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Optimization of Processing Conditions Via Response Surface Methodology (RSM) of Nonwoven Flax Fibre Reinforced Acrodur Biocomposites

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Abstract

Currently, there is a significant drive to switch to more sustainable and renewable materials, whilst still reducing weight and cost and maintaining reliability. In addition, with some renewable materials, end-of-life vehicle issues are more easily addressed because the materials are biodegradable or easily recycled. Natural fibres such as flax fibre (FF)have several advantages that have made them particularly attractive to the automobile industry. These include relatively good mechanical strength, low density better thermal and acoustic insulation and low cost. The aim of this study was to produce optimised Nonwoven Flax Fibre Reinforced Acrodur (NWFA) biocomposites. Response surface methodology (RSM) was employed to study the effect of processing conditions such as moisture content, curing temperature and curing time on flexural strength and modulus. The optimized conditions was analyzed using Analysis of Variance (ANOVA) and the optimized value for the maximum flexural strength of NWFA biocomposites was found at 25% moisture content, 170^{0}C curing temperature and 180 seconds curing time. Maximum flexural strength and modulus of 44.83 MPa and 4.70GPa were attained. From the analysis of variance (ANOVA) technique, namely the Box–Behnken method, curing temperature significantly affects the strength of NWFA biocomposites,

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followed by the moisture content and curing time. The P-value of the model of the experiment is less than 0.05 and the determination coefficient (R^2) is nearly 1 suggesting that the model is significant and implies on the precision and processability in the production.

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*Keywords:*Natural fibre; Flax; Response surface methodology; Analysis of variance; Box–Behnken

Nomenclature

GF	Glass Fibre
CF	Carbon Fibre
FF	Flax Fibre
RSM	Response Surface Method
NWFA	Nonwoven Flax Fibre Reinforced Acrodur

1. Introduction

The use of natural fibre reinforced plastic composites has grown significantly in buildings, furniture andautomotive industries over the last decade because of their unique properties. Synthetic fibres, such as glass fibre (GF) and carbon fibre (CF) have been utilized as reinforcements in composite materials in various automotive components.However, the use synthetic fibres has several drawbacks such as non-biodegradability and recycling difficulty. Currently, there is a significant drive to switch to more sustainable and renewable materials, whilst still reducing weight and cost and maintaining reliability. In addition, with some renewable materials, end of life vehicle issues are more easily addressed because the materials are biodegradable or easily recycled [1–4]. Natural fibres (NF) such as jute, kenaf and flax have several advantages that have made them particularly attractive to the automotive industry. These include relatively good mechanical strength, low weight, better thermal and acoustic insulation and low cost [4–7]. NF are poised to replace synthetic fibres in numerous interior parts i.e. door panels, seat backs, headliners, package trays, dashboards, seat backs, interior sunroof shields and headrests [2].Although many different types of natural fibres are available, FF is a particularly attractive option due to its high strength, low density and better environmental impact. As compared to glass fibre reinforced composite, flax composites have an advantage in terms of specific mechanical properties [8–10]. Furthermore, FF are cheap and biodegradable materials, coming from a bio-sourced agriculture and widely available over the world.

Previously, most studies on natural fibres have been focussed on short, twisted or woven and produced either by compression or hand lay-up technique[11–13]. However, there is not much work reported on non-woven fibre mats. The key of this study is to utilize the non-woven fibre mat-making machine, which involves the continuous processes of fibre opening, carding, cross-lapping and needle punching to produce stitched kenaf fibre mats as natural fibre reinforcement in composites. The term "non-woven" was created as a result of this manufacturing technique of producing fabrics without a weaving or knitting process.

Response surface methodology (RSM) is a well-known up to date approach for constructing approximation models to optimize a response (output variable) which is influenced by several independent variables (input variables).Compared to conventional method the optimization properties for any industrial production of using RSM have several advantages such as short time consuming by reducing the number of planned experiments and effective in finding the optimum parameter particularly when it comes to the interactions of each variable[14]. RSM has the ability to evaluate the relationship between the responses and the independent variables as well as to define the influence of independent variables on the responses either by each single variable or via combination in the process [15].

The purpose of the present work was used to investigate the effectof factors that determine the flexural properties of NWFAbiocomposites. The factors involved are moisture content, curing temperature, curing time and