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ABOUT INFLUENCE OF ENVIRONMENT ON STRAINS OF BORING COLUMNS

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A topical issue of dynamics, durability and reliability of boring columns when drilling slits in oil and gas extraction industry is column interaction with environment. The paper is devoted to modeling of interaction of a boring column with environment. Influence of environment on column deformation is investigated at a blow-down and flushing of slits for the purpose of slime removal.

1. The strains of a chisel bar arising at a blow-down of a slit by oblate air at high pressures and velocities are considered. For this purpose rotation of the oblate braided chisel bar in a stream of gas is modelled as follows:

$$EJ_u \frac{\partial^4 U}{\partial x^4} + M(t)\frac{\partial^3 V}{\partial x^3} + N(t)\frac{\partial^2 U}{\partial x^2} + K_1 U = \Delta P_u,$$
$$EJ_v \frac{\partial^4 V}{\partial x^4} + M(t)\frac{\partial 3U}{\partial x^3} + N(t)\frac{\partial^2 V}{\partial x^2} + K_1 V = \Delta P_v, \tag{1}$$

ΔP_u, ΔP_v characterize cross action of surplus pressure of a stream of gas. The model (1) is linear in view of an assumption of a smallness of strains. Axial forces and a torque are concidered to be constant on the length of a bar. Pressure ΔP at big velocities exceeding the velocity of a sound can be defined by means of a formula based on a hypothesis of plane section:

$$\Delta P = -P_\infty \left(1 - \frac{\chi - 1}{2}\frac{U}{C_\infty}\right)^{\frac{2\chi}{\chi-1}} \tag{2}$$

where U - a normal component of a velocity of a stream on a bar surface; C_∞ - a sound velocity for n undisturbed gas; P_∞ - pressure of undisturbed gas; χ - polytropic exponent. For a case of a space strain of a rod it is possible to present the formula (2) as pressure of gas upon the piston which moves in the one-dimensional channel. The system of many-dimensional equations is reduced by Bubnov-Galerkin's variation method to the system of nonlinear ordinary differential equations (ODE).

In the paper a numerical experiment on research of influence of a stream of gas on strains of steel and dural chisel bars is made. It is established that in case of dural chisel bars their elastic strains are smaller than for steel bars at the same types of loading (fig. 1). The solid line in fig. 1 presents displacements of a dural chisel bar, the shaped line presents displacements of a steel bar. Calculations were carried out for parameters of a chisel bar: external diameter of a boring column D=0,2 m; its internal diameter d=0,12 of m; density of steel and duralumin $\rho_{st} = 7800$ кG/m^3, $\rho_{dur} = 2700$ кG/m^3; module of elasticity of steel and duralumin $E_{st} = 2{,}1 \cdot 10^5$ MPa and $E_{dur} = 0{,}7 \cdot 10^5$ MPa; length of a chisel bar $l = 500$ m.

Influence of parameters of a chisel bar on its strains is investigated. It is established that magnification of pressure and length of a chisel bar leads to growth of strains.

2. Deformation of a chisel bar in a stream of flushing liquid is investigated. Thus the boring pipe is considered as a long cylindrical envelope, having final rigidity on curving. When drilling a slit, it perceives the force of feeding from a drift and the braiding moment when cutting rock in a drift by a tool. For drift refining from slimes in a slit through a boring pipe the flushing liquid representing suspension is forced. It is a solution of anticorrosive substances in water. As liquid under pressure implies from a slit, continuously extracting slime, the current of liquid is considered unsteady as particles of slime have not identical sizes. At a current of unsteady viscous liquid in the pipeline there is a pressure upon a pipeline wall in the radial direction and a force of friction along the pipeline generatrix. The force of friction operating on walls of a pipe will be equal to value $P = \frac{4\mu V}{R}$, where μ - coefficient of viscosity of liquid; V - mean speed of liquid current; R - pipe radius. Pressure drop on length of a pipe is found by the formula $\frac{\partial P}{\partial x} = -\frac{8\mu V}{R^2}$. As a model of a boring pipe the oblate braided cylindrical envelope under the influence of interior pressure and force of friction of flushing liquid is chosen. Interior pressure changes under the linear law along the length of an envelope, and the force of friction of flushing liquid is constant in length.

The equation of not axially symmetric driving of an envelope looks like:

$$\frac{D}{h}\Delta^2\Delta^2 w + \frac{E}{R}\frac{\partial^4 w}{\partial w^4} + \Delta^2 \Pi(P,w) = 0\,, \tag{3}$$

where D - a cylindrical rigidity; h – envelope wall thickness; Δ^2 - biharmonic operator; $\Delta^2 \Pi(P,w)$ - the reduced external efforts which are defined with pressure and force of friction. Accepting hinged support of the envelope on butt ends, the many-dimensional model of deformation of a chisel bar (3) by Bubnov-Galerkin's direct method is reduced to the ODE. As a result of a numerical experiment at the above-stated parameters of a chisel bar and Mach number equal 1 it is established: as well as in the first case, dural chisel bars experience smaller strains than steel ones under the same conditions of loading (fig. 2); magnification of length of bars, pressure of liquid and Mach number (influence of a stream of liquid) leads to growth of strains of a chisel bar and magnification of deviation of a chisel bar from its initial rectilinear form.

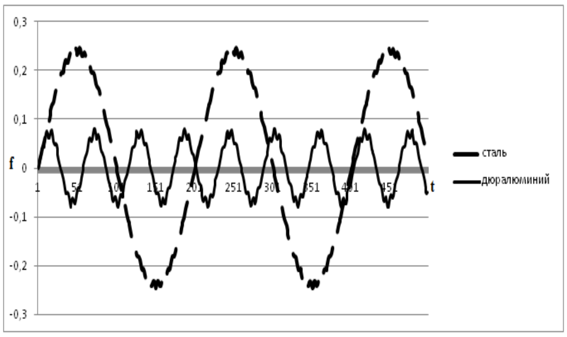

Fig. 1 - Displacements of a chisel bar to a gas stream.

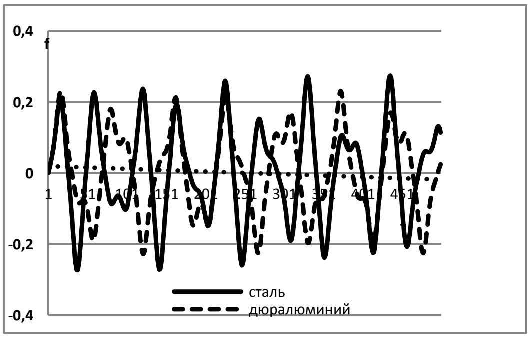

Fig. 2 - Displacements of a chisel bar to a liquid.

The presented models of interaction of a chisel bar with the environment allow to make conclusions concerning strains and dynamic pressure of chisel bars, and also to carry out an analytical or numerical appraisal of strength performances of a boring column.