International Journal of Advanced Technology in Engineering and Science
Vol. No. 09, Issue No. 04, April 2021
www.ijates.com
ijates
ISSN 2348 - 7550

Current Status and Trends in Electric Discharge Diamond Grinding Process

Devlina Gaharwar[1, a)], S.K.Jha[2, b)] , Basanta Kumar Bhuyan[3, c)]

[1] *Student of M.Tech, MPAE Department, NSUT, New Delhi, India*
[2] *Professor, MPAE Department, NSUT, New Delhi, India*
[3] *Professor, ME Department, MRIIRS, Haryana, India*

Author Emails
[a)] *devlinagaharwar@gmail.com*
[b)] *sk.jha@nsut.ac.in*
[c)] *bkbhuyan.fet@mriu.edu.in*

Abstract.

The presented paper sheds light on a kind of hybrid machining process in which grinding is done in the presence of electrical sparks, this machining process is an amalgamation of electrical sparks and Diamond grinding simultaneously. During the machining process, work piece is subjected to continuous emission of high-speed electrons and mechanical abrasion of diamond grains simultaneously and synergistically. This process is particularly suitable for machining of advance materials due to its cost efficiency and faster processing as comparison to other conventional machining or even advance machining process. In case of conventional grinding, frequent dressing of grinding wheel is required to maintain its topography as grinding wheel is subjected to acute wheel loading and glazing. To overcome this limitation, grinding is considered in presence of electric spark which melts the bond material of the grinding wheel simultaneously as it grinds the surface of the work piece. Due to melting of the grinding wheel bond material, underneath diamond grains are exposed for newer cutting operation. Hence, unproductive time of frequent dressing is saved as there is no need for separate dressing and de-clogging operation would not be required. Convolutional Neural Networks (CNNs) models are recommended in order to make a forecast of surface integrity in Electrical Discharge Machining (EDM).The proposed models use the pulse current, the pulse length, and the material as input parameters, and were trained using data from a wide range of EDM experiments on steel grades. According to the findings, the projected CNNs models will accurately predict the surface integrity in EDM. Furthermore, they can be thought of as priceless tools in the process planning for ED Machining.

Key Words: Hybrid machining processes, Electric discharge diamond grinding, Taguchi method, ANOVA analysis, Machining of MMC’s

1. Introduction

Researchers suggested hybrid machining processes to address problems in machining difficult-to-machine materials and limitations of specific machining processes (HMPs). HMPs combine or sequence various material removal procedures, or use energy to assist in material removal, to maximize benefits and reduce potential disadvantages associated with a specific machining process. [1], [2]. Koshy et al. [3] proposed EDDG as one of the HMPs to resolve low rates of material removal and issues analogous to surface finish in EDM. As compared to the EDM method, electric discharge diamond grinding combines erosion by electric discharge and MA of diamond grinding, resulting in a significantly faster rate of material removal. The EDDG process becomes conceivable when used in machining of extremely hard materials, ceramics, carbides, and MMCs. [4]. A metallic bonded grinding wheel with diamond abrasives is employed to abolish material by mechanical abrasion in EDDG. In most of the disquisition

AEDG is introduced as EDDG since AEDG process can be accomplished experimentally with diamond abrasives only. Though, EDM is one of the prominent machining processes adopted by the die and mold building industry, discharge pulse energy substantially affects the surface integrity of the workpiece material. Micro-cracks & recast layers deteriorate the material's fatigue resistance. To vanquishtheproblemsof surface finish noticed in EDM, Koshy et al. (1996, 1997) [5], [6]worked on EDDG for machining of electrically conductive materials. [7].The forces of grinding are mitigated by heating the workpiece material on an atomic-scale with the assistance of the electric spark as the material is softened. [8]. EDDG can be installed in three different grinding configuration setups, as depicted in Figure 1. [9]. thesesetups are known as EDDCG, EDDFG, and EDDSG. With abrasion and sparking actions at the outer surface of the grinding wheel, the EDDCG configuration is used to divide the workpiece into parts or intrude grooves into the workpiece.

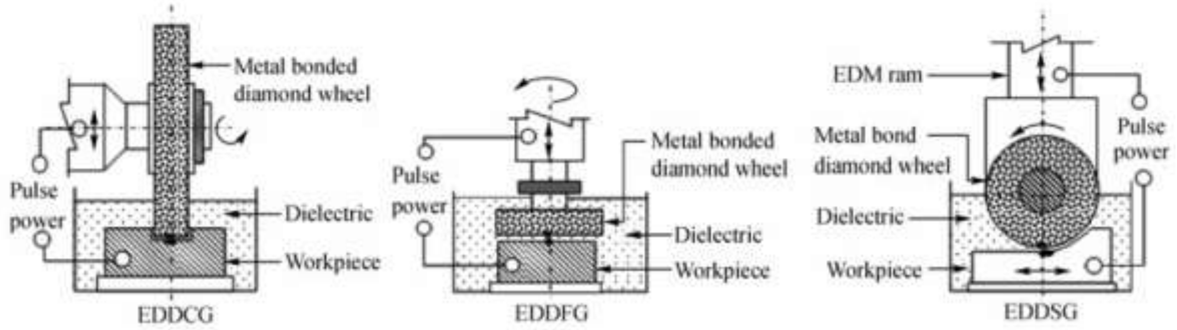

Figure 1 Different configurations of EDDG process [9]

1.1. Mechanics of the grinding process

The kinematic connection between both the grinding wheel and the work movement works in relation to each cutting grain in the grinding process. The process's preliminary readings were focused on the dynamics of a specific grain of the wheel field. [12] [13] Other aspects of the grain grinding process can be determined by the geometric connection between the grain and the processor The form of the chip is shown in Fig 3 The maximum size of the main chip h_mThere are three stages to the milling process: grinding, ploughing, and cutting. The rubbing process occurs when grain participates in the workpiece in the cut up mill and slips without cutting in the work area due to the system's thinning. Plastic is formed when the strain between the grain and the crust is increased above the elasticity threshold. The tool builds the whole pile on the front and sides of the bullets to form a channel The chip is built when the device fails to withstand the pressure of tearing The chip construction phase is the cutting phase In view of the energy requirement for the removal of an object cutting is the eminent phase Rubbing and plowing have been wasted since the energy used in the transformation and dispersal of a small contribution to the removal of property In addition high temperatures can eventually produce an abnormal amount of tire wear and the workplace may experience metal cuts Scratching letters are a cutting tool for the crooked form However Shaw imitated grain on the surface of the wheels as a sector [14] This is not just a complete contradiction remembering the large angles of resistance given to the grain The grain's standard loaded power was thought to be comparable to the Brinell hardness test or the Meyer hardness test. The elastic plastic border maintains the versatility of the operation. The plastic curved region under the surface changes in a slope as the sector travels horizontally. The synthetic materials are pressed upwards forming a chip that is cut in sequence on the face Figure 2 shows the model, in which the direct movement of the square at the cut depth t corresponds to the surface added to the surface at the same depth t. The magnitude of the force needed to reverse the workplace is fixed and independent of the direction it is loaded in the absence of a surface conflict between the workplace and the environment. This proves that the fixed induction area persists regardless of the load path.

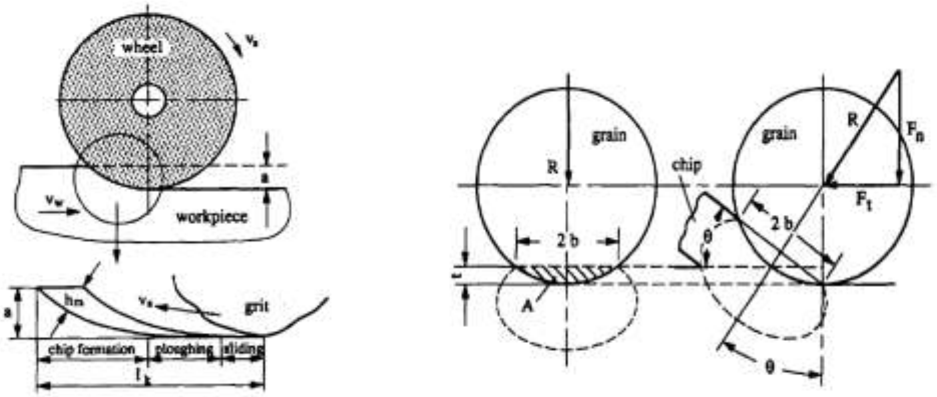

Figure 2 Three stages of chip generation & Action of a spherical grain in grinding [15]

2. Literature review

Workpiece	Parameters for input	Output	Inferences drawn	Ref
AISI p-20 alloy steel	Machining speed, feed rate, depth of cut, nose radius, and cutting surroundings	Power expenditure	Vital parameters in achieving minimum power consumption were analyzed victimization Response Surface Methodology (RSM) and Taguchi" s technique	10
EN8 material	feed rate	surface roughness & MRR	The feed rate is that the very important parameter for surface roughness and material removal rate	11
CBN wheel and Ti-6Al-4V	Temperature	warmth flux	To determine the warmth flux with measured temperature, a heat distribution model was projected using a CBN wheel and Ti-6Al-4V material.	20
Inconel-718	Temperature	Residual stresses	The impact of residual stresses by embedding a supply of warmth with the fabric, tensile residual stress is transferred into compressive stress.	21
EN 24, EN31 and EN 353material	depth of cut,	Ra	For the various method parameters, an analytical model for Ra is created. In addition, the y on x	22

steel	hardness, and work speed		regression is established. The Taguchi optimization technique is used to find the best values for depth of cut, material hardness, and work speed for the lowest Ra.	
1045 steel	speed ratios	Surface topography and grinding power	Grain synchronization was observed in both experiments and simulations for non-integer rational speed ratios, but not for irrational speed ratios. Grain synchronization was delayed, resulting in a more stable surface end than speed ratios that synchronized faster.As a result of the delayed grain synchronization, there was an increase in the number of non-overlapping grain trajectories available for chip removal. Grooved wheels, on the other hand, have a lower surface end than non-grooved wheels. Since the number of cutting edges was reduced, the number of non-overlapping grain trajectories was reduced, resulting in lower power requirements for machining faster synchronization of speed ratios.	23
AISI 1050 Steel	Surface work speed and grinding operation depend on grinding wheel material depth of cut, table feed, grinding wheel speed, and table travel speed.	surface roughness	With grooved wheels, the RSM model predicted high surface roughness (0.9911). Surface roughness was very poor, and GA predictions were in line with experimental values. Investigations into the various grinding performance characteristics using the same model could enhance this report.	24
hardened steel AISI 4340	Feed rate, cutting speed	surface integrity, grinding power, roundness deviation, micrography, diametric G-ratio, and wheel wear	The effect of wheel wear was also taken into account in the surface and power models presented here. These models have been shown to predict process conditions for a wide variety of grinding conditions without requiring extensive experimental work. The effect of uncut chip thickness on steady-state surface roughness and G-ratio has also been demonstrated.	25

Sintered alloy (SMF4030, steam-treated)	Depth of cut,	Surface roughness and straightness	An oscillation operation is necessary to prevent uneven grinding wheel wear. High machining precision, less than 3 microns of roundness, straightness, and surface roughness less than 2 microns.	26
CBN grinding wheels	-	-	According to the simulation, a grinding wheel structure with a true distribution of grains, pores, bonds, and components based on volumetric composition is possible. In addition, a method for transferring and measuring the shape of CBN grains is developed as a way to obtain quantitatively true CBN grains.Grinding wheel topography simulation in the future, based on dressing parameters and volumetric structure. Reducing the number of grinding experiments in order to examine the effect of volumetric composition on grinding force and process temperature.	27
MMB1320 external Semi automatic grinder	Multi parameters	Production time	This paper presents an optimized model for cylindrical plunge grinding that reduces production time while maintaining high surface topography. Experiments and simulations demonstrated the model's accuracy and the feasibility of the best process parameters. The model's industrial exertion has greatly shortened grinding time.	28
-	-	-	The mathematical model for the dynamics of cylindrical plunge grinding. Simulation of the dynamics of cylindrical grinding during an infeed towards the specimen as well as during grinding. Simulation of effects of vibration on grinding wheel spindle as well as grinder table.	29
-	-	-	Better results have been achieved by tuning spindle velocity without affecting productivity. Moreover, research can be done to validate the efficiency of the continuous speed variation technique both for wheel and workpiece chatters through adaptive control. This adaptive controller	30

			can also work with various grinding machines.	
			This model has evaluated the vibrations and the cutting forces, as well as their effects on thesurface topography, which has been analyzed when grinding in given processing regions.	31
-	Workpiece feed rate, material removal and workpiece velocity	Workpiece roundness.	Striking workpiece velocity and Lower worktable feed rate and higher material removal yielded better roundness. Machining elasticity parameter increases with higher material removal. Workpiece velocity can be controlled precisely by an elliptical motion of the ultrasonic shoe. Workpiece roundness upgraded from preliminary value of 24 microns to 0.84 microns	32
EN52 austenitic grade steel.	Grinding feed, dressing feed, dwell time and cycle time	Surface roughness	ANOVA analysis reveals that the grinding feed, dressing feed, and cycle time have a significant influence on response characteristics whereas dwell time was insignificant and well supported by grey relation analysis. This proposed model has greatly reduced the surface roughness and out of cylindricity during feed centerless grinding.	33

3. CONCLUSION

The various process parameters and their contributions to the Electric discharge diamond grinding process in various aspects such as cutting speed, depth of cut, and feed rate are presented in this paper. The analysis of the EDDG method has been completed in all respects and forms.Material removal from electro-spark diamond grinding occurs only when the inter electrode distance is smaller than the protrusion height of the grinding grain. As a result, only a small number of abrasives engage in the substance removal process in operation. According to the literature, relative to diamond grinding and electro-spark machining, higher material removal occurs.To effectively machine difficult-to-cut hard materials, a combination of electro-spark machining and diamond grinding can be used. As compared to electro-spark machining and diamond grinding, the obtained machining efficiency is significantly higher. Increases in pulse on time, current, and service cycle increase the rate of material removal.

4. REFERENCES

[1] Deepak Rajendra Unane, Vijay Pratap Singh, Harlal Singh Mali, 2015,"Experimental Investigations of Abrasive Mixed Electro Discharge Diamond Grinding of Nimonic 80A" International Journal of Materials and Manufacturing Processes, eISSN: 1532-2475, ISSN: 1042-6914 doi:10.1080/10426914.2015.1090598, (SCI)

[2] Unune, D. R.; Mali, H. S. Current status and applications of hybrid micro-machining processes: A review. Proceedings of Institute of Mechanical Engineers Part B: Journal of Engineering Manufacture 2014, 1-13.

[3] Koshy, P.; Jain, V.K.; Lal, G.K. Mechanism of material removal in electrical discharge diamond grinding. International Journal of Machine Tools & Manufacture 1996, 36 (10), 1173-1185.

[4] Kozak, Jerzy. "Abrasive electrodischarge grinding (AEDG) of advanced materials." *Archives of civil and mechanical engineering* 2.1 (2002): 83-101.Koshy, P., Jain, V.K. and Lal, G.K. (1996) 'Mechanism of material removal in electrical discharge diamond grinding', International Journal of Machine Tool Manufacture, Vol. 36, No. 10, pp.1173–1185.

[5] Koshy, P., Jain, V.K. and Lal, G.K. (1997) 'Grinding of cemented carbide with electrical spark assistance', Journal of Materials Processing Technology, Vol. 72, No. 1, pp.61–68, doi: 10.1016/S0924-0136(97)00130-1. Unune, D.R. and

[6] Mali, H.S. (2016) 'A study of multiobjective parametric optimization of electric discharge diamond cut-off grinding of Inconel 718', Int. J. Abrasive Technology, Vol. 7, No. 3, pp.187–199.

[7] Kumar, S. and Choudhary, S.K. (2007) 'Prediction of wear and surface roughness in electro-discharge diamond grinding', Journal of Materials Processing Technology, Vol. 191, Nos. 1–3, pp.206–209, doi: 10.1016/j.jmatprotec.2007.03.032.

[8] Yadav, R.N., Yadava, V. and Singh, G.K. (2013) 'Multi-objective optimization of process parameters in electro-discharge diamond face grinding based on ANN-NSGA-II hybrid technique', Frontiers Mechanical

[9] Shyam Sunder Agrawal &Vinod Yadava (2013) Modeling and Prediction of Material Removal Rate and Surface Roughness in Surface-Electrical Discharge Diamond Grinding Process of Metal Matrix Composites, Materials and Manufacturing Processes, 28:4, 381-389, DOI: 10.1080/10426914.2013.763678.

[10] Deng, J.L. (1989) 'Introduction to Grey system', Journal of Grey System, Vol. 1, No. 1, pp.1–24.

[11] Konrad Wegener, Friedrich Bleicher, Peter Krajnik, Hans-Werner Hoffmeister, Christian Brecher,Recent developments in grinding machines,CIRPAnnals,Volume 66, Issue 2,2017,Pages 779-802,ISSN 0007-8506,https://doi.org/10.1016/j.cirp.2017.05.006.

[12] Peters J., Snoeys R., Decneut A. (1976) The Proper Selection of Grinding Conditions in Cylindrical Plunge Grinding. In: Koenigsberger F., Tobias S.A. (eds) Proceedings of the Sixteenth International Machine Tool Design and Research Conference. Palgrave, London. https://doi.org/10.1007/978-1-349-81544-9_53

[13] M. C. Shaw, A new theory of grinding, Int. Conf. Proc. Science in India, Monash University, Australia, pp.i-16 (1971).

[14] Xun Chen and W. Brian Rowe analysis and simulation of the grinding process. Part ii: mechanics of grinding Int. J. Mach. Tools Manufact. Vol. 36, No. 8, pp. 883-896, 1996, Elsevier Science lad Printed in Great Britain, 0890-6955/96515.00

[15] Kiyak, M., O. Cakir, and E. Altan. "A study on surface roughness in external cylindrical grinding." *12th International Scientific Conference Achievements in Mechanical & Materials Engineering*. 2003

[16] .Rodrigo Daun Monici, EC Bianchi, RE Catai "Analysis of the different forms of application and types of cutting fluid used in plunge cylindrical grinding using conventional and super abrasive CBN grinding wheels" International Journal of Machine Tools & Manufacture 46(2006) 122-131

[17] H. Saglam, F Unsacar, S Yaldiz "An experimental investigation as to the effect of cutting parameters on roundness error and surface roughness in cylindrical grinding" International Journal of Production research vol. 43, No.11,2005, 2309-2322

[18] Arsad Noor Siddique, Z.A. Khan, Z. Mallick “Grey relational analysis coupled with principal component analysis for optimization design of the process parameters in in-feed centerless cylindrical grinding” International journal advanced Manufacturing Technology DOI 10.1007/5001 70-009-2159-8.

[19] Mr. Kamlesh Pal and Vaibhav Shivhare "The Influence of Cutting Parameter of Surface Grinder on the Surface Finishing and Surface Hardness of Structural Steel" International Journal of Basic and Applied Science Research (IJBASR), Vol.1, No. 1, December 2014, pp. 11-14.

[20] Mr. Kamlesh Pal and Vaibhav Shivhare "The Influence of Cutting Parameter of Surface Grinder on the Surfa ceFinishing and Surface Hardness of Structural Steel" buternational Jounal of Basic and Applied Science Res earch(IJBASR), Vol.1, No. 1, December, 2014, pp. 11-14.

[21] Lijohn P George, K Varughese Job, I M Chandran - Study on Surface Roughness and its Prediction in Cylindrical Grinding Process based on Taguchi method of optimization - published at: "International Journal of Scientific and Research Publications (IJSRP), Volume 3, Issue 5, May 2013 Edition".

[22] A.Patel, R.J Bauer, A. Warkentin, Springer- International Journal of Advanced Manufacturing Technology, (2019) – Investigation of the effect of speed ratio on workpiece surface topography and grinding power in cylindrical plunge grinding using grooved and ungrooved grinding wheels.

[23] Ulas Caydas and Mehmut Celik – World Scientific Publishing Company, (2017) Genetic algorithm-based Optimization for surface roughness in cylindrical grinding process using helically grooved wheels.

[24] Choi, Taejun& Subrahmanya, N. & Li, H. & Shin, Yung. (2008). Generalized practical models of cylindrical plunge grinding processes. International Journal of Machine Tools & Manufacture - INT J MACH TOOL MANUF. 48. 61-72. 10.1016/j.ijmachtools.2007.07.010.

[25] Gadelmawla, E.S., Koura, M.M., Maksoud, T.M.A., Elewa, I.M. and Soliman, H.H., 2002. Roughness Parameters. *Elsevier*, 123, pp.133-145.

[26] Kato, K., Maeda, Y., & Tanaka, H. (2016). Grinding Technology of Cylindrical Surface with Protrusion. Advanced Materials Research, 1136, 54–59. https://doi.org/10.4028/www.scientific.net/amr.1136.54

[27] Sebastian Barth, Christian Wrobel, Markus Weiß, Patrick Mattfeld, Karl-Heinz Brakhage, Michael Rom,Modelling of the Grinding Wheel Structure Depending on the Volumetric Composition,ProcediaCIRP,Volume 46,2016,Pages 276-280,ISSN 2212-8271,https://doi.org/10.1016/j.procir.2016.04.066.

[28] G.F Lig, L.S Wang, and L.B Yang, Journal of Materials Processing Technology (ELSEVEIR), (2002) - Multi-parameter optimization and control of the cylindrical grinding process.

[29] F. Orynski, W. Pawlowski,The mathematical description of dynamics of the cylindrical grinder,International Journal of Machine Tools and Manufacture,Volume 42, Issue 7,2002,Pages 773-780,ISSN 0890-6955,https://doi.org/10.1016/S0890-6955(02)00020-2.

[30] Paolo Parenti, Marco Leonesio and Giacomo Bianchi (Mechatronics -Elsevier), (2016) - Model-based adaptive process control for surface finish improvement in traverse grinding.

[31] S, A Voronov and Ma Veidun (Journal of Machinery Manufacture and Reliability), (2016) - Mathematical modeling of the Cylindrical Grinding Process.

[32] W. Xu, Y. Wu, T. Sato, and W. Lin (Journal of Materials Processing Technology), (2010) -Effects of process parameters on workpiece roundness in tangential-feed centerless grinding using a surface grinder.

[33] Noor Zaman Khan, Zahid A. Khan, Arshad Noor Siddiquee&Arindam K. Chanda (2014) Investigations on the effect of wire EDM process parameters on surface integrity of HSLA: a multi-performance characteristics optimization, Production & Manufacturing Research, 2:1, 501-518, DOI: 10.1080/21693277.2014.931261