THE INFLUENCE OF THE TECHNOLOGICAL AND CONSTRUCTIVE PARAMETERS OF THE TOOL SYSTEM ON THE SURFACE ROUGHNESS AT BALL BEARING RINGS SUPERFINISHING

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Abstract. Starting from the mathematical modeling of surface roughness after machining, in the paper is presented some theoretical points of view, based on graphical dependence, regarding the influence of different process parameters, less recorded in the literature, on the roughness variation.

In this sense it is shown the important influence of a cutting fluid quality, by the friction coefficient between the abrasive grains and workpiece surface.

Based on the graphical dependences that were made for the typical machining conditions often used in superfinishing practice it is analyzed and is taken in evidence the influence of the friction coefficient between the abrasive grain and workpiece surface, established by the structural characteristics of the cutting liquid and by its inpure degree, elements that wasn’t examined in the literature.

Keywords: superfinishing, ball bearing, cutting fluid, friction

1. Introduction

It is known that the tool life and reliability of the ball bearings is determined by many factors: type of machining (easy, normal, hard), type of loading (local, circular, oscillator), sizes, and accuracy of manufacturing. The first two factors are determined by the conditions of product function where the ball bearing is assembled, the third factor, accuracy of machining can by influenced by the manufacturer by the process technology optimization.

According with the accuracy of execution, the surface roughness of the ball bearing rings has a great influence on the service life and reliability. The final finishing process for the ball bearing rings is superfinishing with special machine tools.

Together with some technological and constructive factors which influence the surface finish like cutting speed, pression between tool and workpiece surface, the frequency of reciprocal motion and the abrasive grains size [2], other factors that are less known in theoretical and experimental studies have also their importance: feed, cutting depth, the amplitude of reciprocal motion of the tool, and most of all the value of friction coefficient μ between tool and workpiece surface determined by the cutting fluid quality that is used.

Starting from these considerations, it is shown in the paper some researches regarding these factors on the surface finish.

2. The theoretical equation of the surface roughness of the ball bearings rings obtained after superfinishing

Based on the theoretical modelling of the machining process with abrasives, in the conditions of simple assumptions [3] related to the sketch showed in the figure 1, it was obtained the next equation for calculating the roughness parameter R_z in superfinishing process of ball bearing rings.

$$R_z \cong \frac{(0.7...0.85)}{k_1}\mu\sqrt{(1.25...1.5)k\cdot s_l\sqrt{\frac{2t}{RA}}}\ , [\mu\text{m}] \qquad (1)$$

where, μ is the friction coefficient between abrasive grain and workpiece; s_l is the feed [mm/rev]; t is material to be removed [µm]; A is the amplitude of abrasive tool oscillation [mm]; R is radius of oscillation motion [mm]; k is a coefficient [4] that depends on the cutting conditions (table 1), and k_1 = 0.7…0.9, a coefficient which depends on grain numbers that is in working at maximum capacity.

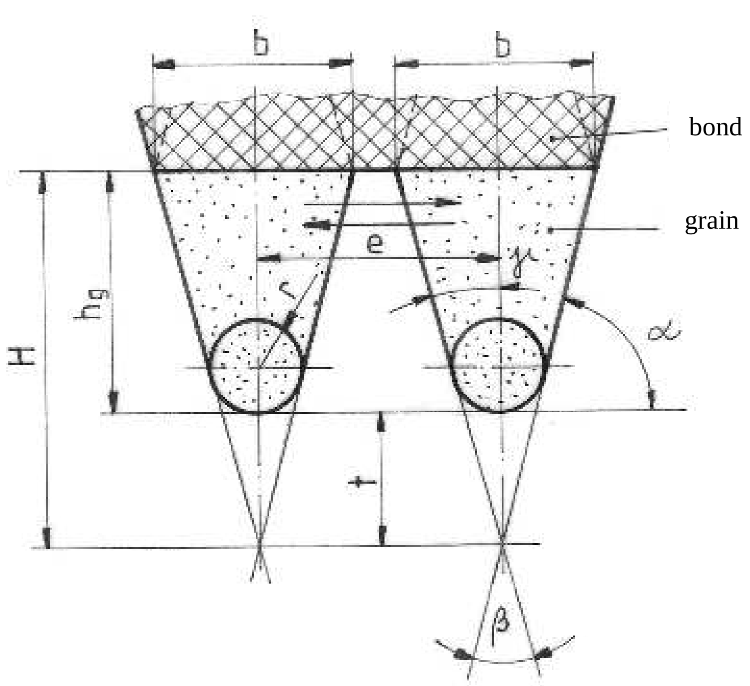

Figure 1. The spherical model of grain at machining with abrasives

Table 1. The values of coefficient *k*

The thickness of the chip, *a* [mm]	The workpiece material		
	Steel		Cast iron
	$\sigma_r \le 700\frac{N}{mm^2}$	$\sigma_r > 700\frac{N}{mm^2}$	
< 0.03	**2**	**3**	**1.5**
0.03-0.07	**3**	**4**	**2**
> 0.07	**4**	**4.5**	**3**

Till now were developed in the literature the theoretical models for the superfinishing process taking into account: the grain paths, the magnitude of the cutting forces, the volume of the removal material, etc., without taking in consideration the influence of the cutting fluid like an important element of the technological system on the machining process performances.

3. Study regarding the influence of constructive and process parameters on the surface roughness at superfinishing

The equation (1) can be written in this way:

$$R_z = f\left(s_l, t, A, \mu, R\right) \qquad (2)$$

where, s_l, t, A, are the process parameters, and R is a constructive parameter of the tool system.

Using the values that are recommended in the literature [2, 4, 5, 6], which often appear in normal condition of machining by superfinishing, in figures 2÷6, is presented the graphical dependence between the roughness and the variable parameters from the equation (2).

4. Observations and conclusions

Based on the previous text the next conclusions appear:

1. The graphical dependences shown in figures 1÷5, permit from the first step of superfinishing process design to make an external optimization of the constructive and process parameters according to the surface roughness which is required.
2. By making the feed double from the figure 2 is shown the increasing of the roughness surface with aprox. 45%. Because the productivity superfinishing process depends on the amplitude of reciprocating motion (figure 4), the value of optimum feed is made taking into account this parameter.

3. In figure 3 is shown the influence of the stock removal on the surface roughness and by increasing the stock material the surface roughness increase also. This fact is because the chips don't go between the space grains, and the grains that remains scratch the workpiece surface.
4. A great influence on the surface quality is the value of the ampitude of the reciptocal motion. From the figure 4 it can be seen the increasing of the amplitude conducts to the increasing of the surface roughness together with the feed value.
5. Other parameter that influences the surface roughness is the oscillation radius R of the tool (figure 6), which is not make estimations in the literature.Because increasing of this parameter conducts to a good surface finish the machine tool must have the possibility to varies it or to modify the length of the abrasive stone.
6. From all parameters, the friction coefficient μ between the tool and workpiece has the greatest influence on the surface roughness, and that depends on the cutting fluid used. This thing was less point out in the literature [5, 7].

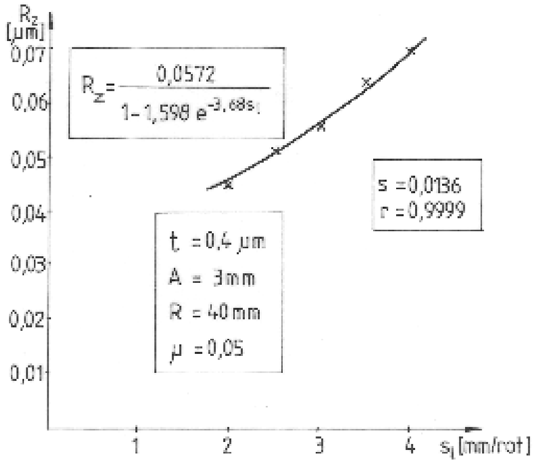

Figure 2. Variation of roughness R_z according to the feed s_l

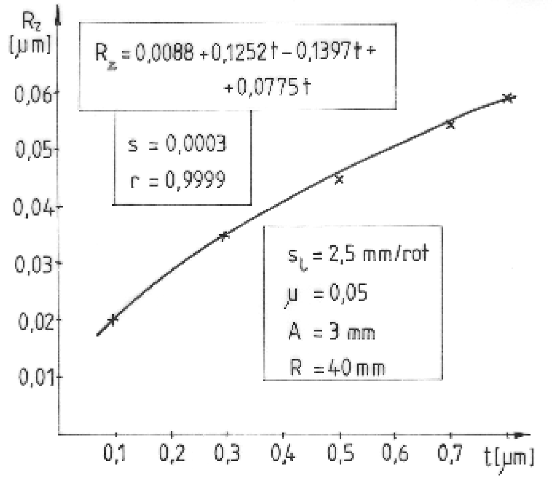

Figure 3. Variation of roughness R_z according to the material to be removed t

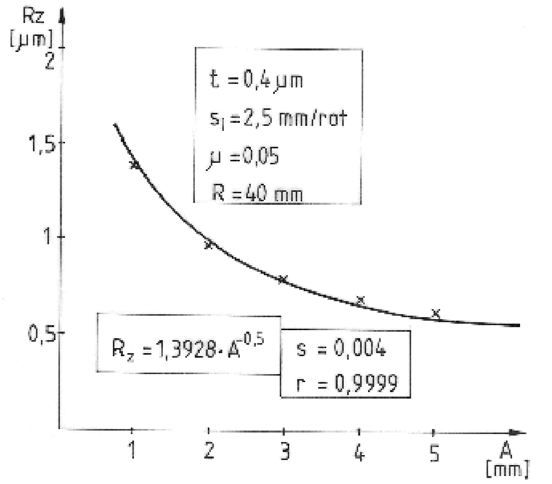

Figure 4. Variation of roughness R_z according to the amplitude A of tool oscillation motion

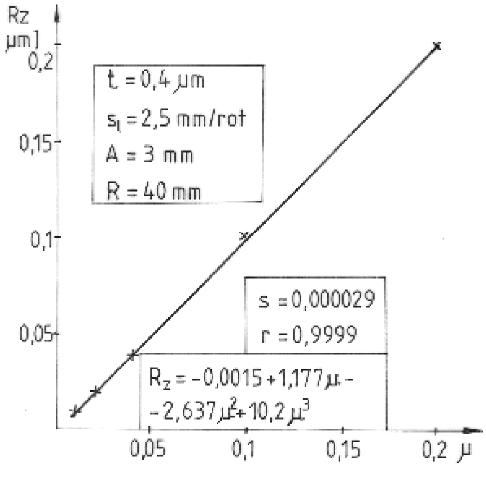

Figure 5. Variation of roughness R_z according to friction coefficient μ between tool and workpiece

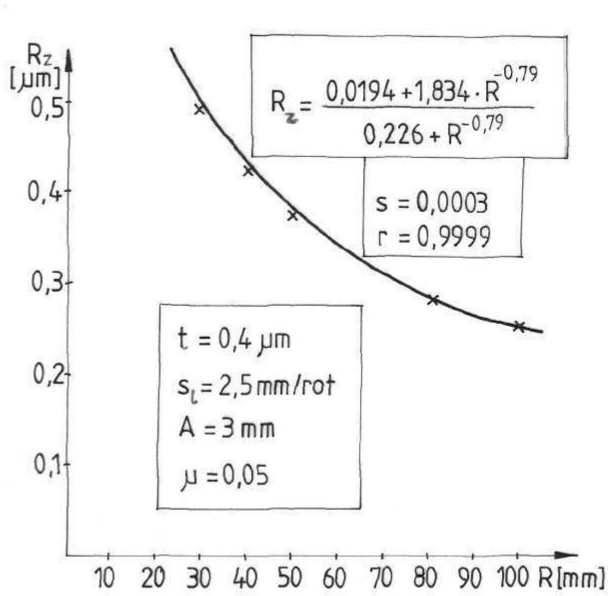

Figure 6. Variation of roughness R_z according to the radius R of tool motion

From this point of view it is necessary to make a management of using cutting liquid to permit to monitorize the dynamical evolution of its characteristics which determines the friction characteristics and the protection of the machine tool operator.

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