed. A clear dependence of the efficacy of the welding cycle from the specific welding tool was highlighted. Resulting WT and HT resulted two times higher than typical values used in welding of solid wood, hinting the need of a strands settling before friction could take place. Final board density was within 700 and 100 kg/m³. IB strength within 0.02 and 0.08 N/mm² and bending MOR within 5 and 8 N/mm² were measured. Even if good compaction of the panel was remarked (Fig. 1), both of these values resulted below the lowest limits suggested for wood panels of general use (DIN EN622-3).

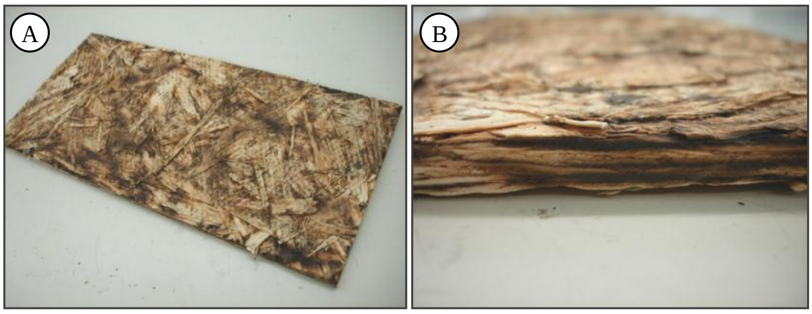

Figure 1. Example of panels produced by linear welding: A) general view, B) edge view

Temperature development during welding with different set of parameters was measured placing three thermocouples in different position the middle layer of the strands panel (Fig. 2). Relevant variations were shown among the data recorded by the three thermocouples during same welding process, most probably due to local significant variations in the actual friction conditions. In general, an initial settling plateau of approximately 4-5 seconds were observed (strands settling), followed by a rapid temperature increase which reached 350 °C for the longer joining times and wider amplitudes. Sharper temperature increase at wider amplitudes was recorded. The results are in good agreement with other published results (Stamm et al. 2005).

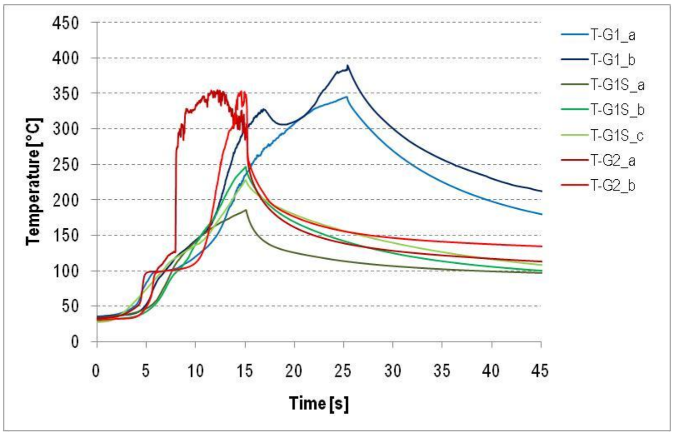

Figure 2. Temperature development inside strand-panel at different welding parameters setting.

A relevant production of vapors and persistence of strong and sour odor up to some weeks from production were noticed. Analysis of VOCs released from a board at 1 month after production showed a total concentration of substance far below the limit recommended in the AgBB guidelines, but evidenced high concentration of furfural, suspect carcinogenic and recognized as a product of the thermal-degradation of hemicellulose in acid conditions (Gfeller et al. 2003). This concentration was high enough to increase the global risk factor R for the individual substances evaluation over the AgBB threshold limit.

The studied technology still represents an interesting alternative to standard glue bonded hot-pressing technology, but is affected by strong limitations like the high amount of volatiles derived from the thermal degradation of wood, and the maximum reachable mechanical properties lower than the existing standards.

References

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DIN EN622-3: *Requirements for general purpose high density mediumboards for use in dry conditions*