Improving the Quality of Technology of Pressing the Tungsten Carbide Inset Cutter in Roller Cone Bit

Andriy Slipchuk[1], Yuriy Datsishin[2]

1. Department of Manufacturing Engineering, Lviv Polytechnic National University, UKRAINE, Lviv, S. Bandery street 12, E-mail: andsl@ukr.net

2. Department of Manufacturing Engineering, Lviv Polytechnic National University, UKRAINE, Lviv, S. Bandery street 12, E-mail: Yurii.R.Datsyshyn@lpnu.ua

Abstract* – The analysis of the nature of the damage to the surfaces of the openings revealed traces of the action of the compressive forces arising along the axis of the tungsten carbide inset cutter when squeezing it into the rock face. Also found traces of deformation from the action of bending to the tungsten carbide inset cutter, depending on the orientation of its slip on the face. Fixing and rubbing, fretting-corrosion, damage to the local areas of the walls of the holes caused by scrolling the tungsten carbide inset cutter around its axis in the opening of the rolling-cutter teeth row. In the case of the use of tungsten carbide inset cutter with symmetrical exacerbation of the breeding part, the orientation of the creature's impressive head of the tungsten carbide inset cutter is determined by an effective angle to the axis of the crown of the tungsten carbide inset cutter pick. Calculations show that an angle of 45 ° is optimal.

Keywords – tungsten carbide, fretting-corrosion, rolling-cutter, crown, roller cone, cutter bits.

I. Introduction

Three-cone rock drilling bit with tungsten carbide inset cutter – equipment have been widely used in the construction of wells of various purposes [1]. The production of such roller cone sets before the chisel construction system new conditions to materials, construction, selection of steels for roller cone, parameters of carbon saturation and heat treatment, technological operations of moulding of holes and assembly of "cone – tungsten carbide inset cutter" connection. The plug-in breakdown equipment is exploited under difficult conditions and often fails due to imperfections in the design and technology of manufacturing roller cones. Therefore, studying ways to improve the quality of inserted rope-destructive equipment at the stages of creating roller cones is an urgent and topical task of the chisel construction [2].

During the rotation of the roller cone around the axis of the tungsten carbide inset cutter which deeper into the spectacular part of the rock, deformation and destruction of the breed are made. When entering the rock of the striking part of the next tooth, the twisting of the chopped rock is preceded by a tungsten carbide inset cutter [3].

The analysis of the nature of working out and loss of working capacity of the inserted rocks destroy the equipment, the facts of loosening, scrolling of the teeth around their own axis, and the change in the orientation of their impressive part, deflection and loss of tungsten carbide inset cutter were established.

The instantaneous load on the tungsten carbide inset cutter can be 80-85% of the total load on the roller cone [4].

II. Formulating the purpose of the article

The analysis of the mode of failure to the surfaces of the holes revealed traces of the action of the compression forces arising along the axis of the tungsten carbide inset cutter when squeezing it into the rock face. Also found traces of deformation from the action of bending to the tungsten carbide inset cutter, depending on the orientation of its slip on the face. Fixing grinding in, fretting-corrosion, damage to the local areas of the walls of the holes caused by scrolling the tungsten carbide inset cutter around its axis in the hole of the rolling-cutter teeth row.

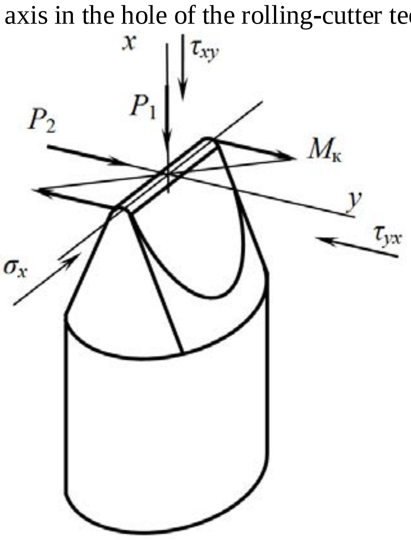

Fig.1 The mode of the stress action on the top of the tungsten carbide inset cutter

If we analyse the mode of the stresses occurring in the tungsten carbide inset cutter, we will use the theory of elasticity [5] and advances in the field of material mechanics [6]. In the orientation of the impressive part of the along the creature tungsten carbide inset cutter, there must be such tensions between the existing tensions [7]:

$$\begin{cases} \dfrac{\partial s_x}{\partial x} + \dfrac{\partial t_{xy}}{\partial y} = 0 \\ \dfrac{\partial s_y}{\partial y} + \dfrac{\partial t_{yx}}{\partial x} = 0 \end{cases} \qquad (1)$$

According to the hypothesis of plane sections of the mechanics of materials, we have the following calculation formulas:

$$\begin{cases} s_x = -\dfrac{P_1}{2x d_з} + \dfrac{P_2 y (x - r_0)}{2x^3 d_з} \\ s_y = 0 \\ t_{xy} = t_{yx} = \dfrac{3P_2 \left(x^2 - y^2\right)}{4x^3 d_з} \end{cases} \qquad (2)$$

The calculation formula for the tangential stresses will look

$$t_{xy} = -\frac{P_1}{2x^2 d_з} y + \frac{3P_2 r_0}{4x^2 d_з} + \frac{3P_2\left(2 - \frac{3}{x} r_0\right)}{4x^3 d_з} \quad (3)$$

whereas

$$\frac{\partial s_y}{\partial y} = -\frac{\partial t_{yx}}{\partial x} \quad (4)$$

$$\frac{\partial t_{yx}}{\partial x} = -\frac{P_1}{x^3 d_з} y + \frac{3P_2 r_0}{2x^3 d_з} + \frac{9P_2\left(1 - \frac{2}{x} r_0\right)}{2x^4 d_з} y^2 \quad (5)$$

$$s_y = -\int \frac{P_1}{x^3 d_з} y dy + \frac{3}{2}\int \frac{P_2 r_0}{x^3 d_з} dy + \frac{9}{2}\int \frac{P_2\left(1 - \frac{2}{x} r_0\right)}{x^4 d_з} y^2 dy \quad (6)$$

$$s_y = -\frac{P_1}{2x^3 d_з} y^2 + \frac{3P_2 r_0}{2x^3 d_з} y + \frac{3P_2\left(1 - \frac{2}{x} r_0\right)}{2x^4 d_з} y + C_3 \quad (7)$$

In the case of the use of the tungsten carbide inset cutter with symmetrical aggravation of the rock-destroying part, the orientation of the creature's impressive head of the tungsten carbide inset cutter is determined by an effective angle to the axis of the crown of the roller cone. Calculations show that an angle of 45 ° is optimal. The development of drill bits with such a construction of rocks destroyed the equipment showed an increase in the efficiency of the destruction of the rock in the face, which positively influenced the rates of the passage of the bit.

Consequently, the value of tension in the connection must satisfy the condition

$$\Delta \geq \frac{0{,}5 M_к b^2}{p\, Ehf\left(0{,}25 b^2 - r_з^2\right) r_з} \quad (8)$$

Proceeding from the data presented in [8] consider the conditions to ensure the reliability of the connection "shank of the tungsten carbide inset cutter – hole of roller cone" from the bending moment to the tungsten carbide inset cutter.

When loading the connection, the bending moment M on the uniform pressure diagram of the fit superimposes the pressure diagram, characteristic for the bend. At the same time, 0,5M has an affecting part of the tungsten carbide inset cutter, the same magnitude of the moment falls on the opposite side of the base of the shank of the tungsten carbide inset cutter.

The value of the allowable torque to ensure the reliability of the connection "shank of the tungsten carbide inset cutter – hole of roller cone" can be taken

$$M = 0{,}2\, pdh^2 \quad (9)$$

Let's assume this

$$p_1 = 0{,}75 p \quad (10)$$

Conclusion

The allowable moment is proportional to the square of the height, so the connections of the exposed bending moments can not be performed with small values of the diameter and height of the chisel shank of the tungsten carbide inset cutter.

In the future, practical interest is in the need to simulate the variants of stress distribution (contact pressures) with different roughness parameters of the conjugated parts, as well as variants of stress distribution (contact pressures) in the crown of the roller bearings at different distances from each other tungsten carbide inset cutter.

References

[1] G. L. Doll, R. D. Evans, C. R. Ribaudo, "Improving the performance of rolling contact bearings with tribological coatings", *Surface Engineering in Materials Science III, The Minerals, Metals & Materials Society Journal*, pp. 153-162, 2005.

[2] T. A. Harris, M. N. Kotzalas, "Rolling Bearing Analysis Essential Concepts of Bearing Technology", Fifth Edition, CRC Press, Boca Raton, 2007.

[3] H. Nixon, X. Ai, J. Cogdell, G. Fox, "Accessing and Predicting the Performance of Bearings in Debris Contaminated Lubrication Environment", SAE Technical Paper #1999-01-2791, International Off-Highway & Power Plant Congress & Exposition, Indianapolis, Sept. 13, 1999.

[4] J. Schroder, "Cone Retention and Tapered Bearing Preload System for Roller Cone Bit," US patent application filed Nov. 2, 2011.

[5] R. S. Zhou, H. Nixon, "A Contact Stress Model for Predicting Rolling Contact Fatigue", SAE Technical Paper 921720 in SEA Transactions Journal, Vol. 101, No. 2, Sept. 1, 1992.

[6] R. S. Jakum, A. M. Slipchyk, “Proektuvannya novykh produktovykh liniy sharoshok dlya rozrobky funktsional’no-oriyentovanoyi tekhnolohiyi yikhn’oho vyhotovlennya,” Zbirnyk tez IV naukovo-praktychnoyi konferentsiyi vykladachiv i studentiv instytutu fizyky, matematyky ekonomiky ta innovatsiynykh tekhnolohiy ”*Aktual’ni problemy suchasnoyi nauky*”, 12.05.2017, Drohobych, pp.178-180.

[7] A. M. Slipchyk, R. S. Jakum, “Pokrashchennya yakosti tekhnolohiyi protsesu zapresovuvannya zubkiv u sharoshky burovykh dolit,” *Vysoki tekhnolohiyi v mashynobuduvanni*. Kharkiv, NTU “KHPI”, Vol. 1 (27). pp. 134-143, 2017.

[8] A. M. Slipchyk, R. S. Jakum, “Pokrashchennya yakosti tekhnolohiyi protsesu zapresovuvannya zubtsiv u sharoshky burovykh dolit,” *Optymizatsiya vyrobnychykh protsesiv i tekhnichnyy kontrol’ u mashynobuduvanni ta pryladobuduvanni*, no. 867, pp. 69-77, 2017.