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Edge and face linear vibration welding of wood panels

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Subject Edge-to-edge linear vibration welding of particleboard, OSB, MDF and plywood gives better strength than face-to-face panel welding. In general, the edge-to-edge weldline is slightly weaker than the panels itself. The face-to-face weldline is stronger than the strength of the material in the same direction.

1 Introduction

Mechanically-induced vibration welding of wood without any adhesives has been shown to yield wood joints satisfying the relevant requirements for structural application. The reasons for this behaviour are explained elsewhere (Gfeller et al. 2003, Leban et al. 2004). As for solid wood, mechanical welding of wood panels of different kinds should in theory be possible, although this has never been tried before. This paper deals with linear vibration welding of different kinds of wood panels directly to each other as well as with their performance. The two different cases of edge-to-edge and of face-to-face panel welding are applied to four different types of panels, namely particleboard, OSB, MDF and plywood.

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2 Materials and methods

A total of 10 specimens in each case composed of two pieces of 4 different kinds of wood panels, preconditioned at 12% moisture content, namely OSB 18 mm thick, MDF 19 mm thick, particleboard 19 mm thick, and 9 plies beech plywood 18 mm thick, and 9 plies okoumé plywood (1-3-2-3-1-3-2-3-1 mm veneers composition) 19 mm thick, each with dimensions of 150 mm × 20 mm× panel thickness, were welded together according to techniques already described by Gfeller et al. (2003) to form a bonded joint by linear welding, namely a linear vibrational movement of one wood panel surface or edge against another at a frequency of 100 Hz to form edge-to-edge and face-to-face joints. The amplitude of the shift imparted to one surface relative to the other during vibrational welding was 3 mm. When the fusion and bonding were achieved, the vibration process was stopped. The clamping pressure was then briefly maintained until solidification of the bond. The optimized conditions of welding are shown in Table 1. The welded samples were maintained at 12% moisture content for 1 day before being tested according to the European Norm EN 205-D1 (1992). Edge to edge longer specimens, the maximum the welding equipment available could handle, were also welded. They consisted of welding specimens with the dimensions of 600 mm × 80 mm× panel thickness. Panel to panel, panel to solid beech wood and beech wood to beech wood as a control were welded in this manner.

Samples of each case were tested by X-ray microdensitometry. The equipment used consisted of an X-ray tube producing “soft rays” (low energy level) with long wave characteristics emitted through a beryllium window. The conditions used for analysis were identical to those already reported for similar types of experiments (Leban et al. 2004).

Table 1 Linear welding parameters used for the different cases. The after welding holding time was always 5 seconds
Tabelle 1 In dieser Studie verwendete Schweißparameter. Die Nachhaltezeit betrug jeweils 5 Sekunden

Panel type	Welding time (s)	Welding & Holding pressure (MPa)	Shear Strength of welding (MPa)	Shear Strength of material (MPa)
Particleboard, faces	7	1.5	1.81 + 0.12	0.55
Particleboard, edges	5	1.16	2.80 + 0.20	3.05
OSB, faces	5.5	1.33	2.34 + 0.83	1.21
OSB, edges	5.5	1.22	3.09 + 0.56	3.55
MDF, faces	10	1.5	3.84 + 0.89	1.64
MDF, edges	8	1.4	4.29 + 1.58	5.75
Plywood, beech, faces	3	1.33	7.22 + 1.19	5.41
Plywood, beech, edges	3.5	1.48	6.21 + 0.82	10.76
Plywood, okoumé, faces	3	1.33	2.09 + 1.17	5.15
Plywood, okoumé, edges	3	1.33	4.36 + 0.64	6.24

3 Results and discussion

The trend for linear vibration welding of different types of panels shows that edge to edge welding gives most often higher or even much higher shear strength values of the weldline than face welding, apart from beech plywood. Notwithstanding this, the inherently high variability of the results obtained, as shown in Table 1, indicates that only in the case of particleboard and okoumé plywood the difference appears to be significant, the rest having to be considered as just a trend. An equally clear trend can be established by comparing the shear strength of the welded pieces with the shear strength inherent to the material used. In the case of edge welding the welded samples strength is in general only slightly below the shear strength inherent to the material. The standard deviation of the welded pieces indicates that for particleboard, OSB and MDF panels, in edge welding no real significant difference between welded strength and the inherent strength of the material might exist in reality. This is not the case with plywood, where in both cases the inherent strength of the material is sensibly higher than that of the welded joint. With the exception of okoumé plywood, due to the inherent weakness of okoumé decorative veneers, the face-to-face weld joints are stronger than the strength of the constituent materials.

As can be seen by the welding times used in Table 1 all the panels tested are relatively easy to weld with the exception of MDF. MDF panels weld well but need a longer welding time (Table 1) and show high variability of results. Both the need for longer welding times of MDF panels and the greater spread of results may be partly due to its relatively higher density than that of other panels. Its high density decreases its friction coefficient, thus delaying the increase of the interface temperature to welding temperature and hence delaying the onset of welding.

One point that has not been addressed in this preliminary study is the influence of the present hardened adhesive bonding of the panels might have on welding. In short, would the hardened adhesive degrade and recompose to contribute to the strength of the weld joint or not? At this stage it is not possible to ascertain this, but with the extremely short welding times used one would not expect this contribution to be determinant, if at all existent.

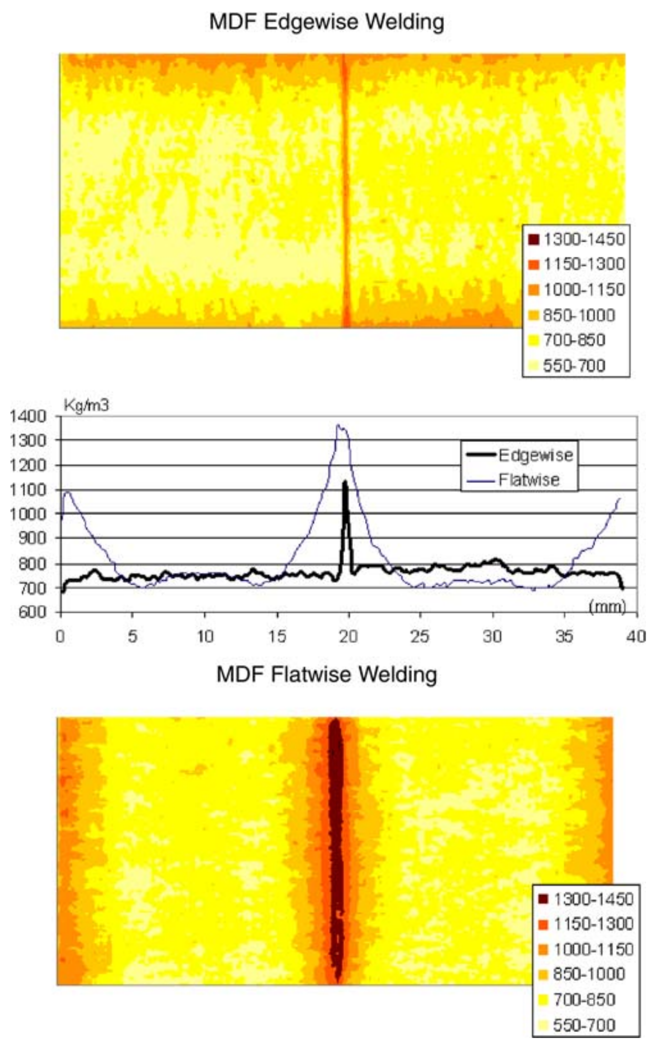

Fig. 1 X-ray microdensitometry map of edge-to-edge (*upper figure*) welded and face-to-face welded (*lower figure*) MDF panels
Abb. 1 Mit Röntgenverfahren ermitteltes Rohdichteprofil von verschweißten MDF-Prüfkörpern. *Oberes Bild*: Schmalflächen verschweißt. *Unteres Bild*: Deckschicht verschweißt

X-ray microdensitometry analysis of the welded joints also showed some interesting features and explained some of the trends observed. In all panels such as particleboard, OSB and MDF (MDF is the example of density profile in Fig. 1) the weldline was sharp, much narrower and of higher density in the case of edge-to-edge welding of particleboard and OSB. In contrast, for face-to-face welding the weldline was always wider, the interface was deeper, with an increase in density more gradually toward the highest weld density, and only in the case of MDF (different to OSB and particleboard) with a higher maximum density peak. This inverse trend of the maximum density peak of MDF panels might be due to the use of more drastic welding conditions which had to be used for this material due to its much higher density. Edgewise welding of plywood also gives a narrow well defined density peak as for all other panels. In the case of plywood face-to-face welding shows a weldline of comparable density of the adjacent adhesive-bonded interfaces for beech plywood and of lower density than the gluelines for okoumé plywood.

In conclusion, panel products such as particleboard, OSB, plywood and MDF panels can be welded to have good bonding strength by linear vibration mechanical welding. Edge-to-edge panel welding gives better strength results than face-to-face welding. In general the strength of the edge-to-edge weldline is only slightly lower than the mechanical strength inherent to the panels themselves while the reason for the trend to face-to-face welding lies in the weldline strength which is stronger than the strength of the material when tested in the same direction.

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