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Methodic of Determination of Coefficient Value of Heat Flow Distribution at the Processes of Drilling and Milling

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Abstract

Carried out researches show that one of the main parameters reducing work capability of well drilling tool is heat release in the drilling process of rocks and metals

It is known that at all the processes of contact friction including the processes of drilling and milling, released big quantity heat in the contacting objects and in the medium according to various thermo physical properties of these materials is distributed irregularly . As the coefficient of heat flow distribution considers difference of heat distribution on the rubbing surfaces and medium. That's why determination of the coefficient value of heat flow distribution at the processes of drilling and milling in well conditions is of great interest [4].

In the article coefficient values of the heat flow distribution in three dimension cases of heat diffusion in the drilling process has been determined. They can also be applied in the milling of the metals as physical parameters of solid rocks and metals are close to each other .Values of FB_i cooling criterion have been considered in the rock and also in metal. On the basis of obtained data the regularities of temperature drop change have been formed depending on various FBI criterion values.

Key words: friction heat, drilling, rocks, milling, metal

1. INTRODUCTION

While drilling rock or metal at the processes of drilling or milling realized mechanical energy completely or partially transfers into heat, warming up thin surfaces of the elements layers and support to 900 C -1000 ^{0}C .Carried out experiments show that in the case of insufficient cooling the drilling tool is overheated [1,2]

While warming the contacting surfaces of the equipment various types of wearing proceeding in normal conditions activate. As a result wearing causes change of crystalline structure of the material , interaction recurrence and development of heat wear .That's why composition of drilling mud and material for construction of the support and heavy loaded elements of the bit must have an increased heat resistance

In the set up task for the arrangement of the heat released on the contacting surfaces of drilling tool and contour of the object the values of the determination the coefficient of heat flow distribution considering difference of heat distribution in the rubbing objects and mediums are required

For solving the set up task and reliability of heat calculation the stationary value of temperature drop and its increment in the metal and rock has been determined considering heat conductivity of the bit and milling, heat influence radii, taking part in the interaction of drilling tool with drilled objects, value of FB_i cooling critetrion in the rock and metal

Carried out researches show that the heat exchange process is not stationary and its concrete values should be determined by calculation

The coefficient of heat flow distribution has been well studied related to breaking by the availability of convective heat exchange necessary for cooling of warmed up well drilling tools

The specifics of the processes of drilling and milling doesn't allow to carry out the processes without discontinuing the instrument out of well bore. The instrument is periodically taken off the well bore and for all this heat sources are excluded and flushing – cooling of the heated tool is carried out . Then the process is repeated several times.

For normal work drilling tool in the well bore in the discontinuing work process the generated heat should be completely or partially taken off excluding heat sources and its following cooling by flushing fluid

Drop of the temperature and its increment considering coefficient of FB_i cooling criterion are presented in the form:

$$\frac{d\Delta\bar{T}}{dx} = \frac{\overline{Q_1}\sqrt{\frac{x_0}{x}}\ \frac{e^{x_0-x}}{x}}{2\{1-FB_i[1-y(x)]\}}$$

$$\Delta\bar{T} = \frac{-\bar{Q}_1\sqrt{\frac{x_0}{x}}\ \frac{e^{x_0-x}}{x}\ [1-y(x)]}{\{1-FB_i[1-y(x)]\}} = \frac{2}{x}[1-y(x)]\frac{d\Delta\bar{T}}{dx} \qquad (1)$$

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In $x \to 0$ $(t \to \infty)$ temperature area passes into stationary state, that is:

$$\frac{d\Delta\bar{T}}{dx} = \frac{Q_1\sqrt{\frac{x_0}{x}}}{2\,(1-FB_i)} = \frac{Q_1}{2}\frac{R_0}{r}\frac{1}{(1-FB_i)}$$

$$\Delta T = -Q_1\sqrt{\frac{x_0}{x}}\frac{1}{(1-FB_i)} = -\frac{Q_1\frac{R_0}{r}}{(1-FB_i)} \qquad (2)$$

According to formula (1) let's determine stationary values of temperature drop in the metal and rock.

$$\Delta T_1 = -\frac{Q_1 R}{F_1 \lambda_1}\sqrt{\frac{x_0}{x}}\,\frac{1}{(1-FB_i)} = -\frac{Q_1 R}{F_1\,\lambda_1}\left(\frac{R}{r}\right)\frac{1}{(1-FB_{i_1})}$$

$$\Delta T_2 = \frac{Q_1 b}{F_1\,\lambda_2}\sqrt{\frac{x_0'}{x'}}\,\left(\frac{1}{1-FB_i}\right) = \frac{Q_1 b}{F_1\,\lambda_2}\left(\frac{b}{z}\right)\left(\frac{1}{1-FB_{i_2}}\right) \qquad (3)$$

where ΔT_1 – is temperature drop in the rock.

ΔT_2 – is temperature drop in the rock

Q_1- is part of heat source influencing external surface of the sphere;

$x'_0 = b^2/4at$ – is value of the rock parameter on the contact surface;

$x' = \frac{z^2}{4\,at}$ - is the variable of the generalized parameter for rocks;

λ_1- is heat conductivity of the drilling tool;

λ_2 – is heat conductivity of the object;

R - is radius of the heat influence;

b - is radius of heat influence of the drilling object;

FB_{i1} – is value of cooling criterion in metal;

FB_{i2} – is value of cooling criterion in the rock;

FB_{i1} and FB_{i2} are determined as following:

$$\begin{cases} FB_i 1 = -\frac{F_3}{F_1}\,\frac{\alpha R}{\lambda_1} \\ FB_{i2} = -\frac{F_3}{F_1}\,\frac{\alpha b}{\lambda_2} \end{cases} \qquad (4)$$

where F_1 – is the action area of heat source, equivalent extreme surface of the cylinder;

F_2 – is internal surface of the cylinder;

F_3 – is the cooling surface of the drilling tool.

Based on the heat balance equation and considering the coefficient of heat flow distribution (ξ) in the friction FB_{i1} и FB_{i2} are determined analogous to [2]:

$$\begin{cases} FB_{i1} = -\frac{\xi}{2-\xi}\,\frac{1}{[\,1-y\,(x_0)\,]} \\ FB_{i2} = -\frac{\xi}{2-\xi}\,\frac{1}{[\,1-y\,(x_0)\,]} \end{cases} \qquad (5)$$

In $t \to \infty$ $(x_0 = 0,$ correspondingly $x_0 = 0{:}(x_0) = 0$ and $y(x_0) = 0)$.

Then formula (5) will get the following form:

$$FB_{i1} = FB_{i2} = -\frac{\xi}{2-\xi} = -\frac{\frac{\xi}{2}}{(1-\frac{\xi}{2})} \qquad (6)$$

Putting (5) in formula (3) for the case $x \to x_0$ and $x' \to x_0'$ the temperature drop in the tool will be:

$$\Delta T_1 = \frac{Q_1 R}{F_1\,\lambda_1}\left(1-\frac{\xi}{2}\right) \qquad (7)$$

Then temperature drop in the rock correspondingly will be:

$$\Delta T_2 = -\frac{Q_1'}{F_1}\cdot\frac{b}{\lambda_2}\frac{\xi}{2} \qquad (8)$$

Coefficient of heat flow distribution is determined from the equation of the temperature on the contact surface.

Equating (7) and (8) and solving the obtained relations relatively to the coefficient of heat flow distribution, we get:

$$\frac{\frac{\xi}{2}}{(1-\frac{\xi}{2})} = \frac{\xi}{2-\xi} = \frac{\lambda_1}{\lambda_2}\frac{R}{b} \qquad (9)$$

Relation $(\frac{R}{b})$ is proportional to the relation $\sqrt{\frac{a_1}{a_2}}$ [2]:

$$\frac{R}{b} = \sqrt{\frac{a_1}{a_2}} \qquad (10)$$

Using physical dependence of the form:

$$a = \frac{\lambda}{c\rho}, \qquad (11)$$

And putting (11) into (10) and after simple change we get:

$$\frac{R}{b} = \sqrt{\frac{\lambda_1}{\lambda_2}\frac{C_2}{C_1}\frac{\rho_2}{\rho_1}} \qquad (12)$$

Considering (12) in formula (6), we obtain:

$$\frac{\xi}{2-\xi} = \frac{\frac{\xi}{2}}{1-\frac{\xi}{2}} = \frac{\lambda_1}{\lambda_2}\sqrt{\frac{\lambda_1}{\lambda_2}\frac{C_2}{C_1}\frac{\rho_2}{\rho_1}} \qquad (13)$$

Using root (13) we assess average quantity of the coefficient of heat flow for rocks and steel.

Knowing that, thermo physical properties of solid and strong rocks on average change in the limits of $\lambda_2 - 1 \div 3\,\frac{\text{kkal}}{\text{m}}\cdot$ hour °C, $C_2 = 0{,}2 \div 0{,}5\,\frac{\text{kkal}}{\text{kg}}$ °C, $\rho_2 = 2300 \div 2700\ \text{kg/m}^3$, and thermo physical characteristics (properties) of the metal on average change in limits of $\lambda_1 = 40$ kkal/m · hour °C: $C_1 = 0{,}11$ kkal/kg °C, $\rho_1 = 7850\ \text{kg/m}^3$, then we can calculate root (13) which is equal to:

$$\sqrt{\frac{\lambda_1}{\lambda_2}\frac{C_2}{C_1}\frac{\rho_2}{\rho_1}} = 0{,}115 : 0{,}117 \qquad (14)$$

For average value of root (14) on formula (13) define values of coefficient of heat flow distribution will be equal ξ= 0,2.

Then values of distribution coefficient the heat flow between rubbing surfaces in milling-metal will be: $1-\frac{\xi}{2} = 1 - -\frac{1}{2}0{,}2 = 0{,}9$ but in the bit in the rock it will be $-\frac{1}{2}$ $\xi = \frac{1}{2}\cdot 0{,}2 = 0{,}1$ in the ratio of metal and rock – 0,9.

CONCLUSION:

1. The formula determining the coefficient of heat flow distribution has been deduced considering physical parameters of the drilling and drilled objects.

2. Values of heat flow distribution between rubbing surfaces in metal is equal to 0,9; in the rock 0,1, and in their ratio – 0,9.

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