Journal of Fiber Bioengineering & Informatics 5:3 (2012) 281–287
http://www.jfbi.org | doi:10.3993/jfbi09201206

Investigation on Damage Mechanisms of PE Self-reinforced Composites by Acoustic Emission Technology

Xu Wang [a,b], Song-Mei Bi [a,*]

[a] *Anhui Provincial Key Lab of Textile Fabric, College of Textiles and Fashion, Anhui Polytechnic University, Wuhu, Anhui 24100, China*

[b] *Key Laboratory of Advanced Textile Materials and Manufacturing Technology (Ministry of Education), Zhejiang Sci-Tech University, Hangzhou 310018, China*

Abstract

The purpose of this study is to investigate the damage mechanisms in UHMWPE/LDPE laminated by Acoustic Emission (AE) technique. Model specimens are fabricated to obtain expected damage mechanisms during tensile testing. Then, relationship among AE descriptors is studied by hierarchical cluster analysis, and AE signals are classified by k-means algorithm. Finally, an Artificial Neural Network (ANN) is created and trained by various optimal algorithms to identify damage mechanisms. The results reveal that typical damage mechanisms in PE self-reinforced composite can be classified in terms of the similarity between AE signals and identified by a well trained ANN.

Keywords: Damage Mechanisms; PE Self-reinforced Composite; Acoustic Emission; Clustering Analysis; Artificial Neural Network

1 Introduction

Acoustic Emission (AE) is a transient elastic wave generated from the rapid release of energy within a material or structure. AE technology has been widely used to investigate damage mechanisms including matrix cracking, fiber breakage, interface debonding and delamination. Kotsikos et al. [1, 2] reported low amplitude AE associated with matrix cracking of glass fiber/polyester laminates, intermediate amplitude associated with delamination and debonding, high amplitude associated with fiber fracture. Giordano et al. [3-5] established a correlation between AE and damage mechanisms by extracting the frequency of AE signals. These experiments showed a feasibility to identify damage mechanisms by AE features. However, it is a problem because a single damage mechanism can make a wide range of AE descriptors [6, 7]. To solve this problem, most researchers [8, 9] use pattern recognition methods to classify and identify AE signals. In recent

*Corresponding author.
Email address: bisongmei@hotmail.com (Song-Mei Bi).

years, Artificial Neural Network (ANN) has been widely used to identify AE signals. Huguet et al. [10-12] classified and identified AE signals in glass/polyester composite materials by ANN. Bhat et al. [13, 14] reported AE signals due to noise or material damage can be classified and identified by a well trained ANN.

In the present study, the classification and identification of AE signals due to damage mechanisms in PE self-reinforced laminates are studied. For this purpose, model specimens are fabricated to generate expected damage mechanisms. Then, AE signals due to typical damage mechanisms are classified by cluster analysis. Finally, the AE signals are identified by a trained two layer feed-forward ANN. The results reveal different damage mechanisms can be well classified based on the similarity in amplitude, duration and peak frequency, and identified by a well trained ANN.

2 Experimental

2.1 Materials and Specimens

The fiber and the matrix of PE self-reinforced composite laminates are Ultra High Molecular Weight Polyethylene (UHMWPE) fiber and Low Density Polyethylene (LDPE) resin, respectively. The density of UHMWPE fiber is 0.97 g/cm^3 and the density of LDPE is 0.92 g/cm^3. The tensile strength and modulus of UHMWPE fiber are 3 GPa and 90 GPa, respectively. Five model specimens (LDPE resin, [90°] laminate, single fiber composite, fiber bundle composite and [±45°] laminates) were fabricated by compression molding technique. According to differential scanning calorimetry (DSC, TA Instruments, Modulated DSC 2910), the melting temperature (T_m) of LDPE and UHMWPE fiber is about 112 °C and 147 °C, respectively. Therefore, model specimens were fabricated by compression molding at temperature of 120 °C, under pressure of 1.0 MPa for 10 minutes. All tensile specimens were cut into coupon with size of 180×20×0.8 mm^3.

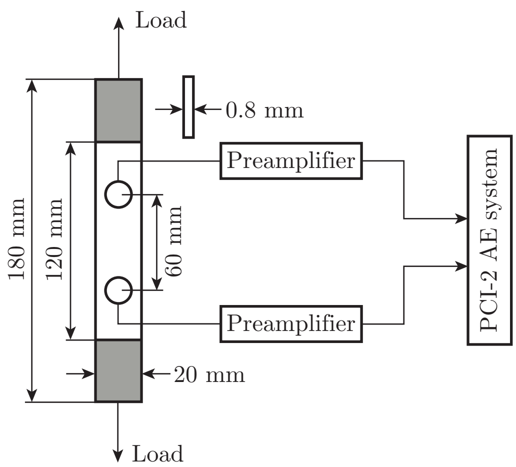

Fig. 1: The scheme of AE testing system