Materials and Design 32 (2011) 1468–1476

Contents lists available at ScienceDirect

Materials and Design

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

Polypropylene/glass fibre 3D-textile reinforced composites for automotive applications

W. Hufenbach [a], R. Böhm [a,*], M. Thieme [a], A. Winkler [a], E. Mäder [b], J. Rausch [b], M. Schade [c]

[a] Technische Universität Dresden, Institute of Lightweight Engineering and Polymer Technology (ILK), Holbeinstraße 3, 01307 Dresden, Germany
[b] Leibniz-Institut für Polymerforschung Dresden (IPF), Hohe Straße 6, 01069 Dresden, Germany
[c] Technische Universität Dresden, Institute of Textile Machinery, and High Performance Material Technology (ITM), George-Bähr-Straße 3c, 01062 Dresden, Germany

ARTICLE INFO

Article history:
Received 11 May 2010
Accepted 28 August 2010
Available online 6 September 2010

Keywords:
A. Polymer matrix composites
B. Fabrics
G. Coupon testing

ABSTRACT

Textile-reinforced thermoplastic composites offer huge application potentials for a rapid manufacturing of components with versatile possibilities of integrating functions. However, an application of these new materials requires the knowledge of the directional dependent material properties. In this study, results are presented concerning selected relevant load cases for industrial applications. For the new group of multi-layered flat bed weft-knitted glass fibre/polypropylene composites (MKF-GF/PP), tensile tests under different temperatures and test velocities have been carried out as well as Charpy impact tests, open hole tension tests and dynamic-mechanical analysis. The mechanical properties of MKF-GF/PP and unidirectional GF/PP composites with tailored fibre surface and interphase, respectively, have been compared to those of woven GF/PP composites and GF/PP composites made of non-crimp fabrics (NCF) as a benchmark.

1. Introduction

In structural applications, textile composites are usually used as reinforcement because of the possibility to tailor the load bearing capacity through the fibre architecture. As a result of their growing potential for lightweight applications, textile-reinforced thermoplastic composites are getting of greater interest for the industry. Thermoplastic composites show a number of advantages compared to classical composites based on thermoset matrices, among which the possibility for a low-cost, rapid production has to be mentioned first [1–5]. Traditionally, textile thermoplastic composites are processed by stacking alternating layers of textile fabrics and polymer sheets in a hot-press. After heating above the polymer melting point, the press is closed to obtain the required product shape. In a subsequent cooling step, the product solidification takes place followed by demoulding. Clear advantages can be made when so-called hybrid fabrics made of commingled yarns are used. Such yarns consist of reinforcing filaments (e.g. glass, carbon) and thermoplastic filaments (e.g. polypropylene, polyetheretherketon). The thermoplastic filaments melt during the pressing process and form the matrix so that no additional polymer needs to be added. The main advantage of commingled yarns is that the thermoplastic yarns are uniformly distributed in the reinforcement yarns to reduce the flow length of the thermoplastic after melting [6,7]. In general, composites made of commingled yarns feature improved basic properties (strength, stiffness, toughness, impact resistance, environmental resistance) compared to traditional thermoplastic composites [6–10].

To be targeted at providing a cost-effective solution to the automotive industry with possible function integration, research focuses on the material combination of glass fibres and polypropylene (GF/PP) [1–12]. Commingled woven GF/PP fabrics are commercially available, and offer distinct advantages over powder impregnated fabrics (notably lower cost and better impregnation by the thermoplastic material). However, industrial demands on high-tech applications increasingly require the use of fabrics with adjustable mechanical properties. Traditional woven fabrics fulfill this requirement profile usually only on a small scale. In this context, the development of novel textiles in combination with adapted manufacturing technologies provide promising alternatives [11,13–15]. Multi-layered flat bed weft-knitted fabrics (MKFs) and non-crimp fabrics (NCFs) with hybrid yarns should be mentioned as typical examples of this new material group.

At present time, the material behaviour of the novel textile GF/PP composites (MKF-GF/PP and NCF-GF/PP) is insufficiently investigated. Most of the existing studies are limited to quasi-static loading conditions. Hence, this research focuses on the behaviour of this new material under practical conditions in automotive engineering which is a crucial topic if hybrid GF/PP textile composites

* Corresponding author. Tel.: +49 351 463 38080; fax: +49 351 463 38143.
E-mail address: r.boehm@ilk.mw.tu-dresden.de (R. Böhm).

0261-3069/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.matdes.2010.08.049