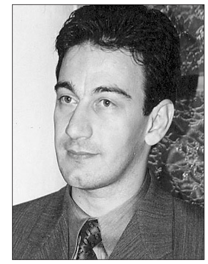
38th International Wood
Composites Symposium

A New Process for Recycling Waste Fiberboards



Mantanis

George Mantanis
Dept. of Wood & Furniture Technology, TEI Larissa
Karditsa, Greece

Eleftheria Athanassiadou
Chimar Hellas S.A.
Thessaloniki, Greece

Panagiotis Nakos
Chimar Hellas S.A.
Thessaloniki, Greece

Aires Coutinho
Valbopan Fibras de Madeira S.A.
Famalicao, Portugal

Abstract

Research efforts enabled the development of a new process for the recycling of end-use wood panels into new marketable fiberboards. This patent-pending process is based on refiner techniques and allows the use of mixtures of fresh wood and waste panel chips as a raw material for dry-process fiberboard production. The process is applicable in existing fiberboard plants with only minor operation modifications. At the refining stage, chemical agents are employed and the process enables the use of significant amounts of waste material replacing over 20 percent of the wood feed and providing significant savings. The aim of the present work was to validate the industrial applicability of the new process in the recycling of waste fiberboards. The new fiberboards obtained during the industrial-scale trials were of acceptable quality. Testing results revealed that under conventional gluing and pressing conditions, the process effectively recycles the waste boards at a wood substitution level of at least 25 percent. Further validation and optimization work is presently underway in the direction of using other waste panel types and also increasing the level of waste in the feed material.

Introduction

The wood panel industry is mainly a worldwide creation of the past century. The pace of development has been rapid and continued high development is expected for this century. Technological breakthroughs with new processing machines, quality control devices, higher quality adhesives, and use of lignocellulosic materials other than wood as a raw material will possibly play an important role in the future of this industry.

In Europe, particleboard and medium density fiberboard (MDF) became the backbone of the furniture industry and displaced, to a very high extent, solid wood. Therefore, it was logical that the development of the furniture industry has been dramatically influenced by that of the fiber- and particleboard industry.

Pieces of furniture have a life span of 30 to 40 years in Europe. According to environmental regulations in certain European countries (e.g., Germany), deploying used furniture to landfills will be forbidden by the beginning of 2005. Because the interaction between organic materials and the environment is of a very complex nature, leached chemicals may influence the groundwater. Moreover, biological degradation leads to the formation of methane, which contributes to the Greenhouse Effect about 80 times more than carbon dioxide. **Figure 1** summarizes the reasons against deploying organic waste materials to landfills.

Due to the reasons mentioned, increasing attention has been given to the issue of recycling in the fiber- and particleboard industry. Many methods have been developed for the recycling of wood panels and wood-derived products (Moeller 1992, Roffael and Dix 1994, Roffael 1997, Paladin 1998, Michanickl and Boehme 1998, Olofsson 1999, Boehme and Wittke 2002, Roffael et al. 2002, Riddiough 2002, Kirchner and Kharazipour 2002). These methods are based on the mechanical or hydrothermal treatment of the wastes or their combination to recover wood elements mostly suitable for the production of particleboard. They also require special equipment for the treatment of waste, which in most cases is of high cost and unconventional to standard board manufacturing processes. Notably, a few of the referred methods are presently used at the industrial-scale level with satisfactory results (Michanickl and Boehme 1998, Paladin 1998, Olofsson 1999).

However, in the MDF industry today, it appears that only limited amounts of waste fiberboard can be re-used in the production (approximately 2% to 3%), without a drop in the press speed (Roffael et al. 2002).

Conventionally increasing costs of landfilling due to reduced landfill capacity.

1. *Legislative measures prohibiting the dumping of organic matter.*
2. *Generation of methane and carbon dioxide in dumps, which can be considered as anaerobic reactors. Methane contributes to the Greenhouse Effect 80 times more than carbon dioxide (1 ton CH_4 equivalent to 88 ton CO_2 in global warming of the atmosphere).*

Polluted leaching water from dumps may penetrate in the Earth's crust and contaminate surface and underground water.

3. *In the dumps, energy content of wood and wood-based panels is wasted, and no utilization is made out of the organic biomass.*

Figure 1.—Reasons against deploying organic materials in landfills.

It is apparent there is a need for a new process that could efficiently recycle waste-wood materials at high levels to produce new MDF. This, eventually, would allow significant savings in raw materials for an MDF mill, apart from the environmental benefits.

Purpose of Work

The purpose of this work was to scale-up a new process, which is patent protected (Nakos et al. 2001), that would enable substitution of fresh wood feed with waste-wood materials at high levels (>20%) without a reduction in the MDF plant productivity. This paper presents the preliminary results obtained from the industrial trials performed using this new process. The industrial trials were carried out at the Valbopan Fibras de Madeira SA MDF mill in Famalicao, Portugal.

Industrial Trials

Pine wood free of bark was used in the trials. Waste boards consisted of fiberboard production residues of four different grades:

a) standard MDF,
b) moisture-resistant MDF,
c) color-impregnated MDF, and
d) hardboard.

A brief description of the trials is given below.

Hammermilling and Mixing

The waste boards were first hammermilled in a conventional way. In the wood yard, chips of fresh wood and waste boards were mixed at a 3:1 ratio (on a volume basis) by a bulldozer.

Screening and Washing

Metal items were removed using a metal detector (magnet). All materials were passed through a screener, where part of the dust was removed. Then they were soaked in water and washed.

Digesting, refining and gluing

The overall digestion time was kept constant at ca. 3-1/2 minutes. The refining conditions were the same as the typical ones used in MDF mills. The pressure used was 8.2 bar. Average fiber throughput was ca. 5.0 ton/hour. A urea-formaldehyde (UF) resin of E2 type was applied in the blowline. The resin hardener was ammonium sulphate (0.85% w/w on dry resin), while the resin addition level was kept constant at 10 percent w/w (on dry fiber). A crosslinking agent (*additive A*) was added in the glue mix (at levels 0%, 5%, and 10% w/w). A wax emulsion was added at 1 percent w/w level based on dry fiber. Another key chemical agent (*additive B*) was added in the system allowing the efficient processing of both fresh wood and waste-board materials. The dosing of this agent was constant at the level of 1 percent w/w on wood fiber (on a dry/dry basis).

Drying and Pressing

Drying was done conventionally with a tube (flash) dryer; the dryer temperatures at both the dryer entrance and exit were rather low. The fiber exited the dryer with a moisture content of 8.0 to 8.5 percent. The press time in the two single-opening presses was 16 sec./mm. Boards of 16 mm (0.63 in.) thickness were produced. Random samples of MDF boards produced during the trials were evaluated for density, mechanical properties (internal bond (IB) and modulus of rupture (MOR)), and 24-hour swelling. Board testing was done in the lab facilities of Chimar Hellas S.A. (former Adhesives Research Institute Ltd.) in order to evaluate the efficiency of the new technology and board performance under different conditions.

Table 1.—Experimental plan of the industrial trials performed.

Run	Raw materials	Additive A	Additive B
	(wood : waste, v/v)	- - - - - - - (%)	- - - - - - -
0	100 : 0	0	0
1	75 : 25	0	1
2	75 : 25	5	1
3	75 : 25	10	1

The experimental plan of the industrial trials is shown in **Table 1**.

Results and Discussion

Table 2 presents the results from the testing of the MDF boards produced in the industrial trials. The IB strength of the control boards was high at 1.02 N/mm^2 (148 psi). With the use of 25 percent waste boards, the IB dropped significantly to 0.60 N/mm^2 (87.1 psi) in run 1. However, at the subsequent runs (runs 2 and 3), when additive A was introduced, the IB improved dramatically (104.5 psi and 142.2 psi, respectively). When additive A was used at a 10-percent level, this property almost completely recovered. Quite similar behavior was observed with the MOR values. Surprisingly, the swell properties also improved when waste boards were used as feedstock. Finally, the boards from the runs 2 and 3 gave significantly better swelling values (7.2% and 7.0%, respectively).

Overall, it can be observed that even at the 25 percent substitution level of wood and without a change in the press cycle and productivity, the new process resulted in 'recycled' MDF boards with properties which far exceed the European standards. It should also be mentioned that the formaldehyde emission of the MDF decreased with the addition of the waste. The boards fit in the E2 formaldehyde emission class (Perforator class, EN 120), since an E2 type UF resin was applied.

Summary and Conclusions

The results obtained from the industrial trials were very promising in the sense that it was possible, for the first time, to recycle in an efficient way high

Table 2.—Properties of industrial MDF produced by recycling.

Run	Density	IB	MOR	24-hr. swell	Perforator class
	(kg/m^3 (pcf))	------- (N/mm^2 (psi)) -------		(%)	(EN 120)
0	755 (47.09)	1.02 (148.0)	36.5 (5,293)	8.0	E2
1	747 (46.59)	0.60 (87.1)	32.4 (4,699)	8.2	E2
2	752 (46.90)	0.72 (104.5)	36.0 (5,221)	7.2	E2
3	745 (46.46)	0.98 (142.2)	37.8 (5,482)	7.0	E2

amounts of waste fiberboards originating from the plant's own production, without any deterioration in physical properties, and without any loss in the mill productivity.

In conclusion, the new process appears to be well operational in MDF mills employing single-opening presses for E2 class MDF products without any technical risk.

Nonetheless, it should be stressed that the results presented have come at the completion of the optimization phase of the new process. Presently, the emphasis is being shifted toward the implementation and adaptation of the process in modern MDF plants employing E1 resin systems and continuous press technology. Preliminary results have been very encouraging in that respect. Notably, another main target is to use as starting materials, not only waste plain fiberboards, but also laminated and/or veneered MDF or particleboards.

Acknowledgments

The technical assistance of Mrs. Alexandra Gouveia, production manager of Valbopan S.A. is greatly appreciated. Professor G. Mantanis greatly appreciates the assistance of Professor E. Roffael of the University of Göttingen in presenting this work at the 2004 WSU Symposium.

References Cited

Boehme, C. and B. Wittke. 2002. Erfahrungen der Industrie mit dem WKI-Verfahren zum Recycling von Holzwerkstoffen. *In*: Proc. of the 2nd Conference on Environmental Protection in the Wood Industry (Umweltschutz in der Holzwerkstoffindustrie), pp. 44-49. University of Göttingen. Göttingen, Germany.

Kirchner, R. and A. Kharazipour. 2002. Recycling von Holzwerkstoffen durch das Verfahren der thermohydrolytischen Spaltung – Die kontinuierliche Prozesstechnologie. *In*: Proc. of the 2nd Conference on Environmental Protection in the Wood Industry (Umweltschutz in der Holzwerkstoffindustrie), pp. 72-81. University of Göttingen. Göttingen, Germany.

Michanickl, A. and C. Boehme. 1998. Process for recovering chips and fibers from residues of timber-derived materials, old pieces of furniture, production residues, waste and other timber containing materials. U.S. patent 5,804,035.

Moeller, A. 1992. Ebenes oder gekruemmtes Halbzeug oder Fertigprodukt aus Holzwerkstoff fuer die Anwendung im Moebel oder Innenausbau, in der Verpackungsmittelherstellung, in der Holzwarenherstellung oder im Hochbau mit einer Wanddicke zwischen 2 mm und 1000 mm und Verfahren zu seiner Herstellung. German Patent DE 4201201.

Nakos, P., E. Athanassiadou, and A. Coutinho. 2001. Production of high added value products from wastes. International patent application WO 01/39946.

Olofsson, T. 1999. Refining technology for low grade materials including urban wood waste. *In*: Proc. of the 3rd European Panel Products Symposium. pp. 155-163. BioComposites Centre. Llandudno, Wales, United Kingdom.

Paladin, R. 1998. Roller device to separate chips and particles of different gradings, and the relative forming machine employing the device. World patent WO 98/40173.

Riddiough, S. 2002. Wood panel recycling: An introduction to the fibersolve process. *In*: Proc. of the 6th European Panel Products Symposium. pp. 159-166. BioComposites Centre. Llandudno, Wales, United Kingdom.

Roffael, E. and B. Dix. 1994. Waste liquor derived from chemical thermal pulping of particleboards and fiberboards containing bonding agents. U.S. Patent 5,705,542.

Roffael, E. 1997. Stoffliche Verwertung von Holzwerkstoffen. Adhäsion 41: 24-27.

Roffael, E., E. Athanassiadou, and G. Mantanis. 2002. Recycling of particle- and fiber- boards using the extruder technique. *In*: Proc. of the 2nd Conference on Environmental Protection in the Wood Industry (Umweltschutz in der Holzwerkstoffindustrie). pp. 56-65. University of Göttingen, Göttingen, Germany.