

Measurement of Changes of the Surface Roughness in Sliding Area

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Abstract

During relative motion of two bodies, in their contact areas forces responsible for friction, wear and change of surface roughness are generated. Present contribution deals with measurement of surface roughness at the contact areas of the rotational sliding pair. Evaluated and analysed are the parameters of surface roughness of steel and polyamide bushings, creating the frictional pair under consideration in this paper. Measurements were made before and after testing the pair. Tests were realized by the equipment Tribotestor M 89 (with adjustable loading force, sliding speed and duration). Roughness parameters R_a , R_z were detected using the surface roughness tester TR-200.

Keywords: sliding pair, roughness of surface, maximum height of profile, arithmetical mean and deviation of assessed profile

1. Introduction

Tribological processes are in progress within layers forming the contact surface. Real surface is that surface which bounds the body and separates it from the surrounding environment. Technically it is not possible and often not even technologically necessary to produce ideally smooth and frictionless surfaces at the present time. Real surface of industrial parts is characterized by a degree of surface roughness. Surface roughness is defined as the sum of the surface irregularities in relatively small distances incipient as a consequence of actual technology used in production (STN EN ISO 4287-2, 1999). Surface roughness is the geometrical characteristics of the surface; however, methods and equipments allowing its direct measurement are absent. Measured are certain suitable characteristics and parameters, which serve as the criterion of surfaces roughness (Slovak Institute of Metrology, 2013). In practice the roughness is most frequently measured by tactile profile method. Stylus instrument scans the surfaces of measured object, evaluates observed deviations and calculates the relevant parameters.

2. Analysis of some parameters of surface roughness

Standard parameters defined in STN EN ISO 4287 are used to evaluate the character of the surface. Basic geometric characteristics are the following parameters:

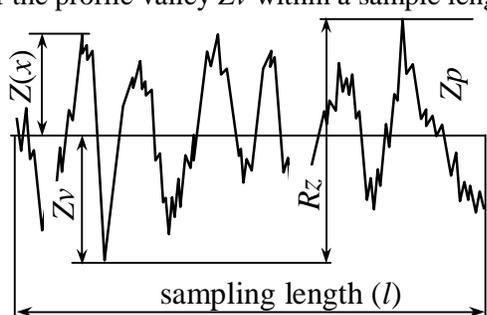
P-parameter - the parameter calculated from the primary profile,

R-parameter - the parameter calculated from the profile roughness,

W-parameter - the parameter calculated from the profile waviness.

Fundamental source of information is therefore the surface profile, which is generated by cutting the actual surface by well-defined surface. Computing system for the evaluation of the parameters of the surface profile, which is used in referenced standard, is based on the system of the mean line for the roughness profile, on the waviness of profile and on the primary profile mean line (Draganovská, D., 2012). The roughness profile mean line is a line of profile with long wavelengths suppressed by profile filter λ_c . The arithmetical mean deviation R_a of the profile under assessment and the maximum profile height R_z are considered to be the most common parameters for assessment of the surface roughness. The Parameter R_z gives less information about general condition of surface, but it takes into account random extreme irregularities of the surface and therefore is a suitable complement of parameter R_a . Parameters R_a and R_z belong to the class of amplitude parameters and they are defined in Fig.1.

Fig. 1 Definition of parameters Ra, Rz

Parameter	Definition	Typical use
Ra	<p>arithmetical mean deviation of the assessed profile – the mean arithmetic value of the absolute deviation of profile $Z(x)$ within the sampling length l</p> $Ra = \frac{1}{l} \int_0^l Z(x) dx$ <p>where $Z(x)$ is the ordinate – the profile height at arbitrary position x</p>	Typically is used to describe the roughness of machined surfaces and to describe the change of the roughness impact friction. It is useful for detecting general variations in overall profile height characteristics and for monitoring an ensamblished manufacturing process.
Rz	<p>maximum height of profile – the sum of the maximum of the profile peak Zp and maximum of the profile valley Zv within a sample length</p> 	Used is for the evaluation of surface texture on surfaces with limited access, particularly where the presence of high peaks or deep valleys have impact on functionality.

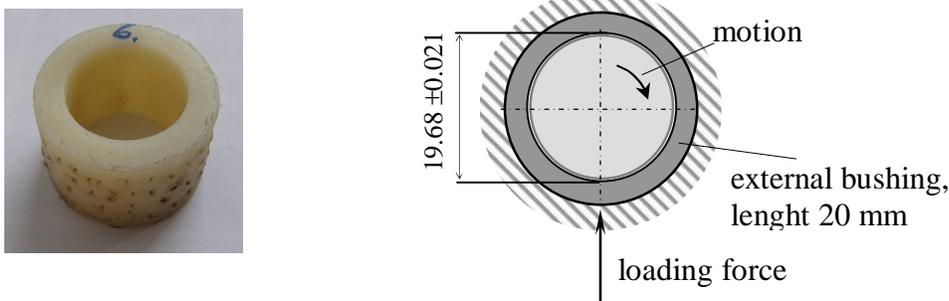
Additional amplitude parameters are introduced in standard STN EN ISO 4316:

- spacing parameters, referred to as the mean width of the profile elements RSm ,
- hybrid parameters, among which the root mean square slope of the assessed profile $R\Delta q$ is referred to,
- curves together with their corresponding parameters.

3. The methodology of experiments

Above mentioned parameters have been detected within the experimental investigation of tribological processes. Sliding pair under the test consisted of a steel bushing (STN 12060), that was pressed on the rotating shaft and of external fixed bushing in the housing. External bushings were made from polyamide. Default constant sliding speed ($v = 0.8 \text{ ms}^{-1}$) of the shaft was kept during the whole duration of the tests (2400s). Loading was subsequently increased from level 50N to 200N during run up in duration of 600s, after this start up the constant level 200N was held during consecutive 1800s. Given load parameters were set according to recommended value of the sliding speed and of the loading force as published in technical literature (Barysz et al, 1995, Stachowiak,G.W.et al, 2004). The basic geometrical parameter of the external bushing with its photography is in Fig. 2. Internal slidig surface was adjusted to the required dimension by reamer.

Fig. 2 Important parameters of external bushing made from polyamide



Roughness parameters were measured by surface roughness tester TR-200. Measurements were performed on every sample (external bushing) before and after the test in presumed places of contact with the internal bushing. 10 measurements were realized on every sample and then the average value was calculated. In aggregate 6 samples were tested.

4. The results of measurements

The results of measurements on polyamide bushings before and after the test are graphically illustrated in Fig. 3. The value of *Ra* has decreased by 0.18 mm and of *Rz* by 1.3 mm. In addition the results of measurement of roughness contacts areas of internal steel bushing show that the surface is smoothed (Fig. 4). Since this is a case of friction between metals and polyamides, we assume that the reduction of roughness appears only on the surface of polyamide bushing. It is deduced, that the observed reduction of metal surface roughness was caused by polyamide particles filling the contact friction surface and as such can not be interpreted as true reduction of the level of roughness.

Fig. 3 Change of the roughness parameters of polyamide bushing friction surface – *Ra*, *Rz*

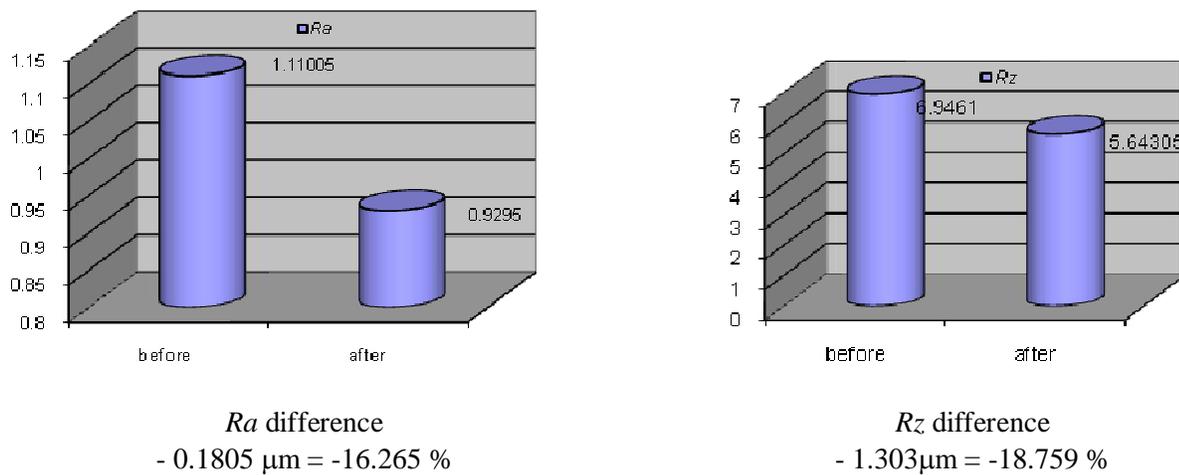
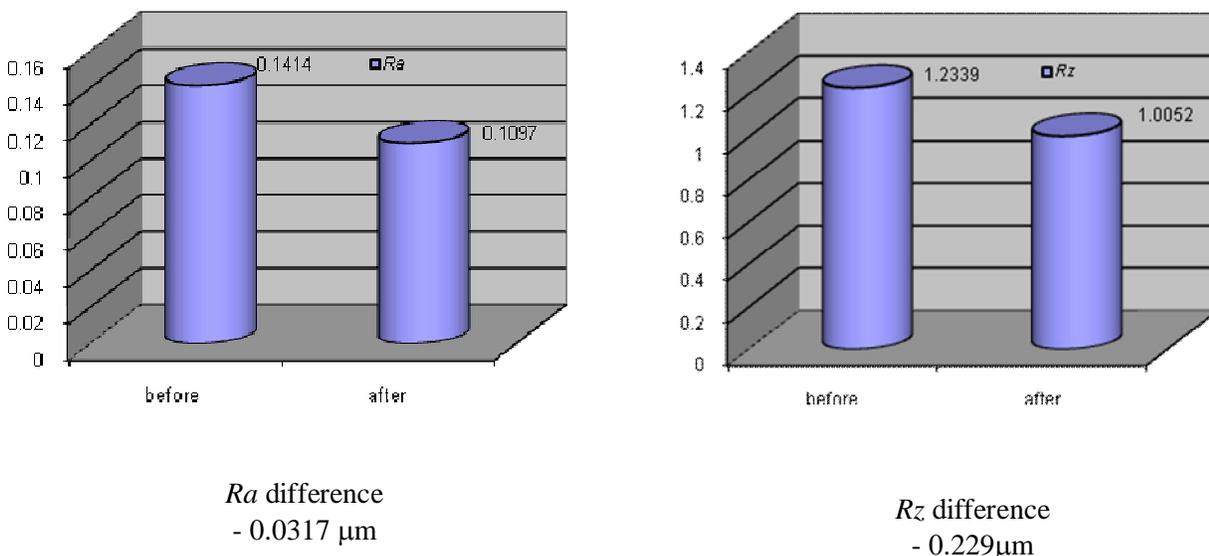


Fig. 4 Change of the roughness parameters of steel bushing friction surface – *Ra*, *Rz*



The surface roughness tester TR-200 in connection with a computer and with appropriate software enables to record the profile graph. Fig. 5 and Fig. 6 present a preview of profile graphs of the measurement of the polyamide bushings before and after the loading test.

Fig.5 Graph of surface profile of polyamide bushing before the test



Fig.6 Graph of surface profile of polyamide bushing after the test



5. Conclusion

The subject of presented paper is investigation of changes of roughness of surfaces of bushings, creating the sliding pair. The experimental tests were realised with the aim to detect the tribological characteristics of rotational sliding joint. Sliding pair under tests was created from polyamide bushing pressed on the housing and steel bushing fixed on the rotating shaft. Values of coefficient of friction and temperature have been monitored during the tests; however, these results are included in the other papers. The input parameters in the tribological tests have been set as follows: Value of loading force was increased from level 50 N to 200 N during run up 600s, after the run up constant level of 200 N was held. The overall duration of the test was 40 minutes, including 10 minutes of duration of the run up. Value of sliding speed ($v = 0.8 \text{ ms}^{-1}$) was constant during the whole duration of the test. Measurements aimed to determination of changes in surface roughness before and after the realised tests are described in this paper. According to the expectations of the values of the roughness parameters Ra and Rz have decreased. The value of the arithmetical mean deviation of the assessed profile has decreased about 16.265 % after loading test at polyamides bushings and value of the maximum height of profile decreased about 18.759%.

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