Physical-Mechanical Model of Fibrous Polymerized Bar Deformation at the Neck Zone

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ABSTRACT

In the paper the author suggests a model of mechanical deformation of a polymerized bar made of fibres in the neck with regard to forces interacting with a matrix. In the paper, the author suggests an experimental-theoretical method that allows one to define the character of deformation non-homogeneity in the neck area. In particular, analytic dependence of mechanical properties of the material on longitudinal coordinate of the sample is established. Numerical comparison of theoretical results with experimental ones is given.

Keywords: Adhesive Strength, Cross-Sections of Neck Along The Length, Neck in Composite Material, Non-Homogeneity, Polymerized Bar Made of Fibres

INTRODUCTION

Adhesive strength of a composite material is connected with interacting forces in the contact area between reinforcing force fibrous structure and a binding material. The binding medium itself also renders essential influence on the character of mechanical deformation of fibrous structure in a binding medium. Therefore, it is necessary to know the model of mechanical deformation of a polymerized bundle-like body with respect to forces interacting with a matrix, in particular if a bundle has necking.

The necking arising in structural elements made of visco-plastic, elastico-plastic or visco-elastic materials is as follows. The experiments on simple tension of samples made of plastic metals show that starting with some moment, the deformed state of the smooth part of the sample stops to be non-homogeneous. The arising deformation is concentrated on some not large area of the sample. This narrowed area is called “a neck”. The following questions are of scientific interest: 1) in what form will be the physico-mechanical dependence between the stress and deformation at the neck zone points; 2) in what form will be the stress-strain state at the points of the area of the neck zone. Up to day, the scientific investigations were carried out mainly on the second theme; i.e. on studying the stress-strain state of the structural elements at the necking zone points. These investigations were carried out at the initial period of necking. In other words, at the moment of collapse of...
homogeneity, the model of mechanical deformation of the material is accepted as before necking. A.A. Ilyushin first investigated the neck phenomena in such a statement. He first gave statement of the problem on stability of visco-plastic flow of a strip and a bar; differential equations and boundary conditions of the problem for defining visco-plastic plane-parallel flows were composed. Complexity of this problem was connected with the Lagrange method for describing the motion of continuous medium (Ilyushin, 1940; Ilyushin, 1943; Ilyushin, 2011). Using the method based on the Euler way of description of medium motion, A. Yu. Ishlinsky used the visco-plastic flow of a strip and a bar (Ishlinsky, 1943). Zhukov A.M. considered a problem on stress strain state at the neck zone of a strip and a bar made of elastico-plastic material. They gave numerical comparison of theoretical results with experimental ones (Zhukov, 1949). A number of scientists carried out experimental investigations on finding true stresses at the neck zone, i.e. the stresses with regard to change of the cross section area at the neck zone. They also analyzed the character of the arising deformation inhomogeneity of the tested materials (Siebel, 1944; Davidenko, & Spiridonova, 1945; Sachs & Lubahn, 1946; MacGrefor, 1944).

In 1970-2000 the necking phenomenon got a new heightened scientific interest. This was connected with appearance of laminated and composite materials made on the base of polymers. One of the important problems in strength of laminated and composite materials is the provision of adhesive strength between the layers of the material. This directly depends on the character of necking in the area of contact of heterogeneous materials. A cycle of experimental investigations on studying the interlayer failure mechanism in laminated and composite materials was performed. Creation of some criteria of adhesive strength in laminated and composite materials (Ogibalov & Suvorova Yu, 1965; Korten, 1967; Aliyev, 1987; Ogibalov, Malinin, Netrebko, & Kishkin, 1972). Aliyev G.G. has created a generalized conception of composite materials mechanics with regard to arising interacting forces between the elements of the composite. He has suggested a more precise hypothesis of adhesive relation between the layers (Aliyev, 1984; Aliyev, 1987; Aliyev, 1998). A new theory of strength, stability and vibration of laminary-reinforced flexible thick-walled pipes and thin-walled shells with regard to arising forces interacting between the elements of the composite has been created on this base.

However, the problem on definition of the mechanism of appearance of deformation non-homogeneity at the neck zone and also establishment of physico-mechanical dependence between the stress and deformation at the neck zone points has not been solved to day because of its complexity. At present this problem belongs to the unsolved problems of continuum mechanics.

Aliyev G.G. (2011) first suggested the appearance of deformation non-homogeneity mechanism at the neck zone, and representation one of the models of physico-mechanical dependence between stress and deformation at the neck zone points. He suggested an experimental-theoretical method on the base of which it was established that the character of deformation non-homogeneity at the neck zone is linear with respect to longitudinal coordinate.

In the considered paper, an experimental-theoretical method that allows to establish the character of deformation non-homogeneity at the neck zone is suggested. In particular, the analytic dependence of mechanical characters of the material on longitudinal coordinate of the sample is established.

**METHOD**

In the paper, we suggest a physical-mechanical model of deformation of a polymerized bar made of fibres at the neck area with regard to arising forces interacting with a binder under the following assumptions:

- The cross-section area of a bar made of fibres at the neck zone is a function of longitudinal coordinate $x$. The cross-section area has the form of the area of a circle,
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