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ACOUSTIC EMISSION

A Procedure for Locating Acoustic-Emission Signals during Static Testing of Carbon Composite Samples

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Abstract—The results of static tests of specimens that were made from carbon fiber reinforced plastic with a honeycomb filler according to acoustic emission (AE) and strain-gauge measurement are given. When using the two-lag method, the stable locations of AE signals are obtained, which indicates the development of fatigue cracks. The dependences between the main informative parameters of AE signals and features of the destruction of a material are analyzed. According to strain-gauge measurement data, the values of the failure stress are determined.

Keywords: carbon fiber reinforced plastic, acoustic emission, two-lag coefficient, strain-gauge measurement, defect, location

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INTRODUCTION

Defects in objects that are made from composition materials (CMs) occur in both the course of their production and operation; this necessitates the improvement of the methods and tools for nondestructive testing (NDT) [1–4]. To perm quality control of composites, the ultrasound, acoustic-emission (AE), X-ray, radiographic, thermal-imaging, thermographic, optical, and several other methods are used [5–9].

The destruction of a structure that is made from CMs is preceded by the accumulation of damage at the structural level (fibers, layers, and inclusions); the causes of this can include cracks in the matrix, the breakage of strengthening fibers, and delayerings that are the consequences of impacts, overloading, and wear of a material, which decrease the strength characteristics [1, 2, 5]. In this case, the redistribution of stresses occurs in the composite of a reinforcing element or interface. The failure stresses in objects that are made from CMs are determined using strain-gauge measurements.

The AE method is valuable due to its high sensitivity and ability to locate a signal from defects that arise at the microlevel and the ability to automate measurement, as well as the recording and processing of information in the online mode. The principal informative parameters of AE signals include the rate of the rise of the leading edge, the amplitude and dominant frequency distribution depending on the time and stress, and the MARSE energy parameter, which is determined from the following ratio:

$$\mathrm{MARSE} = \int_t \overline{U}(t)\,dt,$$

where $\overline{U}(t)$ is the envelope of the AE signal.

After the processing of AE signals in measuring channels, the system forms the diagnostic features; for this reason, it is necessary to analyze the fine structure of a signal that contains information on the maintenance of a test object (TO). In this case, the AE system gives the integrated location pattern of an object, classifies the damage according to the flaw-hazard level, and can estimate the remaining lifetime of the object [5–9].

During the development of aerospace engineering structures, CMs based on carbon plastics that possess high strength are widely used [1, 5–8]. However, the anisotropic structure of carbon fiber reinforced plastic (CFRP) affects not only the strength and mechanical properties of a composite, but substantially complicates the AE signal waveform, which makes it more “diffuse” due to the violation of its frequency–time structure. In addition, during the strength tests of samples that are based on CFRP, various modes of