Exterior OSB preparation technology at high moisture content – Part 1: Transfer mechanisms and pressing parameters

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In the case of panels bonded with adhesives capable to tolerate high to very high percentages M.C. (20%–24% MC) of the mat during pressing, the highest OSB core layer temperature will be reached at longer press closing times. This will result in better plasticization of the core layer. The press temperature will influence the steam front transfer time to the core layer. Furthermore, contrary to the traditional lower moisture content bonding, it was possible to deduce the existence of capillary water and that such a residual liquid water can contribute to heat transfer during hot pressing. Increasing the press temperature will cause the maximum steam pressure peak to appear earlier, but this does not result in a higher core temperature. For long press closing times the initial mat percentage moisture content has a positive effect on the heating rate, but it also leads to high steam pressure in the core layer. These conclusions are valid for both laboratory and industrial boards, with the latter providing much faster heating rates and higher values of temperature and steam pressure. Press closing time, mat permeability and strength development during densification were also found to be determining parameters as regards board densification and consequently as regards boards mechanical performance in the case of panels bonded with adhesives, such as procyanidin-type tannin adhesives, capable to tolerate high to very high percentages M.C. of the mat. Directional mat permeability in relation to steam movement was found to be the cause for the different characteristics of board edges in relation to board centre, and a theory for quantification of the edge effect was advanced. The results also underlined one of the essential characteristics of adhesives capable of bonding at higher moisture content, namely their capacity of developing more quickly a hardened network resistant to dissolving in water.

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1 Introduction

The wood panels industry is in need of new technologies to overcome the problems associated with conventional pressing methods, such as high wood dryer temperatures, lack of tolerance by dense wood species and dimensional stability problems of the panel after manufacture. For example, when wood-based composites are hot-pressed under conditions of high temperature and low moisture content, compressive stresses are imparted to the individual wood cells resulting in damaged wood cell walls and strength losses (Geimer et al 1985; Jahan-Latibari 1982; Price 1976). The subsequent moisture release of these re-
sidual stresses, associated with microfractures of the cell walls, will lead to excessive thickness swelling of the finished board.

As regards the use in panels of high density woods, a greater compressive pressure is required to attain a similar degree of interparticle contact when using high density species (Hse 1975; Van Niekerk and Pizzi 1987). The consequence of this is an increase in thickness swelling (Hse 1975).

Palardy et al. (1989, 1991) have for instance demonstrated that it is possible to reduce structural/damage and residual/stress in wood at higher moisture contents and lower temperature when using a diphenylmethane diisocyanate adhesive. But pressing at higher moisture content is never an easy task, as independently of steam pressure, side problems associated with excessive adhesive migration from the glue-line and retardation of resin hardening occur (Myers et al. 1991, Hse et al. 1994).

There is then a real need to develop a new generation of wood adhesives capable to overcome overpenetration problems, able to harden in presence of water (hence at moisture contents of the resinated wood particles higher than 20%) and able to withstand the high steam pressure developing during hot pressing, the whole at pressing times fast enough to be industrially significant. In short, there is the need for developing a class of high moisture tolerant adhesives. To date only two classes of moisture tolerant adhesives exist, namely the mixes and copolymers of diisocyanates, such as MDI with traditional, synthetic formaldehyde-based adhesives (UF, MF, MUF, PF) (Pizzi 1994, Pizzi and Walton 1992, Pizzi et al. 1993), with the other being the most widespread example of this class, namely tannin-based adhesives, which are well known to work well at higher moisture content in particleboard, and which are used under such conditions in daily industrial practice (Pizzi 1983, 1994).

Pressing at high moisture content also implies getting a better knowledge of the main physical processes involved during wood panels hot pressing. While temperature and steam pressure in the board can be predicted by mathematical models in the 10% to 15% moisture content range (Bolton et al. 1989a, b, Humphrey and Bolton 1989a) neither experimental data nor mathematical models are available for moisture contents of 20% or higher.

This paper then concentrates on the study of the phenomena which occur in oriented strand board (OSB) panels during pressing at high and very high moisture contents and on the development of a new pressing technology designed for the use of high moisture tolerant adhesives in OSB. The reasons why OSB have in particular been chosen for this study are multifold, namely

(i) as pressing technology at high moisture content mainly relies on the optimal use of rheological properties, strands being less pliable than particles or fibres, they constitute the most apt and extreme material to follow the impact of high M.C. on wood pliability and the action of temperature and water as plasticizers.

(ii) as wood pliability increases at higher M.C. this would allow the reduction of the press specific pressure (iii) pressing at higher M.C. would make it possible to reduce board thickness swelling (Palardy et al. 1989, 1991) and improve the dimensional stability of the panel as well as decrease the water absorption sensitivity of phenolic adhesives in OSB panels.

2 Experimental

The adhesive formulation used throughout the study is based on a water solution of a procyanidin tannin extract, namely the commercial tannin extract of Pinus radiata bark, ex Chile, to which 5% paraformaldehyde powder + 5% urea (as a 40% water solution) are added by weight on dry extract as hardener and additive (Pizzi 1994, Pizzi et al. 1994). The adhesive is applied to the wood strands at a load of 12% tannin extract solids on dry wood.

Industrial core and surface layer strands of Pinus maritimus supplied by Isorex (France) were used for both laboratory and industrial trials. The OSB panels were always composed of a weight proportion of the core: surface materials = 50:50. The strands had an initial average moisture content of 7% for the laboratory trials and of 2% in the case of the plant trials. The laboratory OSB panels were of dimensions 500 × 500 × 12 mm for a target density of 700 kg/m³, while the industrial boards had dimensions 2440 × 1220 × 12 mm and had the same target density. The laboratory boards were all made in triplicate and the industrial boards in duplicate for each case. In the case of the industrial boards the resinated strands were conveyed to a Siempelkamp surface layer forming machine, so that the strands in the final board were only oriented in the longitudinal direction. During pressing temperature in the core layer, at the board surface and the press pressure, as well as steam pressure in the board (the gas-pressure probe consisted of a 500 mm length of stainless steel tubing of 1 mm outer and 0.5 mm inner diameter connected to a pressure transducer) were monitored continuously and the specific pressure calculated (Pichelin 1999). The thermocouples were located in the centre of the panel core at 2.5 cm, 5.0 cm, 7.5 cm , 10 cm and 25 cm (hence in the board centre) for laboratory boards, and at 2.5 cm, 5.0 cm, 7.5 cm, 10 cm, 20 cm, 50 cm and 122 cm lengthwise from the board edge in industrial panels. The average conditions used are shown in Table 1. The OSB panels produced were tested according to European Norm EN 300 (1997) for class 4 OSB. The moisture content was always determined according to European Norm EN 322 (1990). The density of each panel and sample was determined according to European Norm EN 323 (1990), while the density profile as a function of board thickness was determined by gamma ray equipment (type LB386–1C): the resulting density profile was smoothed slightly by means of appropriate software (Schönfeld 1998).

3 Discussion

The temperature profile, namely the increase in board temperature as a function of the time after press closure can be divided into five periods (Bolton et al. 1989a) where an