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Issue Article

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# INVESTIGATION OF CRACK GROWTH IN STRUCTURAL STEEL

***Abstract***: *The analysis of the change in the crack growth rate from the crack length in a loaded steel specimen is performed in the article. It is noted that with increasing crack length in the material, the crack growth rate decreases.*
***Key words***: *crack, stress, specimen, volumetric strain.*
***Language***: *English*

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**Introduction**

The fatigue phenomenon is typical for cyclically loaded metallic materials and polymers [1]. The magnitude of the forces acting on the contact surfaces of machine parts during operation is constantly increasing due to changes in the geometry of the surfaces caused by wear. The fatigue of the material is accompanied by the gradual formation of cracks in it, which increase the risk of failure of machine parts [2].

Some works [3-10] have been devoted to the study of fatigue of metallic materials, in which the theoretical aspects of the phenomenon of the metal fatigue under cyclic loads were considered and laboratory experiments were performed to confirm the theory, including finite element modeling in special applications. However, the analyzed scientific papers do not contain studies on the stress state of the material and the rate of crack growth in the plane of damage formation. These results will allow us to obtain analytical dependences describing the mechanics of metal fracture under cyclic loading.

**Materials and methods**

The crack formation analysis was performed for the steel specimen in the form of a plate, which was subjected to stretching. The width and length of the plate were 150 and 450 times the thickness of the plate, respectively. A repeated force was applied to the plate until the crack length was 1/4 of the plate width. Structural steel with the following physical and mechanical properties was used as the plate material: Young's modulus – 206000 MPa, Poisson's ratio – 0.3, density – 7850 kg/m$^3$. To calculate the rate of fatigue crack growth in steel, the coefficient of Paris' law of $1.4\times10^{-11}$ and the exponent of Paris' law of 3.1 were set.

**Results and discussion**

The calculated magnitudes of the deformed specimen material were determined in the area of the formed crack. The von Mises stress and volumetric strain of the material were recorded in the plane of crack formation.

The dependence of the volumetric strain on the von Mises stress of the specimen material is shown in the Fig. 1. The dependence of the crack length on the crack growth rate in the specimen is shown in the Fig. 2.

An increase in the calculated von Mises stress magnitudes from 16 MPa to 28 MPa is characterized by an active phase of crack formation along the width of the steel specimen. At the same time, the change in the initial volume of the material from the volume of the deformed specimen is insignificant and amounts to the volumetric strain coefficient of 0.000007. A decrease in the calculated von Mises stress magnitudes according to the dependence was noted on the remaining undisturbed width of the specimen.

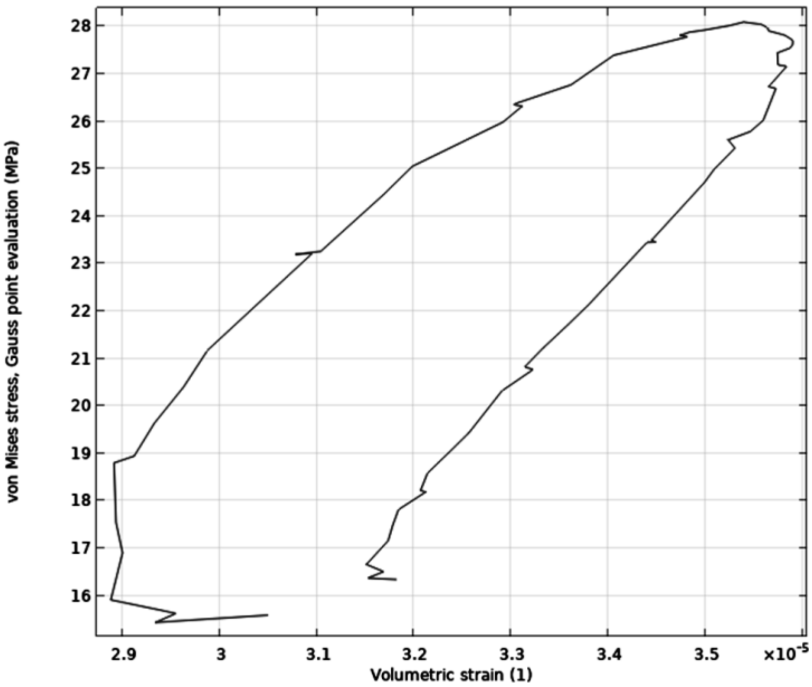


**Figure 1. The dependence of volumetric strain on the von Mises stress of the specimen material.**

The dependence in the Fig. 2 shows that the crack growth rate in the steel specimen decreases with increasing the crack length. It is noted that at the beginning of crack formation, the crack growth rate is the highest in magnitude. As the crack length increases, the crack growth rate decreases dramatically. At 1/2 the length of the formed crack, the crack growth rate becomes almost constant.

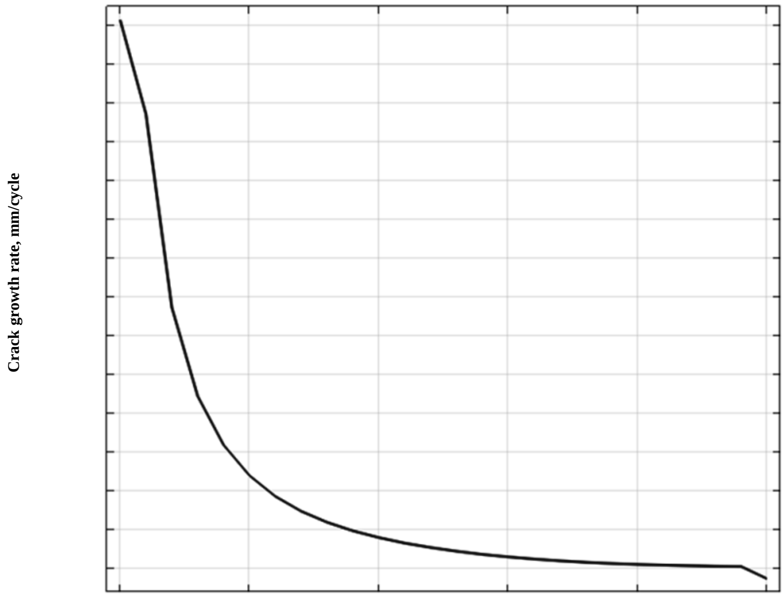


**Figure 2. The dependence of the crack length on the crack growth rate in the specimen.**

**Conclusion**

Based on the results of the calculation of the fracture process of the steel specimen, the following conclusions were obtained:

1. During the formation of a long crack, the stress of the material in the fracture zone increases almost twofold, while the coefficient of volumetric strain varies in a small range from 0.000029 to 0.000036.

2. As the crack length in the steel specimen increases, the crack growth rate decreases. The crack growth rate decreases dramatically when short cracks form.

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