MDF wood fibre strength after several recycling cycles

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Context and objectives

Medium Density Fibreboard (MDF) is a *"panel material with a nominal thickness of 1.5mm or greater, manufactured from lignocellulosic fibres with application of heat and/or pressure"* (AFNOR 2009). Approximately 68% of all fibreboard manufactured in Europe is MDF (EPF 2024). Widely used in the furniture and parquet industries, its worldwide production has increased fivefold in 20 years, and now exceeds 100 million tonnes (FAOSTAT 2024). At present, these panels are mainly made from virgin wood, as there is no cost-effective industrial method for recycling them. The European project EcoReFibre aims to propose a profitable process for incorporating up to 25% of recovered fibres into new MDF panels (EcoReFibre consortium 2024). This raises the question: how many times can the same wood fibre be recycled? According to the paper industry, the length and strength of the fibres greatly influence the breaking energy of the paper (Wathén 2006). As MDF is also a wood fibre network, it is therefore interesting to study these two elements throughout the recycling cycles. The objective is to focus on individual wood fibres and to characterise them mechanically after 1 to 6 recycling cycles to understand the impact of the process on fibre quality. A study of fibre morphology is also being carried out in parallel, but is not discussed further in this paper.

Materials and methods

Recycling experiment

To simulate the effect of recycling cycles on wood fibres, a closed-circuit recycling experiment was designed. The aim was to produce laboratory-made MDF panels. Consequently, certain parameters, such as the amount of water added, were altered at the start of each new cycle. Moreover, the disintegration stage was designed to be as soft as possible in order to preserve the integrity of the fibres as much as possible.

Initial panels were made using industrial fibres from Unilin (step 1 in Fig. 1 and 2; they represent the first generation). Urea-formaldehyde (UF) adhesive was chosen as it is the glue most commonly used on the market (Mantanis et al 2017). The panels were then cut for bending tests (step 2, inspired by EN 310 standard). The tested pieces and panel offcuts were recycled by immersing them in water at 95 °C for about 6 hours and then passed through a hammer mill without a size screen (step 3). Then the fibres were dried in a climatic chamber at 70 °C with a humidity of 25% (step 4), which should result in a moisture content of 4 %. Once dry, the fibres were used to make a new MDF. Only fibres from the previous cycle were used, no virgin fibres were added to the board. In total, 6 recycling cycles have been carried out.

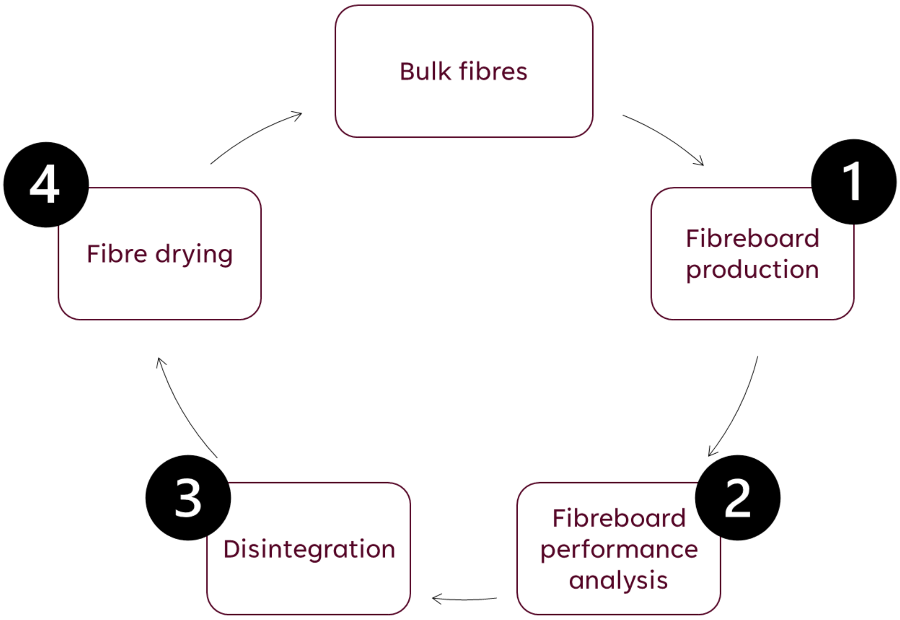

Fig. 1: Simplified diagram of the recycling experiment (4 steps)

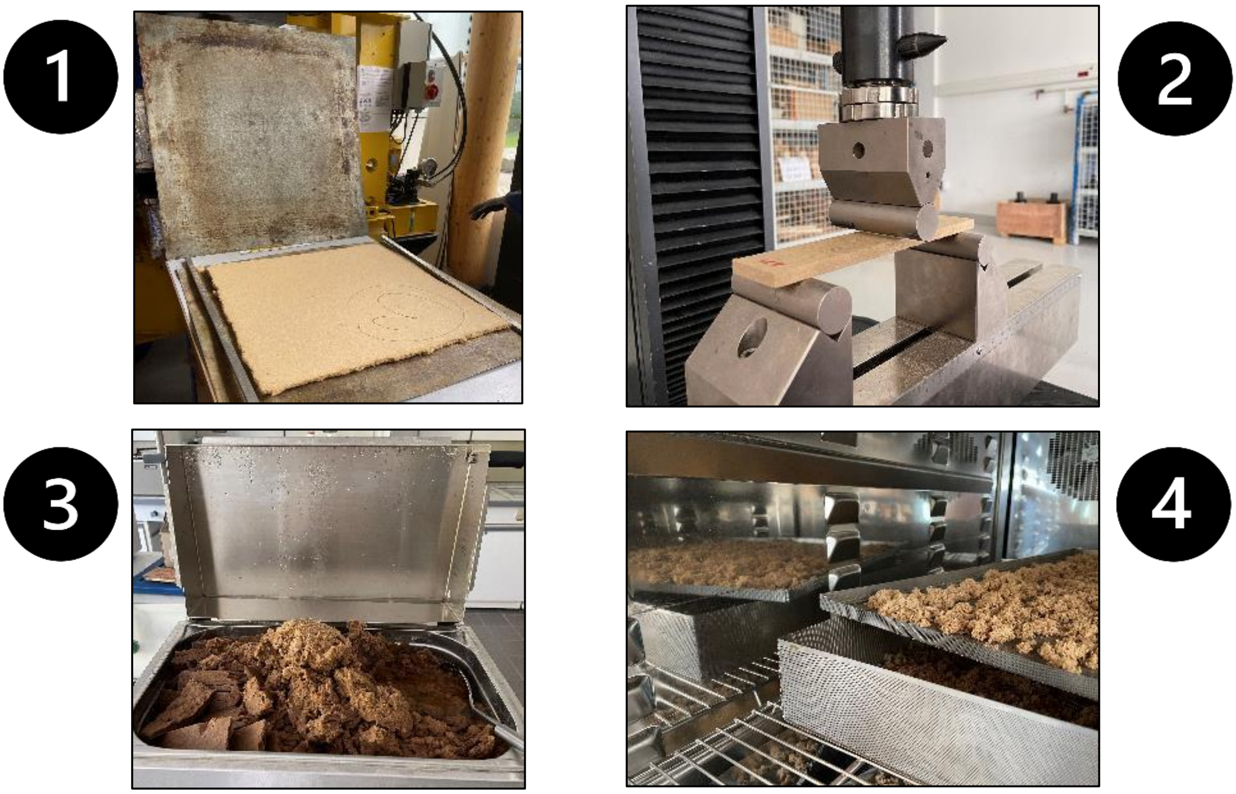

Fig. 2: Images showing the 4 stages of the experiment

Mechanical fibre characterisation

Before making each new generation of panels, fibre samples are taken in order to characterise them. As the fibres were recycled 6 times, 7 samples were collected. All samples were sieved and the fraction smaller than 1 mm, which should contain largely single fibres, was tested.

As testing single fibres was time-consuming and it is difficult to draw conclusions from a small number of tests, a standard paper industry test was also used to determine fibre strength. Handsheets were made following an adapted TAPPI method, with the fibres from each recycling experiment. The tensile strength of the handsheets was measured using a zero-span test (ISO 15361 2000). The strength measured is then only due to the fibres held between the two jaws: this test gives directly the fibre strength.

Sheets containing 100% recovered fibres were too fragile so it was decided to add 15% eucalyptus fibre to strengthen the sheets (Fig. 3). A batch containing 100% eucalyptus fibre has been also added. An average of 11 handsheets from each recycle were formed.

Fig. 3: Example of a 20 cm diameter handsheet containing 85% of recovered fibres and 15% of eucalyptus fibres

Two rectangular samples measuring 2.54 x 10 cm are cut from each sheet, weighed to determine their precise grammage (Eperen 1996) and are tested on the zero-span test machine (Fig. 4).

Fig. 4: Zero-span machine used for tensile tests, left: zoom of jaws containing a sample, right: samples after the test

Results

A poster will include the first results of this study.

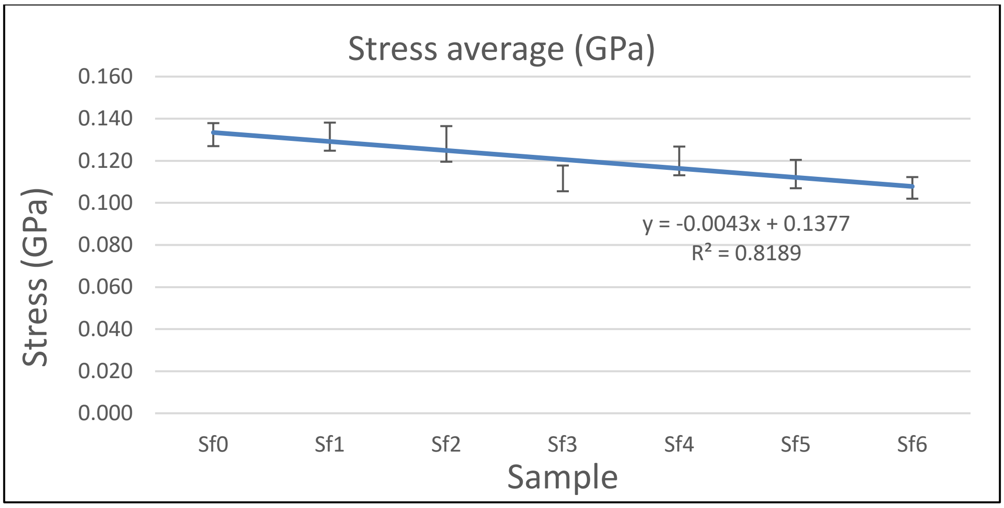

Fig. 1: Average stress for each set of handsheets

"Sf0" refers to sheets made from the first fibres (which have not yet been recycled). "Sf6" represents sheets made from fibres that have been recycled 6 times. The zero span results show very little variation. A linear relationship can be demonstrated between the samples and the recorded stress. A loss of less than 20% is observed between the initial fibres and those that have gone through 6 recycling cycles.

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