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INFLUENCES OF THE TECHNOLOGICAL PARAMETERS ON THE SURFACE TWIST IN GRINDING

Вимоги щодо функціональних поверхонь деталей машин підвищилися протягом часу. Передбачається, що на остаточних етапах обробки має бути створена поверхня, яка забезпечує стійкість, тривалий термін служби, а також має необхідні спеціальні характеристики. Закручування вільної поверхні можна розглядати як особливий стан поверхні. У наведеній статті досліджується вплив режимів шліфування на закручування поверхні.

Ключові слова: закручування поверхні, шорсткість поверхні, режими шліфування

Требования в отношении функциональных поверхностей деталей машин повысились с течением времени. Предполагается, что на окончательных этапах механической обработки должна создаваться поверхность, которая обеспечивает износостойкость, длительный срок службы, а также обладает специальными требуемыми характеристиками. Закручивание свободной поверхности может рассматриваться как особое состояние поверхности. В представленной статье исследуется влияние режимов шлифования на закручивание поверхности.

Ключевые слова: закручивание поверхности, шероховатость, режимы шлифования

The requirement towards to the functional surfaces of the machine components became higher over the time. The final steps in the machining are supposed to create a surface which ensures wear resistance, longer lifetime and has special features on demand as well. The twist free surface can be considered as a special surface condition. The following paper presents the effect of the grinding parameters to the surface twist.

Keywords: twist, surface roughness, grinding parameters

INTRODUCTION

The surface twist is a guided mark on the surface made by the cutting tool along the whole circumference of the workpiece. The surface twist has a microgeometrical supply effect. This can dramatically decrease the sealing function at the radial seals (Fig. 1). The surface twist can cause either oil leakage or dry run between the sealing lip and the shaft surface [1]. Due to this fact, the twist level of the shaft surface under the sealing is standardized [2, 3].

The twist can occur at machining with well-defined edge geometry and abrasive tool also. The surface topology at the well-defined geometry edge tool machined surfaces has a periodical behaviour, therefore it always has a surface twist. The abrasive machined surface topology is random and the results are depending on the machining kinematics and machining parameters. It can be twisted or not.

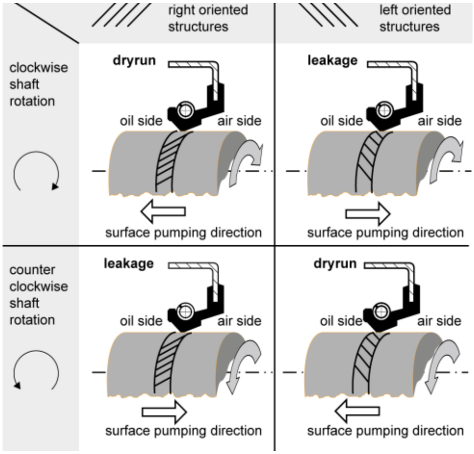


Figure 1 – Effect of twist on the sealing surfaces [1]

The literature [1, 4] makes a difference between micro and macro twist. The macro twist is an axially periodic structure on the surface. We can describe it as a helix along the circumference of the part. One plausible cause of this surface texture is the dressing of the grinding wheel with a single point diamond tool (Fig. 2).

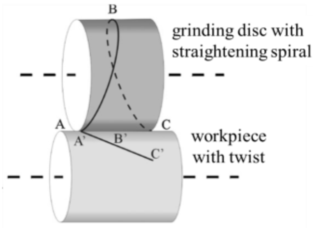
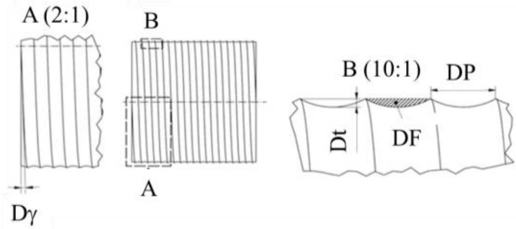


Figure 2 – Projection of the dressing spiral onto the surface [4]

The dressing marks on the grinding wheel surface and an improper speed ratio generate a helix like a structure onto the workpiece surface. The macro twist is mainly long periodic deep groves on the surface. The micro twist on the surface is caused by the small scratches made by the abrasive grains. The scratches are relatively short (<20 μm), axially aperiodic and has a small helical angle. The transport effect of this surface is the same like at the macro twist [5, 6].

1. DEFINITION OF TWIST PARAMETERS

During the twist measurement we have to consider the whole circumference of the part. Therefore the conventional surface roughness measures are not usable for this application. The twist parameters according to DIN-EN-ISO 25175-3:2012-03 are described in Fig. 3.



DP – period length [mm]
Dγ – twist angle [° ’ ”]
Dt – twist depth [μm]
DG – number of threads [-]
DF – theoretical supply cross section [μm^2]

Figure 3 – Twist parameters by ISO 25175-3:2012-03 [4]

2. CALCULATION OF TWIST PARAMETERS

The twist parameters can be measured in several ways, which are still complicated and time consuming.

The first option is to measure the surface roughness profile along the circumference multiple times and create a 2D discrete FFT. This reconstruct the surface twist and the twist parameters [6].

The second option is a laser beam measurement, where the scattering of the laser beam describes the groove depth and surface twist [7]. The full evaluation of the surface twist is not ensured at the current level of measurement technology. The current measurement options are only accurate at macro twist. The standard measurement of micro twist is still under investigation [8]. The University of Stuttgart made research at micro twists using the Wolf Pruning method to measure the parameters of the micro twist (Fig. 4.).

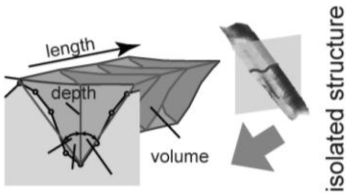


Figure 4 – Calculation of micro twist parameters with Wolf Pruning method [9]

During this method the surface features are separate with a 3D Gauss filter and 20 μm cut-off. The distribution of the surface features with lead angles describe the surface twist parameters.

The simplest and most practical method to evaluate micro twist is the thread run test method. The main principle of the thread run test is the measurement of the axial movement of the measuring thread at rotating workpiece. This method can be used to decide whether the surface has a twist or not, but the twist parameters cannot be measured.

3. EXPERIMENTS

The aim of the experiments is to find a correlation between the grinding parameters (axial feed, number of spark out) and surface twist in axial feed grinding.

3.1. EXPERIMENTAL CONDITIONS

- *Grinding machine*

The part grinding has been made on a Schaudt KU250-04 grinding machine using parameters detailed on Table 1.

- *Grinding parameters:*

Grinding wheel speed 35.81 m/s.
Speed ration (q≈80)
Workpiece speed 26.9 m/min.
Workpiece rpm: 125 1/min
Depth of cut: a_e=0.03 mm
The varying parameters are the axial feed and the number of the spark out runs.

- *Grinding wheel characteristic and workpiece material*

The workpiece material grade is 100Cr6 steel (59-61 HRC). The machining is performed on 68 mm diameter and 30 mm length. The grinding wheel is a ceramic bonded Al_2O_3 wheel 360x34x127 mm.

- *Dressing parameters*

The dressing of the grinding weel has been made with a single point diamond octaeder in one cut, where a_D=0.02 mm.

The axial feed of the dressing diamond is $f_{L,D}$=0.07 mm/rev. The dressing was always done in one direction.

Table 1 – Grinding parameters of the surfaces

Surfaces	$v_{f,L}$ [mm/min]	f [mm/rev]	Number of spark out [-]
G1	10	0,08	-
G2	10	0,08	2
G3	10	0,08	6
G4	50	0,4	-
G5	50	0,4	2
G6	50	0,4	6
G7	100	0,8	-
G8	100	0,8	2
G9	100	0,8	6
G10	200	1,6	-
G11	200	1,6	2
G12	200	1,6	6
G13	400	3,2	-
G14	400	3,2	2
G15	400	3,2	6

3.2. EVALUATION AND MEASUREMENT METHODS

- *Surface roughness measurement*

The equipment for the surface roughness measurement is an Altisurf 520 3D surface roughness measurement device at the University of Miskolc, Institute of Manufacturing Science. The profile diagrams and the topography were recorded with a CL2 chromatic confocal sensor, the vertical resolution of which is 0.012 μm.

- *Twist measurement*

The thread run test was used for the twist measurement. The workpiece was rotating for one minute in both direction and the axial movement of the thread was measured. The measure gained by this method is the mean value of the thread axial movement (a_m). The surface can be considered as twist free in case of values lower than 0.5 mm [2].

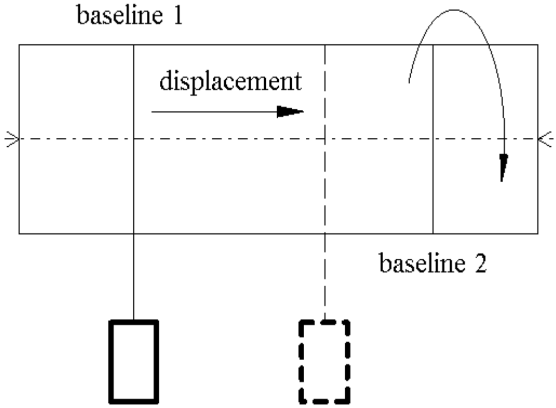


Figure 5 – Scheme of test

The measurements have been made using an Optiturn L440 CNC lathe ensure the correct rotation speed. During the measurement the part was rotating with 20 m/min and the thread displacement was measured from a predefined baseline. The scale helping the measurements was made also on the Optiturn CNC lathe. The displacement was recorded and evaluated using a camera. The time for the travelling between the starting point and the end position can be accurately measured. The exact displacement was measured using AxioVision software.

4. RESULTS AND EVALUATION OF EXPERIMENT

The results of the experiments were summarized in a table format. According to our plan the 2D and 3D surface roughness parameters were measured besides the surface twist. An extraction of the results can be seen below.

4.1. EFFECT OF FEED RATE

You can see the average surface roughness (Ra) and ten-point mean roughness (Rz) values measured on ground surfaces (Fig. 6.) with the variation of axial feed without spark out. The Ra values were increased linear with the increasing axial feed. The Rz values showing also an increasing tendency from 50 mm/min axial feed value, but not that transparent.

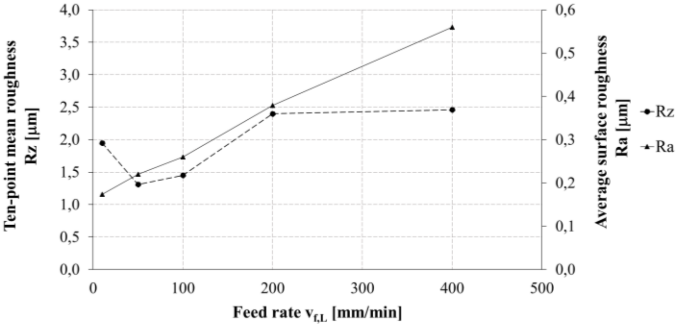


Figure 6 – Average surface roughness (Ra) and ten-point mean roughness (Rz) at various feed

You can find the relationship between the a_m representing the surface twist and the axial feed rate in the next few pictures. You can find some typical profiles in Fig. 7. and Fig. 8. Assuming the results, the surface twist representing a_m is growing with the increasing axial feed. The increasing axial feed at cylindrical grinding cause an increasing surface twist. Measuring the surfaces with 2D methods, the deviation cannot be seen, because those parameters are defined in one plane.

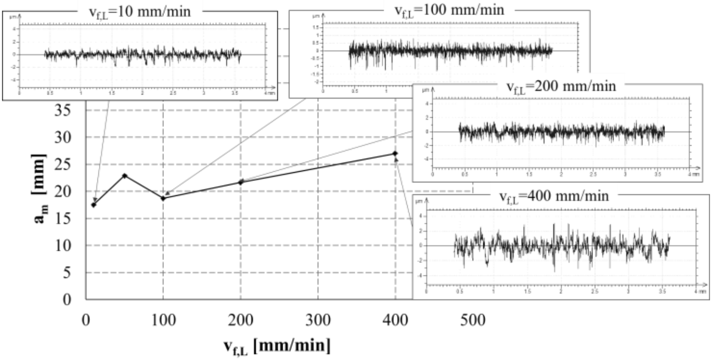


Figure 7 – Effect of feed on roughness profiles

The 3D parameters are more reliable especially at high axial feed rates (Fig. 7). As we explained in the introduction, the 3D surface roughness measurement methods are suitable for the measurement of the standard surface twist parameters.

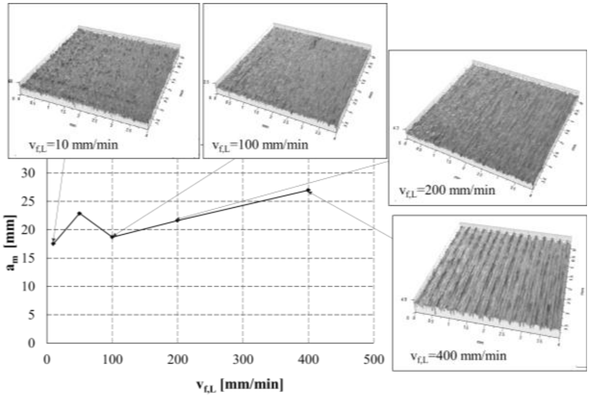


Figure 8 – Ground surfaces at various feed rate

4.2. EFFECT OF SPARK OUT

The measurements were reproduced in machining with spark out grinding wheel movements as well. The values of the surface roughness parameters are showing a decreasing tendency at the increasing number of the spark out movement (Fig. 9.). If the surface roughness measured after 2 spark out movements is the base, the Ra and Rz values are showing a decreasing tendency.

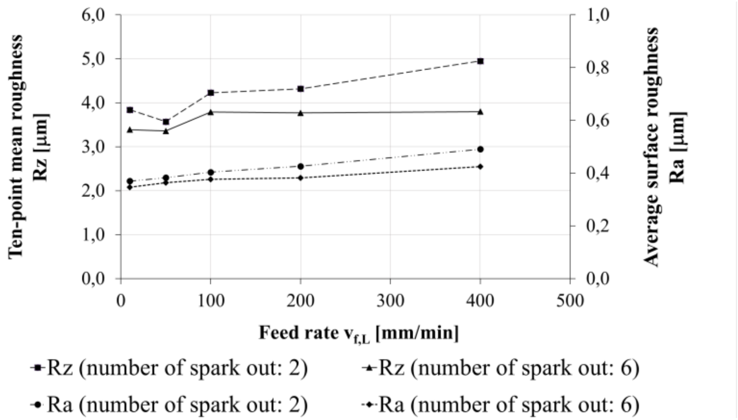


Figure 9 – Influence of spark out on Ra and Rz roughness parameters

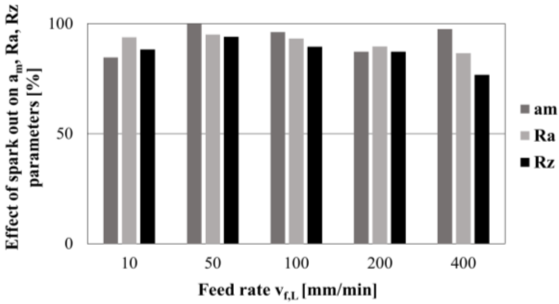


Figure 10 – Effect of spark out on a_m, Ra, Rz values
(2 spark out = 100%)

SUMMARY

In the paper, the axial feed cylindrical ground surface topography were experimented. The main topic was the changing of the surface roughness parameters with the various axial feed rates and the number of spark out movements considering the change of the surface twist parameters as well. The increasing axial feed rates cause rough surface and surface twist.

During the measurements we can assume, that the 2D measures are not capable to describe the surface twist. The 3D surface measurements can give a picture about the surface twsit and a transparent base for the visual evaluation of the results, especially at high feed rates. Besides the methods above we still need additional software aid for the standard evaluation of the surface twist parameters. The deeper investigation of the surface twist parameters will be remaining for the future studies.

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