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INFLUENCE EVALUATION OF THE VIBROPROTECTIVE DEVICES PARAMETERS ON THE CRACK INCREASE IN THE DRILLING STRING

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Summary: *This paper presents the influence evaluation of the vibroprotective devices parameter (VDP) on the fatigued crack increase in the drilling string section on the basis of developed mathematic model. It has been got the dependence for the stress intensity factor from the vibroprotective devices parameter as well as operating mode of the drilling string. It favors to prevent the accidents and determine the remaining life of the damaged element.*
Key words*: drilling string, vibroprotective device, stress intensity factor.*

While drilling the oil and gas wells with rolling cutter drilling tools the impact loads and vibrations appear. It causes the decrease of durability of drilling strings and ground equipment elements. Due to the experience and practice it is known that the pipe with the fault like crack is serviced longer. That is why when determining the servicing reliability it should be known the regularity of appearance and development of the fatigued cracks. But for all that it must be considered that the dynamic loads have the ascendancy on the fatigued damage.

The efficient method of dynamic drilling practice optimization is the wind-proof devices installation in the drilling string. It favors the increase of technical-economic indices and the protection of rock-destroying tool and other elements of string as well as damaged.

On the basis of elaborated mathematic model of the drilling string with crack under sonic fluctuations [1,2] let's carry out the research on parameters affect of wind-proof devices on the fatigued crack increase. We admitted that the deflected mode on the top of the crack is fully determined by the stress intensity factor (SIF). According to the accidents analysis the crack widens in the same plane which is perpendicular to the operating load.

To carry out the mathematic experiment it was chosen the following mounting of drilling string: bit III 295,3 C – GNCh, vibroprotective device, drilling pipes OBT – 160 m, drilling pipes TBVT - 140*11 – 1640 m, drilling rig Uralmash ZD. The basic necessary parameters while calculating are the following: the given mass of movable parts of tackle systems M_m = 9855 kg, ropes rigidity of tackle system k_o = 53·106 N/m, ropes damping factor of tackle system $\alpha_0 = 5 \cdot 10^3 \frac{\text{N}\cdot\text{s}}{\text{m}}$, material density of pipes $\rho_{cm} = 7850 \frac{\text{kg}}{\text{m}^3}$, Yunga's module $E = 2{,}06 \cdot 10^{11}$ Pa, Poisson's ratio ν = 0,3, mass of running meter of pipes for the first

section ρ_1= 204 kg, for the second section – ρ_2= 36,8 kg , square of cross-section are respectively equal: A_1 = 0,026 m^2, A_2= 0,004 m^2.

The parameters of drilling practice are the following: constant load on the bit P_{st}=120kN, speed of rotations $\omega_0=2\pi c^{-1}$, thickness of cleasing liquid ρ_{pr}= 1200 $\frac{kg}{m^3}$ In case of necessity the model allows to change the stem assembly and choose the correspondent drilling practice.

The characteristics of VDP were changed ranging from $0{,}8\cdot10^7$ $\frac{N}{m}$ to $3{,}5\cdot10^7$ $\frac{N}{m}$ under constant viscosity $\acute{\alpha}_a$.

The given model allows to change the seating of vibroprotective devices parameters. It has significant importance as the experience and investigations of some researchers showed. Instead of fluctuations suppression it can be the converse effect. It means the increase of their intensity that can lead to the objectionable result. Thus besides the influence of ka it has been considered the seating of vibroprotective devices parameters.

As it was mentioned above the stress intensity factor was investigated. If it is known the increase of fatigued crack kinetics can be predicted. The analysis of the results shows that by choosing the vibroprotective devices parameters the dynamics of drilling string can be coordinated as well as the cracks development can be ceased.

With the speed load increase the wave processes begin to develop increasingly. It causes the cyclic re-allocation of loads (including the change of sign). In its turn it causes the decrease of link between the damaged element and environment and it starts operating like independent object the processes of damaged in which are localized and autonomous. The pipe with crack gets stable equilibrium that in its turn is apparently connected with the defect increase as a result of numerous reflections and interference of pressing and stretching waves if there is a yielded region at the top of crack.

The results of the research are shown at figures 1-3.

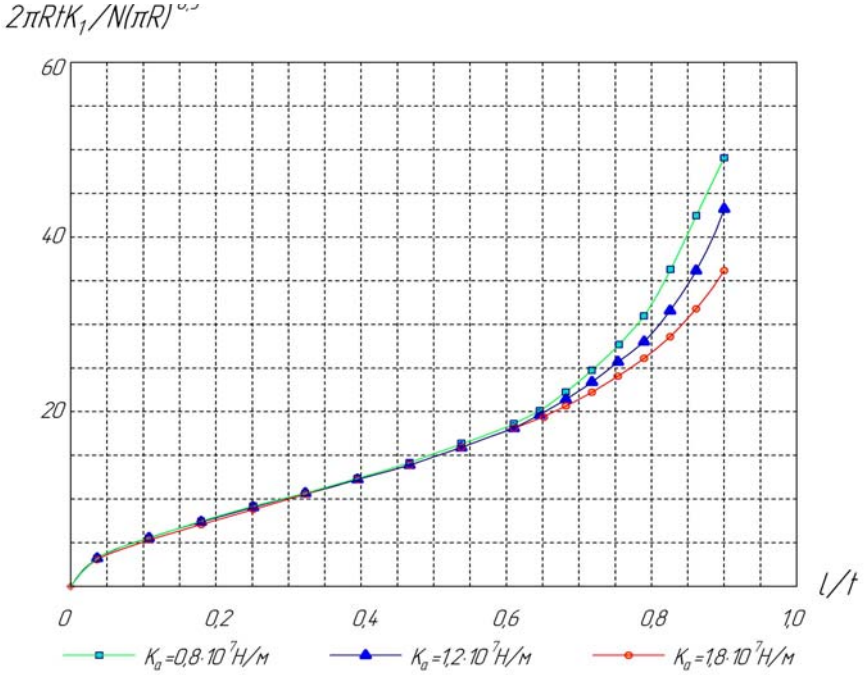

Figure 1 The dependence of given stress intensity factor from the ratio of crack depth l to the pipe thickness at different rigidity of vibroprotective device.

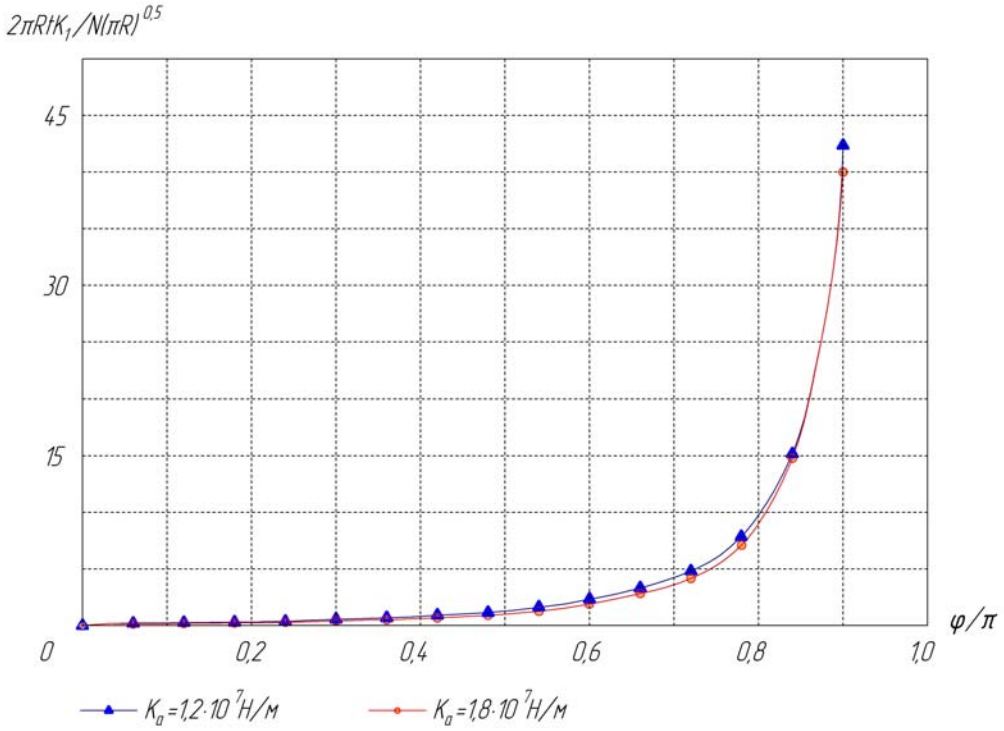

Figure 2 The distribution of given stress intensity factor along the front of the crack at different rigidity of vibroprotective device.

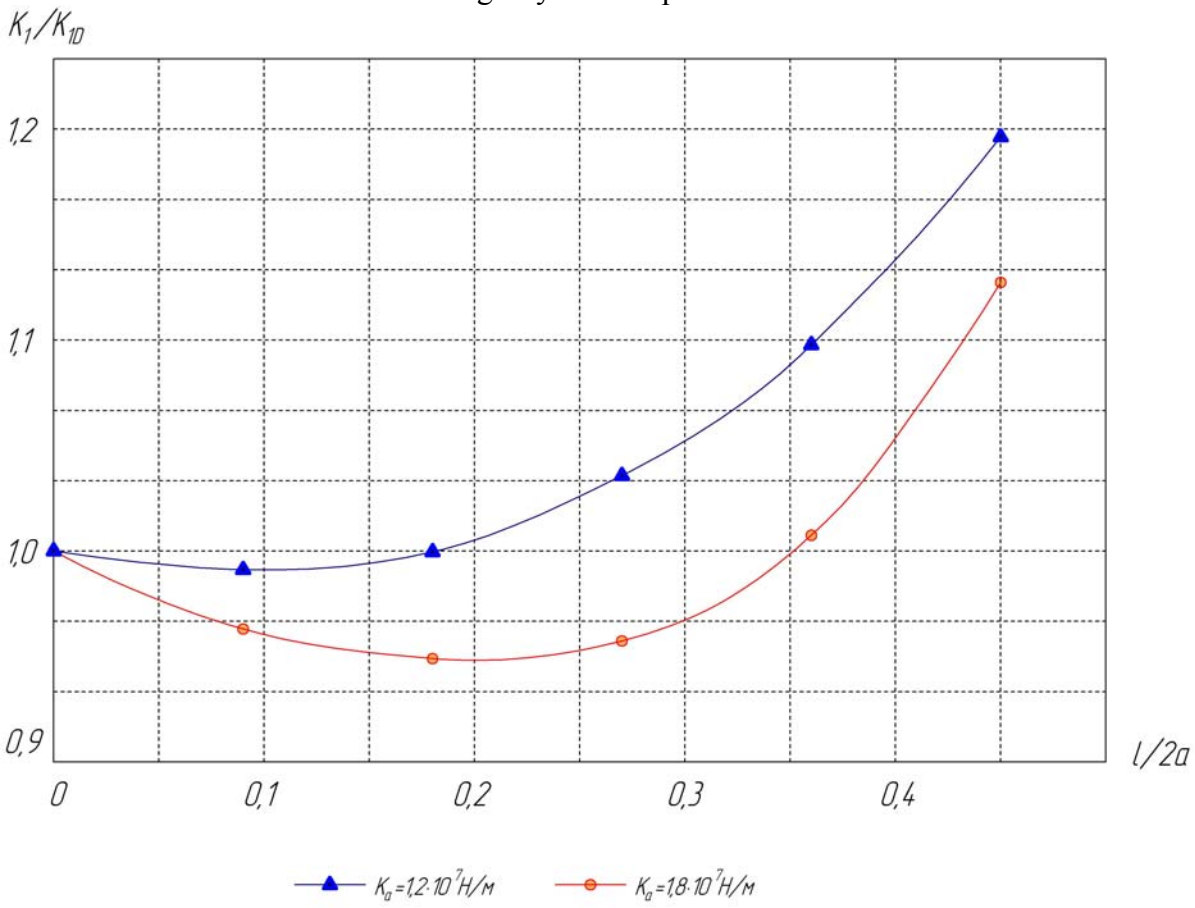

Figure 3 The ratio of static SIF to dynamic SIF depending on configuration of crack at different rigidity of vibroprotective device.

Comparing the received results with the industrial and laboratory research the following conclusions can be made.

1. When changing the rigidity of vibroprotective parameters the increase of fatigued crack can be stabilized that is to bring it to the stable condition and the given pipe can operate some more time at this mounting with right operating mode and seating.
2. The distribution of given stress intensity factor along the front of the crack shows that the most intensity is at the top of the pipe from the inner side. It means that the crack will have the elliptic shape or close to it. It is supported with the fractography of drilling pipes breakings.
3. The vibroprotective parameters can be chosen so that the crack increase is along the circle but not along the pipe. It increases the ratio of degree of safety.
4. The hypothesis that the dynamic loads have the ascendancy on the fatigued damage has been supported. Figure 3 shows the dynamic stress intensity factor under certain correlation of crack semi-axles surpasses the static one that in its turn causes the changes of drilling strings vibrations frequency.

REFERENCES

1. В.В.Тирлич, В.І.Векерик. Модель бурильної колони з тріщиною при повздовжніх коливаннях. //Розвідка і розробка нафтових і газових родовищ. Серія: Нафтопромислове обладнання. – Ів.- Франківськ- 1997.- вип..34.
2. В.І.Векерик, В.В.Тирлич. Визначення коефіцієнта інтенсивності напружень при коливаннях бурильної колони з тріщиною. //Розвідка і розробка нафтових і газових родовищ. Серія: методи і засоби технічної діагностики. – Ів.- Франківськ- 1999.- вип..36, ст..337-342.
3. В.З. Партон, В.П.Борисковский. Динамическая механика разрушения. М.: Машиностроение.- 1985. 263с.