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Enabling of Component Identification by High Speed Measuring of Grinding Wheel Topography

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Abstract

The machining process affects quality and function of components. For this reason, it is an important key competence of the manufacturer. Over the past years, counterfeit products have been threatening the user and damaged the reputation of the original manufacturer. On this account, a method of fingerprinting of ground surfaces was developed in the Collaborative Research Center 653 to protect components against plagiarism. However, this method needs the measuring of every single ground surface, which means a huge expenditure of time in the production chain. If it were possible to predict the grinding surface of the grinding tool precisely, occasional measurements of the grinding tool during the setup time would be sufficient to assign the right tool to the component`s surface and the manufacturer behind it. The presented paper is focusing on methods for the determination of the topography of grinding tools. These topographies enable the manufacturer to predict and thus identify the surface of components.

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1. Motivation

The success of companies is mainly linked with the unique quality of their products. Therefore, plagiarism is one of the biggest problems for manufacturers in mechanical engineering. German manufacturers' estimated sales losses caused by product piracy are about 7.9 billion euros per year [1]. For that reason, the CRC 653 developed a fingerprinting method to identify generally machined surfaces without using conventional marking systems like bar or QR codes [2, 3]. The method uses microscopic, stochastic and thus unique surface areas, which are generated passively in the machining process. In the case of grinding as the last step of most production chains, the identification method is highly promising. Due to the wear behavior of grinding grains, the topography of the tool changes as rapidly as the generated surface does [4]. To keep track of each component, the manufacturer has to measure a surface section of every single component and extract the fingerprint. It is created by the wavelet

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transformation of one or more surface profiles and a subsequent non-maxima suppression of the wavelet image. The detected maxima and minima are called features, and the amount and constellation of features form the fingerprint of the component [5]. The fingerprint and appropriate information are stored in databases of the manufacturer. If customers report a defect or failure, the manufacturer is able to check the originality of the product.

The method has not found an implementation in industry so far. A disadvantage is the need of a 100 percent measuring of products. For a more application-orientated method, an enabling technology is currently under development. This technology will be able to predict ground surfaces by using the complete topography of a grinding tool. The first step to build up a surface prediction model is to investigate the generation of kinematic surfaces by a real tool topography. That means a measuring technology has to be qualified which is able to display the distribution, size and geometry of grains on the grinding wheel topographies. These topographies will be used in a kinematic simulation of the plane grinding process. Inasaki uses a similar approach by measuring a 2 x 2 mm² section of the grinding wheel. Subsequently a grain finding algorithm is applied to identify angles and size of the grains and the component topography is simulated [6]. Another investigation uses triangulated measurement data of a finishing belt to predict to surfaces topography after a honing operation [7]. In this paper, the measuring of grinding tool topographies with a laser triangulation sensor is described. Afterwards, the measured profiles are summarized and compared with the machined surfaces. This comparison serves as a first primitive kinematic simulation in 2D. The future 3D simulation will predict the whole topography and the related fingerprint of the ground surface. This technology enables the manufacturer to identify every ground component by measuring the tool topography.

2. Evaluation of Topography Data

There are numerous instruments to evaluate the micro-geometry of grinding wheels, for example inductive wheel loading sensors, scattered light sensors or reflection sensors. One of the fastest methods uses a laser triangulation sensor and is also applicable for in-process measuring [8]. To qualify the laser triangulation sensor for measuring grinding wheel topographies in shop floor environment, the data is compared with those of conventional surface instruments like tactile devices as well as SEM (scanning electron microscope). For a first application, galvanically bonded cubic boron nitride tools with mean grain diameters of 151 and 252 µm are used. The tool diameter is 30 mm at a width of 8 mm. Consequently, the complete shell surface is 94.25 x 8 mm². These tools are characterized by a high grain protrusion with low bond content and high strength. Therefore, it can be assumed that the summation profile of the tool does not change rapidly during machining. Before the measuring results are compared, the procedure of the different measuring technologies are described.

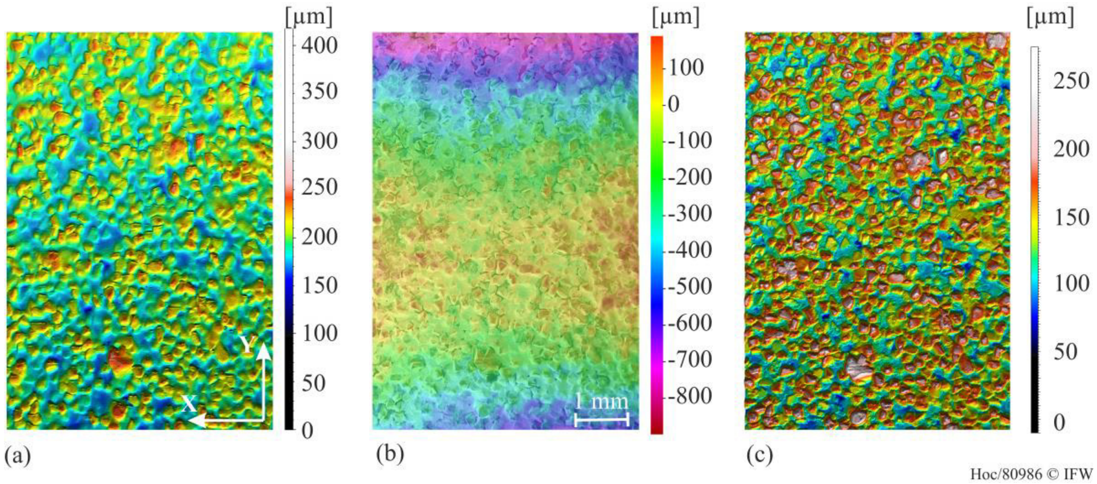

Fig. 1. 7 x 5 mm area of a CBN B252 grinding tool measured with (a) Keyence JL-V7020; (b) Zeiss EVO 60 VP and (c) Mahr LD 130.