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Mathematical Modeling of Thermal Conditions of Drilling Bits in Air Drilling

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ABSTRACT: In order to prevent the drilling mechanism from burning under the influence of high temperatures, air drilling is used to control the circulation system, control the tightness of the drill bit and select the optimal consumption of compressed air, however, the high portion of break downs indicates that these methods are ineffective. In this paper, a mathematical model has been developed that makes it possible to determine the temperature regimes of tricone bits and annular crowns in the process of cleaning wells with compressed air.

KEY WORDS: well, drilling, compressed air, drilling bit, temperature mode, drilling mode , washing fluid, reading pressure , drilling bit number of revolutions , diamond toothed crown.

I. INTRODUCTION

Wells with air during the cleaning drilling process gender disintegrant increasing the temperature of the device departure , gender disintegrant of the instrument workability overdue before loss and this based drilling operations increase in cost cause will be .

Gender disintegrant of the instrument normal temperature profiles supply eng basic methods one this skvajinaga transmitted cooling the temperature of the cleaning compressed air , ie gender disintegrant instrument eliminates heat dissipation in it by transferring cooled air is to reach . However, the practice of drilling wells with compressed air experience that indicates that gender disintegrant temperature modes of the device effective standardization to cool the temperature of the compressed air with together , optimal drilling profiles provide is necessary.

The increase in the temperature of the rock breaker depends on the force required to break the rock and the friction at the bottom of the well, the thermophysical properties of the rock being broken, the material of the rock breaker, the type and consumption of the washing liquid.

II . ANALYSIS OF TEMPERATURE REGIMES OF DRILLING DOLOTS

It is difficult to determine the temperature during the operation of annular drilling crowns, where the average temperature of the crown formed as a result of the distribution of individual temperature fields across the body of the crown as a result of cutting the rock of hard alloy teeth is taken as its magnitude. The temperature of a hard alloy gear ring can be determined by the following expression [1]:

$$t_T = \frac{2K_pN}{\pi\sqrt{\lambda_1(\alpha_1D_1+\alpha_2D_2)(D_2^2-D_1^2)}} + \frac{K_pN}{2Gc_p} + t_1, \quad (1)$$

where, λ_1 is the thermal conductivity of the corona material, W / ch (m ·℃); α_1 i α_2 is the coefficient of thermal conductivity between the crown and core, between the crown and the well, W / (m ^{2} · ℃); D_1 i D_2 - inner and outer diameters of the corona ring, m; t_1 - initial temperature of the washing liquid (on the crown), ℃ ; N is the power consumption of the crown at the bottom of the well, W; G - detergent consumption, kg / s; c $_p$ - relative heat capacity of air, Dj / kg · ℃ ; K_p - dimensionless coefficient of heat flux distribution:

$$K_p = \frac{1}{1+\lambda_2/\lambda_1\sqrt{a_1/a_2}}, \quad (2)$$

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this where , a - temperature conductivity coefficient , m [2] / s (indices 1 and 2 crown material and rock _ relevant).

Sharoshkali gender disintegrant tools in a jar teeth , ball and roller bases , like part of a shell claw complex of the elements availability complicates the analytical study of its temperature regimes . In this case, sharashkali gender disintegrant by selecting the bit part that accurately describes the temperature regime of the instrument during the study get zarurati to the surface comes , [1] in the study as this section sharoshkali gender disintegrant tool tsapfasini transverse section selected:

$$t_ц = \left[\left(\frac{h}{\lambda_1 f_ц} + \frac{1}{\alpha f_л}\right)\frac{k_1 k_2}{m} + \frac{1}{2G_г c_p}\right] N - \frac{\Psi` \Delta W}{2c_p} + t_1, \quad (3)$$

where, h is the average thickness of the claw of the rock crusher, m; $f_ц$, $f_л$- cross-sectional area of the base of the plinth and the outer surface of the paw, m ^{2} ; λ_1- coefficient of thermal conductivity of rock material, W / ch (m ·℃); a - temperature conductivity, m ^{2} / s; s $_r$ is the relative heat capacity of the cleaning air, Dj / kg · ℃ ; G $_g$ - consumption of cleaning air, kg / s; k_1 , k_2- immeasurable coefficient of power loss due to friction on the supports and the distribution of heat flow in the bearings; N - slaughter power, W; m - number of glasses; $\Psi`$- relative heat of vapor formation, Dj / kg; ΔW is the percentage of moisture.

III. STUDY OF THE DEPENDENCE OF DRILLING TEMPERATURE REGIMES ON THE INITIATIVE TEMPERATURE TEMPERATURE

Constructed in the MATHCAD graphics program on the basis of expressions (1) and (3) in order to determine the effect of the initial temperatures of the purified compressed air and the drilling mode on the temperature regime of the rock crusher .

The following parameters were selected in the creation of a mathematical model of the temperature regimes of the annular drilling crown on the basis of 1) expression: λ_1- thermal conductivity of the crown material, W / ch (m ·℃); $\alpha_1$and α_2- heat transfer coefficients, (in the gap between the crown and core; in the gap between the walls of the crown and the well), W / (m ^{2} · ℃); $D_1$and D_2- inner and outer diameter of the corona ring, m; t_1- initial temperature of compressed air, ℃ ; N is the power generated at the bottom of the well (W), G is the mass flow rate of the cleaning compressed air (kg / s), c $_p$ is the specific mass heat capacity of the air , Dj / (kg · ℃) , K $_r$ is the dimensionless coefficient of heat flux distribution.

was carried out in the graphical program MATHCAD by $t_1$expressing the temperature modes (1) . It was set at 12 kg / h. The results of the calculations are shown in Figure 1.

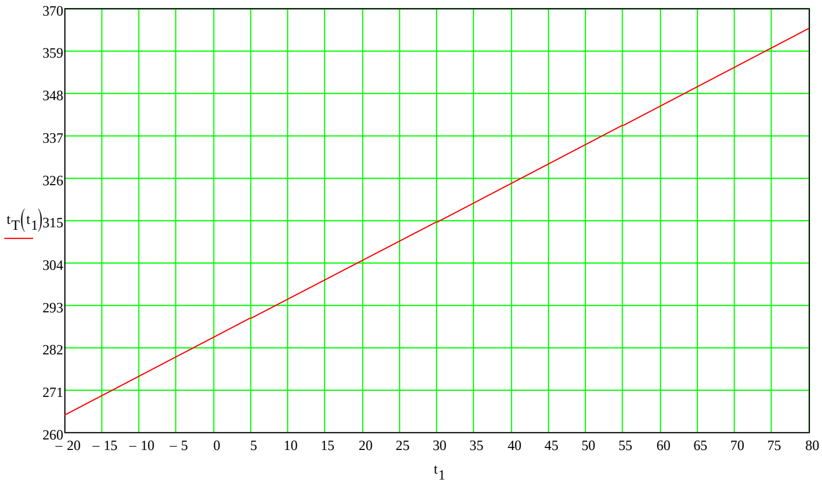

Fig 1: Results of calculation of temperature regimes of annular drilling crown .

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Results of calculation of temperature regimes of annular drilling crown that shows that in zaboyda running the temperature of the corona depends on the temperature of the compressed air being cleaned, i.e. an increase in the temperature (t_1) of the cleaning compressed air with zaboyda running the temperature of the corona (t_T) increases .

Three sharli mathematical model by expressing the temperature modes of the drilling bit (3) in creating and the following indicators selected : h - along the tsapfa axis of the drilling bit claw average thickness , m; $f_ц$, $f_л$- the outer surface of the tsapfa and of the foundation transverse cut surface , m ^{2}; λ_1- thermal conductivity of the crown material coefficients , Vt / ch (m ·℃); a - temperature conductivity coefficients , m ^{2} / s; t_1- initial temperature of compressed air, ℃ ; s_r is the specific of the cleaning air mass heat capacity, Dj / kg · ℃ ; $G_{g \text{ is the}}$ mass of air consumption , kg / s; k_1 , k_2 - loss of power due to friction in the supports and dimensionless distribution of heat flux in bearings coefficients , in units of contribution ; N - power in the tank , W; m - number of glasses ;Ψ` - specific heat of vaporization , Dj / kg; ΔW - moisture , in the unit of contribution .

Three sharli The calculation of the temperature modes of the drilling bit by expression (3) is also in the MATHCAD graphical program instead increased , computational work instead increase during In this case, the value of the initial temperature of the compressed air varies from (t_1-20 to 80,, the rated power is 2500 W, the consumption of purifying compressed air) . while reaching 0.21 kg / s marked . Computational work The results are shown in Figure 2 .

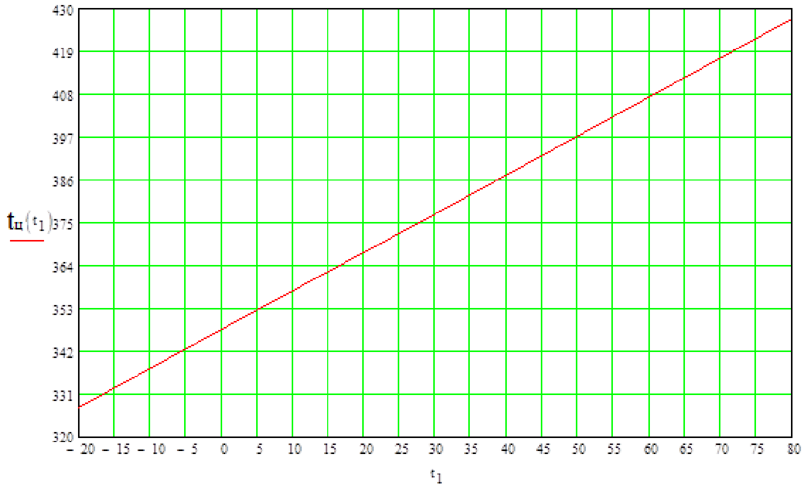

Fig 2: Three sharli the results of the calculation of the temperature regimes of the drilling bit .

Three sharli calculation of the temperature regimes of the drilling bit results that is _ it can be concluded that the temperature of the purified compressed air is running significant to the temperature of the drilling bit degree effect shows .

The results of the calculations performed on the basis of the above expressions 1) and (3) show that the temperature regimes of the rock crusher are influenced by the magnitude of the discharge force (N) at the bottom of the well along with the temperature of the cleaning air. That is, it is required to ensure a rational magnitude of the blasting capacity in order to effectively normalize the temperature regimes of the rock crusher operating at the bottom of the well.

IV. STUDY OF THE DEPENDENCE OF DOLOT TEMPERATURE REGIMES ON DRILLING REGIMES

It is technically difficult to measure the crushing capacity at the bottom of the well during the operation of the crushing tool, the crushing capacity depends on the type of crushing tool and drilling modes, [2]

For annular hard alloy drilling crown

$$N_{заб} = 5{,}3 \cdot 10^{-4} \cdot P \cdot n \cdot D_{ср.к}(0{,}137 + \mu); \qquad (4)$$

where, P is the axial pressure applied to the rock breaker, N; n is the frequency of rotation of the crown, min $^{-1}$; $D_{ср.к}$ - average diameter of the crown, m; μ- coefficient of friction of the crown teeth μon the rock (the values of which are given in the study for different rocks [4]).

For diamond threaded drilling crown

$$N_{заб} = 2 \cdot 10^{-4} \cdot P \cdot n \cdot D_{ср.к}; \qquad (5)$$

Ball dolls for $$N_{заб} = 10^{-3}\cdot\mu\cdot P_{д}\cdot n\cdot D; \quad (6)$$

this where , P_d- diameter of the drilling bit, m.

Skvajina zaboyida running gender disintegrant the temperature of the appliance (1) and (3) can be calculated, but to ensure optimal temperature regimes of the rock crusher, rational drilling modes, i.e., the axial pressure force applied to the rock crusher (R_d), the frequency of rotations (n) and it will be necessary to select the washing liquid consumption (G) .

Using air from wells during the cleaning drilling process gender disintegrant temperature modes of the device standardization for rational drilling modes that is , in order to determine the axial pressure force (R_d) and the frequency of rotations (n) , the magnitude of the borehole force (N) at the bottom of the well given in expressions (1) and (3) was specified using expressions (4), 5) and (3.3).

In this case, the expression (1), which allows to calculate the temperature of the annular drilling crown, has the following appearances (7) and (8):

hard alloy drilling crown for

$$t_T = \frac{K_p 5{,}3\cdot10^{-4}\cdot P_{д}\cdot n\cdot(D_1+D_2)(0{,}137+\mu)}{\pi\sqrt{\lambda_1(\alpha_1 D_1+\alpha_2 D_2)(D_2^2-D_1^2)}} + \frac{K_p 5{,}3\cdot10^{-4}\cdot P_{д}\cdot n\cdot(D_1+D_2)(0{,}137+\mu)}{4Gc_p} + t_1; \quad (7)$$

olmos gear drilling crown for

$$t_T = \frac{K_p 2\cdot10^{-4}\cdot P_{д}\cdot n\cdot(D_1+D_2)}{\pi\sqrt{\lambda_1(\alpha_1 D_1+\alpha_2 D_2)(D_2^2-D_1^2)}} + \frac{K_p 2\cdot10^{-4}\cdot P_{д}\cdot n\cdot(D_1+D_2)}{4Gc_p} + t_1; \quad (8)$$

expression (3), which allows to calculate the temperature of a three-spherical drilling bit , looks like this (9):

$$t_{ц} = \left[\left(\frac{h}{\lambda_1 f_{ц}}+\frac{1}{\alpha f_{л}}\right)\frac{k_1 k_2}{m}+\frac{1}{2G_{г}c_p}\right]10^{-3}\cdot\mu\cdot P_{в}\cdot n\cdot D-\frac{\Psi`\Delta W}{2c_p}+t_1; \quad (9)$$

The above expressions (7), (8) and (9) rationalize the drilling modes, ie the axial pressure force (R_d) and the number of revolutions (n) , which allow not only to determine the temperature of the rock breaker, but also to regulate the temperature regimes during air drilling. allows you to select sizes.

Rock crushing tools can be normalized not only by lowering the temperature of the cleaning compressed air, but also by correctly selecting the reading pressure (R_d) and number of revolutions (n), i.e. the drilling mode parameters applied to the rock crushing tool. In order to confirm these considerations, the MATHCAD program using its graphical interface based on the expressions (7), (8) and (9) established the dependence of the temperature drilling modes of the rock crusher on the axial pressure force (R_d) and the number of revolutions (n).

(t_t) of the hard alloy drilling crown as a function of the axial pressure force (R_d) and the number of revolutions (n).

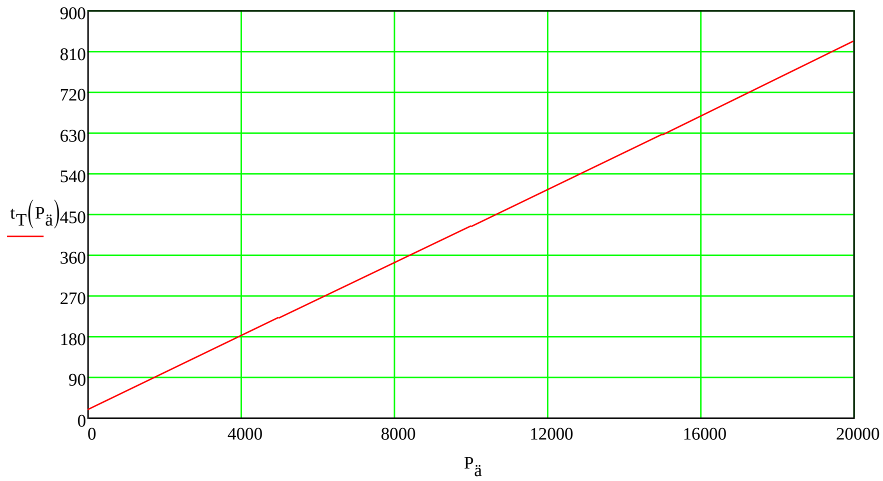

Fig 3: Graph of the dependence of the temperature (t_t) of the solid alloy ring drilling crown on the axial pressure force (R_d) (n = 60 min^{-1}).

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Shown in Figure 3 above In calculating the temperature dependence of the temperature of the hard alloy ring drilling crown on the axial pressure force, the consumption of cleaning compressed air (G) 400 kg / h, the number of revolutions of the crown 60 min $^{-1}$, the coefficient of friction of the crown teeth to the rock (μ) 0.4, the hardness coefficient (f) was carried out for rocks of type 8 equivalent.

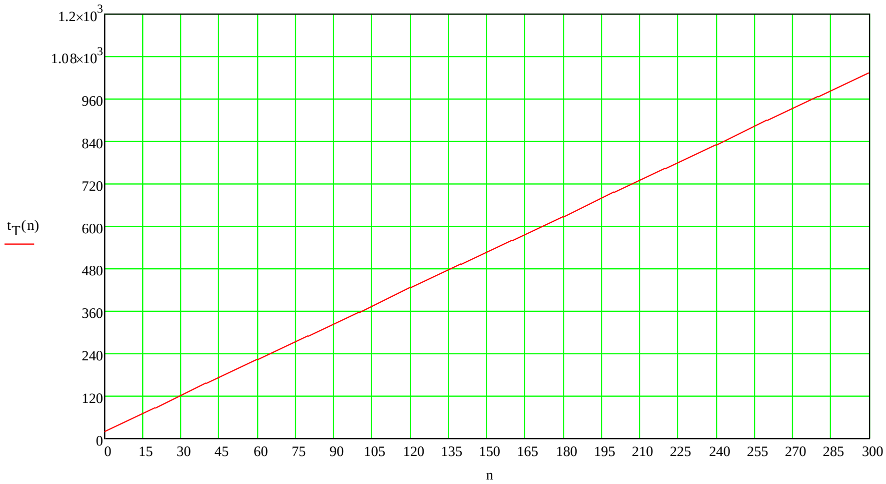

Fig 4: Graph (P $_d$ = 5 kN) of the temperature dependence of the temperature (t $_t$) of the solid alloy ring drilling crown on the number of revolutions (n).

Shown in Figure 4 In calculating the temperature dependence of the temperature of the hard-alloy annular drilling crown on the number of revolutions of the crown, the same magnitudes were chosen as described above, in which only the axial pressure force applied to the crown was 5 kN.

In Figures 5 and 6 below a graph of the temperature (t $_t$) of the diamond-toothed ring drilling crown as a function of the axial pressure force (R $_d$) and the number of revolutions (n) is given.

In the study of the dependence of the temperature of the diamond-toothed ring drilling crown on the axial pressure force (Fig. 5), the consumption of cleaning compressed air is 400 kg / h, the number of revolutions of the crown is 300 min $^{-1}$ were selected, the axial compressive strength was increased from the initial 0 to 15 kN, and the calculations were performed for rocks with a hardness coefficient (f) of 9-10 categories.

The temperature of the diamond-toothed ring drilling crown In the study of the dependence of the number of revolutions (Fig. 6), the axial pressure force applied to the corona was 5 kN, the number of revolutions of the corona was changed from 0 to 300 min $^{-1}$. The sizes of the remaining indicators were maintained as above.

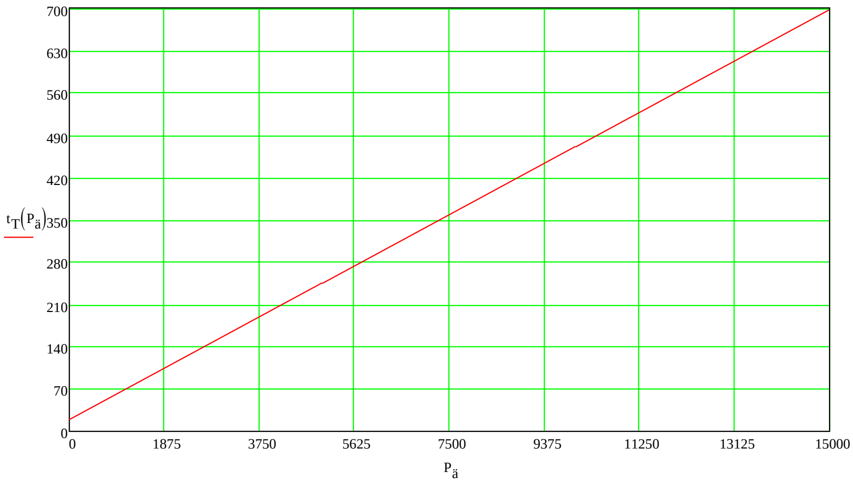

Fig 5: Dependence of the temperature (t $_t$) of the diamond gear ring drilling crown on the axial pressure force (R $_d$) graph (n = 300 min $^{-1}$).

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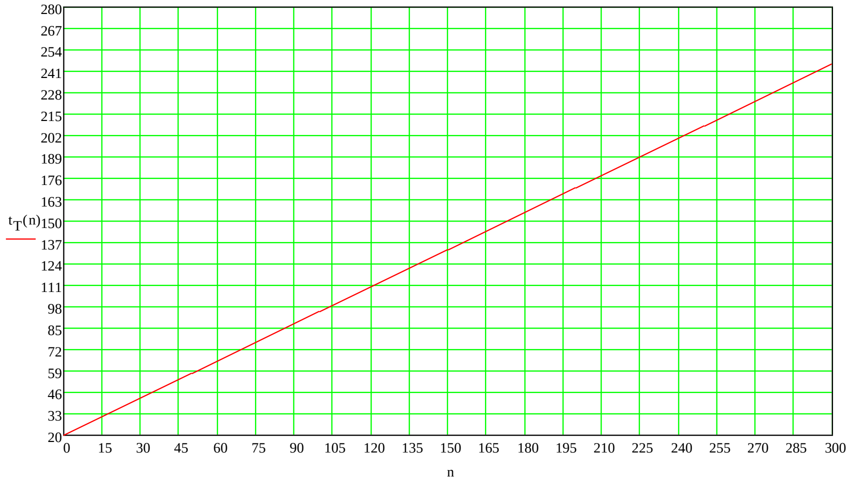

Fig 6: Graph (P_d = 5 kN) of the temperature (t_t) of the diamond-toothed ring drilling crown as a function of the number of revolutions (n).

Also a three-ball drilling bit the dependence of temperature (t_{ts}) on the axial pressure force (R_d) and the number of revolutions (n) was modeled using the expression (6). In this case, the diameter of the three-sphere circle was selected to be ∅76 mm, the consumption of cleaning air (G) was 600 kg / h, and the initial air temperature was 20 ℃. Three ball drilling bit In the study of the temperature dependence of the axial pressure force, the number of revolutions of the drilling bit was 500 min $^{-1}$, and the axial pressure force was increased from 0 to 20 kN. Three ball drilling bit the result of calculations performed to study the dependence of temperature on the axial pressure force Figure 7 is shown graphically .

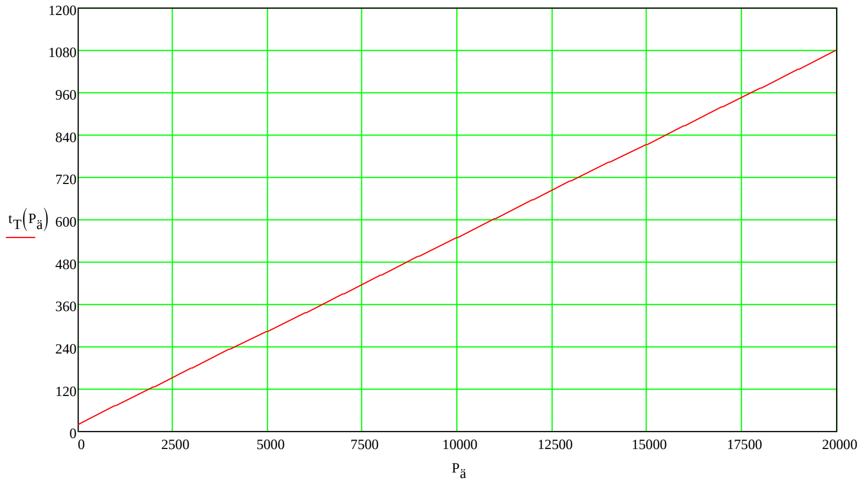

Fig 7: Graph of the dependence of the temperature (t_{ts}) of the three-spherical drilling bit on the axial pressure force (R_d) (n = 500 min $^{-1}$).

Three ball drilling bit In the study of the dependence of the temperature of the drilling bit on the number of revolutions, the number of revolutions of the drilling bit was increased from 0 to 800 min $^{-1}$, and the axial pressure force was 10 kN. The results of the calculations are shown in Figure 8.

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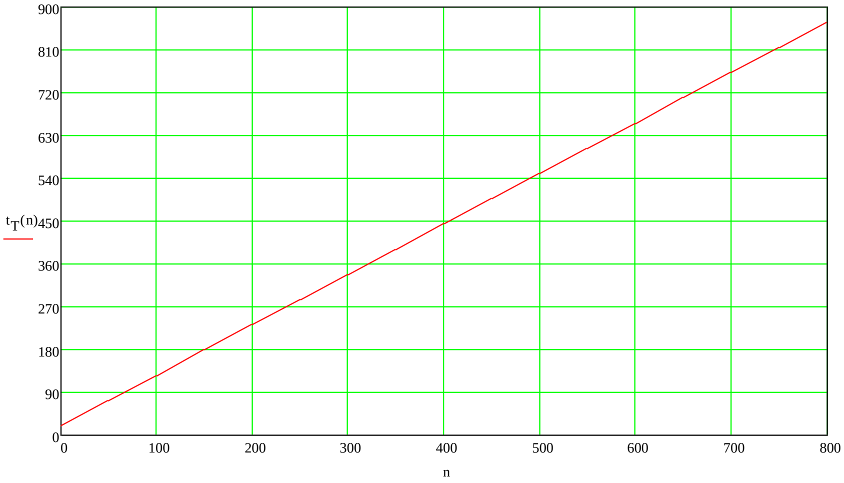

Fig 8: Graph (P_d = 10 kN) of the dependence of the temperature (t_{ts}) of the three-spherical drilling bit on the number of revolutions (n).

As can be seen from the graphs shown in Figures 3, 4, 5, 6, 7 and 8 above, the temperature of rock crushing tools during drilling wells using compressed air depends not only on the initial temperature of the cleaning air but also on the drilling modes.

is necessary to select a rational value of the axial pressure force applied to the drill and its number of revolutions, along with lowering the temperature of the cleaning compressed air supplied to it.

V. CONCLUSION

In drilling practice, in most cases, drilling modes are observed to reduce the transition time of the well by increasing the mechanical speed of drilling, i.e., increasing the axial pressure force applied to the drill and the number of revolutions. However, when drilling wells using air, increasing the drilling mode parameters or selecting them incorrectly can lead to accidents as a result of overheating of the rock crushing equipment. 10-12% of the total time spent on drilling is spent on the elimination of accidents related to the rock crusher, in addition, the reduction of the throughput of the rock crusher leads to an increase in the cost of drilling.

The mathematical model developed above makes it possible to determine the rational parameters of the drilling regime, ensuring that the temperature regimes of the rock breaker do not exceed when drilling wells using air.

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