Comparison of density measurement methods for unidirectional flax-epoxy polymer composites

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ABSTRACT

Towards increasing demand for replacing conventional synthetic fibers with natural fibers as reinforcement in fiber-reinforced polymer (FRP) composites, flax plant based natural fibers have found their place in the industry to replace man-made glass fibers. For design, quality control and research purposes, we need first to know better the physical, chemical and mechanical properties of flax fiber-reinforced polymer (FFRP) composites. Especially, to develop efficient numerical models to these environmentally and economically advantageous materials, we need precise material properties. Density, as a fundamental physical property, determines one of the most important advantages of FFRP composites, i.e. their relatively low weight (leading to high specific properties) in comparison with glass FRP composites.

There are some works regarding the measurement of fiber density [2] and some others dedicated to the density measurement of flax fibers [3], the sensitivity of FFRP composites to different measurement methods has not been studied yet. The literature data are scattered [4, 5] and considering density depends on factors like the fiber volume fraction, fabrication process and condition of fibres used, it is often not possible to use them in other studies.

In this work, three methods to determine the density of unidirectional flax composites we evaluated and compared: Helium-gas pycnometry, Archimedes (water used as immersing liquid) and Archimedes (ethanol used as immersing liquid). The results show that Helium-gas pycnometry and Archimedes with ethanol gave very close and repeatable results, but by using water, even for a short immersion time, an increase in the weight of samples resulted in much lower density values, indicating that some air was trapped on the sample. The density values were all in the range of reported values. However, Helium-gas pycnometry or Archimedes using ethanol can be used to correctly measure the density of flax-epoxy composite while using water should be avoided.

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