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EXPERIMENTAL VALIDATION OF MATHEMATICAL MODEL FOR A 4-SPINDLE GRINDING-POLISHING MACHINE KINEMATICS

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ЭКСПЕРИМЕНТАЛЬНОЕ ОБОСНОВАНИЕ МАТЕМАТИЧЕСКОЙ МОДЕЛИ ДЛЯ ЧЕТЫРЁХ ШПИНДЕЛЬНОЙ ШЛИФОВАЛЬНОЙ МАШИНЫ ПОЛИРОВКИ КИНЕМАТИКИ

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Spindle device kinematic movement model is represented in the article. The expressions of kinematic indicators having major impact on rotation frequencies optimization have been given. The impact of rotation frequencies on numerical values of slip velocity has been outlined.
Key words: *spindle device, grinding-polishing machine, microroughness, sliding.*

In order to prove the obtained mathematical model a preliminary experiment has been conducted. Cutting parameters for the preliminary experiments were chosen from literary sources. Spindle and workpiece rotation frequency is determined as N_{min}=100-1400 rpm, the whole device rotation frequency is $N_{н}$=50 rpm.

The increase in rotation frequency of each of the 4 spindles of the device from 100 to 700 rpm at the starting moment leads to surface undulation magnitude sharp fall from Ra=1.5mym to Ra=0.55 mym. Further spindle rotation frequency increase from nмn=700 rpm to 900 rpm leads to surface undulation minor decay (from Ra=0.55mym to Ra=0.5 mym).

It is explained by the fact that 4 spindles rotation frequency increase at the starting moment from 100 rpm to 600 rpm leads to surface undulation magnitude sharp fall at the expense of resultant sliding velocity rise. Within the range of rotation frequencies Nmin=600-900 rpm slip velocity, between resultant sliding velocity array and chatter marks directions, tends to its optimum value, i.e. in this case the segment has minimum roughness altitude, i.e. these are ideal conditions for cutting. With the speedup Nmin=1300 rpm we observe slight increase in slip velocity, sharp twofold rise in rolling rate and the same increase of angle between resultant slip velocity array and chatter marks. As a result, roughness altitude rises to Ra=0.8 mym. For objective estimation of theoretical and empirical data variation we processed the results of test observations in the existing method (1). Series of experiments consist of tentatives for each one.

We process the measurement results in the following order:

1. Determine medium value of rotation frequency from *n* measurements:

$$\vec{n} = \frac{1}{n} \cdot \sum_{1}^{n} n_{sp} c_i$$

2. Find out inaccuracy of certain measurements:

$$\Delta n_{sp} = \overline{n}_{sp} - n_{sp}$$

3. Determine the root-sum-square uncertainty, measurement series result:

$$\Delta S n_{sp} = \frac{\sqrt{\sum_{1}^{n} \left(\Delta n_{sp} i\right)^2}}{n(n-1)}$$

4. Estimate relative variation of empirical and theoretical data according to the formula:

$$\Delta = \frac{\overline{n}_{sp} - n_{sp}}{\overline{n}_{sp}} \cdot 100\%$$

Having processed the obtained results according to the described above methods we verify that variation of theoretical and empirical data does not exceed 2 %.

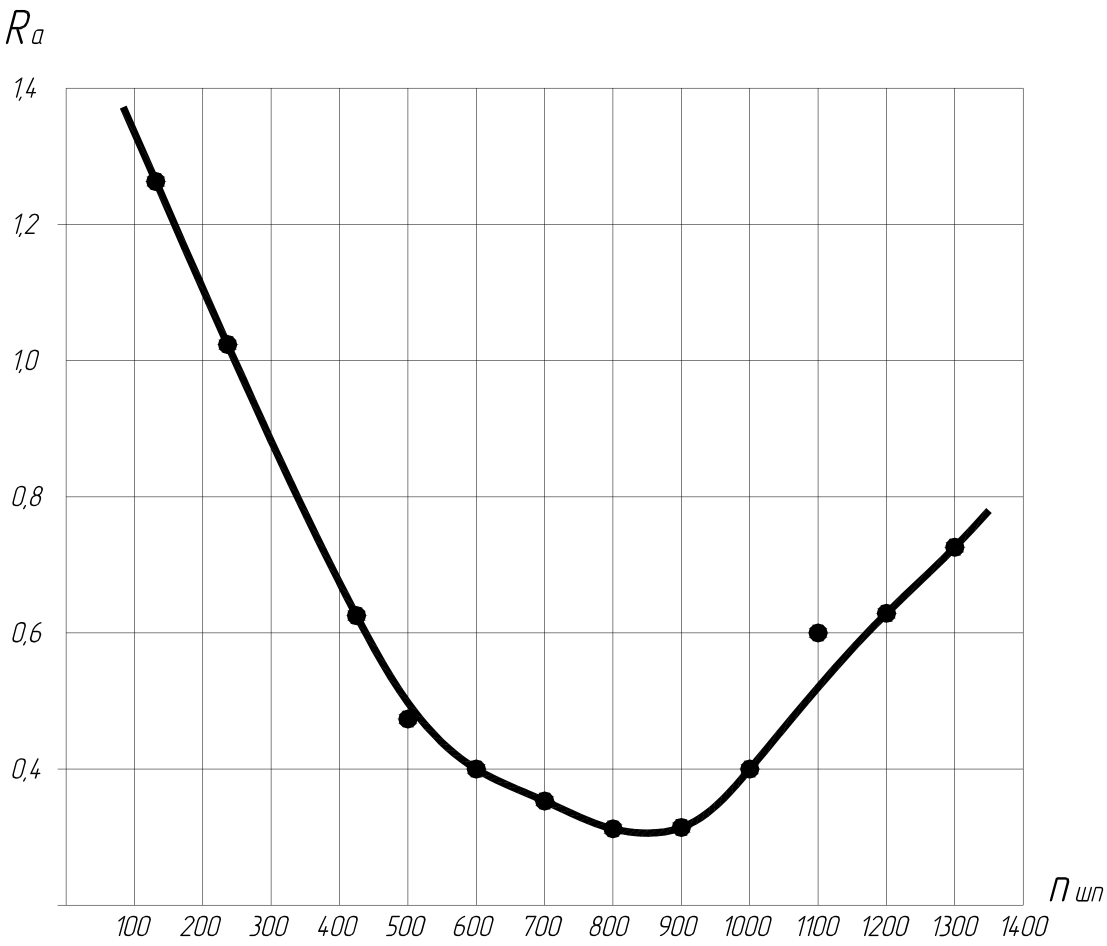

Fig. 1. Ra microroughness altitude – n_{sp} spindle rotation velocity relation

Therefore, the suggested theorizes for determining kinematical indicators are fully plausible for conducting further experimental research.

The datum node of machine tools

The metal-cutting machine tool is a machine, which is intended for processing of feedstock for formation a given surface by taking off a shaving or plastic deformation. Manufacturing equipment, which use electrophysical and electrochemical methods, focused electronic and laser ray, superficial plastic deformation and some other types for processing, is applied to the tools.

e metal-cutting machine tool is subdivided on some the most important parts, usually named as knots.

The *main assembly* of the machine tool informs movement to the tool or to the feedstock for realization the process of cutting with a corresponding speed. At the overwhelming majority of machine tools main assembly (Fig. 1) informs a rotary motion to a spindle, in which cutting tool or feedstock is fixed.

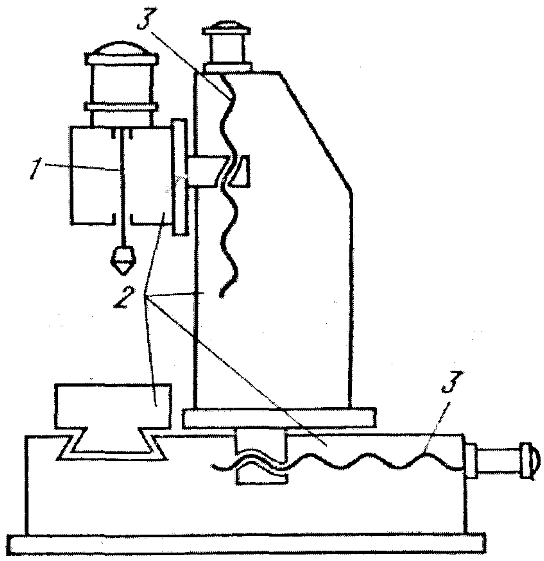

Fig. 2. Datum Node (assembly units) of the machine tool: 1 – main assembly, 2- basic parts, 3 – feeding device

Resume

1. As a result of conducted mathematical investigation a mathematical model of spindle machine kinematical movement has been determined.
2. The expressions of kinematical indicators, having major impact on rotation frequency optimization have been led out.
3. The impact of rotation frequency on numerical values of slip velocity has been determined. As the rotation frequency rises nsp=100-700 rpm slip velocity increases approximately two times. With further rotation frequency increase, slip velocity remains almost unchanged. The diameter change of works from minimum to maximum leads to slip velocity rise, that, in its turn, positively affects the surface quality and work-piece accuracy.
4. Rolling speed survey shows that it is minimal at minimum values of rotation frequencies. As the rolling speed rises they increase approximately 2-3 times. With the work-piece diameter increase rolling speed drops, that, in its turn, favourably affects the treatment process.
5. As a result of pilot experiment the smallest altitude of microroughnesses Ra=0.55 mym will be at spindle rotation frequency equal to n_{sp}=600-900 rpm.

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Мелконов Г.Л. Експериментальне обґрунтування математичної моделі для чотирьох шпиндельної шліфувальної машини полірування кінематики

У статті представлена модель кінематичного руху шпиндельної установки. Відображені вираження кінематичних показників, що надають основний вплив на оптимізацію частот обертання. Відображено вплив частот обертання на чисельні значення швидкості ковзання. В результаті проведених математичних розробок визначена математична модель кінематичного руху шпиндельної установки. Виведені вирази кінематичних показників, що надають основний вплив на оптимізацію частоти обертання. Дослідження швидкості показує, що при мінімальних значеннях частот обертання вона мінімальна, із збільшенням швидкості збільшується приблизно в 2-3 рази.

Ключові слова: *шпиндельна установка, шліфувальні - полірувальна установка, мікронерівностей, ковзання*

Мелконов Г.Л. Экспериментальное обоснование математической модели для четырёх шпиндельной шлифовальной машины полировки кинематики

В статье представлена модель кинематического движения шпиндельной установки. Отображены выражения кинематических показателей, оказывающих основное влияние на оптимизацию частот вращения. Отображено влияние частот вращения на численные значения скорости скольжения. В результате проведенных математических разработок определена математическая модель кинематического движения шпиндельной установки. Выведены выражения кинематических показателей, оказывающих основное влияние на оптимизацию частоты вращения. Исследования скорости показывает, что при минимальных значениях частот вращения она минимальна, с увеличением скорости увеличивается примерно в 2-3 раза.

Ключевые слова: *шпиндельная установка, шлифо - полировальная установка, микронеровность, скольжение.*

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