RESEARCH ON A TECHNOLOGY FOR QUARTZ CRYSTAL PROCESSING

***Genadi Takov* [1], *Milorad Ranchich* [2], *Tsvian Zhepenich* [2]**

[1] University of Mining & Geology "St. Ivan Rilski" 1700 Sofia
[2] High Technical School, 23000 Zrenjanin, Serbia

ABSTRACT: The physical mechanical properties of a great number of crystals, used in building elements of the electronic industry, the instrument engineering and in part of the mechanical engineering, place them in the group of the materials that are difficult to be processed. The present article examines one of the methods for crystal processing, namely the method of abrasive rubbing used in the quartz processing. The purpose of this research is to establish the correlation dependency between the specific pressure at rubbing, and the processing speed and time.

ИЗСЛЕДВАНЕ НА ТЕХНОЛОГИЯ ЗА ОБРАБОТВАНЕ НА КВАРЦОВИ КРИСТАЛИ

***Генади Таков*[1], *Милорад Ранчич* [2], *Цвиан Жепенич*[2]**
[1] Минно-геоложки университет „Св. Иван Рилски", 1700 София
[2] Висше техническо училище, 23000 Зренянин, Република Сърбия

РЕЗЮМЕ: Физико-механичните качества на редица кристали използвани в градивни елементи от електронната промишленост, приборостроенето и в част от общото машиностроене, ги класират в групата на труднообработваемите материали. В настоящата статия се разглежда един от методите за обработване на кристали – метода на абразивно притриване, приложен при обработването на кварц. Целта на изследването е да се установи корелационна зависимост между специфичното налягане при притриване, със скоростта и времето за обработка.

Introduction

Satisfying the needs of the electronic industry for building elements is a many-sided task. The composition of a considerable part of such elements includes materials that are difficult to be processed, such as quartz and silicon crystals, oxide ceramics and others, as expensive technologies and equipment are used for its precise processing. In connection with the needs of the instrument engineering and of the general mechanical engineering for precise details, made by materials that are very difficult to be processed, it becomes clear that the researches of respective technologies and equipment for their implementation are topical issues.

In connection with the implementation of a technology and a number of machines for rubbing quartz crystal plates, there are many theoretical and experimental researches carried out on the process of "rubbing". The present paper presents part of the theoretical researches on the process kinematics, which are in the basis of determining the processing technology.

The research on the work mechanisms of the rubbing machines has resulted in establishing general geometrical and kinematic dependencies, on the basis of which the mathematical type (the geometrical shape) can be determined, which is of the cycle trajectories in the relative movement, a processed detail – rubbing instrument (grind) at mechanisms, different in their structure.

The cyclicly repeatable regularity of the linear speed change and the relative movement acceleration, and therefore their influence on the shape forming of the processed surfaces, depends on the type of the cyclic trajectories. The result of specifying the speed in the relative movement detail – grind, is shown below.

Theoretical Research

The law on the speed and acceleration cyclic change completely depends on the shape of the cyclic trajectories. Whether these changes shall be easy or connected with sudden transitions depends on the type of wear of the work surface of the lapping instrument.

In the property of the computing system for working out the formulae according to the specification of the polar coordinates of the vector $\overline{V_C}$ of the speed of any point C from detail No. 5, representing one whole with separator No. 2, (Fig.1), we shall use the scheme of the velocities $Cb'c'C$ from the scheme poles at point C.

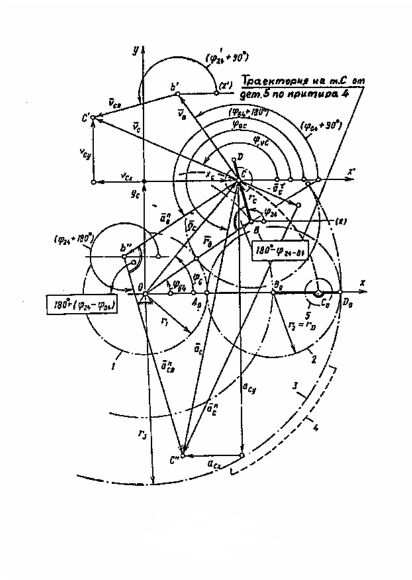

Fig.1

This scheme of the velocities, obtained on the basis of the vector equation, which presents the kinematic dependency of the speed vector of two points on the straight line BC or the straight line BD, which is part of separator No. 2 :

$$\frac{\overline{Vc}}{V} = \frac{\overline{V_B}}{V} + \frac{\overline{V_{CB}}}{V} = \overline{\omega_{B4} r_B} + \overline{\omega_{24}(\lambda r_2)} \qquad (1)$$

where: $\omega_{B4} = \omega_B - \omega_4$; ω_2 и ω_B - angular speed of the separator and respectively of the bar. It is important to notice that section 2 and section B can be lead, and that in solution of the set task the value of the preliminary ratio of these sections with respect to the rubbing instrument is of main importance. If we accept a simplified symbol for the preliminarily specified ratio u_{2B} instead of $u_{24\text{-}B4}$, i.e.

$$u_{2B}=u_{24\text{-}B4}=\frac{\omega_{24}}{\omega_{B4}} = \frac{\omega_2 - \omega_4}{\omega_B - \omega_4} \qquad (2)$$

for determining ω_{B4} and ω_{24}, with ω_{14} and ω_{34} known; $\left(\omega_3 = \frac{\omega_1}{u_{13}}\right)$, we use Smirnov-Vilis formula [3], which presents the law for gearing the cogged couple, as the axis of its cogged wheels is located on the bar. In case of external gearing of cogged couple 1-2 and in case of internal gearing of cogged couple 2-3, we have:

$$\frac{\omega_{14} - \omega_{B4}}{\omega_{24} - \omega_{B4}} = -\frac{r_2}{r_1}; \frac{\omega_{24} - \omega_{B4}}{\omega_{34} - \omega_{B4}} = +\frac{r_3}{r_2} \qquad (3)$$

Thus, after transformation by taking into consideration $r_2 = \frac{r_3 - r_1}{2}$ and denotation $\frac{r_1}{r_3} = k_r$ as well as $\frac{\omega_{14}}{\omega_{34}} = u_{14-34}$ i.e.

$$u_{14-34} = \frac{\omega_{14}}{\omega_{34}} = \frac{\omega_1 - \omega_4}{\omega_3 - \omega_4}, \qquad (4)$$

as we successively have:

$$\omega_{B4} = \frac{\omega_{34} + \omega_{14} k_r}{1 + k_r} = \frac{\omega_{34}(1 + k_r u_{14-34})}{1 + k_r}; \qquad (5)$$

$$\omega_{24} = \frac{\omega_{34} - \omega_{14} k_r}{1 - k_r} = \frac{\omega_{34}(1 - k_r u_{14-34})}{1 - k_r} \qquad (6)$$

The coefficient K_r here is for the relative sizes of the mechanism. It is important to note that we can change the values of $u_{14\text{-}34}$ by setting the rubbing disk No. 4 a revolution with angular speed of ω_4, and thus the shape of the trajectory of a point of the rubbing disk can change, or vice versa, if we set the needed quantity of $u_{14\text{-}34}$ – to determine ω_4 from the formula (4):

$$\omega_4 = \frac{\omega_3 u_{14-34} - \omega_1}{u_{14-34} - 1} \qquad (7)$$

We enter on the scheme – Fig. 1, the angular coordinates of the vectors $\overline{V_B}$ and $\overline{V_{CB}}$, read by the axis CX$^{/}$, which is parallel to OX. These angular coordinates differ from the coordinates φ_{B4} and φ_{24} of the vectors $\overline{r_B}$ and $\overline{\lambda r_2}$, as we add to each of them 90^0 because $\overline{V_B} \perp \overline{r_B}$, and $\overline{V_{CB}} \perp \overline{\lambda r_2}$.

We mark the wanted angular coordinate of the vector $\overline{V_C}$ with φ_{VC}.

We shall obtain the following formula by projecting the vector outline on the coordinate axes, as this vector outline is marked by an equation (1), as its left part on the clarity figure is added by $\overline{V_{CX}} + \overline{V_{CY}}$ - a geometrical sum of the projection of V_c of the X and У axes:

$$V_C = \sqrt{V_B^2 + V_{CB}^2 + 2V_B V_{CB}\cos\varphi_{2B}} = \omega_{B4}\sqrt{r_B^2 + u_{2B}^2(\lambda r_2)^2 + 2u_{2B} r_B \lambda r_2 \cos\varphi_{2B}} \qquad (8)$$

$$tg\varphi_{VC} = \frac{V_B\cos\varphi_{B4} + V_{CB}\cos\varphi_{24}}{V_B\sin\varphi_{B4} + V_{CB}\sin\varphi_{24}} = \frac{r_B\cos\varphi_{B4} + u_{2B}\lambda r_2\cos\varphi_{24}}{r_B\sin\varphi_{B4} + u_{2B}\lambda r_2\sin\varphi_{24}} \quad (9)$$

where, as well as above , $u_{2B} = \frac{\omega_{24}}{\omega_{B4}}$; $\varphi_{2B} = \varphi_{24} - \varphi_{B4}$

It is evident that the wanted coordinates, which mark the value and the direction of the vector $\overline{V_C}$, are marked by the main kinematic parameter u_{2B} of the implemented machine mechanism. Formulae (8) and (9) present the equations of the cycle change of the speed of any point C of detail No. 5 with respect to the rubbing disk No. 4.

We analytically establish the vector $\overline{\alpha_C}$ - the full acceleration of point C, by representing the acceleration plan on the figure in accordance with the vector equation:

$$\overline{\alpha_C} = \overline{\alpha_B^g} + \overline{\alpha_{CB}^g} = \overline{\omega_{B4}^2 r_B} + \overline{\omega_{24}\lambda r_2} \quad (10)$$

where the vectors, known according to value and direction, of the right part $\overline{\alpha_{BD}^g} II \overline{BO}$ and $\overline{\alpha_{CB}^g} II \overline{CB}$. By taking into consideration that ω_{B4} and ω_{24} - constant and successive angular accelerations ε_{24} , ε_{B4} of the bar and the separator 2 are equal to zero.

The scheme of the acceleration with a pole in point C is presented in the figure as a vector outline Cb''c''C, as the clarity vector $\overline{\alpha_C}$ is represented through its components on the X and У axed, i.e. $\overline{\alpha_C} = \overline{\alpha_{CY}} + \overline{\alpha_{CX}}$

The angular coordinates ($\varphi_{B4} + 180^0$) and ($\varphi_{24} - 180^0$) of the vectors $\overline{\alpha_B^g}$ and $\overline{\alpha_{CB}^g}$, which differ by 180^0 from φ_{B4} and φ_{24} , as the wanted angular coordinate of the vector $\overline{\alpha_C}$ is represented by φ_{ac}.

Through the projections of the outline Cb''c''C of the X and У axes, and some changes, we obtain formulae for determining X and У, the combination of which provides the law on the cycle change of the full acceleration of point C from detail No. 5 with respect to rubbing disk No. 4, namely:

$$\alpha_C = \sqrt{\left(\alpha_B^g\right)^2 + \left(\alpha_{CB}^g\right)^2 + 2\alpha_B^g\alpha_{CB}^g\cos\varphi_{2B}} = \omega_{B4}^2\sqrt{r_B^2 + u_{2B}^2(\lambda r_2)^2 + 2u_{2B}^2 r_B(\lambda r_2)\cos\varphi_{2B}} \quad (11)$$

$$tg\varphi_{ac} = \frac{\alpha_B^g\sin\varphi_{B4} + \alpha_{CB}^g\sin\varphi_{24}}{\alpha_B^g\cos\varphi_{B4} + \alpha_{CB}^g\cos\varphi_{24}} = \frac{r_B\sin\varphi_{B4} + u_{2B}^2(\lambda r_2)\sin\varphi_{24}}{r_B\cos\varphi_{B4} + u_{2B}^2(\lambda r_2)\cos\varphi_{24}} \quad (12)$$

After we know the full acceleration $\overline{\alpha_C}$, we establish its main components –the tangential $\overline{\alpha^\tau}$ that is a tangent to the trajectory of point C and the standard $\overline{\alpha_C^n} \perp \overline{\alpha_C^\tau}$, i.e. $\overline{\alpha_C} = \overline{\alpha_C^\tau} + \overline{\alpha_C^n}$, we establish $\overline{\alpha_C^\tau}$ by differentiating the formula for V_c (equation No. 8) according to time:

$$\alpha_{C\tau} = -\frac{\omega_{2B}V_B V_{CB}\sin\varphi_{2B}}{V_C} = -\frac{\omega_{2B}\omega_{24}r_B\lambda r_2\sin\varphi_{2B}}{\sqrt{r_B^2 + u_{2B}^2(\lambda r_2)^2 + 2u_{2B}r_B\lambda r_2\cos\varphi_{2B}}} \quad (13)$$

Then we figure $\alpha_C^g = \sqrt{\alpha_C^2 - \left(\alpha_C^\tau\right)^2}$ and the radius of

The trajectory curve of point C according to the formula $R_C = \frac{V_C^2}{\alpha^g}$

We obtain extraordinary values for V_C and α_C by consecutively placing values for $\varphi_{2B} = 0$ and $\varphi_{2B} = 180^0$ in formulae (8) and (11), namely:

$$V_{C\max} = \omega_{B4}(r_B + u_{2B}\lambda r_2) = \alpha_B^g + \alpha_{CB}^g$$

$\alpha_{C\max} = \omega_{B4}^2(r_B + u_{2Br}\lambda r_2) = \alpha_B^g + \alpha_{CB}^g$ i.e. we obtain a sym of identical in their direction modules of the vectors $\left|\overline{V_C}\right|, \left|\overline{\alpha_C}\right|$

$$V_{C\min} = V_B - V_{CB}; \alpha_{C\min} = \alpha_B^g - \alpha_{CB}^g$$

i.e. the difference of the modules of these vectors. When we have such “extraordinary” positions, the value of $\alpha_C^\tau = 0$ that is evident from the formula (13).

We shall note that the ratios $\frac{V_{C\max}}{V_{C\min}}$ and $\frac{\alpha_{C\max}}{\alpha_{C\min}}$ can be used as indicators for ease in the speed and acceleration cycle change.

Conclusions

1. The flows occurred as a result of accidental power microimpulses in the abrasive grains lead to dynamic loading in the system detail - abrasive layer – supporting surface of the instrument, as a complex pressure field in the material of these

bodies. The abovesaid determined the importance of the scheme proposed for the analytical determination.

2. The theoretical research on the work mechanisms of the rubbing machines, respectively the determination of general geometrical and kinematic dependencies and the establishment of a mathematical model, may be used as a basis for optical researches and as a precondition for implementing the technology.

Препоръчана за публикуване от
Рецензент доц.д-р В.Тенчев, МЕМФ

References

Karnobatlov I., Takov G., Some studies in the field of rubbing to quartz crystals, “Contemporaries engineering technologies”, Varna, 14^{th}-16^{th}, May, 1986.

Орлов П.Н., Савелова А.А. Анализ и выбор прецизных деталей пастами и суспензиами траекторий относителного движения деталей при обработке на плоскодоводочныхстанках.*Известия вузов* Машиностроение, М., 1972 г., № 1

Орлов П.Н., Несторов Ю.И., Полухин В.А. *Процессы доводки*,Машиностроене , М., 1975 г.