Acoustic Emission Measurement on Carbon Fibre Composites

Miroslav J. ČERNÝ

Centre for Composites, Klokner Institute, Czech Technical University in Prague; Prague, Czech Republic
Phone: +4202 24353584, Fax: +4202 24353519; e-mail: cerny@hppro.klok.cvut.cz

Abstract
Paper deals with an acoustic emission measurement on carbon fibre composites. Measurements have been performed on carbon-epoxy composites with unidirectional reinforcement by carbon fibres with approximately 64% volume content of fibres and epoxy matrix at tensile and shear loading. The applied acoustic emission system was PCI-2 (2 channel plug-in card, 18 bit resolution, sampling frequency max. 40 MSa.s⁻¹, Physical Acoustics, USA) and software MISTRAS (Physical Acoustics). It has been found that cumulative AE counts and events increase roughly linearly in time and the curve suddenly changes the slope in two points of whole loading range. Some failure micromechanisms have been correlated to AE measurements.

Keywords: Carbon fiber composite, acoustic emission

1. Introduction

Measurements have been performed on carbon-epoxy composites with unidirectional reinforcement by carbon fibres with approximately 64% volume content of fibres and epoxy matrix. The sheets from carbon-epoxy composites with 50x 1.2 mm cross-section were made by pultrusion technique.

Nowadays, in the majority of efforts to use AE in the direction of material characterization, a ‘conventional’ AE analysis is employed. It usually comprises the investigation of the AE activity in diagrams of cumulative hits (or counts) versus load (or stress) and the correlation of some AE features, such as amplitude or duration, to some basic damage mechanisms [1,2]. Our approach was to extend the method previously used on kevlar-epoxy composites [3], on carbon fibre composites [4].

2. Measurement

Set of specimens 15x 1.2x 200 mm have been cut in longitudinal direction of the sheet. The specimens have been subjected to tension in testing machine Instron 1273 (speed 1 mm.min⁻¹) up to final failure. Load, longitudinal and transverse strains have been measured and data collected by Hewlett-Packard system HP 3852. Transverse and longitudinal strains have been calculated from displacements measured by extensometers (Fig.1),(Fig.2). At the same time AE measurements have been performed by acoustic emission system AEDSP 32/16 (2 channel plug-in card, 18 bit resolution, sampling frequency max. 40 MSa.s⁻¹, Physical Acoustics, USA) and software MISTRAS (Physical Acoustics). AE sensors of type WD (wide band) have been used, preamplifier 1220A, gain 60 dB (both Physical Acoustics). AE sensors were attached to each specimen using suitable coupling agent and placed symmetrically onto the specimen along its longitudinal axis at a distance of 80 mm.

3. Results

Each AE signal is described by a seven component vector. These components, known as AE features, are measured real-time by the data acquisition system AEDSP 32/16 and they namely are: duration (DUR), counts (CNT), amplitude (AMP), counts to peak (CNP), risetime (RT), decaytime (DT), energy (E).
Additional AE features such as rise angle (RAN=AMP/RT), decay angle (DAN=AMP/DT), average frequency (AF=CNT/DUR), initiation frequency (INIF=CNP/RT) and others were calculated at a post processing level. Noise reduction of the main set of AE data is of major importance and high priority. AE signals were detected and stored in memory of PC computer. Cumulative AE counts, events and energy then have been calculated by software MISTRAS and shown in the Fig.3 as a function of the experiment duration.

It has been found that cumulative AE counts and events increase roughly linearly in time and the curve suddenly changes the slope in two points of whole loading range. Approximately in the same area the stress - strain (longitudinal load- displacement) curve slightly bends. Transversal displacements on the contrary have not shown essential changes. Correlation of both curves shows, that the initialization of matrix cracking occurs approximately in 60% of failure load- followed by fibre de-bonding about in 90% of failure load. Finally the failure occurs. Corresponding values for the set of all specimens have been
determined and related to the deformation and failure micro-mechanisms. Future research will be focused on the verification of results by the PR (clustering) method.

**Fig.3 Acoustic Emission Measurement**

4. **Conclusion**

Measurements have been performed on carbon-epoxy composites with unidirectional reinforcement by carbon fibres with approximately 64% volume content of fibres and epoxy matrix.

An analysis of load-displacement and AE cumulative curves show, that the initialization of matrix cracking occurs approximately in 60% of failure load, followed by fibre de-bonding about in 90% of failure load.

*This research has been supported by MŠMT grant No. MSM6840770015*

**References:**