INFLUENCE OF CUTTING SPURS NUMBER ON NONCONTINUOUS ABRASIVE DISK ON PARAMETRIC STABILITY OF ELASTIC SYSTEM OF INDUSTRIAL MASHINE AND ON MACHINED SURFACE ROUGHNESS

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The results of studies aimed at identifying the occurrence of conditions in the elastic system of the grinding machine of parametric resonance while processing with abrasive disks whiel have noncontinuous work surface.

Keywords: elastic system of the grinding machine, parametric resonance, the number of slots, abrasive tools, parametric stability.

Introduction. Grinding as final processing method of allows for high accuracy of sizes and shapes and low roughness of processed surface. The main disadvantage of the grinding process is emergence of high temperatures in the cutting zone. Abrasive disks with noncontinuous work surface is an effective means of lowering the temperature while grinding [1]. However, widespread use of noncontinuous disks in the industry is constrained by the small study of dynamic phenomena inherent to this type of processing, the occurrence of vibration abrasive tools and, consequently, the inability to provide quality indicators of processed surfaces.

Analysis of recent researches and publications. Identification of the conditions of parametric instability of elastic system of the machine and its impact on values of precision of processed surfaces are dedicated works [2-8]. However, issues related to the emergence of parametric resonance while grinding noncontinuous abrasive disks in modern technical literature haven't received sufficient light.

Objective. The aim of this study is to reveal the impact of cutting spurs number of noncontinuous grinding disk and the magnitude of the ratio of width to length of spur to roughness deterioration of processed surface due to the change of parametric stability of elastic system of the grinding machine.

The main material. An unstable condition of elastic system [9]:

$$|L| > \frac{1+M}{2} \quad \textbf{(1)}$$

where

$$L = \frac{e^{-h(\tau_1+\tau_2)}}{h(k_2 + h\sin 2k_2\tau_1)}\Big[k_1^2 \sin k_1\tau_1 \sin k_2\tau_2 - \\ - 2\cdot k_1\cdot k_2\cdot \cos k_2\tau_1 \cdot \cos k_1\tau_1 \cdot \cos k_2(\tau_1+\tau_2) - \\ - k_2^2 \sin k_1\tau_1 \sin(2\cdot k_2\tau_1 + k_2\tau_2)\Big] \quad \textbf{(2)}$$

$$M = \frac{k_1 k_2 e^{-2h(\tau_1+\tau_2)}\cos(2\cdot k_2\cdot(\tau_1+\tau_2))}{h(k_2 + h\sin 2k_2\tau_1)} \quad \textbf{(3)}$$

$\tau_1 = \frac{l_1'}{V_{wh}}$; $\tau_2 = \frac{l_2'}{Vwh}$; $l_1' = \frac{\pi \cdot Dc}{n \cdot (1+N)}$; $l_2' = \frac{\pi \cdot D_c}{n \cdot \left(1+\frac{1}{N}\right)}$; $N = \frac{l_2'}{l_1'}$ – noncontinuity factor; n – the number of cavities on the abrasive disk; l_1' – spur length; l_2' – slot length.

$$k_1 = \sqrt{\frac{C_o}{m} + \frac{C_o \cdot \left(\frac{t_л}{t_ф} - 1\right)}{2 \cdot m} - h^2}\ ;\ k_2 = \sqrt{\frac{C_o}{m} - \frac{C_o \cdot \left(\frac{t_л}{t_ф} - 1\right)}{2 \cdot m} - h^2}\ ;$$

t_c, t_a – cutting depth is set according to the divided circle and the actual cutting depth; h – quantity that characterizes the damping of oscillations in time 1/s; C_0 – the given rigidity of the elastic system N/m; Vwh – disk speed; Dc – disk diameter; m – the given disk weight, $(N \cdot s^2)/M$.

Figure 1 shows the dependence of left $L = f(n, N)$ and right $\frac{1+M}{2} = f(n, N)$ sides of instability conditions that appear in a wave like and flat surfaces, respectively. The lines of mutual intersection of these surfaces delineate the area of parametric instability of elastic system, that are limits the factors that include a combination of such numbers of cutting spurs and values of noncontinuity factor at which adheres instability condition (1), that there is parametric resonance. Fig. 1 shows the effect of cutting spurs number on noncontinuous abrasive disk on parametric instability of elastic system of the machine, and Fig. 2 shows the impact of this instability on the roughness of the processed surface. Fig. 1 shows the investigated range of cutting spurs numbers $3 \le n \le 60$ divided into separate intervals (four spurs each), and on Fig. 2 by letters A, B and C the intervals of cutting spurs are marked, where there is parametric instability of elastic system of the machine. After grinding on machine MAAG by zero circuit with abrasive disks that have 8, 14, 22, 34 and 60 cutting spurs were held roughness parameters measuring on the left and right tooth profiles on comprehensive measuring machine "KIM P-100". The results of measurements are presented as experimental graphs (upper curve - for the left profile, lower curve for the right).

Comparison of these graphs with calculated dependencies $\frac{M+1}{2} = f(n)$, that characterizes the parametric instability of elastic system of the machine, revealed deterioration of roughness surface in case of parametric resonance, which is an indirect confirmation of the correctness of the calculations made. On the graphs $Ra = f(n)$ the improve of surface roughness by increasing the number of spurs on noncontinuous cutting abrasive disk is traced.

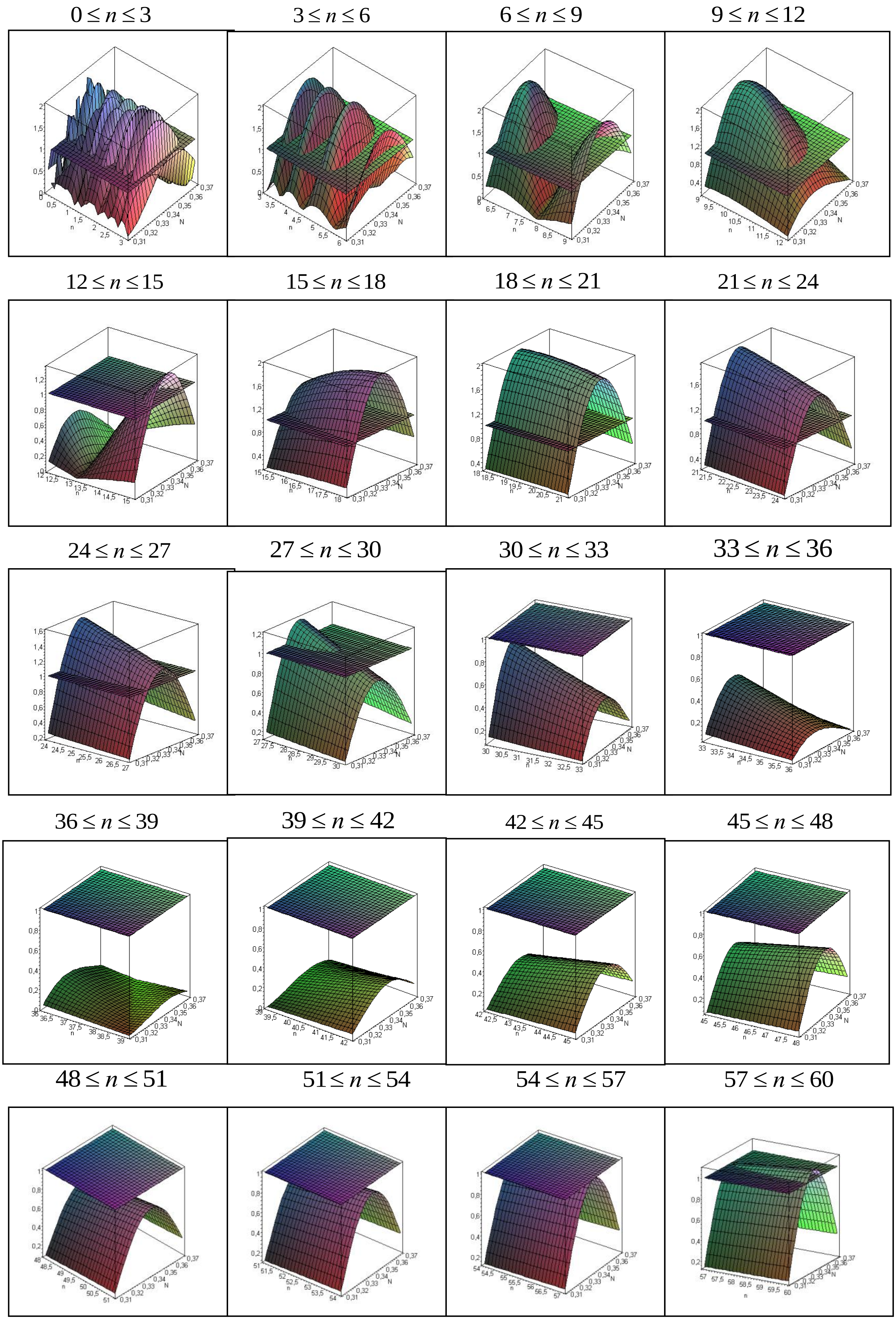

Fig. 1. Parametric excitation of elastic system of the machine at different intervals of changing of cutting spurs number

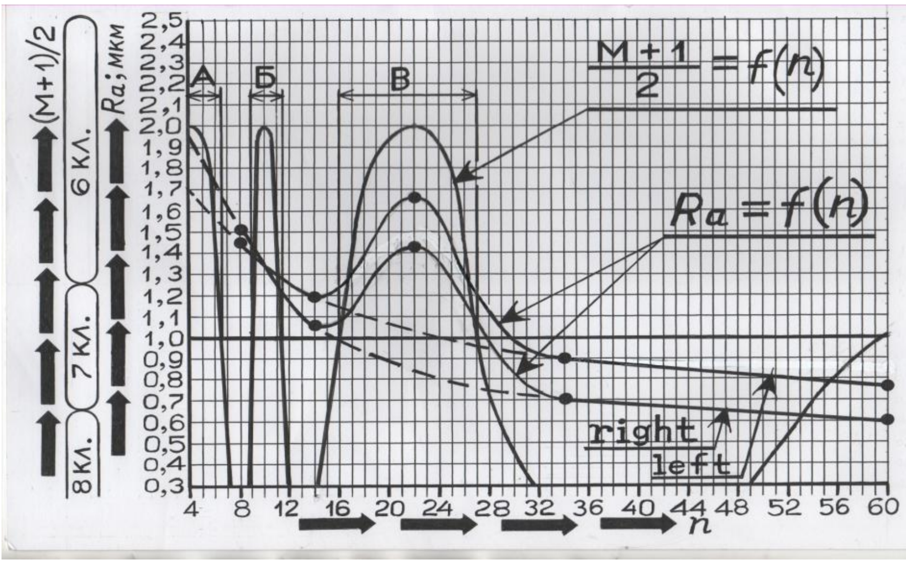

Fig. 2. The impact of parametric instability of elastic system of the machine on the processed surface roughness

The height of processed surface roughness depends not only on the number of spurs on noncontinuous cutting disk.

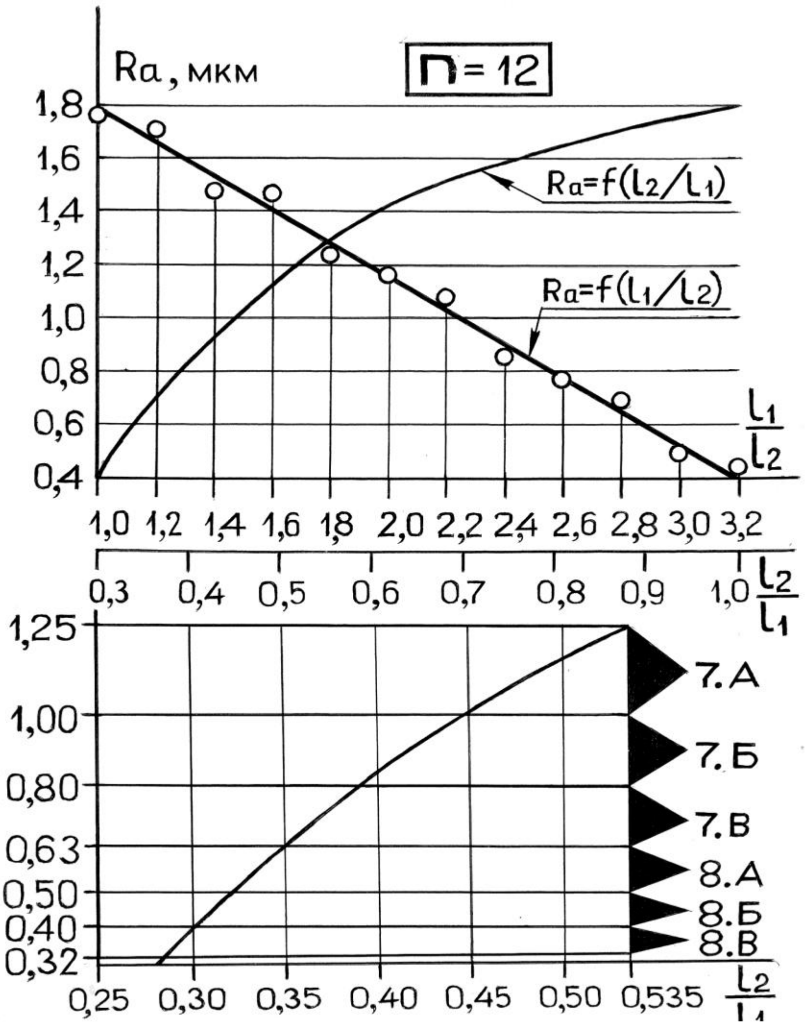

Fig. 3. The dependence of surface roughness on the ratio of the length of the cutting spurs l_1 and slots l_2 of the noncontinuous disk after a 10-minute period of grinding modes: $\boldsymbol{V} = 9$ m/min; $\boldsymbol{t} = 0{,}03$ mm; $\boldsymbol{S} = 2{,}4$ mm/move.

To a greater extent it depends on the ratio of width l_2 to length of the spurs l_1 (from the coefficient of noncontinuity N). The higher value of this ratio, the worse is roughness. This is evident from the experimental data presented in Fig. 3. Experiments were conducted for flat grinding.

Conclusion. Theoretically substantiated and experimentally confirmed that the number of spurs on noncontinuous cutting abrasive disk markedly affect the parametric stability of elastic system grinding machine and on the height of the processed surface roughness. This fact should be considered when designing abrasive disks with noncontinuous work surface.

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ВЛИЯНИЕ ЧИСЛА РЕЖУЩИХ ВЫСТУПОВ НА ПРЕРЫВИСТОМ ШЛИФОВАЛЬНОМ КРУГЕ НА ПАРАМЕТРИЧЕСКУЮ УСТОЙЧИВОСТЬ УПРУГОЙ СИСТЕМЫ СТАНКА И НА ШЕРОХОВАТОСТЬ ОБРАБОТАННОЙ ПОВЕРХНОСТИ

Якимов А.А., Уминский С.М., Дмитриева С.Ю.

Ключевые слова: упругая система шлифовального станка, параметрический резонанс, количество прорезей, абразивный инструмент, параметрическая устойчивость.

Резюме

Приведены результаты исследований, направленных на выявление условий возникновения в упругой системе шлифовального станка параметрического резонанса при обработке абразивными кругами, имеющими прерывистую рабочую поверхность.

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Summary

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