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Review Paper on Abrasive Machining Process

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Abstract
Abrasive Machining is the most important process for material removal in the industries. It refers to the action of removing the fibres from a surface. It requires a deep study to obtain a better understanding of the variables that affect the material removal rate, quality of surface & power consumption. Various experiments are designed to determine the impact of interface pressure, belt speed, surface roughness for different grit sizes. A relation is created between grinding forces & material's resistance to microstructure. Magnetic forces are also applied as a pressure for proper finishing of surfaces. Coordinated system is created by applying theory of face gear's teeth surface.

Keywords*- Surface Texture, Grinding Forces, Parameterization in Granite, Finite Element Analysis, Simulation, Magnetic Abrasive Finishing, Material Removal Rate, Optimization.*

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INTRODUCTION

Recent studies in our laboratory have demonstrated the importance of intergranular microfracture and grain dislodgement in abrasive machining of polycrystalline ceramics. Material removal by lateral crack extension has not been observed to be an active process. In surface grinding, the ceramic workpiece is translated toward the grinding wheel at a prescribed table speed and depth of cut. The forces generated between the grinding wheel and the ceramic workpiece during grinding are related to the hardness and toughness of the material and, therefore, must be related to the proper density of the material to microfracture and grain dislodgement.[1] The purpose of the present study is to examine the possible correlation between the grinding forces and the material's resistance to intergranular microfracture in abrasive machining of ceramics.

High technology industries require ultraclean smooth finished surfaces for their critical applications. Liquid piping systems, vacuum tubes, sanitary tubes, high purity gas tubes and Pharmaceutical industries require smooth finished Inner pipe surface to prevent the Contamination of gas and liquid. Magnetic abrasive finishing is one of such Method which uses a controlled magnetic force to finish surfaces. In magnetic abrasive Finishing, a cutting tool that consists of iron particles and abrasives is flexible in nature.[2] To minimize the surface damage, gentle/flexible finishing conditions are required, namely, a low level of controlled force. Magnetic field assisted manufacturing processes are becoming effective in finishing, cleaning, deburring and burnishing of metal and advanced engineering material parts.

Grinding experiments were performed using a surface grinder and a resin-bonded 80 grit peripheral diamond wheel with a wheel width of 6 mm. The wheel was dressed with an alumina dressing stick before grinding. A soluble-oil grinding fluid was used. The wheel surface speed was 37 m/s and the table speed was 0.12 m/s. The specimens used for grinding had a dimension of 4 X 4 X 20 mm and were ground on the 4 X 20 mm surface longitudinally without cross-feed since the wheel width was larger than the specimen width. Normal and tangential grinding forces were measured with a piezoelectric dynamometer. The depth of cut was varied from 2.5 to 30.0 /Am/pass. At each depth of cut, six passes were made to establish steady-state conditions before the forces were measured. Single crystal SiC as a new generation of wide band gap semiconductors enables whole new classes of commercial and military applications currently impossible or unaffordable with silicon.[3] This is due to its

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unparalleled combination of high breakdown voltage, wide band gap energy, high carrier saturation velocity, extreme temperature tolerance, high thermal conductivity, and radiation hardness, in spite of the low carrier mobility as a disadvantage.

Electrochemical grinding with metal bonded abrasive tool (AECG), consists in combination of mechanical and electrochemical processes, acting on the workpiece, that considerably changes performance indexes of the machining process. Particularly effective is AECG process for machining parts made from difficult to cut materials, such as sintered carbides, creep resisting alloys (e.g. Inconel, Nimonic, EJ), titanium alloys, metallic matrix composites. Increase in performance indexes of hybrid machining processes, such as AECG process, results from interconnections between micro cutting, electrochemical dissolution, changes in surface layer properties of material in machining area, and processes that take place in active layer of the grinding wheel surface. In the simulation, the final objective value of the surface roughness was 0.01 εm according to the algorithm of the sequential reduction of the input current. The finishing efficiency appears to be very sensitive to the magnitude of the magnetic flux density & thus for low pressure.

Various tests are performed by selecting: Two wood species (Maple & Pine), Two belt speeds (2000 & 2600 feet per minute), Two abrasives Aluminium Oxide & Silicon Carbide with grit sizes P100, P150, P220, four pressure level (0.75, 1.00, 1.25, 1.50 psi), Code ASME-B46 and thus MRR, Power consumption & Roughness of the wood pieces are studied.

The 13 kinds of granite are chosen for the experiments in laboratory and in manufactory. The granitesô characters and their commercial names are listed. The micro-hardness was measured by a HX-100 Vickers Micro-Hardness Meter, which is an average of 3ï 5 points for a mineral. In the experiment, it was difficult to identify indention diagonal of various hard brittle minerals due to the fracture around the indention, thus measure load of 100 g was chosen.

Two forms of Silicon nitride were doped in 4 vol % yttrium & then hot pressed. Thus, to change the microstructure, heat treatment was carried out of two pressed forms of Silicon nitride. First form of Silicon nitride had Ŭto ɓ phase ratio of 30/70, while other form had 100 % ɓ phase. Both materials had a porosity less than 1%. Vickers hardness values at a load of 10 N were 20 & 16.3 GPa. Thus, grinding experiments were performed using surface grinder with a resin-bonded 80 grit wheel of width 6 mm. Normal & Tangential grinding forces were measured with a piezoelectric dynamometer. Hence, the grinding forces were plotted as a function of depth of cut, for two Silicon nitrides.[1] Select the first specimen with dimension 4x4x20 mm. Polish on rectangular surface with 1 um diamond paste. Similarly, got the 2nd polished specimen. Now, bonded these specimen with adhesive. Scratches were made on top surfaces with a conical diamond indenter having an apex angle of 120°. After this, two specimens were separated & examined using optical and scanning electron microscopy. Analysis of the density of subsurface micro cracks was made by a thermal wave technique, which is based on Optical Beam Deflection Method.

In the AEDG process metallic or graphite electrode, which are used in electro-discharge grinding (EDG) process, has been replaced with metallic bond grinding wheel. In consequence there is mutual assistance of both the processes, namely electro-erosion process and micro cutting process, together with mechanical effect of abrasive grain impacts. Essential increase in performance indexes of the machining process becomes evident when machining super-hard materials (blanks with synthetic diamond PCD), technical ceramics, sintered carbides and metal matrix composites.

LITERATURE REVIEW

Sr No	Name of Author	Aim of Research Work	Methodology used	Results and Discussion
01	[Daniel E. Saloni, Richard L. Lemaster, Steven D.	Abrasive Machining process, characterization on material removal rate,	Various tests are performed by selecting: • Grit sizes P100, P150, P220	• Material Removal Rate increased when the pressure is increased but, in

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	Jackson, 2005][4]	final surface texture & Power consumption for wood	• Four pressures level 0.75, 1.00, 1.25, 1.50 psi • Code ASME-B46 and thus MRR, Power consumption & Roughness of the wood pieces are studied	one case MRR decreased with increasing the pressure • No specific relation found between MRR of pine & MRR of maple • MRR increased with increasing of speed • MRR for pine using Aluminium oxide showed the same result with MRR for maple using Silicon carbide • Final surface had higher roughness with coarse grit, both for Aluminium oxide & Silicon carbide • Final surface finish was better with high belt speed
02	[Hockin H.K. Xu, Lanhua Wei, Said Jahanmir, 1995] [1]	Grinding force and microcrack density in Abrasive machining of Silicon nitride	• Heat treatment was carried out of two pressed forms of Silicon nitride • Grinding experiments were performed • Grinding forces were plotted as a function of depth of cut • Beam Deflection Method	• It explains an intrinsic relation between the Grinding force and the materialðs resistance • Also, it explains a consistent correlation between micro-cracking and grinding force for different ceramic materials • Examination of the scratches at a higher magnification in the SEM revealed that intergranular microfracture and grain dislodgement occur in both materials
03	[Ling Yin, Lewis K. Ives, Said Jahanmir, E. Dianne Rekow & Elaine Romberg, 2007][5]	Abrasive Machining of Glass-Infiltrated Alumina with Diamond Burs	• Experiment was performed with Diamond Burs & test apparatus • Evaluation of Bur Loading & Wear was studied • Removal rate was studied with Cutting time	• The removal rate decreases with decreasing grit size • The material removal rate increases with increasing bur grit size when comparing ultrafine to fine • The removal rate for Super coarse burs (SC) is twice the removal rate for fine burs (F) & four times higher rate than the removal rates for Ultrafine burs (UF) • With increasing cutting time, removal rate is decreased
04	[J.Xie, J.Tamaki, 2007][6]	Parameterization of micro-hardness distribution in granite related to abrasive machining performance	• Table showing the Granite types, size & hardness • Abrasive machining experiments in laboratory • Production experiments in manufacturing industry	• Micro hardness distribution in granites was observed • Correlation between micro-hardness parameters & Abrasive Machining efficiency was obtained • Diamond blade life was plotted • Polishing performance was obtained

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05	[Sumeet Bhagavat, Imin Kao, 2007][7]	Ultra-Low load multiple indentation response of materials: In purview of free abrasive machining (FAM) process	• Finite element model & details • Abrasive during slicing in wire saw • Load-Depth curves & Indentation profiles are obtained	• Load required to obtain particular depth decreased with increased abrasive spacing • Amount of Elastic recovery upon unloading increased with decreased in indenters spacing • Indenter with tip radius required more load for a particular depth than indenter with sharp tip • Indentation profiles were found to be axisymmetric • Mean contact pressure remained consistent with all spacings
06	[Jerzy Kozak, Kazimierz E. Oczos, 2001][8]	Selected problems of abrasive hybrid machining	• Electrochemical process • Electric discharge grinding • Electrochemical finishing	• Maximum roughness was plotted with machining time • Effect of ñPulse timeò on the ñRelative Material Removal Rateò is studied • Effect of Material Removal Rate is studied with Pressure • Committee of Science Research, Poland had funded this study
07	[Ling Yin, Eric Y.J. Vancoille, Kuppuswamy Ramesh, Han Huang, 2004][3]	Surface characterization of 6H-SiC (0001) substrates in indentation and abrasive machining	• Nano indentation & Vickers indentation tests • Grinding tests with a CNC Grinder • Polishing tests with finest diamond wheel of 7 um grit	• Radial median cracks were observed at the corners at the indentation impression • Large scale edge chipping was observed • Vickers hardness value was estimated to be 31.30 ± 3.86 GPa • No cracks were observed under the load of up to 400 Mn • The Nano hardness value for single crystal 6H-SiC was observed 32.05 ± 0.60 GPa
08	[Jeong-Du Kim, Min-Seog Choi, 1994][2]	Simulation for the prediction of surface-accuracy in magnetic abrasive machining	• Modelling of Magnetic Abrasive Machining system • Modelling & Algorithm of surface accuracy	• Magnetic Flux Density was not affected by cross sectional area but affected by length • Magnetic Flux Density increased with increased air-gap • As Magnetic flux density increased, pressure increased slowly at first but then increased rapidly • Surface roughness decreased with increased machining time

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09	[D.A. Dornfeld, 1981][9]	Single Grit Simulation of the Abrasive Machining of Wood	• Review simulations of grinding by ñHamed and Butteryò • Grit design simulation by ñMulhearn and Samuelsò • Investigation by ñSedricks and Mulhearnò of the attack angle on scratch produced in lead • Forces measurement by ñ Crisp, Seidel & Stokeyò • ñButtery & Hamedò approached the study of factors affecting cutting efficiency	• Coefficient of friction & Moisture content was calculated • Deformation energy decreased with more positive rake angle in transverse machining but it was limited in case of longitudinal machining • Further work is necessary to include adhesion between tool & wood surface, for all ranges of rake angle
10	[Yongxiang Li, Xiaoqin Bi, Junshan Zhang, Guoding Chen and Ning Zhao, 2009][10]	Research on the Abrasive Machining of Face Gear	• Analysis of Coordinate System of Grinding Face Gear • Analysis of Worm Wheelôs Curved Face • Movement Analysis of Grinding Machining • Structure Analysis of Grinding Machine • Geometry model of Grinding Machine	Study of Face Gear Grinding machine is at exploring stage & the related technology was not so mature, hence further study needs to be taken
11	[Mithlesh Sharma, Devinder Pal Singh, 2013][11]	To Study the Effect of Various Parameters on Magnetic Abrasive Finishing	Cylindrical work piece & Brass pipe with abrasives (Al_2O_3 + Fe) within it, were arranged with chuck & dead centre. Magnetic field was applied with the help of electromagnet. Rotational motion (80, 95, 170 rpm) was provided to the cylinder & magnetic particles through magnetic pressure finished the work piece.	• Surface finish was more with more circumferential speed • Increased Magnetic flux density (MFD) reduced the surface finish • Surface finish is more with increased hardness

CONCLUSION

It shows the feasibility of magnetic abrasive particles & gained an understanding of the mechanism. At a prescribed load, the indentation peak depth increases as the spacing between the abrasives decreases. Machining of Glass-infiltrated alumina can be possible with diamond burs. Material removal rate decreases with continuous machining due to wear of diamond grit. Surface roughness & edge chipping damage are sensitive to diamond grit size. Intrinsic relation is created between grinding force & materialôs resistance. Between pressure & MRR, no consistent relation is obtained. Indenter with tip radius required more load for a particular depth than indenter with sharp tip.

FUTURE SCOPE

The extremely small scale of chips produced and the self-sharpening of grinding wheels are key advantages of abrasive machining and should be taken advantage of in future efforts to develop abrasive machining technologies. It should provide grinding wheels with ultrafine grits & molecular dynamics surface integrity assessment techniques.

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