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A numerical approach to analyze ground surface texture based on abrasive belt topography

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ABSTRACT –The ground surface is the result of the geometry interaction between grits and workpiece. Therefore, its profile can be regarded as a reflection of the upper envelope profile of effective cutting grains. Based on that, a numerical method was proposed to investigate the influences of abrasive wear height, cutting depth and contacted belt length separately on surface profile. According to the results of the application case, it has been revealed that the abrasive wear height and the contacted belt length had a significant effect on *Ra* of the surface, while the cutting depth just affects *Ra* within a limited arrangement.

1. INTRODUCTION

Nowadays, belt grinding/finishing has been widely used in many fields, including automotive industry [1], aviation engine blade production [2] and maintenance of high-speed rail [3]. The surface texture of the workpiece has been studied for many years, some valuable works about effects of the working conditions on surface quality have been investigated [1,2].

However, the basic physical mechanisms of the abrasive process are not fully understood. One difficulty is that it is difficult to strictly realize the single-variable controlling principle during the experiment. Although it is possible to control single-variable on working conditions such as applied force, grinding speed, belt feed rate in the experiment. One working condition can influence belt abrasion height, cutting depth and contacted belt length, simultaneously. For example, in a normal belt grinding process with a contact wheel, the applied force will change grains wear situation, average intending depth and the contact length at the same time.

The purpose of this paper is to provide an approach to investigate the change trend of the surface roughness under different working conditions. Firstly, the theory and evaluating procedures were introduced. Then, an application case was given, and the results were analyzed.

2. THE EVALUATING METHOD

2.1 Forming process of surface texture

Before introducing the evaluating approach, it is necessary to understand how the surface texture is formed during belt grinding process. As shown in Figure 1, the first profile (black) of section A is built by the first group of grits at the beginning. The h_a is the abrasion height of the belt and h_t is the cutting depth of grains. As time goes on, when there are a few of new grains (red) coming into interacting, the profile will be reshaped to the red one. At the end of the grinding time T_c, the final profile with black, red and green curves is defined by the upper envelope profile of all the interacting grains. Therefore, the upper envelope profile of the abrasive belt carries the important information of the final surface texture. Studying it will be meaningful and helpful to understand the mechanisms of this interacting process.

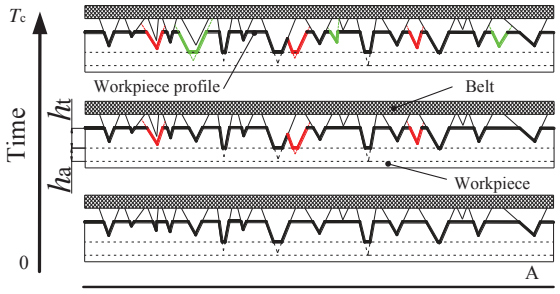

Figure1 The evolution of forming surface texture.

2.2 Evaluating procedures

As shown in Figure 2, there are 3 main steps to complete the evaluation: (a) To obtain a 3D digital surface of the abrasive belt. In this step, the width of the working area should be larger than the value needed for the roughness evaluation. The length of the working area should be larger than the total belt contact length. (b) To extract the zone of interest through the threshold control. For this step, a pair of thresholds should be set to extract all the points between the height of h_{max}-h_a and h_{max}-(h_a+h_t), where h_{max} is the height of the highest grain. One thing should be mentioned is that the wear mode of grains in this paper is assumed as generating a flat plan to replace the original tip. (c) To generate the upper envelope profile of grains within the working area. In this step, every cross section within the working area is going to be projected along the grinding direction. The envelope profile of those sections is decided by choosing the highest points at each location.

3. APPLICATION AND RESULTS

The belt topography with the grains' grade of P120 (average grain size is about 100 μm) was obtained by Nanovea PS50. The scanned area is 10 mm x 20 mm with the depth resolution of 0.01 μm as well as the sampling interval of 30 μm.

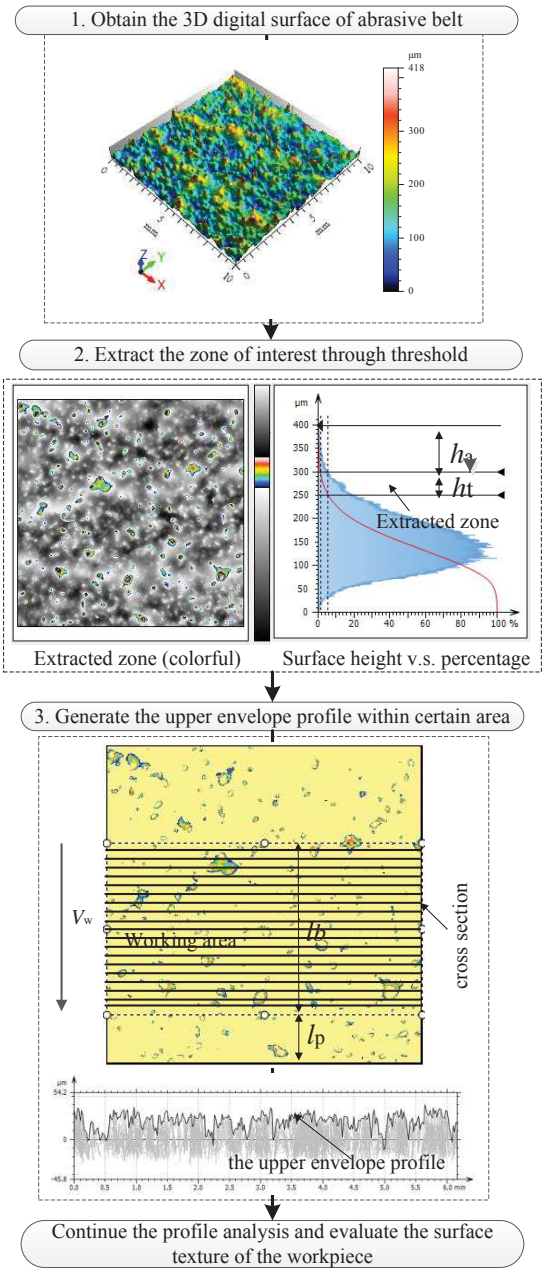

Figure 2 The flow chart of the evaluating procedures.

3.1 The influence of abrasive wear height

Figure 3 reveals that *Ra* decreases with the increase of h_a. The trend can be roughly divided into 3 parts, which accidentally corresponds to the change of the height distribution of the belt.

3.2 The influence of cutting depth

It is clear from the Fig.4 that a larger cutting depth will lead to a greater Ra because of an important increase of the indentation depth of grains. However, this impact can be severely limited both by rising abrasion height and adding the belt contacted length.

3.3 The influence of belt length in contact

Figure 5 indicates that with the growth of the contacted belt length the *Ra* decreases rapidly at first and then tends to be stable. It is interesting that different cutting depths will end up with the same *Ra* when the l_b is over a certain value.

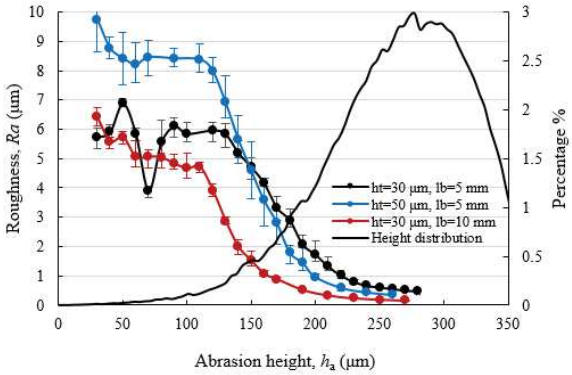

Figure 3 Roughness *Ra* vs. wear height h_a.

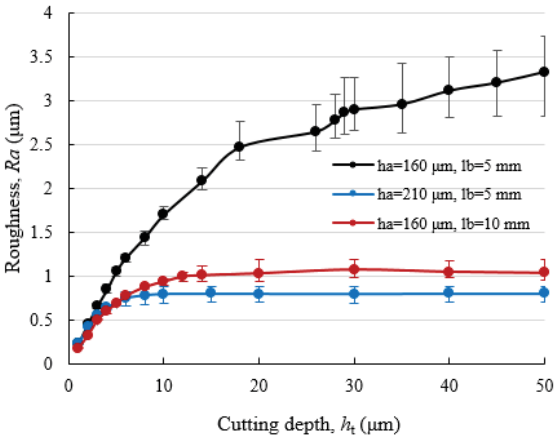

Figure 4 Roughness *Ra* vs. cutting depth h_t.

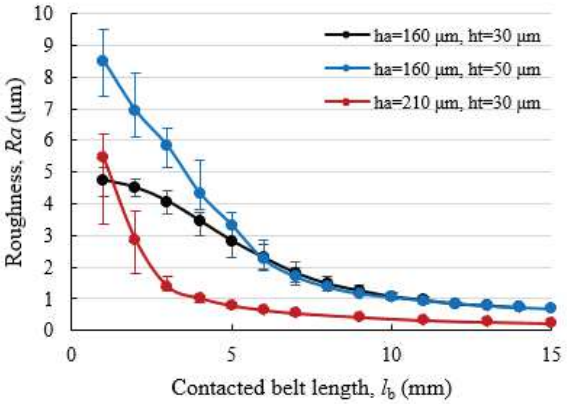

Figure 5 Roughness *Ra* vs. contacted belt length l_b.

4. CONCLUSION

The method proposed is able to separately investigate the influences of belt wear height, cutting depth and contacted belt length on surface texture in belt grinding/finishing.

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