Journal of Material Science and Mechanical Engineering (JMSME)
p-ISSN: 2393-9095; e-ISSN: 2393-9109; Volume 3, Issue 2; January-March, 2016 pp. 117-120

http://www.krishisanskriti.org/Publication.html

An Analysis of Various Machining Process on Composite Materials-A Review

Krishna Murari Pandey[1] and Mriganav Debnath[2]

[1]Department of Mechanical Engineering National Institute of Technology, Silchar
[2]NIT Silchar
E-mail: [1]kmpandey2001@yahoo.com, [2]mriganav228@gmail.com

Abstract—*Composite materials are attaining worldwide popularity for manufacturing, aerospace and automobile industries due to their high ultimate tensile strength, flexural modulus, temperature resistance and good structural stability. This paper focuses on analysis of various machining processes of composite materials. The main objective of this study is to analyse how various machining parameters during machining of various composite materials affect the overall response parameters. Overall, this study emphasizes on finding a proper balance in between productivity and quality of the output product of a composite material while machining with conventional and non conventional machining processes.*

Keywords*: Composite materials, machining parameters, conventional and non conventional machining process*

1. INTRODUCTION

Composite materials are very hard to machine due to their structural non homogeneity and anisotropic nature. Due to various difficulties during machining, the conventional machining processes like drilling, turning or milling can only be used provided proper design of tool and operating conditions are adopted. Non conventional machining processes such as electrical discharge machining (EDM), Wire electrical discharge machining (WEDM) can be effectively used for machining composites which are conducting in nature [1]. However, selection of proper machining parameters is an important criterion while machining in EDM and also the expertise of the operator [2]. This paper focuses on a comparative study for various composites with conventional and non conventional machining processes.

2. LITERATURE REVIEW

2.1. Non Conventional Machining

Lajis et al.[3] studied on Tungsten carbide ceramic material in electrical discharge machining for analysing various input parameters such as pulse duration, peak current, voltage , interval time for output responses such as material removal rate, surface roughness and tool wear rate and to determine the optimal set of parameters. During analysis, it was found that pulse duration had significant effect on material removal rate and peak current was the most effective parameter for surface roughness and tool wear rate. **Lin et al.[4]** analysed on electrical discharge machining for multiple response output using Grey based fuzzy logic. Pulse on time, discharge current and duty factor were the input parameters and surface roughness, material removal rate and electrode wear ratio were the multiple responses considered for study. The Grey based fuzzy logic approach was utilised for optimizing the electrical discharge machining process and to obtain the optimal set of machining parameters.

Muthu Kumar et al.[5] investigated on Wire electrical discharge machining for Incoloy 800 super alloy for multiple response characteristics such as Material removal rate (MRR), Surface roughness and Kerf width and optimized using Grey-Taguchi method.**Huang and Liao [2]** used grey relational analysis for obtaining optimum set of machining parameters for wire electrical discharge machining process. During analysis it was found out that grey relational approach improve the overall response output with optimal set of machining parameters.

M.Kiyak and O.Cakir[6] studied on the influence of various machining parameters on EDM for tool steel. During analysis it was found out that pulse current and pulse time were the most significant parameters for surface roughness and pulse off time was found to be less significant. **Manna A. and Bhattacharya [7] ,** did experimental studies on Al/SiC-MMC with different cutting parameters for CNC-WEDM. They found out that percentage volume fraction fraction and size played an important role on the composites machinability.During experimentation they found out that volume fraction and average size of particles highly influence the surface finish and tool wear. **C. Wang et al. [8]** carried out study on the effect of various machining parameters such as electrode polarity, gap voltage, electrode material, pulse on time, pulse off time. During analysis it was found out that pulse on time was the most significant parameter for surface roughness and tool wear rate.

K.Liu et al. [9] investigated on the various machining parameters pulse-off time, pulse on time, gap voltage , polarity and their effect on various response parameters such as tool wear rate, material removal rate and surface roughness. During analysis, it was found out that with increasing current, gap voltage and pulse on time surface roughness increased but inversely proportional to pulse off time. Moreover, it was found out that material removal rate (MRR) and tool wear rate increased with increase in current.

H.Lee et al. [10] analysed the effect of various process parameters such as pulse on time, duty cycle, polarity, pulse current on various response parameters such as tool wear rate, material removal rate, surface roughness during electrical discharge machining. In this study, it was found out that surface roughness was low at low current while material removal rate increased with increase in pulse duration and current. **S.L.Chen et al. [11]** carried out electrical discharge machining in SUS 304 and found out that material removal rate increased with increase in pulse duration and current. However, tool wear rate increased upto a certain extent of pulse duration and then started decreasing. **P.Cicchosz et al. [26]** analysed the results obtained from electrical discharge machining for Aluminium metal matrix composites with particular importance was given to defected layer thickness obtained after machining. Significance of various machining parameters was presented for matrix material and saffil fibres in the affected zone. For analysing surface finish roughness measurement and scanning micrographs were used. Results showed that due to low current thin layer along with recast structure of increased hardness was formed. **Adrian losub et al. [27]** conducted experiment on Al/SiC metal matrix composite on electrical discharge machining to find out the influence of machining parameters material removal rate, surface quality and electrode wear rate. The reinforcement used in the composite was 3.5 % graphite and 7% SiC. The results showed that for material removal rate current intensity played an important role. With increase in current intensity material removal rate increased while good surface quality was seen under controlled machining parameters. For electrode wear rate, current was found to be the most significant parameter followed by pulse on time.

2.2. Conventional Machining

C.A. Brown et al. [12] carried out experiments on Aluminium Silicon alloy graphite composites and found out that machined surfaces were rougher compared to machined surface of the matrix material without reinforcement. **S.Kanan et al. [13]** found out accelerated tool wear on the cutting tools during the machining of aluminium metal matrix composites. **N.P.Hung et al. [14],**during his research work of machining Al/SiCp composite materials with various cutting tool materials found out that roughing done with uncoated tungsten carbide material and then finishing done with PCD inserts gave good output. **N. Muthukrishnan et al. [15]**, in his research work found out during machining of Al-SiC metal matix composites with PCD inserts, as cutting speed was increased then surface roughness reduced.

M.Gallab et al. [16] during his research work found out that PCD tools work better than that of coated carbide tools while machining composite materials. **Looney et al. [17]** in his study found out that while machining Aluminium SiC particulate composites , cubic boron nitride worked best while with silicon nitrite was not successful.

Koplev et al. [18] carried out research work on fibre reinforced composites and its machining behaviour. Orthogonal machining was performed on CFRP composites and analysed the surface quality, chip formation and cutting forces in two fibre orientation such as parallel and perpendicular direction with relative to cutting direction. Chip formation mechanism showed series of fractures in the fibres and rougher surfaces was observed in fibre orientation 90° as compared to 0° orientation. **Koenig et al. [19]** carried out various machining operations such as turning, drilling, routing, water jet cutting and milling on FRP based composite materials and studied the damage phenomena in details occurred during machining. **Takeyama et al. [20]** experimented on machining GFRP composites and studied the chip formation while machining. It was observed that quality of chip formation greatly dependent on fibre orientation in reference to the cutting direction.

Kim et al. [21] carried out experiment on orthogonal tool wear test on CRFP composite specimen. In his study, he found out that cutting speed and fibre orientation angle played important role to the flank wear. Moreover it was found out that fibre orientation and feed played more important role to the surface roughness as compared to cutting speed. **Karnik et al. [22]** had done investigation on various parameters of drilling during delamination of FRP and found out that higher speed could reduce the delamination because of higher cutting temperature. **Santhakrishnan [23],** during his study found out that machined surface of CFRP composites is much better than that of KFRP composite materials. In this study, he also analysed the mechanism of tool wear rate (TWR), material removal rate (MRR) and cutting forces while machining the composites. **Ramulu and Wern [24]** studied on the influence fibre orientation for fibre pull out and cutting forces for glass fibre reinforced polymer composites.They found out that tool with positive rake angle caused least damage on the machined composite. Tests were conducted in counterclockwise for 45^0,90^0 and 135^0 from cutting direction. **Nayak and Bhatnagar [25]** during their study found out that with increase in fibre orientation caused increase in cutting forces and sub surface damage while rake angle had least effect on the cutting force and surface damage. Fibre orientation, machining parameters and tool geometry are the important parameters for tool wear, surface quality and cutting forces.

3. CONCLUSION

Composite materials are now used in all kinds of applications such as bridges, buildings, sophisticated cars, bikes, sensors, robotic materials and more advanced applications like aircrafts and spacecrafts. However, in modern manufacturing industries success greatly depends on quality and productivity which are inversely proportional to each other. In order to find a proper balance in between productivity and quality, detailed study of the behaviour and mechanical properties of the composites along with the study of the effect of various process parameters while processing and machining is required, so that these materials can be used more efficiently and effectively for the welfare of human beings.

Abbreviations

EDM-Electrical discharge machining

WEDM- Wire electrical discharge machining

GFRP-Glass fibre reinforced polymer

FRP-Fibre reinforced polymer

PCD-Polycrystalline diamond

MRR-Material removal rate

SR-Surface roughness

TWR-Tool wear rate

REFERENCES

[1] W.S.Lau, T.M. Yue , T.C.Lee, W.B. Lee, Un-conventional machining of composite machining, J. Mater. *Process. Technol. 48 (1995) 199–205.*

[2] J.T.Huang, Y.S.Liao, Optimization of machining parameters of wire-EDM based on grey relational and statistical analysis, *Int. J. Prodn. Res. 41 (8) (2003) 1707–1720.*

[3] M.A.Lajis, Radzi H.C.D. Mohd. , Amin A.K.M. Nurul (2009) ,The implementation of Taguchi method on EDM process of Tungsten Carbide, European Journal of Scientific Research, Vol. 26, No. 4, pp. 609-617.

[4] J.L.Lin ,C.L.Lin (2005) The use of grey-fuzzy logic for the optimization of the manufacturing process, *Journal of Materials Processing Technology*, Vol. 160, pp. 9–14.

[5]V.Muthu Kumar, A.Suresh Babu, Venkatasamy R and Raajenthiren Md (2010) ,Optimization of the WEDM parameters on machining Incoloy800 super alloy with multiple quality characteristics, *International Journal of Engineering Science and Technology*, Vol. 2, No. 6, pp. 1538-1547.

[6] M.Kiyak , O.Cakir , Examination of machining parameters on surface roughness in EDM of tool steel., *Journal of material processing technology Vol, 191, (2007), pp. 141-144.*

[7] A.Manna and B. Bhattacharyya , .A study on machinability of AlSiC-MMC., *Journal of material processing technology Vol. 140, (2003) pp. 711-716.*

[8] Che Chung Wang and Biing Hwa Yan., Cutting austempered ductile iron using an EDM sinker., *Journal ofmaterial processing technology vol, 88, (1999) , pp. 83-89.*

[9]S. Clijsters and K.Liu., EDM technology and strategy development for the manufacturing of complex parts in SiSiC., *Journal of material processing technology Vol, 210, (2010), pp. 631-641.*

[10] Yan-Cherng Lin and Ho-Shiun Lee., Machining characteristics of magnetic force assisted EDM., *International journal of machine tools and manufacturer Vol, 48, (2008), pp.1179-1186.*

[11] S.L.Chen, M.H.Lin, S.F.Hsieh ,S.Y. Chiou ; .The characteristics of cutting pipe mechanism with multi-electrode in EDM., *Journal of material processing technology Vol, 203, (2008), pp. 461-464.*

[12]C.A.Brown, M.K.Surappa , The machinability of a cast aluminium alloy-Graphite Particle Composite, *Material Science and Engineering, A102 (1988), pp31-37.*

[13] S.Kannan, H.A. Kishawy, 2008, Tribological aspects of machining aluminum metal matrix composites, *Journal of material processing technology, 198, 399-406.*

[14]N.P Hung , Z. Zhong , 2000, Diamond turning and grinding of Aluminium based metal matrix, *Materials and manufacturing Processes, Volume 15,Issue 6.*

[15]N. Muthukrisnan, J.P. Davim , An investigation of the effect of work piece reinforcing percentage on the machinability of Al-SiC metal matrix composites, *Journal of Mechanical Engineering Research Vol. 3.(1), pp. 15-24, January 2011*

[16] M.*El-Gallab., M.Sklad , Machining of Al/SiC particulate metal matrix composites. Part II: Work piece surface integrity. Journal of Material Process Tech 83(1–3), (1998), 277–285.*

[17] L.A.Looney , J.M.Monaghan ,D.M.R.Taplin ,1992, The turning of Al/SiC metal matrix composites, *Journal of material processing technology,33,453-468.*

[18] A. Koplev, A. Lystrup, T. Vorm, The cutting process, chips, and cutting forces in machining CFRP, *Composites 14 (4) (1983) 371–376.*

[19]W.Koenig,Ch.Wulf,P.Grab,H.Willerscheid,Machining of fiber reinforced plastics, *CIRP Annals 34(2)(1985)537–547.*

[20] H. Takeyama, N. Iijima, Machinability of glass fiber reinforced plastics and application of ultrasonic machining, *Annals of CIRP 37 (1988) 93–96.*

[21] K.S. Kim, D.G. Lee, Y.K. Kwak, S. Namgung, Machinability of carbon fiber– epoxy composite materials in turning, *Journal of Materials Processing Technology 32 (1992) 553–570.*

[22]S.R.Karnik,V.N.Gaitonde,J.C.Rubio,A.E.Correia,A.M.Abr~ao,J. P.Davim,Delaminatin analysis in high-speed drilling of carbon fiber reinforced Plastics(CFRP)using artificial neural network model,*Materials and Design 29 (2008)1768–1776.*

[23] G. Santhakrishnan, R. Krishnamurthy , Malhotra S.K., Investigation into the machining of carbon-fibre-reinforced plastics with cemented carbides, *Journal of material processing technology,Volume 30,Issue3, April 1992*

[24] C.W. Wern, M. Ramulu, Machining mechanics in fiber reinforced plastics, ASME, *Applied Mechanics Division, AMD 208 (1995) 1–28.*

[25] D. Nayak, N. Bhatnagar, Machining studies of uni-directional glass fiber plastic (UD-GFRP) composites part 1: effect of geometrical and process parameters, *Machining Science and Technology 9 (2005) 481–501.*

[26] P. cichosz, P. karolczak, Sinker electric discharge machining of aluminium matrix composites, *Materials Science- Poland, , Volume 26, Issue3, pp.2172-2192, 2008.*

[27] Adrian Iosub, Eugen Axinte, Florin Negoescu, A study about micro drilling by electrical discharge method of an Al/ SiC composite, *International journal of academic research ,Volume 2, Issue 3., 2010.*

[28] D. Satishkumar & M. Kanthababu & V. Vajjiravelu &R. Anburaj & N. Thirumalai Sundarrajan & H.Arul, Investigation of wire electrical discharge

machining characteristics of Al 6063/ SiC composite, *International Journal of Advanced Manufacturing Technology, Volume 56, pp. 975-986,2011*

[29] Rabindra Behera, Nihar Ranjan Mohanta,G.Sutradhar , Distribution of SiC particulates in stir cast Aluminium alloy Metal matrix composites and its effect on mechanical properties, *Inter. Journal of emerging trends in engg. and development, vol. 1 ,pp. 194-205, 2012.*

[30]A.R.Hyde,Ceramic matrix composites, *Materials and Design 11 (1) (1990) 30–36.*