Manufacturing of Riblet-Structures by Profile Grinding with Metal Bonded Wheels

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Abstract

Riblet structures on surfaces can reduce the skin friction and the near wall shear stresses in turbulent flow up to 10%. Metal bonded grinding wheels have been applied to manufacture riblet geometries with smallest dimensions (s = 20 µm). For the generation of the necessary roof profile on the grinding wheel, electro contact discharge dressing (ECDD) is used, due to the absence of mechanical loading on the grinding wheel profiles. This paper shows the influence of the dressing parameters and strategies on the minimal dressable profile peak geometries and the ground riblet structures.

1 Introduction

For the technical application of riblets on compressor blades, riblets with an aspect ratio between width and depth of 0.5 are needed. By using vitrified bonded grinding wheels, microgrooves with a width down to 60 µm and a depth of 30 µm can be achieved. Due to the tool wear it is not possible to produce riblets with smaller geometries and with the aspect ratio of width and depth of 0.5 with vitrified bonded wheels [1, 2]. In order to shift the process limit concerning downscaled riblet geometries, grinding wheels must be applied, which have a better tool wear behavior. Metal bonded grinding wheels have a favorable tool wear behavior, but they are difficult to dress.

2 The dressing principle and strategy with ECDD

Latest investigations show, that electro contact discharge dressing (ECDD) is in principle suitable to generate complex profiles on metal bonded wheels [3, 4]. The aim of the dressing experiments in this study is to generate a roof profile with a peak geometry, which is limited by the grain size. In this case is only one grain on the peak of the profile. Figure 1 displays the kinematics and the dressing conditions. In order to evaluate the wheel profile the difference between the ideal profile height and the actual profile height Δh has been selected. The ideal wheel profile has the shape of an isosceles triangle. The ideal profile height is defined as the height of the roof profile. The actual profile height h_{actual} is measured at profile widths of s = 40 μm and s = 20 μm. First dressing results show, that the target profile angle of 60° can be achieved. However, the difference between the ideal profile height and the actual profile height at a width of s = 40 μm is 22 μm. The actual profile height at the width of s = 20 μm is in the area of the rounding off of the profile peak and the actual profile height is about 3 μm.

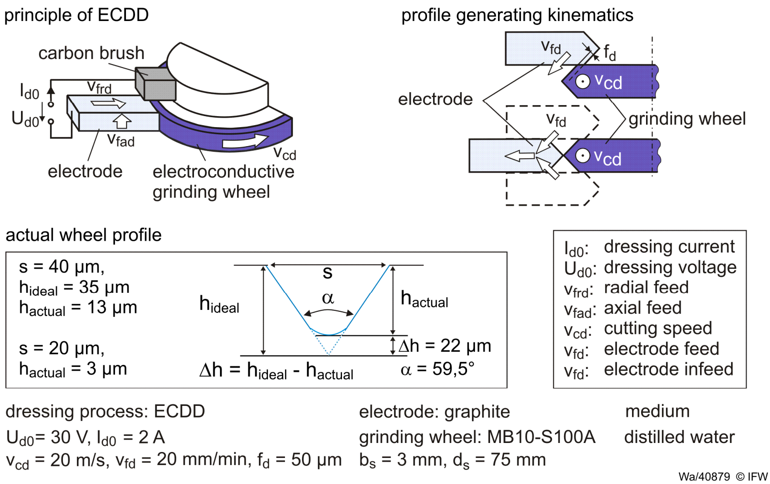

Figure 1: Profile generating with ECDD and the resulting wheel profile geometry

In order to reduce the profile height difference on the profile peak, the dressing parameters and strategy have been investigated. Figure 2 left shows the influence at the variation of the dressing infeed from f_d = 50 μm to f_d = 10 μm on the actual profile height. Furthermore, a new dressing strategy has been applied. Instead of reaching the middle of the profile peak, the electrode path ends 0.5 mm before the profile peak (Figure 2 right). Due to the optimized strategy and parameters, the profile peak geometries can be reduced. At a profile width of s = 40 μm the actual profile height increases from 13 µm to 23 µm and at a profile width of s = 20 µm the actual profile height rises from 3 µm to 10 µm. Calculations show, that with a grain size of 10 µm the smallest possible actual profile height at a width of s = 40 µm is about 26 µm. In this way the minimal dressable profile peak geometries are achieved.

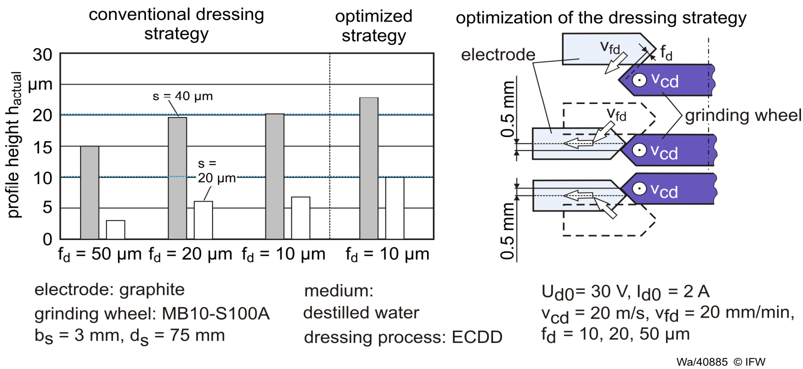

Figure 2: Variation of the dressing parameters and optimizing the dressing strategy

3 Wear behavior and grinding of riblets

In order to produce riblet structures profile grinding is applied to transfer the dressed wheel profile geometries onto the workpiece. As a key issue for the grinding process, the profile height wear h_{wear} has been investigated as a function of the grinding length.

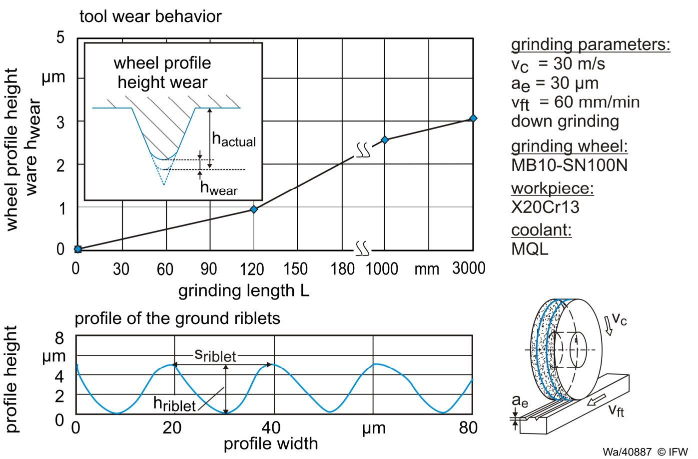

Figure 3: Tool wear behavior and the ground riblets

Figure 3 up shows that the profile height wear is about 3 µm by a grinding length of 3 m. Figure 3 down shows the ground riblets by profile grinding with axial profile overlapping. The height of the riblets is about 5 µm at a profile width of s_{riblet} = 20 µm.

4 Conclusions and Outlook

Metal bonded grinding wheels can be applied to produce riblet structures on steel workpieces. The resulting difference between the target profile height and the actual profile height at the ECDD process can be reduced by optimization of the dressing parameters and the dressing strategy. The grinding experiments show that the wheel profile wear is marginal due to the high strength of the metal bonding. Further investigations on the dressing and grinding processes will be carried out to achieve the ideal riblet geometries with a width of 20 µm and a depth of 10 µm.

5 Acknowledgements

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