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Application of Design of Experiment (DoE) for Parameters Optimization in Compression Moulding for Flax Reinforced Biocomposites

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Abstract

Lately, widespread research on polymer composites that consist of natural fiber as reinforcement have been widely discussed. In this work, an attempt on optimizing the hot press forming process parameters using Response Surface Methodology (RSM) have been made to improve the mechanical properties of the woven flax/PLA composites. Three independent process variables, including moulding temperature, time and pressure were studied. Through the Box Behnken approach, a set of experiment runs based on various combination of compression moulding via Minitab 16 were established. As a results the optimum value for the variables of compression moulding technique parameters were 200°C, 3 min and 30 bar in order to yield 48.902 kJ/m^{-2}ofimpact strength.

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Keywords: Response surface methodology; Flax fibre reinforced composites; Compression moulding

1. Introduction

In recent years, there are growing interests in the use of natural fibers as reinforcement in fiber reinforced plastics in order to minimize the environmental problem associated with disposal of non-biodegradable polymer.[1–3]

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As a natural fiber, flax fiber has been regarded as alternative material to synthetic fiber because it is abundant, low cost environmental friendly and good specific strength properties.[3] Recent developments in natural polymer composites have heightened the need to improve its mechanical properties and one of the solution is the utilization of woven fibre as reinforcement. Woven fibre promotes higher fibre packing and offers good toughness through its mechanical interlocking.[4]

Compared to many of the forming process for polymer composites, compression moulding is frequently used as manufacturing process that requires specific design, especially for woven natural fibre. In compression moulding process, selection of suitable parameters is important in order to yield the optimum composites products. Among the compression moulding parameters, moulding temperature, pressure, and heating time are the most important parameters that influence the mechanical properties.[5]Traditonally, most researchers follow the classical experimental method where by changing one parameter at a time while keeping others factors at fixed level.[6,7]However, due to its time-consuming nature and cost issues, response surface methodology (RSM) have been identified to be efficient statistical tool because of less number of experiments required, thus experiments are faster and more effective.[2,6,8]

Although, a considerable amount of literature has been published on applying RSM on compression moulding process however optimisation of compression moulding process for flax fiber reinforced PLA has not been reported yet. In this works, the Box Behnken design approach was employed on woven flax/PLA aiming improve the mechanical properties through optimization series of the compression moulding factors via Minitab16.

2. Experimental

2.1. Materials

The material studied is a commercially available Biotex 40% flax/PLA woven fabric supplied from Composites Evolution based in Chesterfield, United Kingdom. The material comes in preconsolidate sheet form that have 2x2 twill woven weaves style as shown in Fig.1. The flax/PLA preconsolidated sheet has a measured average thickness of 0.80 mm. The composite woven fabric properties as given by the manufacturer are summarized in Table 1.

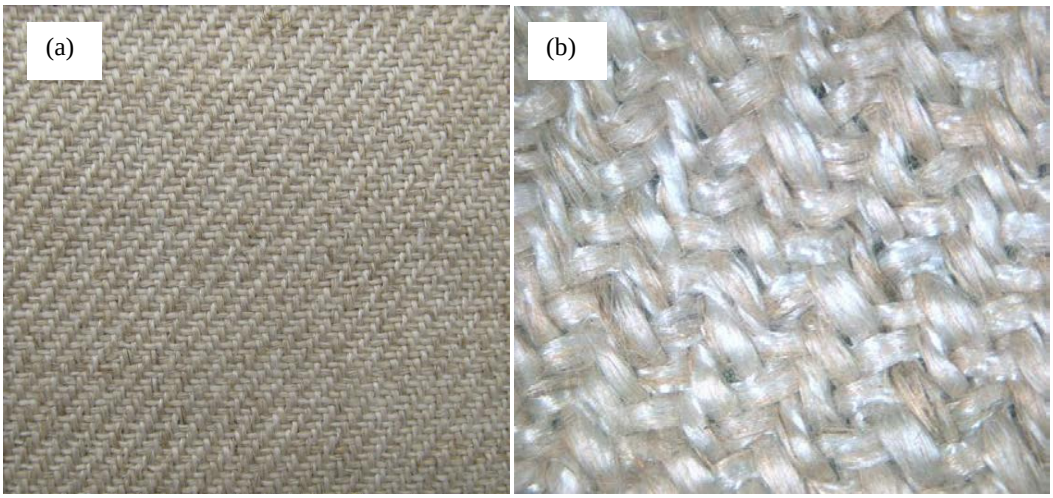

Fig.1. Woven flax/PLA 2x2 twill fabric at (a) visual observation; (b) 10x magnification.