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3D woven composites for automotive applications: structure parameters/impact energy relationships

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Abstract

The overall goal of this research is to establish structure/property relationships of 3D woven composites and better understand their performance characteristics in terms of their structure parameters such as Fiber Volume Fraction, number of layers, thread density, and thread size. This will lead to identify new automotive applications for such high performance materials and replace the heavy metal with lightweight composites. While the emphasis is on automotive applications, the findings of the research would allow identifying other applications such as marine, personnel and vehicle armor, industrial, aerospace, wind energy generator, recreational and others. To achieve the goal, a range of 3D preforms with varying construction parameters namely linear density (g/km or tex) and thread density of x-yarn, number of layers, and weave construction were manufactured using 3D weaving technology. The preforms were consolidated using Vacuum-Assisted Resin Transfer Molding (VARTM). In this paper, we investigate the influence of construction parameters on the Iozd impact energy. Our research revealed that the Izod impact energy was significantly affected by number of layers, thread density, and thread size. It was also found that the Fiber Volume Fraction is highly affected by number of layers, thread density, and thread size and hence the impact energy is strongly correlated to the Fiber Volume Fraction.

***Key words**: 3D woven creforms, Composites, Impact energy, Fiber volume fraction, Automotive*

1. Introduction

The increasing interest in composite structures from fibrous preforms inspired researchers to conduct intensive basic research led to the establishment of new generation of products and processes (Mohamed *et al.*, 2001; Desplentere *et al.*, 2003; Gama *et al.*, 2004). Among these is a novel process of manufacturing 3D woven fabrics, invented at the College of Textiles, North Carolina State University (NCSU) in the early 1990s (Mohamed and Zhang, 1992). The new technique outperforms the traditional 2D weaving technique that introduces crimp in the interlaced yarns, which causes negative impact on composite performance. The 3D woven structure is achieved by simultaneous multiple filling insertions for each weaving cycle and does not involve the building up of layers one layer at a time. Rather, an integrated single unit of thick fabric is formed from three orthogonal straight yarn systems (Figure 1). Figure 2 shows the invented

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