

Development of thermoplastic biocomposites based on aligned hybrid yarns for fast composite manufacturing

Behnaz Baghaei

Thesis for the degree of Doctor of Philosophy at the University of Borås to be publicly defended
on **Nov 27th 2015, 10:00 AM** in room **D207**, University of Borås, Allegatan 1, Borås, Sweden.

Language: English

Faculty Opponent is:

Associate Professor Anders Sjögren

Department of Design Sciences

Lund University

PhD thesis available at: Swedish Centre
for Resource Recovery University of
Borås
SE-50190 Borås. +46 (0) 33 435 4000



UNIVERSITY
OF BORÅS

Abstract

The interest in natural fibres as reinforcement for composite materials has been steadily increasing due to their attractive mechanical properties and the possibility of making more eco-friendly materials. Currently, various alternatives are being introduced for commercial applications, as fibres such as hemp, jute and flax exhibit properties, which make them appropriate for structural composite components. Biocomposites offer reductions in weight and cost and have less reliance on foreign oil resources, making them attractive. Several investigations have revealed that the full utilisation of fibre mechanical properties in the final composites can be exploited, provided an aligned fibre orientation is chosen. In fact, a major challenge for natural fibre reinforced composites is to achieve high mechanical performance at competitive prices. The use of commingled/hybrid yarns is one of the more promising methods for manufacturing structural thermoplastic composites.

Commingled yarns of thermoplastic and reinforcing fibres offer a potential for cost-effective production of composite parts, thanks to reduced applied pressures and impregnation times during processing. Besides economic advantages, there is also direct control over fibre placements and ease of handling of fibres in yarn process. The yarn technologies provide homogenous distribution of reinforcing fibre and matrix. Variation in natural fibre properties has been a major problem facing composite manufacturers, compared to carbon and glass fibres that have well-defined production processes. This issue can be addressed by regenerated cellulose fibres. These fibres can be reproduced easily with high surface evenness and even quality, making it possible to get consistent results, which is not possible with natural fibres. Combination of natural and regenerated cellulose fibre brings together the best of both materials. The end result is a product with superior properties, which could not be obtained by the individual components.

This thesis describes the development of aligned hybrid yarns with low fibre twist, for high performance natural (hemp) and man-made (Lyocell) cellulose fibre-reinforced biocomposites, suitable for use in structural or semi-structural applications. The properties of composites in terms of fibre orientation, off-axis angle and alkali treatment were investigated, focusing on determining void%, water absorption, mechanical and thermo-mechanical properties. The results show that combining hemp and Lyocell in PLA composite leads to the reduction of moisture absorption and can improve the mechanical properties. The mechanical properties of the composites were highly affected by the fibre direction. The alkali treatment on hemp fibre improved the mechanical properties of the composites.

Keywords: Hybrid yarns, Mechanical properties, Porosity, Weaving, Alkali treatment, Compression moulding