INDUSTRIAL HEMP TRANSFORMATION FOR COMPOSITE APPLICATIONS: INFLUENCE OF PROCESSING PARAMETERS ON THE FIBRE PROPERTIES

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ABSTRACT

The main objective of this collaborative work is to characterize the influence of the different transformation steps of hemp on the fibre properties, from the straw retting to the preform manufacturing. The main highlight is the major influence of retting on the tensile properties of individual fibres before and after the primary processing of hemp stalks. Different technologies such as spinning, and use of natural binder system are also proposed to produce yarns and woven fabrics. The effect on these technologies and their parameters on the fibre properties are also characterised.

INTRODUCTION

Today, in Europe, the only well developed and marketed plant fibre continuous reinforcements (tapes, roving, fabrics and so on) for composites applications (PFCs) are mainly based on flax fibres (Shah, 2013). Therefore, it is relevant to consider alternatives to current commercial flax-based solutions and to mobilize additional resources. Comparatively, there is a large gap of knowledge and engineering between hemp and flax. The deficit for hemp is assigned to less intensive research activity, to an insufficiently structured production sector and to technological barriers, such as fibre separation and the alignment of fibres throughout the transformation process. Today, the main applications for hemp fibres are in the fields of pulp and paper (55%), insulation (26%), thermoplastic polymer composites (14%) and mulch (2.7%) (Hobson et al., 2001). So, hemp has a great opportunity for market capture in composite for secondary structural applications.

For hemp, the preservation of the integrity of the fibres through the transformation processes and up to the composite scale is a real challenge and requires an optimization of the extraction and transformation processes for plant fibre reinforcements currently used in industry. The existing processes, derivatives from paper and textile technical processes, do not have the same objectives as for applications in composite, particularly in terms of fibre properties. They particularly lead to damage within the cell wall, which is detrimental for the mechanical properties of individual fibres.

In this work, the influence of processing parameters, including the retting level (pre-processing parameter), primary processing of stalks, combing, spinning and weaving on the mechanical properties of single hemp fibres are characterized. **The gathering of results is the fruit of collaborative projects between several labs**.

RESULTS AND CONCLUSIONS

The results from the tensile tests on single fibres after decortication are shown in Tab. 1. Three batches of fibres were tested, coming from straws with different durations (and levels) of retting. Table 1 shows that the intermediate duration of retting lead to the highest tensile strength at the scale of single fibres after decortication.

Table 1 Tensile properties of single hemp fibres after mechanical extraction, and as a function of the retting levels of the straws (mean value ± st. dev. determined on 30 fibres with a mean diameter of approx. 25 µm)

Retting level of hemp straws	Apparent Young's modulus (GPa)]	Ultimate tensile stress (MPa)	Strain at failure (%)
Non-retted	**15.7** ±11.6	**480** ±245	**3.5** ±1.4
Low-retted	**17.5** ±11.2	**660** ±265	**3** ±1.1
High-retted	**16.6** ±12.7	**340** ±335	**2.2** ±0.9

100% hemp-based yarns were manufactured from a combed roving (15000 Tex). Table 2 describes the different yarn structures. Figure 1 synthesises the tensile strength measured on different batches of single fibres taken in yarns after their processing using the different technologies. Results show that the chosen technologies have a greater impact on the scattering rather than on the mean value of the strength, meaning that they lead to different numbers and families of defects.

Table 2 Description of the different manufactured hemp yarn structures

Nomenclature	Yarn description
15000	Combed roving – 15000 Tex – obtained after primary processing
500 ENR	Non-twisted natural polymer binder yarn - 500 Tex
500 ER	Twisted natural polymer binder yarn – 50 tr/m, 500 Tex
500 NENR	Non-twisted yarn – 500 Tex
500 NER	Twisted yarn – 50 tr/m, 500 Tex

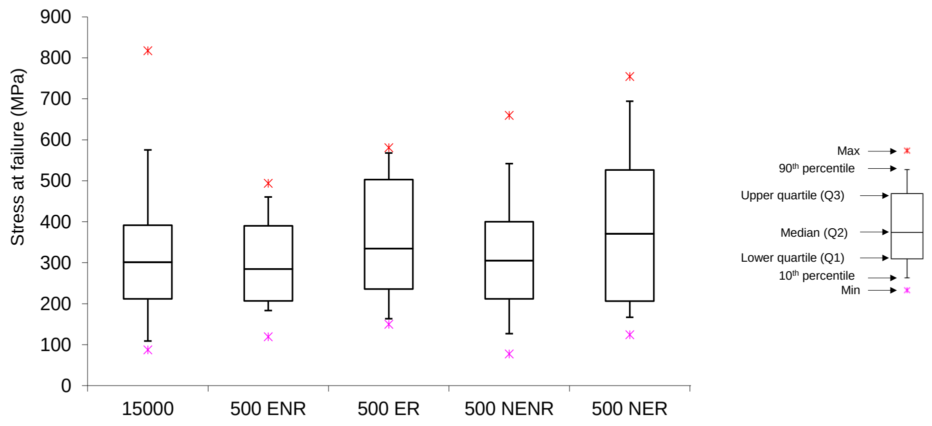

Fig.1 Tensile strength of single fibres taken in the different types of yarns

The origin of these variations of the tensile properties as a function of the processing steps will be explained and detailed during the presentation.

REFERENCES

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