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A NEW RECYCLING PROCESS FOR WASTE PANELS

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ABSTRACT

At the end of their service life, wood-based panels become eventually waste wood. Deploying in landfills is no longer considered as an acceptable solution for their handling due to the high organic load included. The recycling of this waste to be employed as raw material for the wood panel industry, which traditionally makes use of wood processing residues, has hence gained more importance and been examined from earlier times. Technical problems and the lack of enforcing legislative regulations have delayed, however, the industrial implementation of the new technologies proposed. Recent research efforts enabled the development of a new process for the recycling of end-use wood panels into new marketable fibreboards. This patent pending process is based on the refiner technique and allows the use of mixtures of fresh wood and waste panel chips as a raw material for dry-process fibreboard production. The process is applicable in existing fibreboard plants with only minor operation modifications and therefore, there is no need of major capital investment in additional equipment to effect the recycling. At the refining stage, chemical agents are employed and the process enables the use of significant amounts of waste material replacing over 20% 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 medium-density fibreboards. The new fibreboards obtained during the industrial scale tests were of acceptable quality, and the testing results revealed that under conventional gluing and pressing conditions, the process effectively recycles the wa-

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ste boards into new ones at least at 25% wood substitution level. Further validation and optimisation work is underway in the direction of using other waste panel types and also increasing the level of waste in the feed material.

INTRODUCTION

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

In Europe, particleboards and medium density fibreboards (MDF) became the backbone of furniture and displaced to a very high extent solid wood from this area. Therefore, it was logical that the development of the furniture industry has been dramatically influenced by that of the fibre- 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 of used furniture on landfills will be forbidden by the beginning of 2005, as the interaction between organic materials and the environment is of a very complex nature. Leached chemicals may influence the groundwater, and moreover, biological degradation leads to the formation of methane, which contributes to the Green-House-Effect about 80 times more than carbon dioxide. Figure 1 summarises the reasons against dumping of organic waste materials.

1. Conventionally increasing costs of landfilling due to reduced landfill capacity
2. Legislative measures prohibiting the dumping of organic matter.
3. Generation of methane and carbon dioxide in dumps, which can be considered as anaerobic reactors. Methane contributes to the green house effect eighty times more than carbon dioxide (1t CH4 equivalent to 88t CO_2 in global warming of the atmosphere).
4. Polluted leaching water from dumps may penetrate in the earth crust and contaminate surface and underground water.
5. In the dumps energy content of wood and wood-based panels is wasted and no utilization is made of the organic biomass.

Figure 1. Reasons against deploying organic materials on landfills.

Due to the above-mentioned reasons, increasing attention has been given to the issue of recycling in the fibre- and particleboard industry. Many methods have been developed for the recycling of composite wood panels and wood derived products[1-9]. They are based on the mechanical or hydrothermal treatment of the wastes or their combination to recover wood elements mostly suitable for the production of particleboards. They also require special equipment for the treatment of the waste, which in most cases is of high cost and unconventional to standard board manufacturing processes. Also processes have been developed for the recycling of wood wastes and are presently used with satisfactory results[10-11].

However, in the medium-density-fibreboard (MDF) industry today, it appears that technically only limited amounts of waste fibreboard can be re-used in the production (2-3%), without a drop in the press speed. In the market it is apparent the need for a new process that could recycle efficiently waste wood materials at high levels to produce 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 therefore to scale-up an innovative process - which is patent protected[12] - that would enable substitution of fresh wood feed with waste wood materials at high levels (>20%) without a reduction in 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 facilities of the MDF mill VALBOPAN Fibras de Madeira SA, in Portugal.

MATERIALS AND METHODS

Pine wood free of bark was used in the trials. Waste boards consisted of fibreboard production residues of four different grades: (a) standard MDF, (b) moisture resistant MDF, (c) colour impregnated MDF and d) hardboard. A brief description of the trials is given below:

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

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

Digesting/Refining/Gluing: The overall digestion time was kept constant at ca. 3½ min. The refining conditions were the same as the typical ones used in MDF mills. The pressure used was 8.2 bar. Average fibre throughput was ca. 5.0 t/h. 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% w/w (on dry fibre). 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% w/w level based on dry fibre. 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% w/w on wood fibre (on a dry/dry basis).

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

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

Table 1. Experimental plan of the industrial trials performed.

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

RESULTS AND DISCUSSION

Table 2 presents the results from the testing of the properties of the MDF boards produced in the industrial trials. The internal bond (IB) strength of the control boards was high at 1.02 N/mm². With the use of 25% waste boards, the IB dropped significantly down to 0.60 N/mm² (run 1). However, at the subsequent runs (runs 2 & 3) when the additive A was introduced into the system, the IB improved dramatically. When additive A was used at 10% level, this property was almost completely recovered. Quite similar behaviour was observed with the modulus of elasticity (MOR) values of the boards. Surprisingly, the swell properties, apparently, improved also when waste boards were used as feedstock; finally, the boards from the runs 2 and 3 gave significantly better swelling values.

In overall, it can be observed that even at the 25% substitution level of wood - and without a change in the press cycle and productivity – the new process can result in 'recycled' MDF boards with properties which far fulfil 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) since a UF resin of the E2 type was applied).

Table 2. Properties of industrial MDF produced by recycling.

Run	Density kg/m^3	IB N/mm^2	MOR N/mm^2	24h swelling %	Perforator class
0	755	1.02	36.5	8.0	E2
1	747	0.60	32.4	8.2	E2
2	752	0.72	36.0	7.2	E2
3	745	0.98	37.8	7.0	E2

CONCLUSIONS

The results obtained from these trials are very promising in the sense that it was possible, for the first time, to recycle in an efficient way high amounts of waste MDF originating from the plant's own production (or from end users) without a deterioration in physical properties and without any loss in the plant 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 above-mentioned results have come out at the completion of the optimisation phase of the new process. Presently, the emphasis is being shifted towards 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 raw MDF, but also laminated and/or veneered MDF or particleboard (already tested with satisfactory results).

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