Influence of micro patterned grinding wheels on the work piece quality

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Abstract

Thermal damages of a workpiece are a limiting factor regarding the performance of grinding processes. The thermal load can be minimized when grinding with a reduced contact area between grinding wheel and workpiece. In this paper an experimental setup and machining strategy for the manufacturing of micro patterned grinding wheels are presented. Furthermore the results of grinding experiments with the use of micro patterned grinding wheels are shown.

1 Introduction

Grinding processes are frequently used as a finishing process in the industry, when high form accuracies and surface qualities are required. In view of increasing global competition, manufacturing processes have to be continuously improved in order to keep up with competitors. Besides the development of new abrasives or bondings, possibilities to enhance the grinding performance are given e.g. by ultrasonic assisted grinding or the use of segmented grinding wheels [1, 2]. Such processes reduce the effective contact area and friction between tool and workpiece, so that less heat is generated. A reduction of the effective contact area can also be realized by the application of micro patterned grinding wheel surfaces. However the potential to reduce the thermal load by the use of micro structures has not been fully investigated yet.

2 Experimental Setup

The patterning process of grinding wheels is integrated into a conventional surface grinding machine by using a common dressing spindle equipped with a patterning tool. The experimental setup is shown in figure 1. The grinding machine is a Blohm Profimat 307, which is upgraded with a rotary pulse encoder for measuring the rotational frequency of the grinding wheel. The patterning is conducted with a dressing spindle of the company Dr. Kaiser and a rotating tool with one single diamond cutting edge. The tool is placed beneath the grinding wheel such as a standard form roller. By adjusting the speed of grinding wheel and patterning tool (v_c and v_{tool}), as well as the depth of patterning cut (a_{ed}) and feed rate (v_{ft}), the patterning can be conducted.

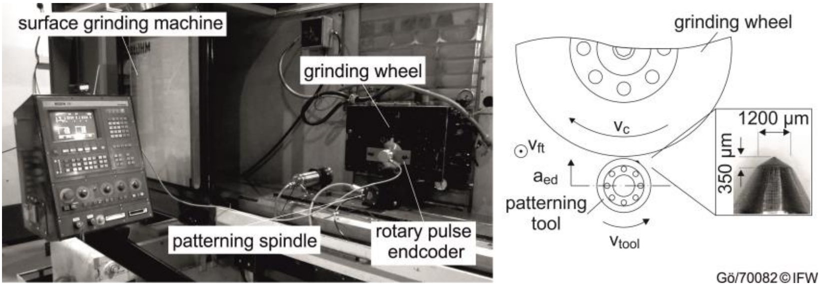

Figure 1: Experimental setup for the micro patterning of grinding wheels

3 Patterning Process and Machining Strategies

The pattern size and pattern arrangement is a function of the process parameters described above. The number of patterns created by one single turn of the grinding wheel depends on the frequency ratio (λ) between grinding wheel rotational frequency (n_c) and tool rotational frequency (n_{tool}). The tool trajectory of a single grinding wheel revolution with a frequency ratio of 8 is schematical illustrated in figure 2 for up- and downdressing mode. During updressing the pattern gets more stretched, due to a longer cutting path compared to the downdressing mode. Nevertheless this difference in length can be siginifcantly reduced when machining with high frequency ratios.

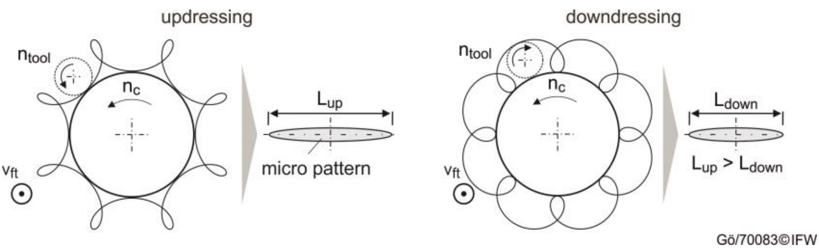

Figure 2: tool trajectory in dependence of the machining direction according to [3]

Another process parameter influencing the pattern length is the patterning depth (a_{ed}). An increased depth leads to a larger pattern width, due to the conical tool profile as well as to a longer contact length between tool and grinding wheel. The pattern density can be varied by means of feedrate (v_{ft}) and frequency ratio (λ). By using the tangential feed motion (v_{ft}), several tool trajectories repeat itself with a defined offset between each other. The described relations between pattern arrangement and process parameters enable a calculation of the effective contact area (A_{eff}) between grinding wheel surface and the workpiece, which is reduced as the number of machined patterns rises.

4 Experimental investigation of micro patterned grinding wheels

In order to examine the potential of micro patterned grinding wheels, face grinding experiments were conducted with a patterned and a non-patterned grinding wheel. Both wheels were primarily dressed with constant dressing parameters, following a patterning process for one of the grinding wheels. By adjusting the frequency ratio (λ) and the tangential feedrate (v_{ft}), an effective contact area of A_{eff} = 57 % was realized. In figure 3 the influence of patterned grinding wheels on the process forces and the topography is shown.

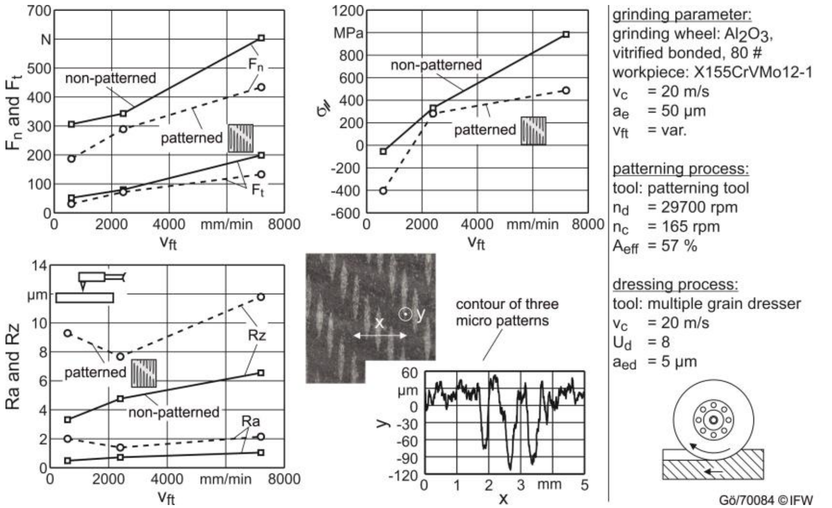

Figure 3: Influence of the patterned grinding wheel surface on the process forces and the topography

It can be stated that a patterned grinding wheel surface is able to reduce the process normal forces up to 30 % and the tangential forces up to 35 %. The development of the process forces correlates with the induced residual stresses and burning marks. Less thermal damage was detected, when grinding with patterned grinding wheels.

However a significant higher surface roughness was measured after grinding with a patterned grinding wheel. This is mainly due to the fact, that fewer dynamic cutting edges are involved in the grinding process, accordingly less kinematic overlappings of cutting pathes that even the workpiece surface occur.

5 Conclusion and future work

The investigations verified the assumption that a reduction of the effective contact area between grinding wheel and workpiece would lead to less mechanical loads and thermal damages. The results also showed that surface qualities comparable to a non-patterned grinding wheel cannot be achieved so far. However with regard to roughing processes, the results show great potential for increasing the overall grinding perfomance, since high surface qualities are generally achieved by subsequent finishing processes.

In further investigations the influence of the pattern arrangement and pattern size on the workpiece quality will be examined in order to identify appropriate pattern parameters for enhancing the grinding perfomance without signifanctly decreasing the workpiece quality.

6 Acknowledgement

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