International Journal of Plasticity 27 (2011) 1267–1293

Contents lists available at ScienceDirect

International Journal of Plasticity

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

Cyclic behaviour of short glass fibre reinforced polyamide: Experimental study and constitutive equations

A. Launay [a,b,c,*], M.H. Maitournam [a], Y. Marco [b], I. Raoult [c], F. Szmytka [c]

[a] Laboratoire de Mécanique des Solides (CNRS UMR 7649), École polytechnique, 91128 Palaiseau, France
[b] Laboratoire Brestois de Mécanique et des Systèmes (EA 4325 ENSIETA/UBO/ENIB), 2 rue François Verny, 29806 Brest Cedex 9, France
[c] PSA Peugeot Citroën (Direction Scientifique et des Technologies Futures), Route de Gisy, 78943 Vélizy-Villacoublay Cedex, France

ARTICLE INFO

Article history:
Received 26 November 2010
Received in final revised form 19 January 2011
Available online 18 February 2011

Keywords:
Cyclic loading
Constitutive behaviour
Elasto-viscoplastic material
Polymeric material
Mechanical testing

ABSTRACT

Polymer matrix composites are widely used in the automotive industry and undergo fatigue loadings. The investigation of the nonlinear cyclic behaviour of such materials is a required preliminary work for a confident fatigue design, but has not involved many publications in the literature. This paper presents an extensive experimental study conducted on a polyamide 66 reinforced with 35 wt% of short glass fibres (PA66 GF35), at room temperature. The material was tested in two conditions: dry-as-moulded (DAM) and at the equilibrium with air containing 50% of relative humidity (RH50).

An exhaustive experimental campaign in tensile mode has been carried out, including various strain or stress rates, complex mechanical histories and local thermo-mechanical recordings. Such an extended database allowed us to highlight several complex physical phenomena: viscoelastic effects at different time scales, irrecoverable mechanisms, non-linear kinematic hardening, non-linear viscous flow rule, cyclic softening.

Taking into account this advanced analysis, a constitutive model describing the cyclic behaviour is proposed. As the experimental database only includes uniaxial tensile tests, the general 3D anisotropic frame is reduced to an uniaxial model valid for a specific orientation distribution. The robust identification process is based on tests which enable the uncoupling between the underlined mechanical features. This strategy leads to a model which accurately predicts the cyclic behaviour of conditioned as well as dry materials under complex tensile loadings.

1. Introduction

In a context of CO_2 emission reduction, the automotive industry increasingly uses plastic materials to take advantage of their light weight and their complex mould designs. Polymer matrix composites (PMCs) and especially short glass fibre reinforced (SGFR) thermoplastics exhibit the required stiffness for structural applications (such as intake manifolds, inlet gas compressor exit, engine mount limiter) thanks to the glass fibres. The choice of a polyamide matrix provides a good thermal strength for a moderate cost.

Those components undergo cyclic loadings during their service life, induced by mechanical (pulsed pressure) as well as environmental sources (temperature, humidity). One of the main issues for the engineers therefore lies in the prediction of the fatigue life duration under complex loadings. Two steps are classically involved in solving the problem. On the one hand,

* Corresponding author at: PSA Peugeot Citroën – Direction de la Recherche et de l'Ingénierie Avancée, VV1415, Route de Gisy, 78943 Vélizy-Villacoublay Cedex, France.
E-mail address: antoine.launay@mpsa.com (A. Launay).

0749-6419/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ijplas.2011.02.005