TRIBOLOGICAL PROPERTIES OF GROUND SURFACES

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ABSTRACT

This paper presents the results of tribometric investigations of ground surfaces machined with different combinations of grinding regime. Though they belong to the same class of surface roughness, they show significant differences in tribological properties.

This is a consequence of differences in the state of material in the surface layers, which arise from the machining regime parameters variation. These results emphasize the essential importance of correct definition of tribological criteria for contact surface states in the design phase.

INTRODUCTION

In engineering practice, in choosing the types and orders of technological operations of triboelement machining, basic attention is paid to attaining the geometrical accuracy and contact surface roughness set by the design. Technical conditions defined in such a way can, in principle, be satisfied by different types of final machining, as well as by different conditions of their realization. However, investigations show that triboelements obtained this way can demonstrate significant differences in their tribological characteristics [1,2,3].

To understand this phenomenon it is necessary to keep in mind that the character and intensity of tribological properties in tribomechanical systems are caused by the quality of the contact surfaces.

In this paper results are presented of tribometric investigations of ground surfaces from different conditions of planar grinding. Though they belong to the same class of roughness, they are characterized by large differences in wear resistance. This, of course, suggests the necessity of extending the list of technical requirements of contact surfaces.

KEYWORDS
Tribological properties, ground surfaces, roughness, microhardness, friction, wear

ROUGHNESS AND MICROHARDNESS OF GROUND SURFACES

The specimens made of steel C.5432 (0.3C, 2.0Cr, 2.0Ni, 0.4Mo) in the hardened and tempered state were machined by planar grinding with three grinding depths (0.005 mm, 0.02 mm and 0.06 mm), and three feed speeds of the workpieces (1.5 m/ min, 8.0 m/ min and 15 m/ min).

The contact surfaces that were obtained by the given grinding conditions were investigated in terms of microgeometry and microhardness. If the obtained results are analyzed from the aspect of parameters Ra and Rtm, which represent criterion for definition of the roughness classes (according to JUS M.A1.021), one can come up with the conclusion that all the specimens have contact surfaces in the limits of the N5 quality (Ra= 0.2 - 0.4 µm, Rtm= 0.8 - 1.6 µm).

However, though they are within the same roughness class, surfaces machined by different combinations of the grinding regime parameters have different structural characteristics of roughness. The most obvious differences are in the bearing curves that correspond to surfaces machined with the smallest grinding depth (0.005 mm). These differences are a consequence of the specific kinematics of the process of micro cutting that are caused by the small grinding depth and different feed speeds vr. At the smallest velocity vr, multiple overlapping occurs of parts of the trajectories of individual abrasive elements of the grinding tool In the machined surface, this causes tp = 50 % to be realized at just 30 % of the relative roughness profile. Higher velocities vr prevent this type of
micro cutting, which causes a very inconvenient distribution of material with roughness depth.

The results of microhardness measurement have indicated that some relaxation of the material took place in the surface layers. Decrease of the microhardness corresponds to smaller feed speeds of the workpiece and higher grinding depth. The obtained grinding effects are determined by the influence of the tested grinding parameters on the thermal regime of machining.

FRICITION AND WEAR OF GROUND SURFACES

Investigation of the tribological properties of the ground surfaces was done on the universal tribometer TR-3 with the block on disk system under conditions of boundary lubrication.

Case-hardened chromium-nickel steel C.5420 disks (8 mm thickness, 68 mm diameter, 60 HRC hardness) were used as the movable contact pairs during all tests. All the disks were machined at the same conditions. The roughness of the contact surfaces was $Ra = 0.2 \mu m$.

Investigation of the tribological behavior of the ground surfaces was done under the following conditions: normal loading 8 daN, sliding velocity 1.0 m/s, contact duration time 90 min, lubrication method - boundary.

The distribution of the friction coefficients values is within relatively narrow limits of for all tested surfaces. Somewhat more prominent differences can be seen only during the running in period, which happens during relatively short time in contact with a disk surface made of material with significantly higher hardness.

By measurements of wear, significant differences were seen in the wear resistance for the tested specimens obtained from different combinations of grinding regime parameters.

The influence of the grinding depth on the wear resistance of the machined surfaces is not expressed in the same way for all the three values of feed speed $v_r$. At the smallest speed of machined piece relative motion, wear of the corresponding machined surfaces increased with increasing grinding depth. However, at higher speeds $v_r$ the change of grinding depth does not result in a unique change of tribological behavior of machined surfaces.

These results can be explained by the consequences of the cutting process on the surface micro geometry and the physical - mechanical state of material in the surface layers. For different combinations of the grinding regime elements, either influence can be the more dominant.

Surfaces that are obtained at the smallest value of $v_r$ have very similar structural and other characteristics of roughness. The differences seen in the wear resistance are, in this case, a consequence of the thermal influence of machining on the relaxation of material in the surface layers, and the decrease of the micro hardness.

Differences in the wear resistance of surfaces obtained at higher $v_r$ are a consequence of both differences in structural characteristics on the surfaces roughness and the uneven thermal effects of the surface layers micro hardness. Due to the short time of the thermal influence in these cases, the more prominent mentioned process of micro hardness decrease is possible only at the largest grinding depth ($\delta = 0.06$ mm).

The results show that the contact surfaces obtained for different combinations of the grinding regime parameters, in spite of belonging to the same roughness class, (they even have a similar level of the friction coefficient corresponding to them), have very different wear resistances. This is a consequence of the different structural characteristics of roughness, as well as of the change in the material micro hardness in the surface layers, which are a result of the changed machining conditions.

According to the above, by relying only on the roughness class of the contact surfaces, obviously one neglects the tribological aspect in the essential phase of creating technical systems – the phase of design. In order to realize tribologically advanced technical systems, it is necessary to respect the whole list of tribologically relevant criteria, which, besides the conventional height parameters and basic material hardness, includes, above all, the parameters of structure and shape of micro roughness and the physical - mechanical state of material in the surface layers.

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