ASPECTS REGARDING THE INDUCTORS
DIMENSIONING USED BY BRAZING OF THE METAL
CARBIDE PLATES ON THE DETACHABLE BITS

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Abstract: In this paper there are presented specific aspects concerning the accomplishment of joints by brazing in medium frequency currents of metal carbide plates on the alloyed steel body of the detachable bits used for percussive and pivoting drilling. Also, there are presented certain aspects related to the calculation of size determination for the inductors used to accomplish the joining, according to the required geometry of the drill bits used for the perforation of rocks and coal.

Key words: detachable bits, metal carbide plates, join by brazing

1. INTRODUCTION

In the mining industry one of the rock cutting methods, in order to obtain useful mineral substances, is the one by drilling - blasting. During the use of this method, the rock drilling activity has an utmost importance in respect of obtaining high level performances, namely high drilling speeds and, as a result, a high productivity. In order to carry out the drilling operation, there are used various types of drills and working principles, equipped with auger bits that can be in one piece or demountable (auger stem and detachable cutting bit). This paper is aimed at achieving detachable auger bits, with high performances in respect of their blades’ abrasion hardness.

2. OBJECTIF

The working principle of drills can be percussive, pivoting or percussive-pivoting and accordingly the drilling process is percussive, pivoting or percussive-pivoting. According to the drilling type, the shape of the detachable auger bits varies.

Figures 1 and 2 present the standardized constructive solutions (STAS 7476-
90) for detachable auger bits armed with metal carbide plates for DCP type percussive drilling (in simple, continuous and parallel edged chisel) and for CR type pivoting drilling.

Fig. 1. Detachable bit armed with metal carbide plates for DCP type percussive drilling.

Fig. 2. Detachable bit armed with metal carbide plates for CR type pivoting drilling.

The body of these detachable bits is made of alloyed steel OSC 7 or OSC 8 type, and the metal carbide plates must have a minimum bending hardness of 1400 MPa in the case of percussive drilling and of 1300 MPa in the case of pivoting drilling.

In order to build the detachable bits, the following constructive and technological requirements must be observed:
- the DCP type detachable bits are built with a conical shaped joining hole, and the CR type detachable bits are built with a cylindrical shaped joining hole. Their body must not show any cracks, fissures, deposits or crusts;
- the exterior surface must be clean in order to allow the determination of possible defects.
- the radial bit of the exterior surface of the detachable bit to the hole’s axis, measured on the $D$ diameter, must not exceed 0.5 mm. Also, the blade of the metal carbide plates must be perpendicular on the metal body’s axis.
- the width of the joint where the junction material is applied between the plate and the detachable bit’s body must be of 0.2...0.3 mm for each side.
- the junction’s quality must ensure a hardness of minimum 150 MPa to static shearing force; for the CR type detachable bit, the junction’s quality must ensure a hardness equal to the shearing limit of the metal carbide
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- the hardness of the detachable end must comply to the prescriptions of the standard in force for steel in a normalized state;
- after the sharpening of the plates, the detachable bit is protected against corrosion by exterior painting and interior greasing.

The research team of the Machines, installations and transports’ department, led by University of Petrosani Professor Ph.D. Eng. Carmen Florea, took a particular interest in accomplishing performing detachable bits, aiming to establish a technology as adequate as possible for them. In the attempt to accomplish this goal, during the first stage the improvement of the quality of the auger bits’ blades of types DCP and CR was targeted, maintaining their standardized geometry.

The stages of the detachable auger bits’ manufacturing process for pivoting drilling are:

1. stamping of the detachable bit’s body;
2. debarring;
3. milling of the bearing for hard plates;
4. milling of the joining section with the auger bit’s stem;
5. turning of the detachable bit’s line;
6. joining of the hard plates on edges;
7. sharpening of the edges;
8. painting of the detachable bits.

The stamping of the detachable bit’s body, as well as the other mechanical processing operations is carried out on existing equipment, without requiring special endowments.

The DCP type detachable bit (simple, continuous and parallel edged chisel), designed for percussive drilling, presented in figure 1, is made of a steel body on which a tungstate carbide hard plate that represents its edge is mounted on by joining with a brass alloy. The CR type detachable bit, designed for pivoting drilling, presented in figure 2, is made of two blades, the head and the line used for fixing it inside the auger bit’s stem. The edges result from mounting tungstate carbide hard plates on the detachable bit’s steel body by soldering. Stamping, as previously shown, OSC 7 type steel makes the detachable bit’s body.

### 3. INDUCTOR DIMENSION CALCULUS

In order to join the hard plates on the detachable bits’ body a brazing installation with medium frequency currents is used, so that the plates’ structure and materials properties do not change during this operation. Brass plate is used as an alloy for the joining procedure. In order to join the plates, the detachable bit’s body is fixed on a device positioning it so that it can be maintained at the same distance from the inductor of the installation with medium frequency currents.

The type of inductor required for heating up the brass and for carrying out the joining procedure of the hard plates on the detachable bits steel body is of the series...
called „demountable”, being made of copper pipe with a size of Ø11×1 mm. For the inductor’s size determination calculation, the following imposed input data were used: [1], [3]
- maximum heating temperature $T_{\text{max}}$: 900 °C;
- electric power $P$: 110 kW;
- intensity of current $I$: 210 A;
- frequency, $f$: 8000 Hz.
- depth of the heated layer $x_k$: 0.45 mm;
- the piece’s diameter $D_2$: 40 mm;
- length of the heated band $a_3$: 26 mm;
- specific power transmitted into the piece to be heated up $p_0$: 81.4 kW/mm$^2$.

According to this data, the inductor’s diameter $D_1$; the inductor’s width $a$; the inductor conductor’s wall thickness $d_1$; the inductor’s interior section’s surface $S$; the radius of the pipe of which the inductor is made $r$; the inductor’s width $a_1$; the current in the inductor $I_i$; the power absorbed by the inductor, $P_i$ will be determined.

1. The inductor’s interior diameter.

$$h = D_1 - x_k = D_1 - (D_2 - 2d_1),$$

where $h$ is the air gap between the inductor and the piece to be heated up. This space is usually considered between the limits of 2...5 mm, if $D_2 < 50$ mm, and 5-10 mm if $D_2 > 100$ mm. In the given situation it is considered to be $h=2$ mm.

2. The thickness of the wall crossed by current.

$$d_1 = 2\left(\frac{P}{\pi f (D_2 - 2d_1)} - d_1\right)$$

At simultaneous heating, when the conductor has a permanent cooling, it is carried out from the laminated copper pipe. At $f < 10^4$ Hz, the pipe’s thickness is considered, when possible, as closed as possible to the optimum one:

$$d_1 = \delta$$

The 1 mm pipe wall’s thickness of which the inductor is made is taken into consideration.

3. The inductor’s interior section’s surface.

$$S = \frac{q}{v}, \quad \text{m}^2,$$

where: $q$ is the inductor’s cooling water’s flow; $v$ – the water’s velocity.
\[ S = \frac{3.7 \times 10^{-3}}{0.7} = 5.04 \times 10^{-3} \text{ m}^2 \]

4. The pipe’s radius of which the inductor is made:

\[ r = \sqrt{\frac{S}{\pi}} = \sqrt{\frac{5.04 \times 10^{-3}}{\pi}} = 4.05 \times 10^{-3} \text{ m} = 4.05 \text{ mm} \quad (5) \]

5. The inductor’s width.

The real width of the layer heated up to the given temperature will not equal the inductor’s width. If only one part of the surface is subjected to the heating process, then the heated layer’s width will always be smaller than the inductor’s width due to the heat loss in the metal’s non-heated parts.

If the hardening procedure is carried out on the entire surface, then there is no heat loss laterally. The inductor’s width is considered to be smaller than the piece’s length \( l \).

In average, it can be considered that at radio frequencies:

\[ a_i \approx l - h \quad (6) \]

where \( h \) is the air gap (the distance between the piece and the inductor’s interior surface), and the medium ones (\( f \leq 10^4 \text{ Hz} \)):

\[ (7) \]

6. The piece’s calculation diameter:

\[ \delta_i = 0.5 \sqrt{f} = 0.5 \sqrt{8000} = 0.0447 \text{ m}; \quad (7) \]

At the calculation of the active layer’s depth \( \xi \) will be considered the average value of environment’s magnetic permeability \( \mu = 16 \).

To this value of the piece’s calculation diameter corresponds a coefficient \( k=0.534 \) so that the active layer’s depth will be \( \xi = k \delta_i = 0.023 \text{ m} \). In a hot regime, the calculation diameter is:

\[ (8) \]

7. The recalculated value of the specific power

\[ p'_0 = p_0 \frac{D_2}{D'_2} = 8.14 \times 10^6 \frac{0.058}{0.057} = 8.28 \times 10^6 \text{ W/m}^2 \quad (9) \]

The specific power \( p_0 \) corresponds to the piece’s exterior surface. As during
the calculation, the formula for plane wave is used, by developing the heated up layer according to the calculation diameter, the specific power for the layer’s calculation surface must be recalculated.

8. Power transmitted into the piece

\[ P_t = \pi D_2 a p_0 , \quad W \]  
\[ p_0 = \pi \cdot 0.058 \cdot 0.0312 \cdot 8.14 \cdot 10^6 = 4.63 \cdot 10^4 \quad W \]

9. The current in the one spiral inductor

\[ I' = \sqrt{\frac{P_t}{r_2}} = I = \frac{4.63 \cdot 10^4}{4.2 \cdot 10^{-4}} = 10488 \quad A \]  
(11)

where \( r_2 = 4.2 \cdot 10^{-4} \Omega \) is the reported hardness of the heated up layer.

10. Tension on the one spiral inductor conductor

\[ \text{where } \ \Omega \text{ is the inductor’s impedance.} \]

11. Inductor’s number of spirals

\[ \text{where } \ z_e = 8 \cdot 10^{-4} \Omega \text{ is the inductor’s impedance.} \]

12. Power absorbed by the inductor

\[ P_i = \frac{P_t \cdot 10^{-3}}{\eta_i} = \frac{4.63 \cdot 10^4 \cdot 10^{-3}}{0.718} = 64.48 \quad kW \]  
(14)

The calculation is made for a cylindrical inductor designed to heat up a cylindrical piece.

4. Obtained results

The inductor’s final shape resulted after several practical attempts to join the hard plates accomplished with an installation with medium frequency currents existing in the specialized laboratory of the University of Petrosani. [1], [2]

In figure 3 there are presented the arming plates, made of tungstate carbide, that are joined by brazing on the CR type detachable bits and are designed for pivoting drilling, and in figure 4 the DCP and CR type detachable bits are presented, on which the tungstate carbide arming plates were soldered.
In figure 5 the inductor’s constructive form is presented that was used for joining the tungstate carbide plates on the steel body of the CR type detachable auger bits used for pivoting drilling.

In figure 6 the installation with medium frequency currents is presented that was used to join the plates by brazing.

**5. CONCLUSIONS**

The accomplishment of the DCP and CR type detachable bits involves mounting arming plates made of tungstate carbide on the sides of then bits’ steel bodies which represent the cutting edges. Joining with brass alloy, using an installation with
medium frequency currents, in order not to modify the metal carbide’s properties of which the arming plates are made, does the mounting of these plates. In order to carry out the brazing operation it was necessary to make a size determination calculation for the corresponding inductor. During the calculation the following were taken into consideration: the detachable end’s steel body’s sizes, as well as the sizes of the arming plates. As a result of this calculation, and based on practical trials an inductor was made, using copper pipe with cooling by water circulation.

With this inductor’s help, mounted on the installation with medium frequency currents, it was possible to carry out the joining operation of the tungstate carbide hard plates on the detachable auger bit’s body.

Thus, a high quality joining was achieved; obtaining detachable auger bits for percussive drilling (of the DCP type) and for pivoting drilling (of the CR type) that are currently used in production with good results.

REFERENCES