MODEL OF THE INFLUANCING OF SIZES ON FATIGUE LIFE OF SHEET DETAILS FROM AN ALUMINUM ALLOY

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Key words: fatigue, scale, statistical factor, model

In science about strength of structural materials the fact of influencing of a detail absolute sizes on its longevity for a long time is known at variable stresses. The numerous attempts were undertaken to give satisfactory explanation of this appearance, and as defining reasons the scale and statistical factors were advanced. The models, constructed on this basis, of a germing of a fatigue failure in the series of cases well agreed with outcomes of experiments. However, the universal model usable to different materials and details from them, is not obtained till now. In opinion of the authors, the reason it mainly is connected to an irregularity of the indicated models or incorrectness of their application.

In the present report the outcomes of special experiment on the fatigue which has been carried out on sheet specimens from an aluminum alloy with a system of circle orifices are analyzed. Five groups of specimens was tested. These were distinguished by an amount and size of orifices. The data of this experiment have a large volume and are a good input information for realization of the analysis of a considered appearance. The tendered model of a germing of a fatigue failure in essence does not differ from many known, i.e. guesses as the base scale and statistical factors. The following initial premises are put in the fundamentals of model:

1. For the given material, condition of an intermediate product, technological methods of manufacture of a detail, quality of handling of its surface there is some elementary area A_0 , which one is structural unit, defining fatigue strength of details under the indicated conditions. The fatigue life N up to a germing of a crack distribution law $F_0(N,\sigma,G)$ on such area depends only on cyclical parameters of the first principal stress σ for and its relative lapse rate G in a direction of a normal to a surface.

2. The fatigue life N up to a germing of a turnpike crack distribution law $F(N,\sigma)$ in some critical range of a detail at a given level of rated load is determined on the basis of model of the "weakest" link.

Thus, the fatigue life N up to a germing of a turnpike crack distribution law $F(N,\sigma)$ in some critical range of a detail at a given level of rated load is determined under the formula

$$F(N,\sigma) = 1 - \prod_{i=1}^{n}\left[1 - F_0\left(N,\sigma_i,G_i\right)\right], \tag{1}$$

where parameters n, σ_i, G_i is set by results of the analysis of a state of stress in a considered zone of a detail.

In the report the comparison of calculated estimations of distribution parameters of fatigue life with obtained in the circumscribed experiment is given.

TEORETICAL MODEL OF FRACTURE OF A THIN UNIDIRECTIONAL FILAMENTARY COMPOSITE

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Key words: model, fracture, filamentary composite

Some hypothetical model of the flat isolated layer of a unidirectional filamentary composite with regular structure is constructed. In this purpose the integro-differential equation for the definition of the fiber axis force is got.

The infinite elastic plate by width δ with elastic constants of an original material (a matrix) E and ν, reinforced thin straight-line fibers with a modulus of elasticity E_0 and cross-sectional area A_0 in cross-section which was removed enough from a zone of fracture is considered. The fibers of infinite length are parallel among themselves with distance among them L. It is supposed, that one of fiber in cross-section *(0,0)* is torn and on a segment $/x/ \leq \pm a$ there is its delaminating from an original material. The stress in infinite part of a plate are $\sigma_{x\infty} = \sigma, \quad \sigma_{y\infty} = \tau_{xy\infty} = 0$.

According to the scheme of loading of an elementary segment of a fiber with number i aggregate intensity of force interaction $g_i(x)$ of this fiber with a matrix. From an equilibrium condition follows

$$\frac{dp_i}{dx} = g_i(x), \tag{1}$$

If ordinate of a point, in which one is considered interaction of a fiber and plate $y_i = iL$, where $i = 0, \pm 1, \pm 2, ...,$ that in a point with coordinates x, y_i on a plate acts an elementary concentrated force $dX_i = g_i dx, dY_i = 0.$

From a consistency relation of a strain in a final kind the following integral-differential equation for definition of forces in fibers can be obtained

$$k\int_{\Gamma} K(x,y,\xi,\eta)p'(\xi)d\xi = 1 - p(x), \tag{2}$$

where $k = \dfrac{E_0 A_0}{\mu\sigma}$, and $\Gamma = \sum_{i=-\infty}^{\infty} \Gamma_i$ is a line of a contact of fibers with a plate.

The main attention is given to study of passing of fracture after a rupture of one fiber that calls a sharp redistribution of the stresses. In the total it become potentially probable fracture of adjacent fibers because of a increase of load on them, shear on an interface of a fiber and matrix, and also cracking of a matrix. It is shown that the growth of layer fracture completely defines the fiber strength, the crack resistance of matrix material at normal rupture and transversal shear, but also the adhesion strength at transversal shear in interface “matrix – fiber”. Sufficient conditions of applicability of brittle fracture Rozen’s model is shown.

DETECTION OF A FATIGUE CRACK BY METHOD OF AN ACOUSTIC EMISSION

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Key words: acoustic emission , fatigue, fracture, reliability

At usage of a method of an acoustic emission (AE) for a state estimation of a material at variable stresses in laboratory experiments or under operating conditions in essence relevant value there is a problem of reliability of conclusions using the restricted information. It is known, that the existing methods of diagnostic using the data AE allow to give a reliable enough inference about development of processes of deformation and fracture after full completion of trials, i.e. to conduct the retrospective analysis. The prognosis using the restricted information, arranges which one the spectator during trials, is much less reliable. It is connected mainly to strong statistical dispersion of intensity of signals AE.

The purpose of the present report is the definition of connection between an information content about AE and reliability of a conclusion about appearance of a turnpike fatigue crack.

By results of the earlier carried out experiments the following main regularities of development of process AE are defined:

1. At a stage before appearance of a turnpike fatigue crack the process AE has concerning small mean intensity and large statistical dispersion.

2. During formation of a turnpike fatigue crack the intensity of process AE will increase sharply. But the duration of this stage is rather small.

3. After completion of shaping of a turnpike fatigue crack the intensity of process AE is sharply decreased, but its mean value essentially exceeds similar performance at a stage before appearance of a crack.

The following scheme of organization of engineering diagnostic of a condition of a material is considered. During experiment a line of values of intensity AE is obtained $\dot{N}_1, \dot{N}_2, ..., \dot{N}_k$. In following measurement the value of intensity AE is obtained $\dot{N}_{k+1}$. Under the introduced information it is necessary to draw a conclusion about availability or lack of a turnpike fatigue crack, i.e. from the mathematical point of view the task of a test of hypothesis takes place.

Under the data of experiments on a fatigue with fixation of process AE the attempt of a system log-on between an information content and error probabilities of the first and second kind is made.

CONDITION OF CONSERVATION OF RADIAL TIGHTNESS IN CILINDRICAL JOINT

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Key words: conservation, radial tightness, cylindrical joint

The task about conservation of radial tightness in cylindrical joint obtained by statement of elastic including in a circle orifice in a sheet is considered. Tightness will be derived or because of plastic deformation at the installation of an including, or at the expense of greater radius of including in a reset state as contrasted to in radius of an orifice. The material of a sheet is supposed isotropicly elasto-plastic. After statement of including between units of joint there is a pressure $\boldsymbol{p}$ of contact interaction and residual stresses $\boldsymbol{\sigma_{res}}$ in each of details. These stresses also are a main factor, defining increasing of a fatigue strength of joint.

If at the active load on a sheet and an including is rather small, the field of stresses and strains does not vary, and their quantitative performances are determined by a solution of the appropriate elastic task, and the connection between environing $\boldsymbol{\sigma_\theta}$ and radial $\boldsymbol{\sigma_r}$ by contact stresses (in a long of the first principal stress on perpetuity) is determined under the formula

$$\sigma_\theta = \sigma_r + \frac{\beta}{\pi}\left[(3-\nu)\Gamma_1 - Q\right] + 1 + \gamma - 2(1-\gamma)Cos\,2(\theta-\varphi), \qquad (1)$$

where ν - Poisson's ratio, $\beta = \dfrac{Sin\,\theta^*}{1-Cos\,\theta^*}$ and θ^* - central angle of contact surface, θ - polar angle of a point of a contact surface, γ - ration of the second and first principal stresses on perpetuity, φ - angle between a direction of an including force and first principal direction. The parameter Γ_1 is a linear combination of principal stresses on perpetuity, and $\boldsymbol{Q}$ - function from a force on the including.

From the formula (2) it is following, that the maximum shearing stress in points of a contact surface at a given external loading is determined only by size of a contact surface, which one in turn depends on pressure of interference. With a decreasing θ^* this stress will increase. Thus, if an active load is large enough, in the most stressing areas there are adding plastic stains changing character of a stress distribution. In particular, the magnitude of contact surface pressure is decreased, the distribution of residual stresses and field of stresses from an active load varies.

Thus, the condition of preservation of radial tightness in joint looks like the following

$$\sigma_{\vartheta res} + \sigma_\theta - \sigma_r = \sigma_{\theta res} + \frac{\beta}{\pi}\left[(3-\nu)\Gamma_1 - Q\right] + 1 + \gamma - 2(1-\gamma)Cos\,2(\theta-\varphi) \geq \sigma_y, \qquad (2)$$

where $\boldsymbol{\sigma_y}$ a yield point of a material of a sheet.

The numerical parametric analysis of implementation of a condition (2) is carried out.