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STUDY OF THE EFFECT OF INTERPHASE INTERACTION ON THE FRACTURE OF A REINFORCING CARBON FIBER BY A SINGLE FIBER COMPOSITE TEST

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ABSTRACT

It is known, that the failure of a reinforcing fiber in the composite under tensile loading occurs according to its strength scale dependence on length. The extent of its fragmentation is determined by a level of adhesive interaction on the fiber - matrix interphase. In the given work experimentally it is shown, that there is an essential impairment of strength scale dependence at reaching length of filament fragments 150-200 micron. Evidently, that breaks of fiber with such lengths starts to be determined by not surface flaws, but more uniform structural one. The breaking of fragments with such length is accompanied by acoustic emission signals with high amplitude. The strength distribution of a carbon fiber changes a trend from monomodal to bimodal, owing to an electrochemical surface treatment. The second mode is realized only at a high level of adhesion between fiber and matrix. The surface fiber treatment leads to the sufficient narrowing of critical length distribution that also indicates the change of the nature of strength scale dependence.

Keywords: interface, carbon fiber, single fiber composite test, strength.

INTRODUCTION

It is difficult to overestimate the role of interphase interaction of reinforcing filler and polymeric matrix in composite. A great number of papers is dedicated to both the development of modes of surface treatments of fibrous fillers, modification of polymeric binders for strengthening of adhesive interaction, and investigations of interphase phenomenon. The most widespread and informative research technique is a single fiber composite (SFC) test. Rather a simple from technical point view method allows obtaining the diverse information on properties of fiber reinforcements, adhesion to a matrix, to estimate the effect of fiber surface treatments, of technological parameters and to predict elastic - strength properties of real composites [1]. The application of an acoustic emission to SFC test essentially enriches this method. The detailed analysis of the obtained experimental data allows better to understand the mechanism of composite fracture and to receive the information on structure of a reinforcing fiber. The given paper is a sequel of study of the effect of carbon fiber surface treatment on realization of their elastic - strength properties in a polymeric composite [2]. It is known, that the fracture of the reinforcing fiber in a composite under tensile loading is controlled by its scale strength dependence on length. The degree of breakdown of a filament in a model composite is determined by a level of adhesion interaction between fiber and polymer matrix. The number of breaks of an elementary fiber, determined on number of signals of an acoustic emission, is related directly to the average length of pieces. The dependence of number of elementary fiber breaks or average lengths of

pieces on stress (elongation) of a sample in log-log coordinates is linear up to some value l_k. After one there is a knee on the graph (Fig.1). During further deforming the process of fragmentation slackens, since for a part of fragments the adhesion interaction with a matrix breaks. There is the plastic shear on the interface of such pieces with a matrix. At the same time pieces with length more than their area of interphase shear continue to break. The gradual diminution of number of breaking fragments results in stopping of fragmentation at reaching some average length δ. The inequality of values l_k and δ testifies to existence of broad distribution of critical lengths. It is confirmed by direct measurements of lengths of pieces in samples with a transparent matrix [3]. The analysis of the experimental data of SFC tests and shear strength of actual composites has allowed the authors to recommend the l_k as value of critical length for estimation of adhesion strength [3]. However determination of critical length and strength scale dependence of fibrous reinforcement does not exhaust at all the resources of SFC test due to application of an acoustic emission. In the given paper it will be shown how to determine strength of fiber with lengths close critical and on what the length the strength of fiber tends to «flawless» fiber one. The enriching of interphase interaction will be directionally used for the investigation of basic properties carbon fibers.

RESULTS AND CONCLUSION

In the present study it has experimentally shown, that weakening of strength scale dependence occurs at reaching length of pieces 150-200 microns. Obviously, that the fracture of a fiber with such lengths starts to be determined by not *surface* flaws, but more uniform structural one. The breaking of fragments with such length is accompanied by signals of an acoustic emission with high amplitude. The strength distribution of a carbon fiber changes a trend from monomodal to bimodal, owing to an electrochemical surface treatment. The second mode is realized only at a high level of adhesion between a fiber and matrix. Thus, the directional change of a degree of interphase interaction has allowed approximately to determine a level of structural strength and maximal length of fiber, on which one this strength is realized. It is possible, that for more perfect fibers, than UKN-01, this length will be more than 200 microns.

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