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Electrical discharge conditioning for indexable insert grinding

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Abstract

Metal bonded diamond grinding wheels have a great potential for grinding hard materials. However, the toughness of the metal bond in combination with fine grit sized and highly concentrated diamonds makes these wheels very hard to condition conventionally. This paper presents a novel approach for conditioning metal bonded grinding wheels using Electrical Discharge Conditioning (EDC). Here, a rotating electrode is continually sharpening, cleaning and shaping the optimized grinding wheel with bronze alloy bond. Experimental results regularly show a doubling of the material removal rate and simultaneously reduced edge chipping and finer surface finish. The process is fast, stable and leads to excellent product quality in terms of dimensional accuracy, surface- and edge-integrity. Over all, the presented industrial-strength Electrical Discharge Conditioning technology boosts productivity and quality.

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1. Introduction

Modern indexable insert materials include carbide, cermet, ceramics, polycrystalline cubic boron nitride (pCBN) and polycrystalline diamond (PCD). Necessarily, these materials are very hard, some are also brittle. In the process chain for the production of indexable inserts, grinding is a central step, creating macro and micro geometry of the indexable insert. Grinding determines crucial quality properties such as dimensional accuracy, surface roughness and edge shipping. In an industrial set-up, inserts are ground on high productivity grinding-centers. Insert manufacturers are continuously optimizing the productivity of their operations and the manufactured product quality.

During the last years, new developments of metal bonded diamond grinding wheels enabled huge progress in processing ultra-hard materials. Diamond grit exhibits superior hardness and wear resistance and is therefore specially apt for grinding hard, brittle and short-chipping materials. Metal bonded grinding wheels with diamond grit maintain a very high geometric precision; they show high thermal conductivity and thermal durability. In conjunction with the strong bonding of the diamond grit in the metal bond, these wheels allow high grinding forces, making this kind of wheels attractive for grinding hard and ultra-hard materials. However, tough metal bonded diamond wheels in combination with fine grit sized and highly concentrated diamonds are extremely hard or even impossible to condition conventionally. As a solution, a novel conditioning method is introduced here.

1.1. Conditioning grinding wheels

The abrasive material for grinding hard materials is diamond grit, which can be embedded in different bond materials. In the sequel, cleaning, sharpening, and truing of the grinding wheel are distinguished [1]. Cleaning includes the removal from workpiece material and bond material from the grinding wheel surface. Sharpening refers to the process of removing bond material and hence producing good grit protrusion. With truing the process of shaping and creating the outer dimensions of the wheel is denoted. This is the only process influencing the macroscopic shape of the wheel. All three processes are summarized in the term conditioning, whereas the combination of profiling and sharpening is often

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denoted dressing. In practice, the borders between sharpening and cleaning are floating. Depending on the choice of conditioning tools and wheels, cleaning, sharpening and truing can happen simultaneously or separately, and they can be performed alternatingly with the grinding process or in parallel (in-process). Further one can distinguish between continuous and intermitted operation of the conditioning process. In this paper, a continuous, in-processes conditioning method for metal bonded diamond grinding wheels is presented.

Metal bonded diamond wheels can be cleaned and sharpened with conventional dressing wheels made of silicon carbide (SiC) or aluminum oxide (Al_2O_3). However, the dressing wheel will show high wear and it is not possible to efficiently condition the grinding wheel with these conventional dressing tools because chattering of the grinding wheel occurs. The novel Electrical Discharge Conditioning (EDC) technology has been developed for conditioning metal bonded, conductive grinding wheels. This physical process is always maintaining maximal diamond grit protrusion. The same time, the wheel is cleaned and the macroscopic shape is kept flat. The method is based on electrical discharges between a rotating copper electrode and the conductive grinding wheel. An elevated voltage (200-300V) is driving the discharge across a dielectric medium. The discharge is locally melting away the metal bond, without damaging the abrasive diamonds. This important property has been proven for a comparable dressing process using Raman spectroscopy [2].

For reference, a complete overview of conditioning methods can be found in [3]. Recent developments in the use of lasers for dressing have been reported in [4]. This process seems to be applicable for dressing small, sharp-edge tools with limited stiffness of the tool body; which is opposite of the task considered here.

Our paper is organized in four main sections. Following this introduction, section 2 will present the system technology of an insert grinding machine with the novel in-process EDC (Electrical Discharge Conditioning) technology. Then, section 3 will discuss the optimal grinding wheel composition for the process. This is followed by the presentation of experimental results in section 4.

Nomenclature

EDC	Electrical Discharge Conditioning
F_n	Normal force [N]
F_t	Tangential force [N]
TB	time break, pause time [µs]

2. System technology

2.1. Periphery grinding of indexable inserts

Consider grinding the periphery of indexable inserts using a face grinding process. The kinematics of a four axis machine is depicted in Fig. 1 following the Agathon axis conventions. (X) denotes the infeed direction of the grinding wheel (1). The oscillation of the wheel is performed in the orthogonal (Y) direction. The workpiece – that is, the indexable insert – (2) is fixed between drive and clamping anvil. By synchronized movement of the rotation axes (B) and (C) together with the linear axes (X) and (Y), complex insert shapes are created.

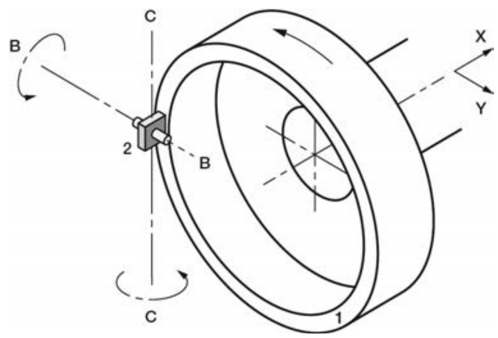

Fig. 1. Face grinding the periphery of an indexable insert.

2.2. EDC system components

The main EDC system components within the grinding area are depicted in Fig. 2. (1) is the metal bonded, electric conductive grinding wheel. The electrically conductive wheel is mounted on an electrically insulated grinding spindle. The dielectric cooling lubricant (2) is completely covering the rotating erosion electrode (3) within the flooding chamber (4). Adequate sensors are used to ensure that this erosion chamber is always completely filled and the erosion gap is submerged in dielectric cooling lubricant.

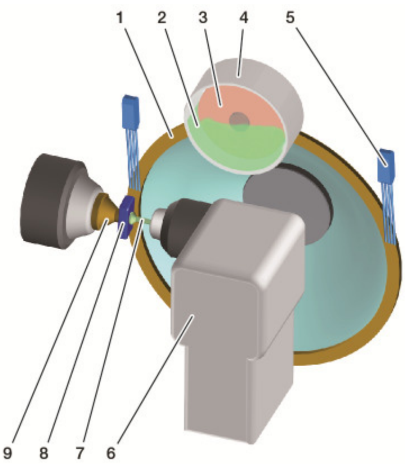

Fig. 2. EDC system components in the grinding area.

2.3. EDC principle schematic

A simplified schematic drawing of the EDC principle is given in Fig. 3. The erosion gap (2) is located between grinding wheel (1) and electrode (3).

The electrical conductive grinding wheel (1) is kept in constant rotation by the grinding spindle motor (7). (X) is the grinding wheel infeed direction, directed towards the