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Mechanical Properties of Carbon Fibre Reinforced Thermoplastic Composites Consisting of Recycled Carbon Fibres and Polyamide 6 Fibres

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Abstract : With the increasing demand and use of carbon fibre reinforced composites (CFRC), disposal of the carbon fibres (CF) and end of life composite parts is gaining tremendous importance on the issue especially of sustainability. Furthermore, a number of processes (e. g. pyrolysis, solvolysis, etc.) are available currently to obtain recycled CF (rCF) from end-of-life CFRC. Since the CF waste or rCF are neither allowed to be thermally degraded nor landfilled (EU Directive 1999/31/EC), profitable recycling and re-use concepts are urgently necessary. Currently, the market for materials based on rCF mainly consists of random mats (nonwoven) made from short fibres. The strengths of composites that can be achieved from injection-molded components and from nonwovens are between 200-404 MPa and are characterized by low performance and suitable for non-structural applications such as in aircraft and vehicle interiors. On the contrary, spinning rCF to yarn constructions offers good potential for higher CFRC material properties due to high fibre orientation and compaction of rCF. However, no investigation is reported till yet on the direct comparison of the mechanical properties of thermoplastic CFRC manufactured from virgin CF filament yarn and spun yarns from staple rCF. There is a lack of understanding on the level of performance of the composites that can be achieved from hybrid yarns consisting of rCF and PA6 fibres. In this drop back, extensive research works are being carried out at the Textile Machinery and High-Performance Material Technology (ITM) on the development of new thermoplastic CFRC from hybrid yarns consisting of rCF. For this purpose, a process chain is developed at the ITM starting from fibre preparation to hybrid yarns manufacturing consisting of staple rCF by mixing with thermoplastic fibres. The objective is to apply such hybrid yarns for the manufacturing of load bearing textile reinforced thermoplastic CFRCs. In this paper, the development of innovative multi-component core-sheath hybrid yarn structures consisting of staple rCF and polyamide 6 (PA 6) on a DREF-3000 friction spinning machine is reported. Furthermore, Unidirectional (UD) CFRCs are manufactured from the developed hybrid yarns, and the mechanical properties of the composites such as tensile and flexural properties are analyzed. The results show that the UD composite manufactured from the developed hybrid yarns consisting of staple rCF possesses approximately 80% of the tensile strength and E-module to those produced from virgin CF filament yarn. The results show a huge potential of the DREF-3000 friction spinning process to develop composites from rCF for high-performance applications.

Keywords : recycled carbon fibres, hybrid yarn, friction spinning, thermoplastic composite
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