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3D EXAMINATION OF ENVIRONMENTALLY FRIENDLY MEANS DRILLED HOLES

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ABSTRACT

Nowadays more and more scientific papers deal with drilling. In recent years there have been limited changes to the drill design but considerable improvements have been made in the selection of drill materials, drill coatings, flute design and the cutting fluid guiding methods. All of these improvements have been introduced to improve the surface finish of the drilled hole, reduce the energy during the drilling process and to reduce ecological damage to the cutting fluids, which carry away heat and debris from the cutting zone.

The paper briefly describes the development of surface characterization to its current 3D capability. The paper is supported by a sample-drilling test to demonstrate the power of the proposed analysis. In the paper, experimental formulas made by the use of Factorial Experimental Design, are shown for some chosen surface parameters.

Keywords: 3D surface characterisation, environmentally conscious machining

1. INTRODUCTION

Production in the engineering industry can have harmful effects on the environment. As the engineering industry has a significant role in the economy we have to deal with its environment impairing effects and with the possibilities of prevention. In a developing economy the increasing production can be resulted - for lack of an appropriate environmental policy - with more and more increasing damage to the environment.

2. ENVIRONMENTALLY CONSCIOUS MACHINING

Research in environmentally conscious manufacturing and design can be categorized into two areas, namely, environmentally conscious product design (ECD) [10], [11] and environmentally conscious manufacturing (ECM). The principle of ECM is to adopt those processes that reduce the harmful environmental impacts of manufacturing, including minimization of hazardous waste and emissions, reduction of energy consumption, improvement of materials utilization efficiency, and enhancement of operational safety [2].

Neglecting the lubrication or selecting lubricant with minimal volumes for a machining process and particular workpiece material involves taking into account several factors. These factors have effects on the different type of wear of the cutting tool as well [1]. In dry machining, the functions of coolants-lubricants must be substituted. For the cutting process, these functions are cooling, lubricating and swarf disposal, and for the machine they include cooling and flushing.

Machining with minimum volume coolants and lubricants is defined as the dispensing of cutting fluids at optimal flow rates, tiny quantities of cutting fluid are sprayed to the cutting zone directly [3]. Near Dry Machining offers the following advantages: decreased use of metal working fluids, reduced costs as compared to flood applications, reduced industrial hygiene hazard, opportunity to employ more benign fluids and improved process performance as compared to dry machining.

3. SURFACE FINISH AND INTEGRITY

3.1 Characterisation of surface finish

Surface finish influences not only the dimensional accuracy of machined parts, but their properties as well. Whereas surface finish describes the geometric features of surfaces, surface integrity pertains, which are influencing surface integrity are: temperatures generated during processing, residual stresses, phase transformations, and surface plastic deformation, tearing, and cracking [12].

3.2 Development of 3D surface characterisation

At present, 3D surface texture measurement is not yet covered by international standards, but it is the object of on-going research projects in Europe and abroad; standards concerning this area are expected to appear in the future. In the research carried out within the European Program a set of fourteen 3D parameters has been proposed [4], [5], [6].

The primary 3D parameter set proposed in [6] Amplitude parameters (**Sq** Root mean square deviation, **Sz** Ten point height, **Ssq** Skewness of height distribution, **Sku** Kurtosis of height distribution) Spatial parameters (**Sds** Density of summits, **Str** Texture aspect ratio, **Sal** Fastest decay autocorrelation length, **Std** Texture direction) Hybrid parameters (**Sdq** Root mean square slope, **Ssc** Arithmetic mean summit curvature, **Sdr** Developed surface area ratio) Functional parameters (**Sbi** Surface bearing index, **Sci** Core fluid retention index, **Svi** Valley fluid retention index).

4. ENVIRONMENTALLY-FRIENDLY DRILLING EXPERIMENTS

The main goal of the researches was to examine how the different environmentally friendly technological solutions such as: different type of cutting tools, type and material of coating of the tool, type and quantity of coolants and lubricants, different technological parameters have effect on the state of cutting edges, quality of the machined surfaces, load of the machine tool and effectiveness of the machining as well.

4.1. Experimental conditions

The environment friendly drilling experiments were performed by a program elaborated on the base of preliminary experiments. The technological parameters and values to be adjusted were determined using the method of Factorial Experiment Design [7].

Manufacturing experiments: Drilling of holes of diameter 10 mm, the length of the machined hole was l=30 mm. Material of workpiece: GG200 grey cast iron

4.2. 3D surface analysis of drilled specimen

By using of Factorial Experiment Design a great number of experiments were elaborated. We have chosen 8 experiments among them in order to show the results of 3D surface analysis. The codes and the technological data are given in Table 1.

Table 1. Codes of specimen and technological data applied

Number	Feed rate mm/rev	Cutting speed m/min	Volume of oil cm^3/h	Drilled length m	Number of holes drilled
1	0,2	80,0	“dry” (0,0001)	0,03	1
2	0,2	80,0	“dry” (0,0001)	10,03	333
3	0,2	80,0	10,0	0,03	1
4	0,2	80,0	10,0	10,03	333
5	0,2	120,0	“dry” (0,0001)	0,03	1
6	0,2	120,0	“dry” (0,0001)	10,03	333
7	0,2	120,0	10,0	0,03	1
8	0,2	120,0	10,0	10,03	333

4.2.1. Characterized 3D views of measured surfaces.

For each groups a featuring 3D view of surfaces are summarized on Table 4. The measurements were done at School of Engineering at the University of Huddersfield, England [8].

4.2.2. Featuring 3D parameters of measured surfaces

In previous papers [8], [9], we have presented the features of the amplitude and spatial parameters. Now we concentrate on the hybrid parameters: which parameters make approximately equal use of the information contained in the elevations and in their position.

The goals of the study are to quantify the parameters characterising of the 3D surfaces due to distinct cutting speeds, drill wears, and different type of cooling and lubrication. Results of the measurements for examining of effect of lubrication can be found on Figure 1, Figure 2 and Figure 5. Similar type of diagrams can be created to the other characterising 3D surface parameters as well.

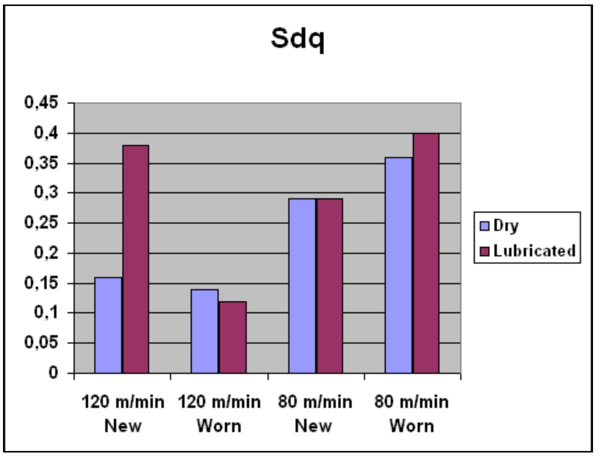

Figure 1. Sdq - Root mean square slope of the surface

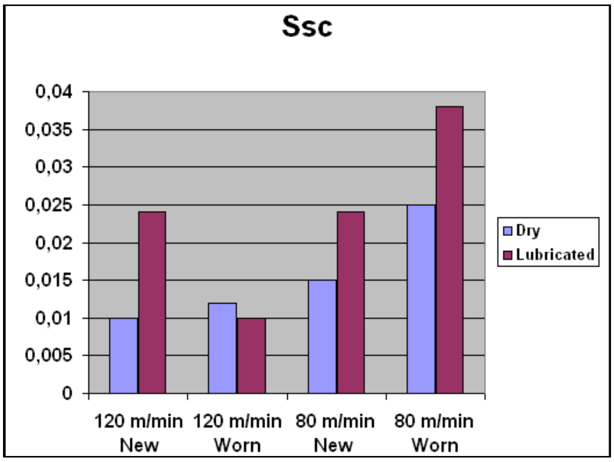

Figure 2. Ssc - Arithmetic mean summit curvature

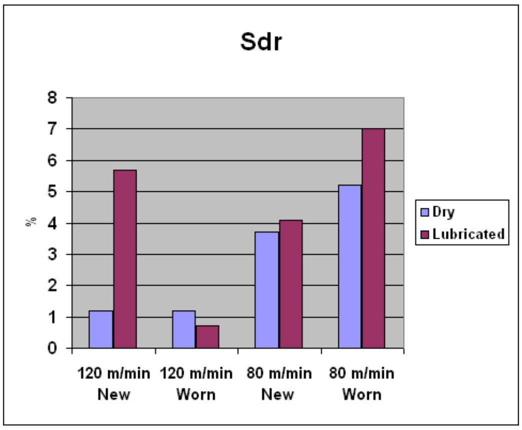

Figure 3. Sdr - Developed interfacial area ratio

Sdq and Ssc

Slope Sdq (Fig. 1) and curvature (Fig 2) show that the slope is higher when height of the profile has significant changes (at lower cutting speeds) (Fig. 3. Fig. 4.)

Dry
v_{c1}=80 m/min
High profile
Small slope

Lubrication
v_{c2}=120 m/min
Low profile
Large slope

Figure 3. Illustration for the results of slope

Dry
v_{c1}=80 m/min
High profile
Large curvature

Lubrication
v_{c2}=120 m/min
Low profile
Small curvature

Figure 4. Illustration for the results of curvature

Sdr

Using a high cutting speed (v_{c2}=120 m/min) the ratio Sdr (Figure 3) is a bit higher in case of lubrication while we would expect it to be lower because the height of the profile is larger when there is no lubrication. Maybe the matching of coating of the twist drill and the material of lubrication was not proper.

Formulas can be created for the examined Hybrid parameters by the use of Factorial Experiment Design. Here can be found how the Ssc parameter depends on the cutting speed v_c, volume of coolants V_o, and the drilled length L_0.

$$Ssc = \frac{24{,}023 \cdot L_o^{3{,}714x10^{-3}} \cdot V_o^{0{,}033}}{v_c^{1{,}56}} \quad (1)$$

5. SUMMARY

More recently eco-techniques have been introduced which enable a more structured approach to drilling performance by measuring the surface topography of the resulting surface and relating its character to the drilling condition. The topography of the drilled surface provides a fingerprint of the process and giving information on cutting conditions, the conditions of the drilling machine itself as well as important information on the drill chip interface.

6. ACKNOWLEDGEMENTS

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