Experimental Investigation on The Effect of Boron Carbide In PMEDM of Ti-6Al-4v

S.Rajamanickam[1], A.Abdulasif[2], K.J.Ashwinrajan[3], S.JoethomNickalson[4]
[1, 2, 3, 4] Assistant Professor
[1, 2, 3, 4] Vel Tech High Tech Dr. RangarajanDr.SakuntalaEngg. College, Chennai,
Tamilnadu, 60002, India,

Abstract- *The present project work aims to optimize machining parameters by mixing B4C additives in different dielectric fluids on EDM of Ti-6Al-4V using a copper tube as electrodes. EDM oil and pungai oil are considered dielectric fluids. B4C mixed in dielectric fluids enhance the discharge energy and sparking phenomenon. Three controlling parameters were selected such as dielectric type, abrasive concentrations, and gap voltage, and changed to explore their performances on Material Removal Rate (MRR) and Tool Wear Rate (TWR). In this investigation, Taguchi L18 Orthogonal Array (OA) was utilized to execute a minimum number of experiments. It was observed from the experimental results that the additives in dielectric fluids augmented the MRR and reduced the TWR. Analysis of Variance (ANOVA) test has revealed that dielectric fluid type, is an important machining parameter affecting MRR; abrasive concentrations were highly relevant process parameter influencing TWR. An empirical expression for MRR and TWR was constructed by using Minitab 18 statistical software. Moreover, surface analysis was conducted at optimized PMEDM conditions by using Scanning Electron Microscope (SEM) photographs.*

I. INTRODUCTION

Ti–6Al–4V alloy with excellent metallurgical, physical, and mechanical properties such as high strength-to-weight ratio, high-temperature stability, and good corrosion resistance compared with other titanium alloys, is the most important and most applicable titanium alloy in different industries such as aerospace, automobile, chemical, biomedical applications and in many corrosive environments. Titanium alloys such as Ti–6Al–4V, because of their low toughness and low thermal conductivity and chemical reactivity with most materials of cutting tools, are classified as difficult-to-cut materials, so traditional machining of Ti–6Al–4V, economically is not so beneficial as the result of higher cutting tool costs. Therefore, electrical discharge machining (EDM) was used to machine Ti–6Al–4V. To overcome the limitations in EDM, powder mixed EDM (PMEDM) has been developed in which suitable abrasives have been mixed with the dielectric to make the machining process efficient**.** Machining is a process in which a material (often metal) is cut into a desired final shape and size by a controlled material removal process. Machining also refers to the process of cutting a piece of raw material into different shapes and sizes to come up with the final product. During the method of manufacture, controlled material addition is completed by the utilization of hand tools and power tools. Modern machining is also carried out by the use of computers. The machining process is classified into two types Conventional and Non-Conventional Machining Processes. The conventional machining process involves the direct contact of tool and work piece, whereas Non-conventional machining does not require the direct contact of tool and work piece. The conventional machining process has lower accuracy and surface finish while non-conventional machining has higher accuracy and surface finish. Powder Mixed EDM (PMEDM) is an advanced EDM technology in which fine abrasive electricity conductive powder is added to the dielectric. Suspended metallic powders in electricity decrease its insulating strength and consequently, increases the inner-electrode gap conditions which improve EDM Performance and deliver a superior surface finish compared to conventional EDM. The working principle of the PMEDM process states that upon application of appropriate voltage an Electric field is generated which gives rise to the positive and negative charge on the powdered particles which causes the spark gap between the electrode.

II. EXPERIMENTAL DETAIL

Electrical discharge machining (EDM), also mentioned as spark machining, spark eroding, die sinking, wire burning or wire erosion, could also be a metal fabrication process whereby a desired shape is obtained by using electrical discharges (sparks). The process depends upon the tool and work piece not making physical contact. All experiments were conducted on a die sinking EDM machining setup (make: Electronica, India; model: EDM-550×300 ZNC).

The recirculation system consists of a working tank of 10 liters, a work holding fixture, a dielectric reservoir(bucket), 0.5 HP pump and delivery pipes. A pressure gauge was also attached to the system to measure the dielectric pressure during experimentation. The pump receives the dielectric fluid from the outlet of the tank and recirculates it to the tool-work inter electrode gap to flush out the debris. The continuous circulation of the dielectric fluid avoids the settlement of powder particles in the flushing system. In the current investigation, side jet flushing was selected to flush out the debris.

III. SELECTION OF MATERIALS

(a)WORKPIECE AND TOOL:

The presence of aluminium prevents corrosion whereas Vanadium Possesses good corrosion resistance to alkalis, sulphuric acid, hydrochloric acid and salt water. The high percentage of Titanium increases its strength properties. However, the same properties pose a great challenge during conventional machining processes. Since Ti-6Al-4V is conductive in nature, it is suitable for electric discharge machining. However, EDM characteristics of the same alloy have hardly been reported so far. Hence, Ti-6Al-4V was chosen as the work piece material in the form of thin plates with dimensions of 1.5cm x 1.5 cm x 0.5 mm. The properties of Ti-6Al-4V An electrolytic copper tool with a diameter of 0.7 mm and length of 40 cm has been used to perform the experiments**.**

(b)POWDER MATERIAL:

Boron Carbide (B4C) is chosen as the abrasive material. The average particle size of the powder claimed by the manufacturer (Nice-Micro fine chemicals), is ~10 µm. The thermophysical characteristics of B4C is shown in (Table 1) were used as additives in EDM oil – Pungai dielectric

Table (1)Properties of powder materials

Property	Boron Carbide (B4C)
Density (mg/mm)	2.55
Electrical resistivity (Ω.m)	1e+008
Thermal conductivity (W/m-K)	17-42
Heat of fusion (kJ/kg)	2030
Specific heat (J/kg-K)	842-1288
Melting temperature (K)	2780

(c)**PROCESS PARAMETERS:**

The process parameters are often divided into two categories i.e. electrical and non-electrical parameters. Major electrical parameters are discharge voltage, peak current, pulse duration and pulse interval, electrode gap, polarity, and pulse waveform. Non- electrical parameters include mostly flushing pressure, electrode rotation, workpiece rotation etc.The input parameters are chosen are peak current (Ip), powder concentration (Cp), Dielectric fluid concentration, duty cycle (τ), and gap voltage (Vg). Choice of parameters was influenced by the fact that these parameters have a significant impact on various EDM and PMEDM characteristics as evident from Chapter 2. Lateral flushing with a pressure of 0.5 kg/cm2 and positive polarity (workpiece +ve) was used for all the experiments. The output parameters that will be observed are Material Removal Rate (MRR), Tool Wear Rate (TWR)

(d)**DESIGN OF EXPERIMENT:**

The procedure genereatethe foremost popular set of Taguchi designs. Taguchi uses the subsequent convention for naming the orthogonal arrays. Taguchi experimental designs, often called orthogonal arrays (OA's), contains a group of fractional factorial designs which ignore interaction and consider main effect estimation.

(e)**ABRASIVE(BoronCarbidePowder):**

In Boron Carbide abrasive which is mixed with the dielectrics used in the process and to improve MRR and TWR.

(f)**COPPER ELECTRODE :**

In Copper Electrode tool during the machining of work piece. The diameter of copper electrodes is 0.7mm with which hole will be made in work piece.

TITANIUM WORKPIECE (Ti-6Al-4V):

This is the work piece on which the machining (Hole making) process will be done and analyzed with SEM analysis. The dimension of the work piece is 1.5cm×1.5cm ×0.5mm.

POWDER MIXED EDM:

The working rule of the PMEDM process states that upon application of appropriate voltagean electric field is generated which provides rise to positive and negative charges on the powdered particles. These energized powder particles get accelerated and start moving in a zigzag manner which leads to improving the spark gap between electrodes.

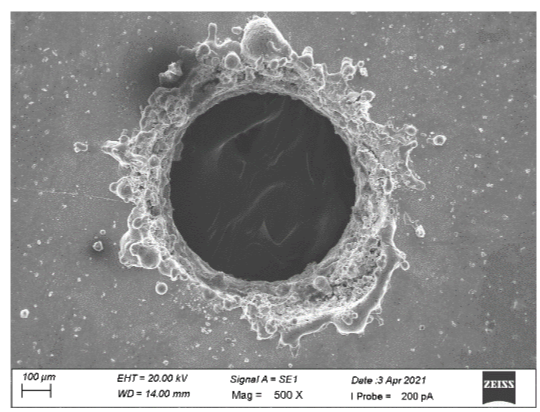
IV. RESULT AND DISCUSSIONS

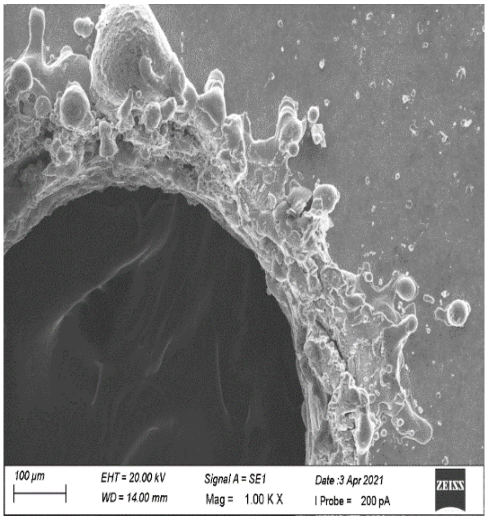
Experimentation has been successfully completed under L18 Taguchi design of experiments. After that, MRR and SR of the machined specimen were measured and calculated. The results of MRR and SR obtained under the action of each electrode is presented in Table 4.1. It is noticed that copper tool provides the comparatively higher MRR (8.32 mm3 /min) as compared to other electrodes. High melting temperature of Copper electrode is the primary reason for high value of MRR. In EDM, material erosion happened by thermal energy produced thanks to the electrical sparking between electrode and surface . Higher the worth of thermal energy produced, the upper are going to be MRR. Discharge current is presumed to be the most think about governing the quantity of thermal energy duringEDM.The erosion of material is not specifically from the workpiece material.If the melting temperature of the tool is relatively low,then it will be eroded more readily instead of the target material and subsequently MRR is reduced. Since the melting temperature of copper electrode is (1085℃) lower the selected tool material,the tool erosion rate of graphite is maximum.On the other hand,he melting temperature of the work surface is in the range of 1800-1878℃ which is higher of the melting temperature of copper.Hence,the wear rate of copper electrode is more than the work piece surface. Consequently, the work piece surface gets harshly machined relative to the tool surface and result into comparatively higher MRR.

SEM ANALYSIS:

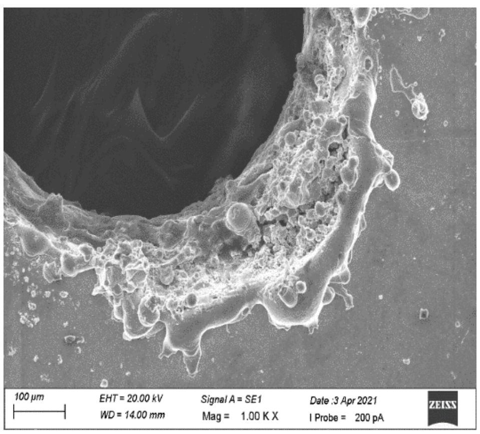
Scanning microscopy or Sem Analysis provides high resolution imaging useful for evaluating various material for surface fractures,flaws,corrosions through sem analysis.

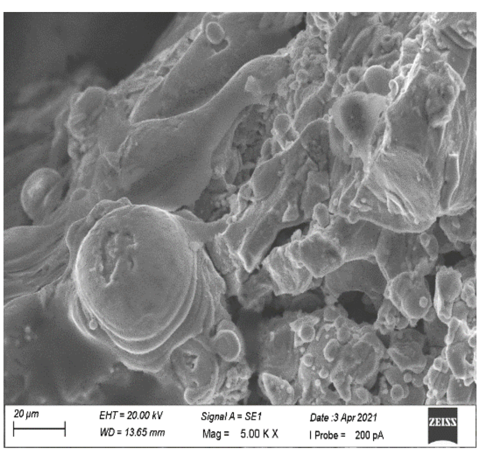
(a)**MRR TEST IN EDM OIL:**





(b)**MRR TEST IN PUNGAI OIL:**





V. CONCLUSION

Machinability of titanium alloy (Ti-6Al-4V) through EDM has been investigated so as to make a decision the foremost appropriate tool material for better machining performance which is that the novelty of this research. The impacts of copper electrodes on machining performance are evaluated to identify the most appropriate tool electrode(s) offering high MRR and good surface finish.

- Current is the most influential parameter which significantly affects MRR.
- Copper tube tool produced the best results compared to brass tube tool.

VI. FUTURE SCOPE

- Effect of Nanosized powder mixed dielectric need to be investigated as the smallest sized powder will have better suspension.
- Very less amount of literature is available for the application of EDM and PMEDM in biomedical implant machining.

REFERENCES

[1] Mr. Mohd. YunusKhan ,Mr.P. Sudhakar Rao, Mr.B.S. Pabla on “Powder mixed electrical discharge machining (PM-EDM): A methodological review” October 2020.

[2] Mr.S. Rajamanickam and Mr. J. Prasanna on “Effect of Conductive, Semi-conductive and Non-conductive Powder-Mixed Media on Micro Electric Discharge Machining Performance of Ti-6Al-4V” 2020.

[3] Nitesh Kumar, NiladriMandal& A. K. Das on “Micro-machining through electrochemical discharge processes: a review” 2020.

[4] Quang Dung Le, Huu Phan Nguyen, Tien Long Banh and Duc Toan Nguyen on “Comparative study of low-frequency vibrations assigned to a work piece in EDM and PMEDM” 2020.

[5] Van Tao Le, Van Thao Le, Tien Long Banh, Xuan Thai Tran and Thi Hong Minh Nguyen on “Studying the micro hardness on the surface of SKD61 in PMEDM using tungsten carbide powder” 2020.

[6] Mr. A. P. Tiwary, Mr. B. B. Pradhan & Mr. B. Bhattacharyya on “Influence of various metal powder mixed dielectric on micro-EDM characteristics of Ti-6Al-4V” 2019.

[7] Ayanesh Y. Joshi, Anand Y. Joshi on “A systematic review on powder mixed electrical discharge machining” 2019.

[8] Mr.M. Jawahar, Mr.Ch. Sridhar Reddy, Mr. Ch. Srinivas on “A review of performance optimization and current research in PMEDM” August 2019.

[9] Mr.B.V. Dharmendra, Mr. Shyam Prasad Kodali, Mr. B. Nageswara Rao on “A simple and reliable Taguchi approach for multi-objective optimization to identify optimal process parameters in Nano-powder-mixed

electrical discharge machining of INCONEL800 with copper electrode" 2019.

[10] LalitYadav, SachinLal, Nishant Kumar Singh, D.S. Chouhan, Yashvir Singh on "Impact of powder additives in liquid and gaseous dielectric fluids on electrical discharge machining through aerospace region Applications-review" 2019.

[11] MunmunBhaumik&KalipadaMaity on "Effect of deep cryo-treated tungsten carbide electrode and SiC powder on EDM performance of AISI 304"2018.

[12] Mr. VineetDubey, Mr. Balbir Singh on "Study of Material Removal Rate in Powder Mixed EDM of AA7075/B4C Composite" 2018.

[13] AsmaPerveen, M.P. Jahan, SyrymbetZhumagulov on **"Statistical** Modeling and Optimization of Micro Electro Discharge Machining of Ti Alloy"2018.

[14] Wujun Feng, Xuyang Chu, Yongqiang Hong & Li Zhang on "Studies on the surface of high-performance alloys machined by micro-EDM" 2017.

[15] Mr. Chander Prakash, Mr. K. Kansal, Mr. B. S. Pabla& Mr. SanjeevPuri on "Experimental Investigations in Powder Mixed Electric Discharge Machining of Ti-35Nb-7Ta-5Zr β-Titanium Alloy"2016.

[16] L. Li, L. Zhao, Z. Y. Li, L. Feng & X. Bai on "Surface Characteristics of Ti-6Al-4V by SiC Abrasive Mixed EDM with Magnetic Stirring" 2016.

[17] Afzaal Ahmed on "Deposition and Analysis of Composite Coating on Aluminum Using Ti-B4C Powder Metallurgy Tools in EDM" 2015.

[18] Mr. MurahariKolli and Mr. A Kumar on "Effect of Boron Carbide Powder Mixed into Dielectric Fluid on Electrical Discharge Machining of Titanium Alloy" 2014.

[19] S.L. Chen, M.H. Lin, G.X. Huang, C.C. Wang on "Development of metal based biomedical implant" 2014.

[20] Mr.P.C. Tan, Mr.S.H. Yeo on "Simulation by considering multiple crater phenomenon in PMEDM" 2014.

[21] Dr Rajiv Kumar Garg, DrKuldeepOjha on "Parametric Optimization of PMEDM Process with Chromium Powder Suspended Dielectric for Triangular Electrodes"2014.