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Direct Part Marking by Vibration Assisted Face Milling

Berend Denkena[a], Thilo Grove[a], Alexander Seibel[a,*]

[a] *Institute of Production Engineering and Machine Tools, Leibniz Universität Hannover, Germany*

Abstract

Critical or safety components have to be identified during maintenance especially if exposed to harsh conditions during the time of operation. Direct part marking (DPM) is a process to permanently mark parts with product information such as serial numbers, part numbers, date codes and barcodes. An advanced machining technology is presented (vibration assisted face milling, VAFM), enabling the machining of Data Matrix Codes (DMC) and similar shapes carrying inherent data into the components surface without any additional process step. The technology is based on a piezo-electrically driven milling tool. The dynamics of the tool enable a highly dynamic and controlled depth of cut variation during the cutting process while using process parameters applied in real-life industrial processes. As an example for safety components, the technology is demonstrated on TiAl6V4, one of the most important titanium alloys in the aerospace industry. The machined result is evaluated on the machining quality of the DMC data cells edges and the contrast.

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Keywords: direct part marking, dmp, data matrix code, dmc, machining, fast tool sevo, fts, face milling, vibration asstisted face milling, vafm

1. Introduction

Direct part marking (DPM) is a process to permanently mark parts with product information such as serial numbers, part numbers, date codes and barcodes. Information encoded in 2-dimensional barcodes such as QR-Codes or Data-Matrix-Codes (DMC) are used in a wide array of industries to identify and trace parts during manufacturing and their lifetime [1]. Especially system-critical or safety relevant components in the automotive or aerospace industry are predestinated for DPM as they often undergo maintenance procedures or have to be identified in case of an unexpected

* Corresponding author. Tel.: +49-511-76218234; fax: +49-511-7625115.
E-mail address: seibel@ifw.uni-hannover.de

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failure. For the most part, such components are made out of metal and can be exposed to harsh conditions such as heat, chemicals and/or abrasive contacts during their time of operation. For such conditions the data cells in the DMC matrix have to be marked in a robust way, for example as contrast structures within the surface or as a colourization. Various technologies exist to mark metal parts. The most frequently used ones are laser etching, chemical etching and dot peening [1, 2] (Fig. 1). They all have in common that they require an additional step in the manufacturing process chain and a specialized machine which is designed only for this purpose.

Fig. 1. Common methods for marking metal parts with DMC's [1]

In this paper a machining based marking technology is demonstrated to enable the storage of information in form of Data-Matrix-Codes (or similar shapes) during a conventional face milling process. This technology is based on the vibration assisted face milling process (VAFM), enabling the machining of microstructures in various shapes on flat metal workpiece surfaces [3]. A big advantage of this technology, over existing marking technologies, is that it can be used on conventional CNC milling centres on any flat metal workpiece surface during the finishing process step. This is made possible with a piezo actuator based face milling tool, developed within the Collaborative Research Centre (CRC) 653 [4]. The initial intention of the development of this tool was to machine microstructures, representing binary information, similar to a CD (Fig. 2). This approach was successfully demonstrated in [5], however this type of data storage is not an industry standard like Data-Matrix-Codes and requires specialized reading and decoding technology. The research focuses of the CRC653 are innovative component properties and concepts for their manufacturing and implementation in production engineering processes. One of the CRC's visions is the inherent storage of significant component information, such as production date, process parameters, process forces or even production drawings on the component itself [6]. In addition, these advanced properties provide an excellent basis for protection of components against plagiarism. To demonstrate this novel marking technology, DMC's varying in size and cell contrast enhancing features, are machined with process parameters used in real-life industrial process on TiAl6V4. The result is then evaluated on the machining quality of the DMC data cells edges and the contrast.

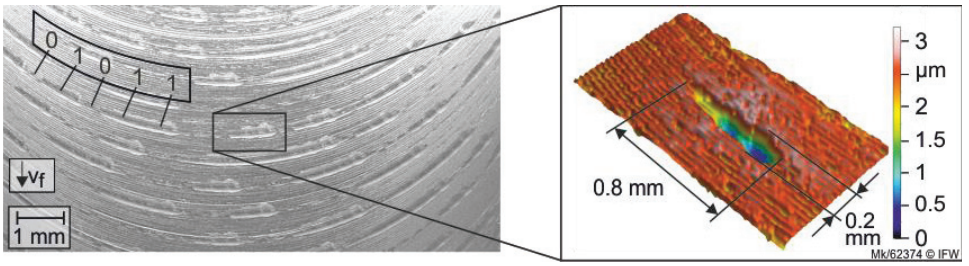

Fig. 2. Machined binary patterns for information storage on metal surfaces [3]

2. Vibration assisted face milling of data matrix codes

2.1. Tool design

Machining of micro-structures requires highly dynamic tool movements as well as a high stiffness. Thus, the presented fast tool servo (FTS) is actuated by a piezoelectric element. Due to the fact that highly dynamic operations cause a significant heat development, a ring-actuator is used for a better heat dissipation. At the maximal used voltage