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ENGINEERING THE MECHANICAL PROPERTIES OF NONWOVEN REINFORCED FLEXIBLE COMPOSITES

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Introduction

Flexible fibre reinforced composites employ elastomeric matrix materials with a characteristic range of deformation much larger than that of conventional fibre reinforced composites. Flexible composites find applications as tyres, conveyor belts, coated fabrics, inflated structures, hoses, surgical replacements, diaphragms and reinforced membranes to give a few examples. The mechanical properties of such composites could be engineered by suitable selection of fibre and matrix materials as well as by tailoring the geometric configurations of the reinforcement.(Andersson et al. 1998, Chou 1989) High strength fibres are commonly employed as reinforcement for fibre reinforced composites and the use of standard textile fibres for low cost composites could be a useful substitute for certain applications. Nonwoven fabrics are directly made from fibres/filaments by choosing a suitable web formation and bonding method. The low number of process steps and high production speeds translates in to low cost fibres with opportunity to engineer structures.(Russell 2007) The current study aims to compare the mechanical properties of nonwoven reinforced flexible composites prepared from standard textile fibres to that of prepared from high strength aramid fibre.

Materials and Methods

Polyphenylene terephthalamide (PPTA), Polyethlyene terephthalate (PET), Nylon 6,6 and Lyocell fibres were carded (70 g m^{-2} and parallel-laid) and pre-needled (42 punches cm^{-2}) to form fibrous reinforcement. Thermoplastic polyurethane (TPU, Elastollan® A C 88 A 12, Shore A: 88, BASF Polyurethanes GmbH) was employed as matrix materials in the form of sheets (≈ 315 g m^{-2}). The aforementioned nonwoven webs were sandwiched between two layers of TPU and compression moulded at 200°C and 20 kg cm^{-2} (1.96 MPa). The nonwoven webs (WSP 110.4-09, 100 mm gauge length, 100 mm min^{-1}) and prepared composites (ISO 527-4, 55 mm gauge length, 10 mm min^{-1}) were tested for mechanical properties on universal testing machine (Zwick Roell Z010).

Results and Discussion

The tensile strength of pre-needled nonwoven webs, both in machine- and cross-direction, is shown in

Figure 1. The webs exhibited higher strength in MD due to preferential orientation of fibres in the machine direction. Despite the same needling density, the webs exhibited different mechanical properties owing to inherent properties of the fibres. Despite the fact that PPTA fibre was strongest among the studies fibres, lyocell nonwovens exhibited higher strength owing to its flexibility allowing for high entanglements. The exhibited properties are the network strength of fibrous assembly which is enhanced by higher number of deflections of fibre segment with barbed needles. The mechanical properties of flexible composites, in machine direction only, are given in Figure 2. The compression moulding of composites showed that initial strength of webs is not critical and the matrix to fibre load transfer occurs during the application of tensile force. Compared to that of the homogenous TPU sheet

significant improvements in mechanical properties were achieved for all composites, depending on the inherent properties of the employed fibres.

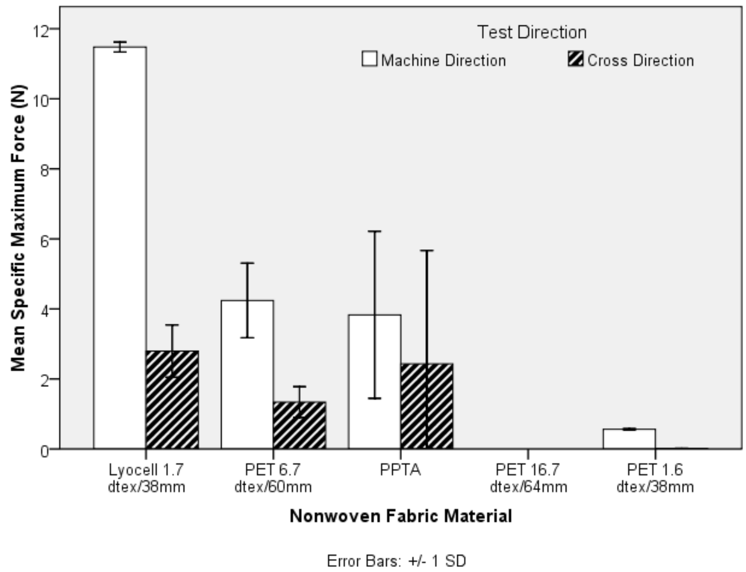

Figure 1: Tensile strength of pre-needled nonwovens in MD and CD.

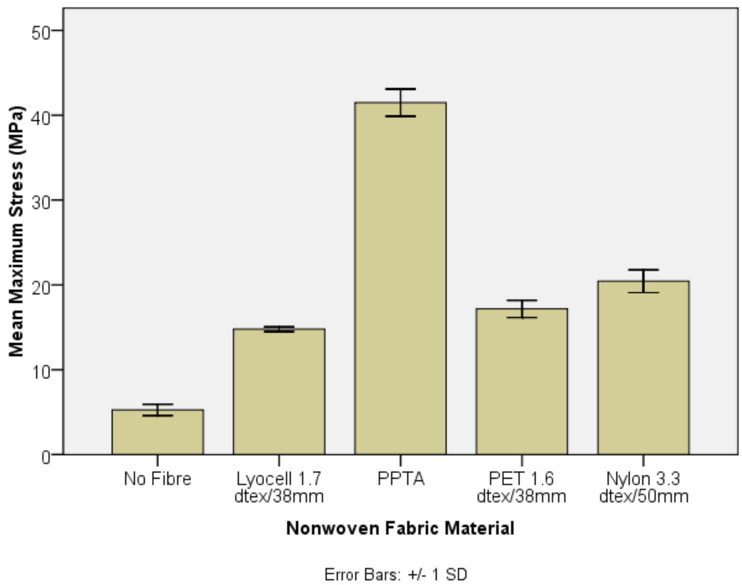

Figure 2: Tensile Strength of nonwoven reinforced TPU composites

The increase in Young's Modulus with addition of nonwovens reinforcement is given in Figure 3. Though nylon based composites exhibited higher maximum strength, it demonstrated a lower Young's Modulus compared to PET and Lyocell. Cross-sectional analysis of composites will investigate fibre to matrix adhesion and characterisation of surface energy of nonwoven webs will help to study the correlation between interfacial energy and its influence on final mechanical properties of composites.

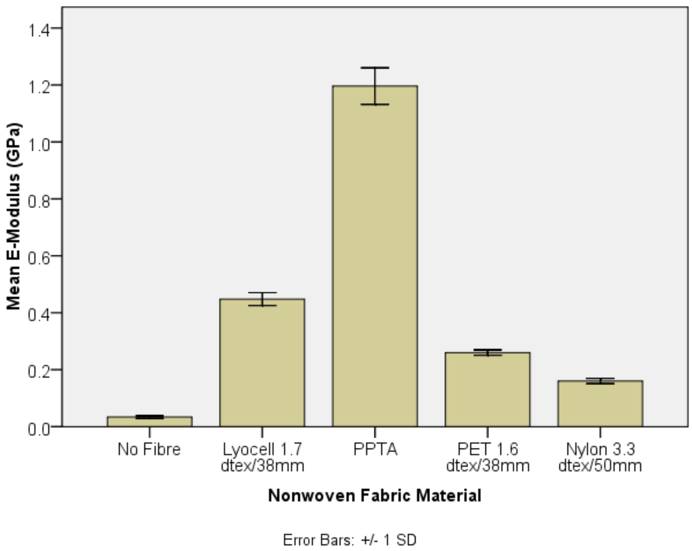

Figure 3: Tensile modulus of studied flexible composites

Conclusions

Nonwoven reinforced flexible TPU composites were manufactured by employing standard textile fibres and were compared with high performance aramid nonwoven reinforced composites. Initial results indicate that a range of stiffness and tensile strength values can be engineered by selection of appropriate material for required application. Furthermore, the initial bonding of nonwoven web appears not to affect the final mechanical properties of the webs. The characterisation of surface energy and cross-sectional analysis will help to understand the underlying interfacial mechanisms and lead to surface modification of reinforcement for improvement in mechanical properties of flexible composites.

Keywords: nonwovens, flexible, composites, fibre reinforced, mechanical properties

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For further details about the "Sports Infinity" project, please visit following website:
http://www.adidas-group.com/en/magazine/stories/specialty/farewell-recycling-infinity-cycling/

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