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ANALYSIS OF SOME DAMAGES OF CLAMP-FORMING MACHINE BOOM CARRIAGE

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Abstract. The task of assessing the durability of the elements of the boom section of the clamp-forming machine, made from a 45×45×5 mm angle is considered. This object is modeled by a plate with a crack. Analytical relations are given and the stress intensity coefficients and their rate of change near potentially possible crack-like defects are investigated. The criterion crack lengths are determined based on the results of experimental studies.

Keywords: clamp-forming machine, boom carriage, fatigue crack, durability.

Reliable and safe operation of various equipment is anurgent problem. Planned operation resource of the equipment is exhausted and in recent years there appear more more and more damages of various nature. As it is known, the design of structural elements for their functioning in the present conditions of operation loads is performed on the basic of continuum mechanics approach. However, each structural element always possesses certain imperfections. Formed both at the stage of it's manufacture and at the stage of further functioning. In this connection, to provide reliable and trouble-free operation of the equipment, quantitative approaches to assessment of the degree of the danger at the detected crack like defects are necessary. [1]

Also, methods of express-analysis are needed, these methods, proceeding from the data of non-destructive control or information, regarding the state of the studies surface of the material, will be able to evaluate the particular defects and residual resource of structural element or structure in general. [1]

In [1] the analysis aimed at determination of corrosion-cyclic crack resistance of profile steel (steel 3) of 45×45×5 mm angle of operated clamp-forming machine БУМ-65М2Б3-К type frame has been carried out. However, the results of the research do not give a clear answer regarding further evaluation or durability of this construction element. For such assessment the given paper contains analytical relations for stress intensity factor (SIF) K_1 and their change rate dK_1/da near a size crack tip in the plate used for modeling of the investigation clamp-forming machine (fig. 1). Along with this, on the basis of experimental research, presented in [2] critical values of crack depth were determined with quarterelliptical corner crack.

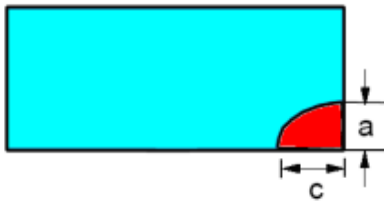

Fig. 1. Quarterelliptical corner crack:
a – length of the crack; c – its width

$K_{I\,a} = K_{\varphi}$ ($\varphi = \pi/2$); where K_{ϕ} is function of a.

It should noted that the crack is set by various ellipse like figures, by changing the relation of ellipse axes of crack like defect of different geometry.

In the research corresponding dimensions less dependences for the considered cases form and location on the basis of the given analytical relations and constructed: $\frac{\sqrt{t}}{\sigma}\frac{dK_I}{da} = F\left(\frac{a}{t}\right)$, where t – size of structural element in the direction of crack propagation; σ – applied load,.

That is why, in further study of the result of research, we will introduce variable parameter $(a/t)^*$ that characterizes the effective size of the defect.

It should be noted that characteristic feature of this dependences is that certain value of the parameter $(a/t)^*$, is always observed on them, starting from this value sharp increase of stress intensity coefficient K_I change rate takes place. This value$(a/t)^*$ was considered as characteristic one for assessment of the strength and reliability of structural elements with crack like defects.

For determination of the characteristic values of the crack length in the studies of structural elements experimental base and analytical relation, described by Paris power dependence, was used $\frac{dc}{dN} = C(\Delta K)^n$, where C and n – constant characterizing system "material-environment" (table 1).

Table 1. Constants of "material - environment" and the criterion values of SIF

System "material-environment"	Constants ofsystem "material-environment"		ΔK_{th}	ΔK_{fc}
	C	n		
Exploited				
Air R = 0.1	2.50E-13	3.87	4.703	28.026
Air R = 0.6	1.28E-11	2.76	2.106	25.729
Corrosion R = 0.6	1.42E-10	1.88	0.83	32.714
Air R = 0.75	1.99E-13	4.85	3.605	14.979
Corrosion R = 0.75	4.71E-11	3.14	1.271	11.47

Values ΔK_{th} and ΔK_{fc} given in the Table 1 were the base for determination of the characteristic values a_{th} and a_{fc} correspondingly. Along with these values obtained on the base of experimental data processing, values of a^* were calculated using the technique [8] that corresponds to characteristics value $(a/t)^*$. Also, its should be noted that in the investigated angle of clamp-forming machine frame 45×45×5 mm it was taken into consideration is the parameter of 5 mm angle, all further calculations are given for this case, when the crack propagates perpendicularly to the main axis of this parameter.

Assessments of the durability of the investigated element of the construction with potentially possible crack like defects of various forms and geometry is performed on the base of the relations: $N_{fc} = \int_{a_{th}}^{a_{fc}} \frac{da}{F(\Delta K_I)}$ and $N_* = \int_{a_{th}}^{a_*} \frac{da}{F(\Delta K_I)}$, where N_{fc} – number of load cycles prior to destruction of structural elements; N_*, is calculated during this period crack like defects achieves characteristic size a_* starting from which the rate of SIF K_I change rapidly increase.

mm are given in Table 2.

Table 2. Data for calculating of the durability of clamp-forming machineframe angle

	System "material - environment"	a_{th}. mm	a^*. mm	a_{fc}. mm	N^*. loadcycles	N_{fc}. loadcycles
Model № 5 (*a/c=0.1*)	Air R = 0.1	0.33	2.18112	2.9	2.55968E+9	2.58262E+9
	Air R = 0.6	0.06		2.76	1.32074E+9	1.33582E+9
	Corrosion R = 0.6	0.01		3.14	6.31235E+8	6.5642E+8
	Air R = 0.75	0.2		1.87	1.2519E+9	1.25295E+9
	Corrosion R = 0.75	0.02		1.42	4.53023E+8	4.53771E+8
Model № 5 (*a/c=0.4*)	Air R = 0.1	0.44	1.89196	4.79	3.16376E+9	3.40914E+9
	Air R = 0.6	0.08		4.44	1.6599E+9	1.75638E+9
	Corrosion R = 0.6	0.01		4.99	8.17629E+8	9.16876E+8
	Air R = 0.75	0.26		2.66	1.64067E+9	1.66308E+9
	Corrosion R = 0.75	0.03		1.95	5.36172E+8	5.44873E+8

From the results, obtained in the table, its seen that corrosion environment greaten influences the durability of the investigated structural element.

On the basis of experimental research criterial value of SIF for the steel 3, used for manufacturing of clamp-forming machine frame angle 45×45×5 mm is determined. Applying analytical relations for SIF characteristics value of crack like defects length, that may take place in the considered frame construction are calculated. Engineering calculations for assessment of the given object durability are suggested and presented with modelled crack like defects on the base of load cycles number.

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АНАЛІЗ ДЕЯКИХ ПОШКОДЖЕНЬ СТРІЛИ БУРТОУКЛАДНИКА

Анотація. *Розглянуто задачу оцінки міцності елементів стріли буртоукладника, виготовлених з кутника 45×45×5 мм. Цей обєкт моделювався за допомогою пластини з тріщиною. Наведено аналітичні співвідношення та досліджено коефіцієнти інтенсивності напружень та швидкість їх зміни поблизу потенційно можливих тріщиноподібних дефектів. За результатами експериментальних досліджень визначено критеріальні довжини тріщин.*

Ключові слова: буртоукладник, стріла буртоукладника, втомна тріщина, довговічність.

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