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ORIGINAL RESEARCH

Mechanical and high velocity impact performance of a hybrid long carbon/glass fiber/polypropylene thermoplastic composite

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Abstract

This research explores mechanical and high velocity impact response of hybrid long carbon/glass fiber-reinforced polypropylene thermoplastic composites (HLFT) with different fiber lengths. The work examines three hybrid long fiber thermoplastic composites, i.e., 5, 10 and 20 mm. The HLFTs were prepared by a combination of extrusion and pultrusion processes and using a cross-head die. Tensile and Izod impact tests were carried out to evaluate the mechanical performance of each HLFT compound. A gas gun with a spherical projectile was used to conduct high velocity impact tests at three velocities of 144, 205 and 240 m/s. The results showed that internal mixing operation caused extensive reduction in fiber length of all three LFT lengths. Tensile strength, modulus and Izod impact test results were the indications of higher values with increase in HLFT length. Comparison of these results for the HLFT with that of corresponding glass/PP LFTs, adopted from earlier work by Shayan Asenjan et al. (J Compos Mater 53:353–360, 2019), showed better performance of HLFT. The high velocity impact results showed a steady higher impact performance with the increase in HFLT fiber length for all impact velocities tested. Comparison of HLFT high velocity impact performance revealed better results for all impact velocities tested with that of the corresponding glass/PP LFT composite.

Keywords Long fiber thermoplastic composite · High velocity impact · Hybrid carbon/glass fiber · Mechanical properties

Introduction

Utilization of thermoplastic composites in various industries, such as aerospace, military and automotive, has increased significantly due to their good performance and recyclability characteristic. Composite with thermoplastic matrix can be divided into two groups of long fiber (LF) and short fiber (SF) composites. Long glass fiber (LGF)-reinforced thermoplastic composites are a new class of polymeric materials that have a special place in composite materials. This is because of their properties which are strongly influenced by the fiber final length in composite specimens. LGF-reinforced thermoplastic composites are usually prepared by a combination of pultrusion and extrusion processes. In these two processes, continuous glass fibers with a polymer matrix surrounding them are pulled through a cross-head die. LGF-reinforced thermoplastic composites compared to SGF exhibit excellent mechanical property, in particular, impact performance. The long length of the fibers leads to improved mechanical properties of the composite specimens, however, it also leads to an increase in the polymer melt viscosity. Therefore, the long glass fiber thermoplastic composites endure higher shear force, leading to sever fiber length shortening [1]. Polypropylene (PP) as the most common matrix used in LGF is a semi crystalline thermoplastic polymer which has good processing features, high chemical stability and electrical insulation. However, it has low mechanical properties which limit its usage [2]. Literature review revealed quite a few reports on the long glass fiber thermoplastic composites usage. Weidenmann et al. [3] reported the temperature and time dependency of long glass fiber-reinforced polypropylene. They reported that the increase in strain rate results in an increase of the elastic modulus with decreasing service temperature. Thomason et al. [4–6] in a series of reports investigated the mechanical performance of injection moulded long glass fibre-reinforced polypropylene with a glass fibre content in the range

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