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RESEARCH

Topography of the Surface Layer of the Tooth Flank in Gears Produced by Uncoated and Coated Hob Milling Tools*

Hob milling process is one of the important links in the chain of mechanical processing, because productivity, final geometrical accuracy and surface finish of toothing are very dependant on it. By development of technology of gear hobbing is successully used in preliminary processing as well as fine machining of toothing. For that reason, the demand for process optimum grew up, both from the point of view of surface finish and from the point of view of productivity. A prerequiaite for the successful optimum and adequate process control is its identification, respectively identification of occurrences originated during the hob milling. Surfaces produced by metal cutting processes have the traces of cutting elements passage. The thin layer beneath the working surface has the deformed crystal structure. Also, the hardness of this layer is sometimes even higher than the hardness of the basic material. In this paper the methodology for the topography recording of teeth made by uncoated and coated model hob milling tool is presented.

Keywords: *topography, hob milling tools, gear*

1. INTRODUCTION

The problems occurring in the metal working process, with all types of processing, appear due to the presence of tribological processes on the contact surfaces of the elements of tribo-mechanical systems contained in the means of production /1/. It is already known that the wear of elements in production is the result of tribological processes; the wear can after a certain period become so great that it can be the cause of the discontinuation of their operation.

The interaction of surfaces in the relative motion is a complex phenomenon entailing the changes of surfaces of the basic material and any coat occurring between the surfaces. These changes are brought about by a change of the chemical composition of surfaces, change of the metallurgical properties of certain layers, as well as the changes of the physical properties of lubricants due to the increase caused by the relative motion Fig 1.

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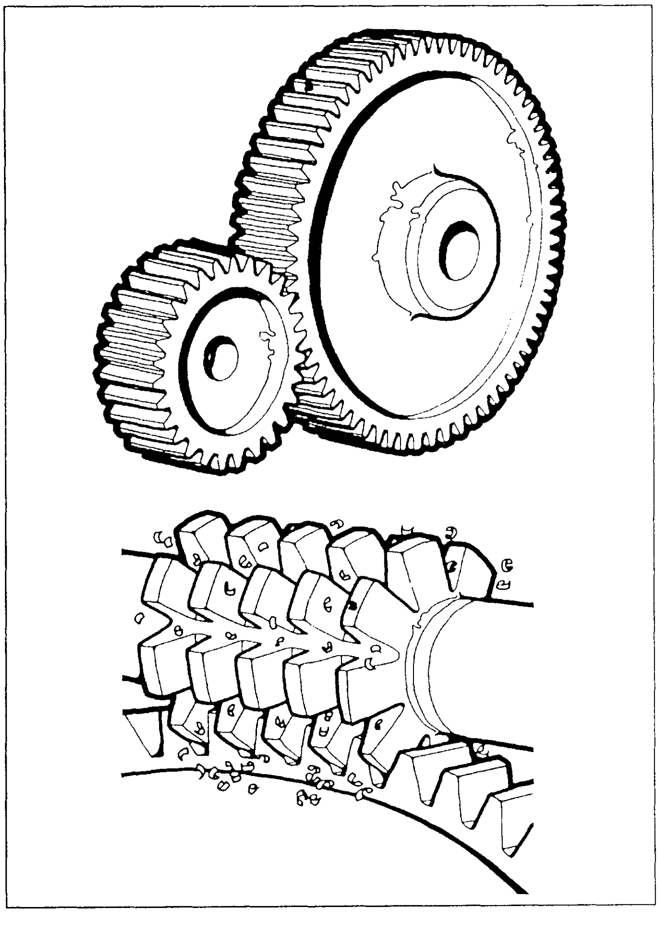

Fig. 1

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The nature of the contact between tribo-mechanical elements is not statical but dynamical because every repeated contact between the surfaces is accomplished along the surfaces, the microstructure of which differs from the preceding one. Tribological processes take place during the constant destruction of the parts of contact surface and during the appearance of new parts, physically or topographically similar or completely different from the preceding ones. Destruction and occurrence of parts of contact surfaces taking place is disharmonious and spatially discrete.

Surfaces produced by metal cutting processes have the traces of cutting elements passage and the thin layer beneath the working surface has the deformed crystal structure while the hardness is sometimes considerably greater than the hardness of the basic material.

The contact surfaces produced in any kind of metal processing are always rough. There are no ideally smooth surfaces, which means that the contact between the surfaces takes place at a certain number of points. The number of these points depends on the size of rough areas and their arrangement. The shape and size of rough areas on the surfaces belong to the field of micro-geometry of surfaces and the knowledge of this field is extremely significant for following and learning about tribological processes.

The contact surface is defined by topography i.e. by micro and macro-geometry, which includes roughness, corrugation and flaws of shape. In defining topography from the tribological aspect the value of the level is extremely significant. The processed contact surfaces can, in general, be rough in macro and micro terms.

The relation between the topography of contact surfaces and development of tribological processes is a complex one. The change of topography in development of tribological processes can be represented by a model in Fig 2 /2/.

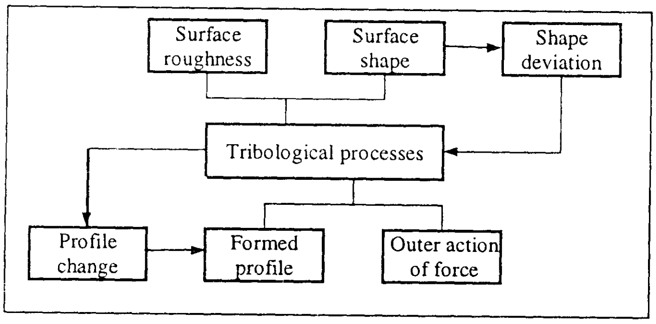

Fig. 2 Change of topography in development of tribological processes

The change of the state of a tribological process occurs due to a development of tribological processes and it is reflected in the change of the contact surface topography.

The existence of correlation between the quality of the processed surface and degree of cutting tool wear in machining has been noticed earlier. For some aspects of processing mathematical models for determining the quality as a function of the degree of cutting tool wear have been elaborated /3/. Hob milling of cylindrical gears is a specific type of processing since, on contrary to some processes of producing the workpiece, as in lathe processing, for example, where a small portion of the cutting edge within the feed is reproduced on the machined surface, the hob miller tooth influences the roughness with its inlet, tip of tooth, and outlet cutting edge.

2. RESEARCH RESULTS

In the cutting process the contact between the hob miller and the workpiece material is accomplished between the scraping and the tooth face and between the tooth clearance surface and the machined surface. Tribological processes occurring in the cutting process on both tooth surfaces of a tool develop under specific conditions. The influence of hob miller wear on the characteristics of state and output effects of the machining process is extremely great and negative /2/.

In hob milling machining of cylindrical gear, as has been noticed earlier, there is a relative rolling and the machined surface is the envelope of the consecutive positions of the hob miller tooth. With model manner of production, the hob miller tooth moves tangentially, the change of feed is abrupt, since in a single tangential feed the lowering, i.e. the hoisting of the tool support is performed manually i.e. the hob miller tooth itself for the feed value all of which contributes to the complexity of determining the correlation between topography of the machined surface and wear of the cutting elements of hob milling tool. Determination of this correlation is significant because it can serve to measure indirectly the parameters of wear by measuring the parameters of surface roughness. This method is based on experiments according to which the values of parameters Ra and Rt, after a certain period, increase suddenly. The increase is taken as a criterion for evaluating the wear i.e. the bluntness of a tool with regard to the quality of conformity /4/.

The objective of this paper is to establish i.e. determine the correlation between the roughness and degree of wear of hob miller cutting elements. In order to accomplish this, it was necessary to perform topography of single-tooth hob millers. The topography of analyzed tools was recorded by Talysurf-Taylor Hobson instrument. According to the plan of experiment the recording has been based on the methodology presented in Figure 3.

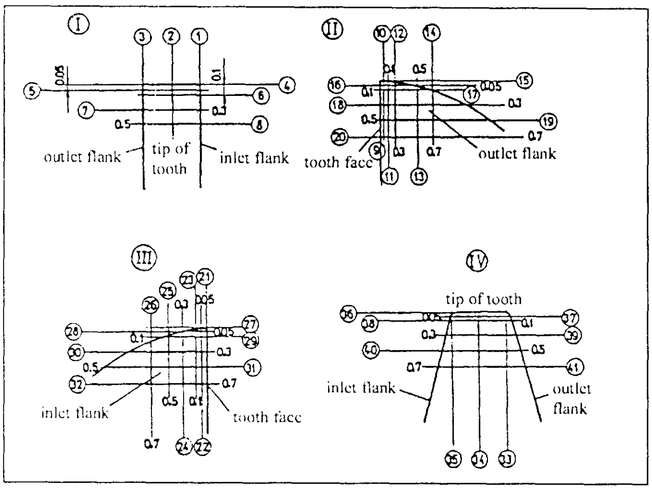

Fig. 3 Methodology of recording of hob miller teeth

Before conducting the experiment, the topography of new coated and uncoated teeth of hob miller has been recorded. Recording of the topography of all tools has been performed on a temperature surface, outlet tooth flank, inlet tooth flank and tooth-face. The recording we refer to has been conducted for approximate values of wear parameters h_1 = 0,1; 0,3 and 0,6 mm.

For the machined gear the teeth have been recorded according to the methodology presented in Fig. 4. The topography has been recorded on the left and right tooth flank along the involute, as well as along the tooth itself.

In Fig. 5. the profiles and curves of percents of support of face and tip surfaces of a profile in plane 4 for the first, second and third recording of hob miller tooth topography 9-79 are presented. A difference of the profile can be noted in this plane during the first, second and third recording. During the first recording in this plane, a recess can be noted in the mid-area of the surface of the tip of tooth, while during the second recording a greater number of recesses can be seen towards the outlet flank. During the third recording a greater number of recesses can be observed, the longest groove being towards the outlet flank /2/.

On the basis of experimental results a graphic correlation between the roughness and wear degree of cutting element of model hob miller can be obtained /2/. Roughness profiles of machined surface, obtained as a record on the apparatus for measuring the roughness, represent an incidental occurrence.

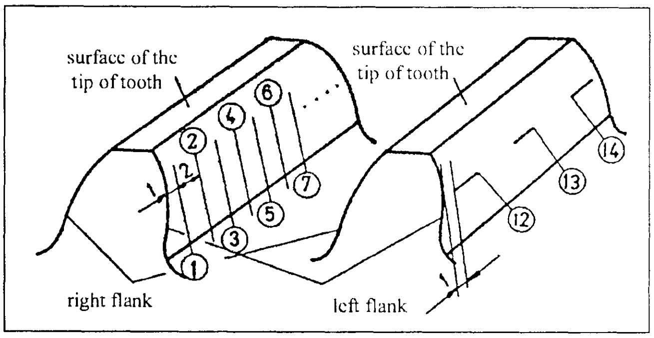

Fig. 4 Methodology of recording the topography of machined gear teeth

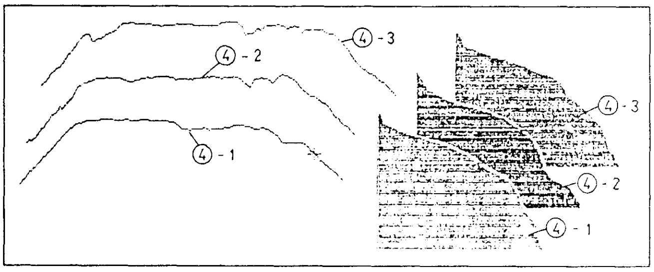

Fig. 5 Profiles and curves of percents coating the tip back surface in plane 4 *during the 1^{st}, 2^{nd} and 3^{rd} recording of topography of hob miller tooth*

In production conditions, development of the wear process and recorded corresponding roughness have been followed. In Fig. 6, development of wear process on the outlet flank cutting edge of hob miller 05 (a) and corresponding roughness Ra(b), wear on the outlet tool flank 58 (c) and corresponding roughness Ra(d) /2/ are given.

Based on data from Fig. 6, a correlation between roughness and degree of wear of hob miller cutting element has been determined.

The correlation between roughness and degree of wear of the cutting element of uncoated hob miller has the form:

$$h = 0,07314 \cdot R_a^{5,041872} \tag{1}$$

$$R_a = 1,67992 \cdot h^{0,19834} \tag{2}$$

the coefficient of correlation being r = 0,9901.

The correlation between roughness and degree of wear of the cutting element of coated hob miller has the form:

$$h = 0,28929 \cdot R_a^{7,55980} \tag{3}$$

$$R_a = 1,17830 \cdot h^{0,13828} \tag{4}$$

the coefficient of correlation being r = 0,96.

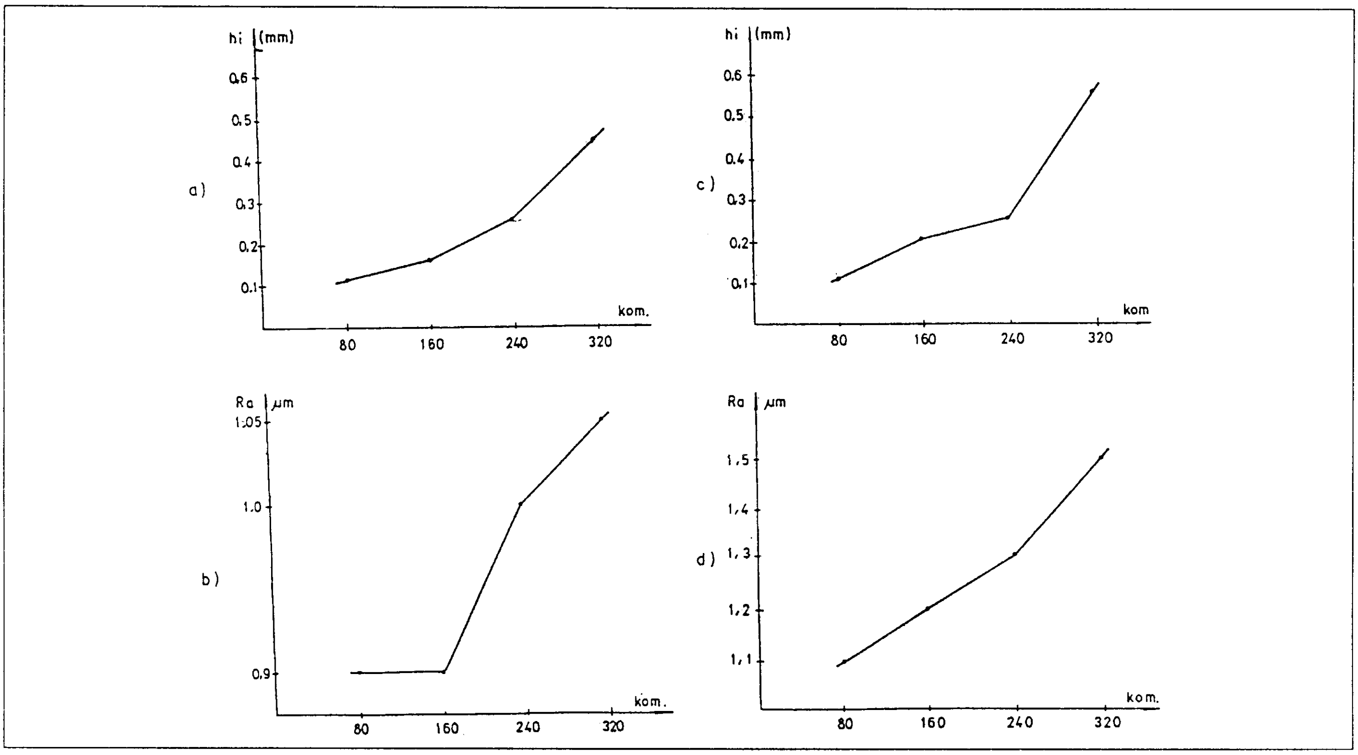

Fig. 6 Process of development of wear at the outlet tool flank 05(a) and corresponding roughness Ra(b), development of the wear process at the outlet tool flank 58(c) and corresponding roughness(d).

Obtained dependency of roughness parameters of gear teeth machined surface on the wear parameters of hob miller has high correlation coefficients in a particular case. It is possible, based on this, to follow indirectly for that case the hob miller wear also by following the roughness.

3. CONCLUSION

In model researches the correlation, which has been verified in production conditions, between the roughness parameters could been foreshown both for coated and uncoated tools, whereby high degrees of correlation have been accomplished. This can serve as a basis for drawing a conclusion that by following the roughness parameters on flank gear teeth a moment of hob miller blunting can be determined, which in turn is of great practical significance for axial tool feed i.e. its replacement.

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