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INFLUENCE OF OPERATIONAL EXTERNAL LOADS ON PARAMETERS OF THE SURFACE GEOMETRIC STRUCTURE

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Abstract

In this paper, a proposal of a new method for assessment of changes occurring in geometric structure of elements of turning bearing surfaces has been presented. The bearing curve parameter value changes serve as the measurement of the observed changes in the function of stress amplitude, for different use times. The research was carried out within BS 06 on the subject „Selected problems of a product manufacture and life engineering”. The results of the performed empirical tests reveal that description by means of the proposed method of changes occurring in the structure of the tested surfaces, throughout the wear process, is possible.

Keywords: *surface geometric structure, bearing curve*

1. Introduction

The surface layer of the machine elements is a factor which largely determines their properties and combination of surface layers of two cooperating elements determines properties of the kinematic pair formed by these elements. One of the quantities characteristic for the surface layer is the surface of geometric structure which determines the process of wear.

Extending knowledge on profiling the surface geometric structure (SGP), elaboration and application of new ways for its assessment (qualitative and quantitative) has been made possible, also thanks to the precise and computer aided measuring equipment. New programming possibilities of the surface analysis in a spatial system (3D) which , in combination with improved precision of measuring tools, allows for observation and measurement of SGP elements in a nanometric scale as well as for its description by means of numerous parameters, not only areal, but also volumetric, spatial, hybrid and functional ones, and with the use of characteristics in the form of curves. The most popular example is the Abbot-Firestone’s chart, called a bearing curve. The parameters of the curve served for the evaluation of the investigated surface changes.

2. Object and method of investigations

An oblique ball bearing was accepted for the investigations. This type of bearing was selected due to its structural form and the resultant kinematics of its elements, big intensity of phenomena accompanying transformation of the surface geometric structure which improves the observation conditions.

For the investigations, stress values σ_ψ = 200MPa, 621MPa, 887MPa, 1381MPa, 1520MPa were accepted. Such values demonstrate changes on the whole perimeter of the ring.

The tests results were registered for three time values τ:

- at the beginning of the investigations (beginning of period I), for τ_1=0 s,
- in the period of a fixed intensity of changes (more or less in the middle of period II), $\tau_2=2,1\cdot10^5$ s,
- at the end of the bearing life (period III), $\tau_3=3,9\cdot10^5$ s.

Measuring points with the above coordinates were accepted on the basis of results of overall research on oblique turning bearings, contained in works[7].

In figure 1, a typical wear process has been presented. Three periods can be easily seen in them.

I – fast increase in wear intensity,
II – fixed level or slight wear changes ,
III – repeated fast increase in wear intensity.

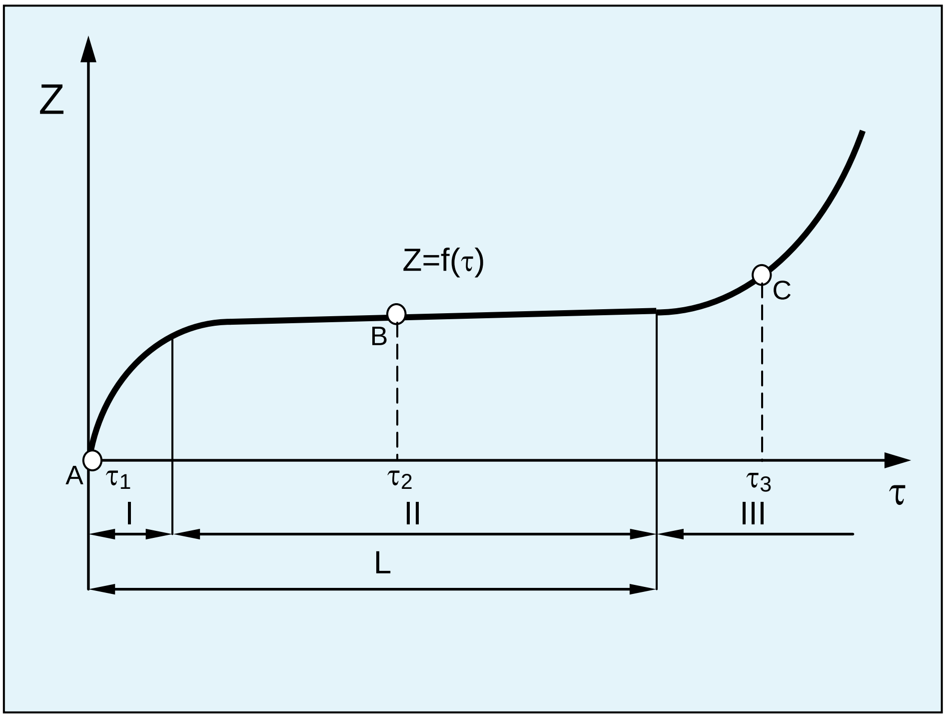

Fig 1. Graphic record of a typical wear process

According to a traditional approach it is accepted that the life is a sum of period I and II. On the basis of investigations [7], it was found that with the life criterion in the form of the motion resistance level, a part of period III can also be considered as the period determining the usability boundary, that is the bearing life. Therefore, in this period the third point was also accepted, in which changes were registered. Coordinates of measuring points: A,B,C , used for measurements and observations, are marked in Figure 1.

Parameters of the bearing curve were accepted as parameters defining properties of the examined surfaces. The curve called Abbot –Firestone's chart describes the material distribution in the profile. Since the bearing curve provides information on the profile course, in a precise form, it is possible to read from it the profile properties, significant for surface function [4]. Parameters characterizing the bearing curve of roughness profile are:[3,6]:

- Sk – height of the core roughness, μm,
- Spk – reduced height of roughness profile elevation, μm,

- Svk – reduced depth of roughness profile hollow, µm,
- Sr1 – bearing share of peaks ,%,
- Sr2 – bearing share of hollows, %,
- A – the core area,
- A1 – area of elevations filled with the material,
- A2 – area of hollows free from the material

Graphic interpretation of these parameters are presented in figure 2.

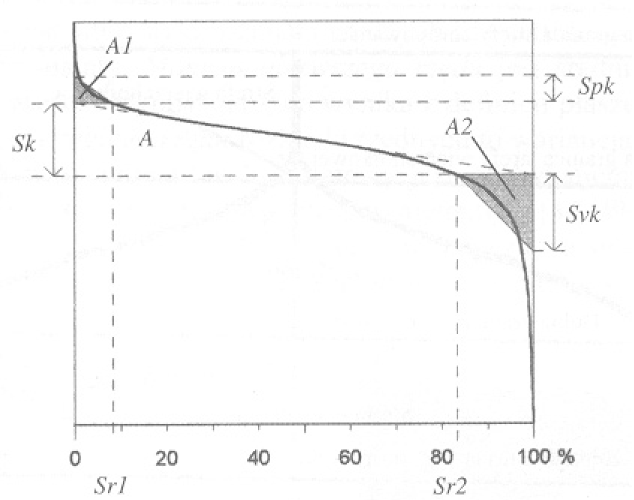

Fig.2. Characteristics of bearing curve [5]

Parameter Spk can serve as a measurement of effective roughness depth. The value of parameter Spk reflects the surface abrasion resistance – the smaller it is the bigger the resistance is. Parameter Svk is a measurement of the cooperating surfaces capability to maintain the fluid, therefore, the aim of finish machining is to obtain its possibly high value.

3. Investigation results

Commonly used amplitude parameters do not fully define properties of the examined surfaces, so for this purpose the surface characteristics in the form of bearing curves, were used to extend the evaluation.

In Tables 1, 2 and 3, determined values of the bearing curve parameters are compared for three times, in which the effects of changes in SGP were observed, depending on the stress amplitude.

Tab. 1. Parameters characteristic for bearing curves for $\tau_1=0$ s

Stresses / Parameters	σ, MPa				
	200	621	887	1381	1520
Sk, *µm*	2.26				
Spk, *µm*	1.05				
Svk, *µm*	1.38				
Sr1, *%*	9.30				
Sr2, *%*	88.80				

In the first transformation period (from τ_1 to τ_2), parameters Sk, Spk decreased by about 40%, whereas, parameter Svk underwent minor changes – it decreased in the range from 11.6% to 24.6%. This proves that in result of the balls rolling over the path there occurred lowering of peaks in the direction to the roughness core. Further operation – until τ_3 time, caused significant changes (increase) of parameters: Spk and Svk by 10 times, and Sk even by 20 times. The cause of such a situation is an increase in the wear process intensity reflected in the form of all kinds of damages to the surface (craters, cracks, grooves, etc.).

Tab. 2. Characteristic parameters of bearing curves for $\tau_2=2{,}1\cdot10^5$ s

Parameters \ Stresses	σ, MPa				
	200	621	887	1381	1520
Sk, μm	0.23	1.26	1.27	1.31	1.34
Spk, μm	0.28	0.58	0.58	0.58	0.60
Svk, μm	0.10	1.04	1.09	1.14	1.22
Sr1, %	9.80	9.30	9.20	9.10	8.90
Sr2, %	88.90	90.00	89.50	88.70	88.20

Comparing parameters of the bearing curve in the function of stresses, presented in Table2 and Figure 3, it was found that along with the stresses increase, values of all parameters increased, as well. For minor changes $\sigma_\psi \left\langle 200;621 \right\rangle$, the increase was a few times higher, and then slight. The only parameters whose value in the whole stress changeability range σ changed to a small degree, were material shares – Srl and Sr2. A slight increase in the value of parameter Sr1 along with time proves grinding in of the observed surfaces of working bearings under the influence of turning elements rolling on them, whereas slight changes of Sr2 parameters met the expectations as the action of external loads at the micro-unevenness base should be insignificant.

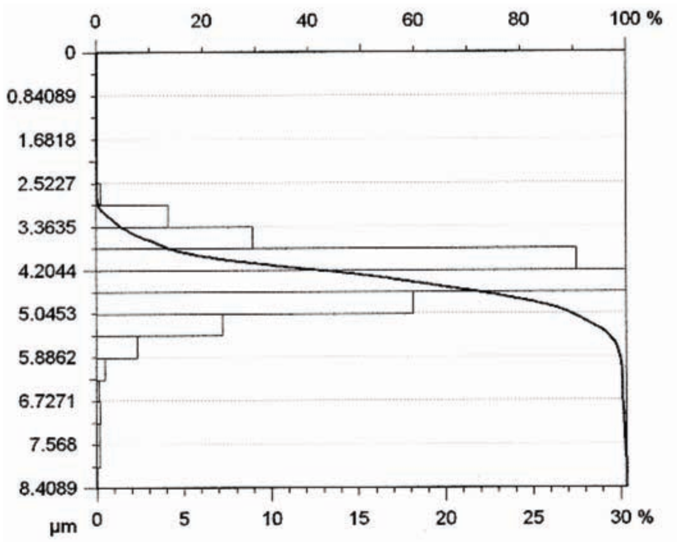

Fig. 3. Chart of bearing curve for time τ_2 (621 MPa)

In Table 3 and Figure 4, there have been presented dependencies of parameters accepted for the surface geometric structure on stresses, for the third period of use.

The character of changes is similar as for time τ_2 for the smallest stresses, a large rise of the examined parameters values was found.

Tab. 3. Characteristic parameters of bearing curves for τ_3=3,9· 10^5 s

Stresses / Parameters	σ, MPa				
	200	621	887	1381	1520
Sk, *μm*	0.29	19.30	22.40	25.78	28.80
Spk, *μm*	0.13	5.70	5.90	6.41	6.50
Svk, *μm*	0.28	10.70	10.94	11.15	11.30
Sr1, *%*	9.60	9.60	9.60	9.80	9.80
Sr2, *%*	88.00	90.20	89.40	88.90	89.00

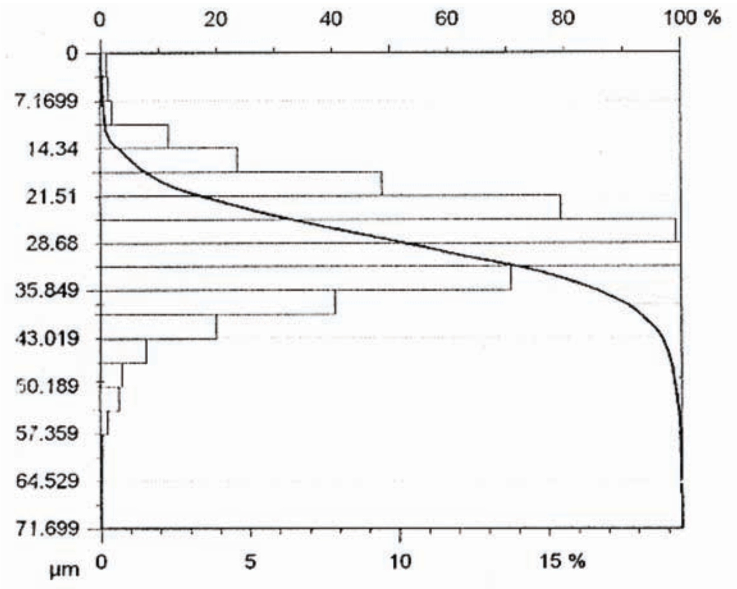

Fig. 4. Chart of bearing curve for time τ_3 (621 MPa)

On the basis of the results contained in tables 1,2,3 it can be found that the paths of turning bearings in period II are characterized by the best features of bearing surfaces. A big difference between values Sr1 and Sr2 and a small value of Sk prove that the roughness profile is of the plateau surface type character. Surface of this type is featured by high bearing capacity, small friction and abrasion resistance, that is features highly desired for working surfaces of turning bearings. These observations are confirmed by the expected stabilized intensity of the surface wear process in this period.

4. Summary

Dependencies of parameters describing SGP, that is, characteristics of the bearing curves and stresses in the points of turning elements contact with the turning path, on the internal elements, produced by the bearing external loads, facilitate the choice of the surface layer properties, for which it will be characterized by the expected usability features. As these characteristics depend on the kind of finish machining and its parameters, being familiar with these dependencies should make easier its choice, which is of great importance for the final effect of machining.

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