Accepted Manuscript

Analysis of the micro-cracking behaviour of carbon fibre reinforced flywheel rotors considering residual stresses

I. Koch, G. Just, F. Otremba, M. Berner, M. Gude

PII: S0263-8223(18)31023-7
DOI: https://doi.org/10.1016/j.compstruct.2018.07.130
Reference: COST 10048

To appear in: *Composite Structures*

Received Date: 15 March 2018
Revised Date: 5 June 2018
Accepted Date: 30 July 2018

Analysis of the micro-cracking behaviour of carbon fibre reinforced flywheel rotors considering residual stresses

I. Koch*; G. Just*, F. Otremba[#], M. Berner[+], M. Gude*

* Institute of Lightweight Engineering and Polymer Technology - ILK, Technische Universität Dresden, 01069 Dresden, Germany

[#] Stornetic GmbH, Stetternicher Staatsforst, 52428 Jülich, Germany

[+] Leichtbau-Zentrum Sachsen GmbH, Marschnerstr. 39, 01307 Dresden, Germany

Corresponding author: ilja.koch@tu-dresden.de

Abstract:

The main challenge in today's power grid management is the inclusion of renewable energy sources with inconstant energy production such as wind and solar plants and modern high technology fabrication or electric transportation with their uneven power consumption. For that purpose energy storage systems, such as high efficiency flywheels, with extraordinary cycle stability and charging-discharging rates are needed. Here carbon fibre reinforced composites play an important role as rotor material. In this study the cracking behaviour of helical layers of a cylindrical flywheel rotor is analysed under consideration of fabrication induced residual stresses and their viscoelastic reduction over long term storage. Based on static and fatigue experiments with crack counting inspections a finite fracture model is identified and calibrated for modelling the damage behaviour of flywheel rotors under cyclic loading.

Key words: flywheel, fatigue of composites, residual stresses, finite fracture mechanics

1 INTRODUCTION

Renewable energy resources such as wind and solar energy are characterised by inconstant availability. Additionally, the power consumption of the private and industrial sector is highly inconstant. Controlling and managing these contrary effects is a key challenge in the todays design and management of power grids. Besides the introduction of flexible gas power plants and the combination of different energy resources, energy storage systems have a significant share in solving this challenge. For compensating higher frequency fluctuations high efficiency flywheels may play an important role. Compared to other technologies, such as accumulators, flywheels are characterised by extraordinary cycle stability and high charging-discharging rates.

The working principle of flywheels is the energy storage in kinetic energy. For hollow cylindrical rotors, which are focussed here, the kinetic energy E_{kin} is given according to

$$E_{kin} = \frac{1}{2} J\omega^2 = \frac{1}{4} m(r_1^2 + r_2^2)\omega^2 \tag{1}$$

with J – mass moment of inertia, ω – angular velocity, $r_{1,2}$ - the inner and outer radius. The storage capacity is therefore defined by the mass in a linear and the angular velocity in a quadratic manner.