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Grinding polycrystalline diamond using a diamond grinding wheel

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GRINDING POLYCRYSTALLINE DIAMOND USING A DIAMOND GRINDING WHEEL

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CERTIFICATION

I, Maryam Agahi, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Master of Engineering Research, in the Faculty of Engineering, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Maryam Agahi

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GLOSSARY

C	Concentration
Conc.	Coolant concentration
CVD/PCVD Diamond	Chemical vapour deposited polycrystalline diamond
d_K	Grit diameter
d_S	Cup wheel diameter
DOS	Disc operating system
DSP	Digital signal processor
ECD	Electrochemical in-process controlled dressing
ECDM/ECAM/EEDM	Electro chemical discharge machining
EDG	Electrical discharge grinding
EDM	Electro discharge machining
ELID	Electrolytic in-process dressing
F_A	Contact force
F_d	Force in X direction
FFG	Form and finish grinding
F_N/Fn	Normal cutting force
F_R	Radial force
F_T/Ft	Tangential force
G-ratio/G	Grinding ratio
HPAWJ	High pressure abrasive water jet
HSS	High-speed steel

I/O	Input/output
Matlab	Matrix laboratory
MMC	Metal matrix composite
MRR/Q_W	Material removal rate
PcBN/PCBN	Polycrystalline cubic boron nitride
PCD	Polycrystalline diamond
RAM	Random access memory
R_P	Peak to mean line height
SEM	Scanning electron microscope/microscopy
SRG	Stock removal grinding
t_d	Sharpening cycle
TI	Texas Instrument
V_C/V_S	Peripheral speed
v_d/V_W	X-axis velocity/oscillation rate
VWW	Volumetric wheel wear during dressing
VWWR	Volumetric wheel wear rate during grinding
WC	Cemented tungsten carbide
WEDM	Wire electrical discharge machining
δ	Truing feed
α	Vertical angle between the work piece and the grinding wheel centre
μm	Micron
μ	Grinding coefficient

ABSTRACT

Application of ultrahard cutting tool materials is continuously expanding. One example of an ultrahard cutting tool material is polycrystalline diamond (PCD), which is widely used in tool making and machining. However, because of the high wear resistance of PCD it is characterised by low grindability and machinability. So, any mechanism used to machine PCD has to meet specific requirements. Grinding with a diamond grinding wheel is one of the economic ways to machine PCD compacts. This thesis considers the grinding of polycrystalline diamond using a conventional grinding machine and makes machining parameter recommendations to support the optimisation of PCD grinding.

The PCD grinding forces are mathematically analysed. These grinding forces are measured using a force sensor installed on a conventional grinding machine. The forces produced during grinding are investigated as a function of in-feed, contact zone, material removal rate (MRR) and oscillation rate. Wheel conditioning, another major aspect of PCD grinding, is studied and optimised in order to reduce the grinding forces, increase the cutting efficiency and achieve maximum removal rates and minimum wear ratios.

Grinding wheel wear is investigated as a recognized problem in PCD grinding. A series of experiments are conducted in which the material removal rate, the rate of wheel wear and the grinding forces are measured. The effects of in-feed, sharpening process and work piece hardness on the wheel wear are studied.

The edge quality of the PCD compacts is investigated as an important issue in tool making. Factors affecting PCD grinding quality include the in-feed, material removal rate, the condition of the diamond grinding wheel and the rigidity of the grinding machine. These are all studied to find their effect on edge quality.

The work presented in this thesis also shows that the capability of a conventional grinding machine designed for non-PCD is sufficient to grind PCD with acceptable quality.

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