Materials and Design 32 (2011) 4931–4935

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Mechanical behaviour of textile-reinforced thermoplastics with integrated sensor network components

W. Hufenbach [a], F. Adam [a], W.-J. Fischer [b], A. Kunadt [b], D. Weck [a,*]

[a] Institute of Lightweight Engineering and Polymer Technology (ILK), TU Dresden, Holbeinstr. 3, 01307 Dresden, Germany
[b] Institute of Semiconductor and Microsystems Technology (IHM), TU Dresden, Nöthnitzer Str. 64, 01187 Dresden, Germany

ARTICLE INFO

Article history:
Received 24 February 2011
Accepted 27 May 2011

Keywords:
A. Composites: polymer matrix
E. Mechanical
G. Destructive testing

ABSTRACT

The embedding of sensor networks into textile-reinforced thermoplastics enables the design of function-integrative lightweight components suitable for high volume production. In order to investigate the mechanical behaviour of such functionalised composites, two types of bus systems are selected as exemplary components of sensor networks. These elements are embedded into glass fibre–reinforced polypropylene (GF/PP) during the layup process of unconsolidated weft-knitted GF/PP-preforms. Two fibre orientations are considered and orthotropic composite plates are manufactured by hot pressing technology. Micrograph investigations and computer tomography analyses show different interface qualities between the thermoplastic composite and the two types of bus systems. Mechanical tests under tensile and flexural loading indicate a significant influence of the embedded bus system elements on the structural stiffness and strength.

1. Introduction

Fibre-reinforced composites have high specific stiffnesses and strengths. Additionally, these materials offer the possibility to design load-adapted material characteristics. In order to make these outstanding properties available for high-volume production, textile-reinforced composites with thermoplastic matrices are advantageous because of their feasibility of short processing times. Thermoplastic composites offer various forming possibilities, weld-ability, high ultimate strain and fracture toughness, and good resistance to media and corrosion, which makes them interesting for industrial applications [1,2]. Additionally, these composite materials are easy to recycle compared to composites with thermosetting matrices [3,4]. In current research, the material combination of glass fibres and polypropylene is focused with regard to cost-effective solutions. Several studies consider the hybrid yarn fabrication and modification [5], the influence of processing parameters on the structural properties [6,7], the identification of material characteristics [8–10] and adapted joining technologies [11].

Composites can be functionalised by integrating various electronic components into the material structure. Sensors based on optical or carbon fibres are used to perform strain measurement [12,13]. Piezoceramic modules are utilised to modify the structural behaviour of the component [14] or to perform structural health monitoring [15]. Current studies are also dealing with specifically designed piezoceramic modules for thermoplastic composite structures capable for series production [16,17]. Furthermore, embedded sensor networks open new fields of application by comprising the functionality of sensors (data recording), integrated circuits (data processing), and actuators (structure manipulation). Such systems are able to work as antennas [18] or distributed force sensors [19]. Further studies disclose their potentials in manipulating the dynamic behaviour of the composite structure [20], in automatically and continuously surveiling the structural performance [21], or in transmitting collected data by wireless techniques [22]. Besides of preserving the functionality of the electronic components during the manufacturing process [23–25], ongoing research analyses the influence of these embedded electronic elements and networks on the mechanical performance of fibre-reinforced composites. Lin and Chang [15] analysed amongst others the interlaminar shear strength and transverse impact damage tolerance of carbon fibre-reinforced composites with epoxy matrix and embedded piezoceramic modules. Kim et al. [26] investigated the effect of embedded thermocouples and metallic strain gauges on the bending and compressive strength of carbon fibre-reinforced composites. The study compasses different layups as well as composites with thermosetting and thermoplastic matrix systems. Ling et al. [27] considered the effects of embedded optical fibres on the mode II interlaminar fracture toughness of glass fibre-reinforced specimens with various delaminations. Schaaf et al. [28] investigated the influence of integrated chip resistors and flexible printed circuit boards on the interlaminar shear strength of glass fibre-reinforced

* Corresponding author.
E-mail address: d.weck@ilk.mw.tu-dresden.de (D. Weck).

0261-3069/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.matdes.2011.05.047