



Aging, Moisture & Viscoelastic Properties

Moisture Penetration into Composites under External Stresses: A Scale Transition Analysis

G Youssef, F Jacquemin, S Freour (Univ of Nantes)

A multi-scale approach coupling the internal mechanical states localised within the plies constituents to the Fick's law governing the moisture diffusion process was used for modelling the response of composite laminates submitted to environmental hygroscopic loads, from the transient part of the diffusion process to its permanent stage. **(F1:1)**

Seawater Aging of Composites for Ocean Energy Conversion Systems

A Boisseau, P Davies, D Choqueuse (IFREMER) P Nellissen, L Peters (3B) R Nickel (Hexion) G Adolphs, C Renaud (OCV) F Thiebaud, D Perreux (MaHyTec)

This paper describes a test programme designed to evaluate the durability of composites for ocean energy conversion systems. The critical importance of material selection is illustrated by results from fatigue tests in natural sea water, which show that glass fibre type has a strong influence on lifetime. **(F1:2)**

The Effects of Moisture and Physical Ageing on the Elastic Behaviour of a Structural Epoxy

P Custódio, J Queiroz, JL Morais (CITAB) RM Guedes (Univ of Porto)

Three point bending tests indicate that elastic modulus diminishes linearly with moisture content, at a rate dependent of the ageing time. On the other hand, it seems that any curve modulus versus time of ageing for specific moisture content can be vertically shifted to coincide with other curves. A comparison of the DSC and bending tests data in the present work suggests that the ageing rate constants are not the same. **(F1:3)**

Durability of Fibers in Aggressive Alkaline Environments

A Coricciati, P Corvaglia (Consorzio CETMA) G Mosheyev (BG Polymers)

Fiber Reinforced Plastics (FRPs) are innovative materials that are going to replace some traditional structural strengthening techniques. Evaluating durability of composite materials in aggressive environments is basic for long-term performances assessment. In this study aging tests were made on glass and basalt fibers in alkaline environment. **(F1:4)**

Out-of-Plane Deformation Behaviour of Multi-Layer Paperboard Subjected to Transient Moisture Diffusion

M-L Dano, JP Bourque (Univ Laval)

An analytical method to predict the through-thickness moisture content and associated induced deformations of paperboard sheets subjected to relative humidity changes is presented. Out-of-plane deformations are predicted as a function of time. Comparisons with steady-state analyses reveal major differences in the shape of one cardboard sheet. **(F1:5)**

Characterizing Thermo-Oxidative Behavior of Multi-Directional Laminated Composites

K Pochiraju (Stevens Inst of Tech) G Tandon (Univ of Dayton RI) R Hall (US Air Force RL)

In this work, the influence of ply stacking sequence on oxidation growth is investigated in isothermally aged multi-directional composites through the use of fluorescence imaging using dye impregnation in conjunction with optical microscopy. Oxidation simulations are performed for several lamina stacking sequences and the results are correlated with experimental observations. **(F1:6)**



Oxidation Induced Shrinkage and Stress in Composite Materials at High Temperatures: Numerical Simulations and Experimental Assessment

M Gigliotti, DQ Vu, L Olivier, MC Lafarie-Frenot, J-C Grandidier (LMPM/ENSMA)

In the present paper the thermo oxidation induced shrinkage and stress in carbon fibre reinforced polymers at high temperatures are simulated by a numerical multiphysical coupled model implemented within the ABAQUS commercial finite element code; the shrinkage profiles are experimentally measured through confocal interferometric microscopy and compared successfully to numerical predictions. **(F1:7)**

The Effect of Cyclic Water Absorption on the ILSS of CF/BMI Composites

Y Luo, Y Duan, Y Sun, Y Zhao, S Du (Beihang Univ)

The moisture weight and ILSS of CF/BMI composites specimen of each stage during three absorption-desorption cyclical stages was tested. The results showed the ILSS of composites after water absorption dramatically decreased, but it could make a comeback on the whole after removal of water. **(F1:8)**

Ageing of Biopolymers Reinforced by Alterable Glass Fibers

N Pons, A Bergeret, J-C Benezet, L Ferry (Ecole des Mines d'Alès)

This study focuses on the ageing of biocomposites made by a natural biodegradable polymer (PLA, PolyLactic Acid) and soluble glass fibers. Evolution of mechanical properties was observed and degradation phenomena have been determined. Resistance to ageing was attributed to the interface degradation that is less damaged than the fibers. **(F1:9)**

Hot Water Degradation of Natural Fiber Reinforced SMC

M Nishiura, S Teraoka, M Sarata, M Okano, A Nakai, H Hamada (KIT)

In this study, the hot water degradation of the SMC in which reinforcement was jute cloth was evaluated. As a result, it was found that the fracture mechanism changed from the combination of crack propagation in matrix area and delamination in the interface around the fiber bundle to only crack propagation in matrix area by the water immersion. **(F1:10)**

Biodegradation Kinetics of Biopolymers and Biocomposites

J-C Benezet, N Pons, A Bergeret, L Ferry (Ecole des Mines d'Alès)

This study focuses on the biodegradation of biocomposites made by a natural biodegradable polymer (PLA, PolyLactic Acid) and innovative glass fibers. Evolution of PLA biodegradation kinetic was observed and degradation phenomena have been determined. Differences in biodegradation kinetic were attributed to the fiber nature. **(F1:11)**

Oxidation Degradation of GFRP

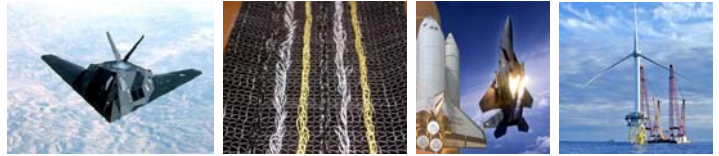
M Okano, A Nakai, H Hamada, Y Fujii (KIT)

In this study, the promotional experiment was executed to investigate a degradation behavior under high temperature, and bending properties of the GFRP with heating attack were examined. As a result, color change didn't show the decrease of strength change. **(F1:12)**

Time-Dependent Failure Criteria for Polymer Matrix Composites: A Review

RM Guedes (INEGI)

This paper reviews theoretical approaches for long-term failure analysis and discusses different time-dependent failure criteria to predict lifetime of polymer matrix composites. Actually, regarding engineering applications, the global and homogeneous analysis is more convenient. Fracture mechanics, damage mechanics and energy-based failure criteria are presented and illustrated with published experimental data. **(F1:13)**



Creep Behaviour of Epoxy/Clay Nanocomposite

T Glaskova, A Aniskevich (Univ of Latvia)

In the current study the peculiarities of creep behavior of epoxy/clay nanocomposite (NC) under effect of moisture are estimated. The viscoelastic properties of NC were investigated experimentally and their dependence on filler and moisture effect was determined. The obtained results of quasistatic tensile tests and creep tests were compared and effect of moisture and filler on NC and matrix properties was analyzed. **(F1:14)**

On Moisture Induced Viscoelasticity and Stress Analysis of a Single Fiber Composite during Ageing

M Lai, J Botsis, D Coric, J Cugnoni (EPFL)

The hygrothermal response of an epoxy is reported as function of average moisture uptake. The specimen used is a single fibre composite with axially located optical fibre that presents a Bragg grating sensor. Bragg grating strain data are compared with stress analysis accounting for moisture diffusion in the specimen. **(F1:15)**

Improved Procedure for the Determination of Tg in Advanced Composites by Dynamic Mechanical Analysis

GD Sims, SJP Gnaniah (NPL)

Thermal analysis techniques are used widely to characterise composite materials for material qualification. Dynamic Mechanical Analysis (DMA) is a particularly favoured and provides a fuller description of material behaviour. This paper seeks to provide a traceable procedure for Tg determination eliminating the heating rate dependent behaviour of DMA equipment. **(F1:16)**

Viscoelastic Stress-Strain Analysis during Moisture Uptake under Tensile Creep

AN Aniskevich (Univ of Latvia) RM Guedes (Univ of Porto)

Viscoelastic analysis of stress-strain state is performed for model epoxy polymer during moisture uptake under tensile creep. Comparison with elastic case is given. The effect of stress level and relative humidity of ambient atmosphere is analysed. **(F1:17)**

Determination of Time-Temperature Shift Factor for Long-Term Life Prediction of Polymer Composites

K Fukushima, M Nakada, Y Miyano (KIT)

The methodology for accurately determining the time-temperature shift factor used in the accelerated testing for the long-term life prediction of polymer composites is proposed in this paper. **(IF1:1)**

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