The desired path of motion for the CNC hollow mill, round-ended slotting chisel's wear & dust conditions in the facsimile engraving technology for minerals

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Požadovaná dráha pohybu CNC korunovej frézy, opotrebenie zaobleného drážkovacieho hrotu a prašnosť pri faxovej technológii rytia do minerálov

Pri faxovej technológii rytia do minerálov musí byť pôvodný polotónový obraz nahradený mikronárazovým obrazom na CNC korunovej fréze zaobleným drážkovacím hrotom. Konečný mikronárazový obraz je výsledkom vzdaľovania mikrodotykových prvkov. Práca popisuje rovnice pre opotrebovanie a veľkosť dotyku zaobleného drážkovacieho hrotu. Doporučené sú tiež podmienky rytia ako je rýchlosť, hĺbka, atď.

In facsimile engraving technology for minerals the facsimile copying of images on mineral surface can be made by rastration (dithering), when the original halftone image is replaced by microstroke image, consisting of line and dot elements. In this case we need a CNC hollow mill and a round-ended slotting chisel.

Brittle materials (minerals, cast iron, bronze, etc.) have an ultimate compression strength more than 20-100 higher than the ultimate tensile strength. As a result, the fragile destruction is typical for minerals in the facsimile engraving technology. The crater has no built-up edge and the waste looks like a dust.

In general, in the process of facsimile engraving, a videosignal is transformed, amplified and fed to the electromechanical converter with the slotting chisel, which creates image elements by penetrating into the material. Different halftones are reproduced by a pulse modulation of a 2-dimensional signal. Engraving of an image is performed by scanning moving along the lines of the image with raster impact moving of the converter.

The impulse force $\boldsymbol{F}$ (amplitude modulation and frequency modulation) is proportional to the videosignal

$$U_{video} : F = f_{sign} (U_{video}). \qquad (1)$$

In the process of facsimile engraving the total force consists of potential and kinetic forces

$$F_{\Sigma} = F_p + F_k = F_p + Q_k / \Delta_z , \qquad (2)$$

where

F_{Σ} - total impulse force axial component

F_p - electromagnet rotor clearance potential force axial component

F_k - the first kinetic force axial component (at the beginning of slotting chisel contact with the surface of mineral)

Q_k - the second kinetic force axial component (at the end of slotting chisel contact with the surface of mineral)

Δ_z - rotor shift along the Z-axis

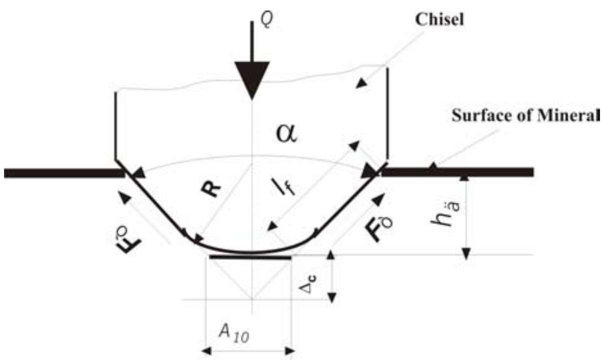

Fig.1

The linear shift along the axis orthogonal to the material surface is transformed into a relative area of a spacing element. The form and size of the crater do not repeat the form of the chisel. There are two types of chisel wear: initial wear (break wear) and abrasive wear. As a result of initial wear (Fig.1) the width of area A_{10} is determined by the formula

$$A_{10} = (2QE/\sigma \sigma_0)^{1/3} , \qquad (3)$$

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where
Q - amount of energy **E** - Young Module σ - chisel material tensile strength σ_0 - 3-dimensional chisel material strength

Slotting chisel linear wear after one hit the surface of mineral Δ_w

$$\Delta_w = [Q f E Y \sin(\alpha/2)] A^2 \sigma^2 \sigma_0 k_t, \tag{4}$$

where
A – chisel width **f** – coefficient of friction K_t - temperature coefficient ($K_t = 10^7 \ldots 10^8$)
E – chisel material Young Module

Machine engraving by dithering is identical to the destruction by impact and includes 3 technological stages. The first technological stage is a preliminary stage, when the chisel does not touch the surface of mineral. In the second technological stage, the chisel hits the surface. Practically, there is a small amount of dust in the area of elastic plastic deformation (zone of halftone engraving) and a lot of dust in the area of material destruction (Fig.2).

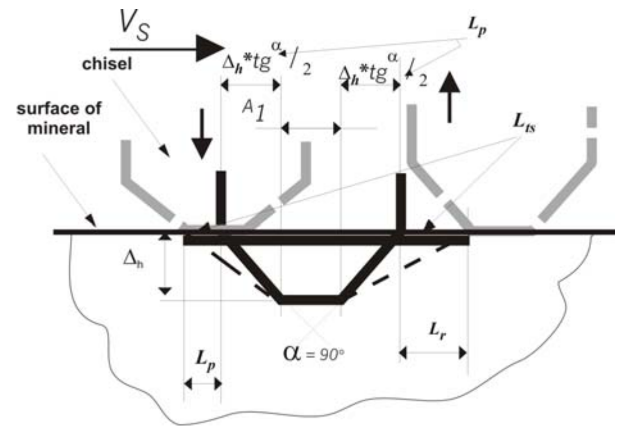

Fig.2

Formulas for dust conditions are:

Touch stage $L_{ts} = V_s\ \tau + L_p + A_1 + L_r,$ (5)

Penetration stage $L_p = 2\Delta_h\, tg\ \alpha/2,$ (6)

Return stage $L_r = V_s\, (\Delta_h/(\Delta_h + \Delta_c))\ t_r,$ (7)

where
L_{ts} – stroke length V_s – stroke speed A_1 –chisel width
L_p – penetration stroke length
L_r – return stroke length α- chisel cutting edge
Δ_h – depth of penetration
Δ_c – clearance between chisel and surface of mineral
τ - time of penetration

$$\Delta_h = f\,(U_{video}) \tag{8}$$

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