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Abstract

A hybrid composite based on flax/PLA fibers has been manufactured using a non-woven textile produced by CETI by the dry layup technique. The compression moulding technique was adapted to manufacture a complex-shaped demonstrator. During the draping step, the preform exhibited no draping defects. The addition of PLA films was challenging owing to the complex mold shape. The final composite part had no visible defects, however and was easy to demould. This demonstrator proves that these flax/PLA non-woven fabrics can be used in industrial production of composites.

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1 Introduction

Compression molding (CM) is a well-adapted manufacturing technique for plastic and composite products in many industrial sectors owing to its high volume production rate. The advantage of this process is that it requires a shorter preparation time and can be mostly automatized to ensure the same processing conditions for every part produced using CM. CM calls for high equipment costs in terms of heating systems and molds, however, and the part size is also limited to 1 m. Thus, this process is mostly used for manufacturing small parts with complex shapes. The process should be optimized by adjusting several parameters, such as mold closing speed, consolidation pressure, and mold temperature, for each new material, to obtain a high quality of final products and avoid manufacturing defects. In the case of flax/PLA/coPLA composites, not only the difference of the melting temperature between the reinforcing PLA and the coPLA matrix, but also the difference between the temperature of the thermal degradation of flax fibers and the melting temperature of coPLA matrix, play an important role in the selection of mold temperature.

In the current project, SEABIOCOMP, three kinds of flax/PLA/coPLA non-woven fabrics with different flax fiber volume fraction, i.e. 40%, 50% and 60% (see Figure 1) were developed by CETI, France. In Figure 1, we can see that the color of the fabric becomes darker as the flax fiber mass fraction increases. In particular, coPLA film layers were added to the preform in the compression molding to supplement the matrix amount. The compression molding parameters were optimized previously and were discussed in D 1.2.5. In this report, we present the methodology to produce a complex-shaped demonstrator with the flax/PLA/coPLA non-woven fabrics.

2 Materials

To manufacture the demonstrator, the dry laid Flax/PLA/coPLA nonwoven fabric with an areal weight of 100g/m² developed by CETI, France, was used. The non-woven fabrics were cut to the mould dimensions and were stored at 23°C and 50%RH for a duration of 24 hours. The non-woven fabrics were then stacked on each other and were transferred into the mold (see Figure 1). The preform contained approximately 24 layers. Additional coPLA films were produced via film extrusion method and were placed symmetrically between the adjacent non-woven layers.

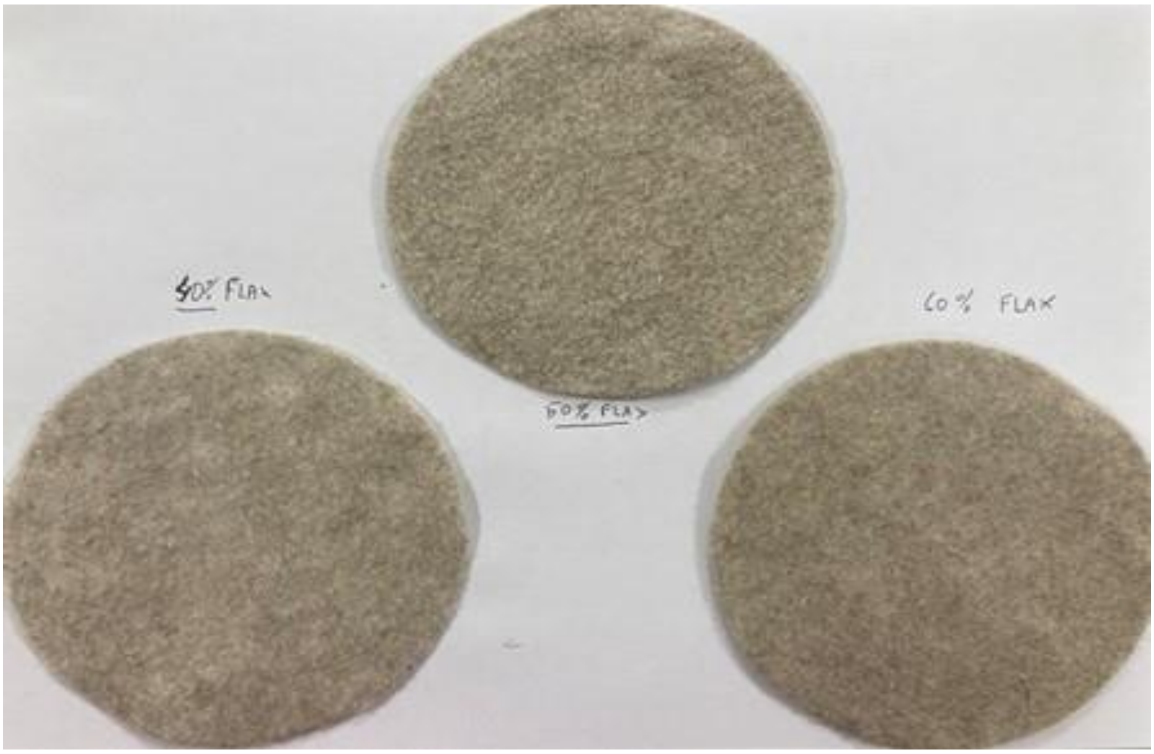

Figure 1: Samples of flax/PLA/coPLA fabrics

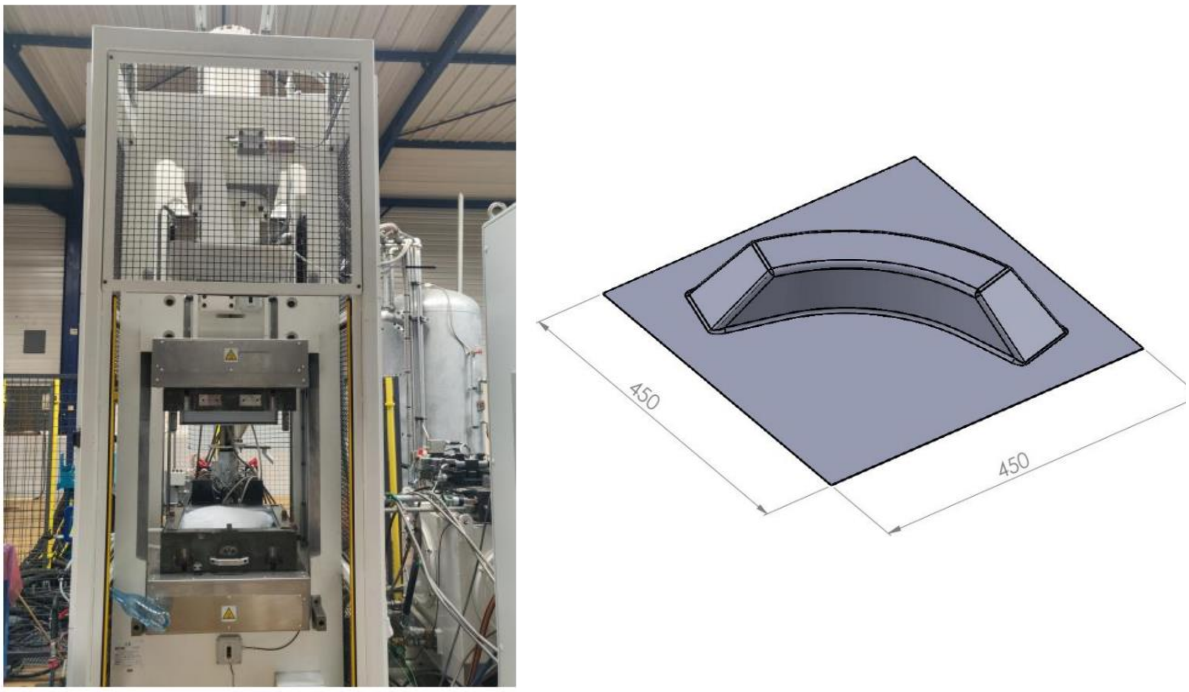

Figure 2: Hydraulic press used for compression moulding (left); CAD image of mold geometry and dimensions (right)

3 Compression moulding

Compression moulding of Flax/PLA/coPLA composites was carried out using a hydraulic press (PEI, France) with a capacity of 120 tons. The mould resembles a curved stiffener with high draft angles (see Figure 2). The mould can be heated via two routes; one with an external heating system that uses oil as a heating agent, and second is by using the heating coils built into the mold. The compression cycle used in this study was optimized in a previous study (refer to D 1.2.5). After the non-woven fabrics and coPLA film layers were placed into the mould, the mould was closed partially by maintaining a gap of 150mm. The mould was then heated to 100°C, and the gap was decreased to 50mm (see Figure 3). Once the mould reached a constant temperature 155°C, the consolidation cycle shown in Figure 4 was applied. The mould was then cooled immediately using air and water (below 100°C) as cooling agents. The final estimated mass fraction of flax fibre was about 28 % and that of PLA fibres was about 23%.

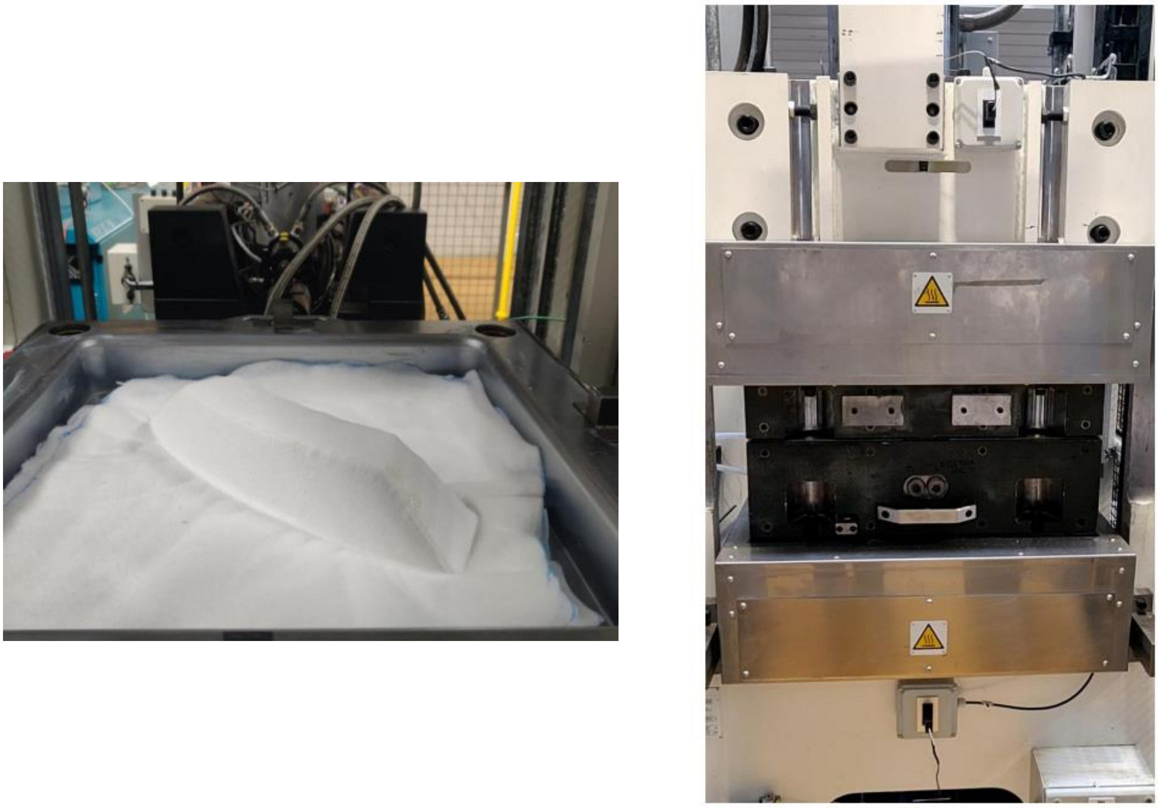

Figure 3: Manufacturing steps: Preforming of flax/PLA non-woven fabrics (left); Partial closing of mould at room temperature (right)

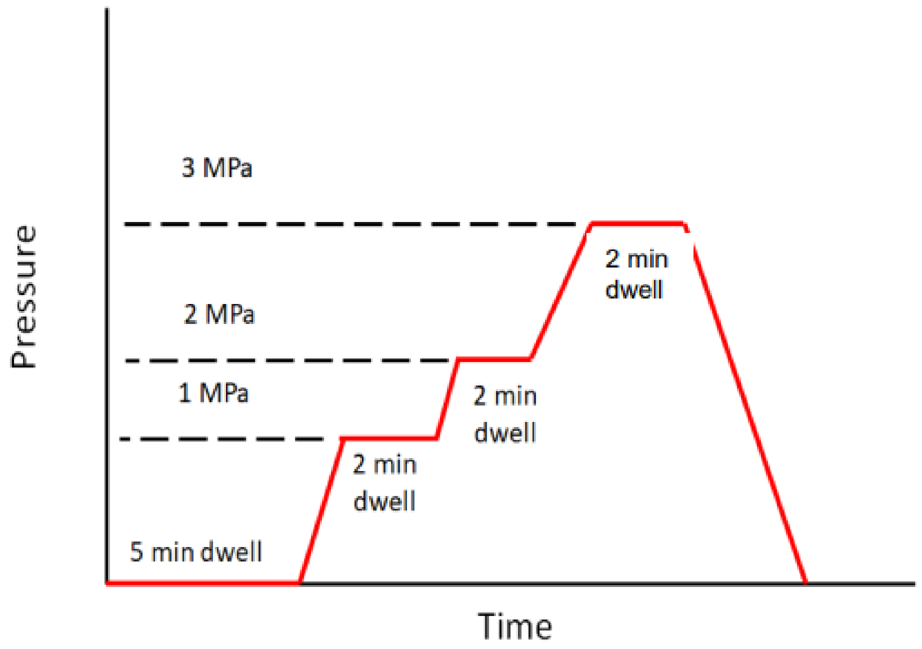

Figure 4: Consolidation cycle for Flax/PLA/coPLA composites

Figure 5: Flax/PLA/coPLA composite demonstrator

Once the cooling step was completed, the Flax/PLA/coPLA composites were demoulded at 40°C. The resulting demonstrators are shown in Figure 5. It can be noticed that there are no wrinkles or any draping defects in the composite. Furthermore, the impregnation quality was good and no dry zones were observed in the composite. It was noticed that the edges of the composite were a bit frayed and dry. This was caused due to the shrinkage of the preform. Moreover, because the preform thickness was lower, it was not totally compacted, thus resulting in a partial dry zone. This will be machined out, however, during the real production as shown in Figure 5. It would be less laborious if the coPLA films were thin and easily drapable. Lower thickness of coPLA layers would facilitate better distribution of matrix between the non-woven fabric layers, thus resulting in high quality composites.

4 Conclusion

In this report, a Flax/PLA/coPLA demonstrator has been successfully produced using the novel non-woven fabrics developed within the project. It was identified that these flax/PLA/coPLA non-woven fabrics can be easily draped into complex forms without great difficulty and were easy to handle. The demonstrator exhibits no visible defects.