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Performance analysis of process parameters on machining of Inconel 718 using electrical discharge machining with brass electrode

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ABSTRACT

Electrical Discharge machining is an Unconventional machining technique, which is utilized to produce components with complex profiles that are difficult to be generated using conventional manufacturing techniques. Moreover, materials wish are difficult-to-machine in conventional process that can be done in the EDM Non-conventional machining process such as electric discharge machining (EDM) are being widely used to machine hard tool and die materials used in industries. Inconel 718 is one of the metals that have poor machining in the conventional process. In this present work, different bottom shape electrodes to be used in EDM and the effectiveness of the machining process has been measured. Brass rods with Flat, Convex ends have been used as electrode and Inconel 718 has been used as work piece. The electrodes of different bottom shape during machining i.e. the conduct between the work piece and the electrode varies. From the experimental results, it is observed that the machining time has been reduced and better quality surface produced.

KEYWORDS: EDM, Inconel 718, brass electrode.

1. INTRODUCTION

In the field of nuclear and aerospace application of INCONEL 718 is vast because of his light weight and high strength in high temperature because of the predicate hardening. The main objective of this study is on machining Inconel 718 with brass tool electrodes having different bottom shape like Flat and Convex ends using the EDM process is to study and analyze the effects of different bottom shape tool electrodes on response in the thermal erosion process. Recent days more research is concentrated on improving the machinability of INCONEL 718. The spark erosion process or electrical discharge machining (EDM) is a relatively modern machining process having distinct advantages over other machining processes and so its use is getting more and more widespread. The review of EDM and its use on advanced aerospace alloys including work piece integrity constraints, data are presented after machining Ti–6Al–4V and Inconel 718. Roughing and finishing strategies were employed on two high specification machines with pulse generators designed to provide minimum work piece integrity damage. A pulsating D.C power supply or EDM generator applies voltage pulses between the electrode and work piece generating sparks or current condition through the gap. The effects of cutting speed on tool wear and tool life when machining Inconel 718 nickel-based super alloy have been experimentally investigated. Minimum flank wear is seen with SNGN tools at low cutting speeds while it is seen with RNGN tools at high cutting speeds. Ming Zhou made adaptive system that improves the machining rate by, approximately, 100% and in the meantime achieves a more robust and stable machining than the normal machining without adaptive control.

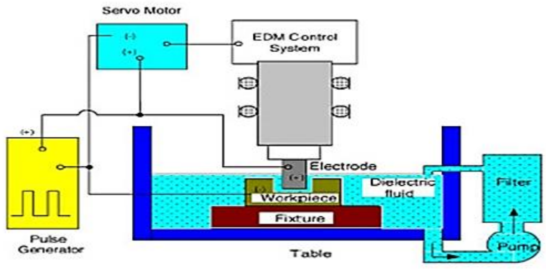

Figure.1.Schematic Diagram of EDM process

Ming Zhou et.al makes clear that variations of EDM process represented by gap states can be predicted online with a high precision. W.M. Wang, found that, highest the MRR is for round electrodes, followed by square, triangular and diamond shaped electrodes. The surface and subsurface damages and have also assessed and characterized using scanning electron microscopy (SEM). The results provide valuable insight into the dependence of damage and the mechanisms of material removal on EDM conditions. P. Narender Singh, presents Scanning electron microscopy is employed to analyse the machined surface, and the concept of a Crack Critical Line (CCL) is introduced to explore the influence of electrode size, EDM parameters and material thermal conductivity on surface cracking.

C.Y. Nian, revealed system features, that are critical for EDM machining and makes suggestions to the designer to alter the features by keeping the overall functionality of the product. Therefore, in this present work an investigation on the influence of process parameters such as Peak Current (Amps), Pulse on Time (µs) and Pulse off Time (µs) on the responses viz. Machining time, Electrode wear rate, Material removal rate using Taguchi method.

The different bottom shape tool electrodes to be used in EDM and the effectiveness of the machining process have been measured. Brass rods with Flat, Convex ends have been used as electrode and INCONEL 718 has been used as work piece. In this study, the substance of different bottom shape tool electrode in EDM process has been discussed and analyzed.

2. EXPERIMENTAL DETAILS

Selection of Work piece: INCONEL 718 is a precipitation hardenable nickel-chromium alloy. It contains substantial levels of iron, molybdenum, and niobium as well as trace amounts of titanium and aluminium with a high level of strength and flexibility. It Nickel-base super alloy Inconel 718 is a high-strength and thermal-resistant material. It is also noted for its excellent corrosion resistance. It has a wide application, some of them are in nuclear reactors, spacecraft, and rocket motors. However, it does have more common applications, as well. It can be very effective in tooling and gas turbines. The work material is INCONEL718 in the form of a circular disc with a thickness of 3mm. Chemical composition of work material is measured using a BRUKER S1 TURBOALLOYING ANALYSER. It is a portable composition measuring device in which a peltier cooled high-performance Si-pi N X-ray detector projects. X-rays on work piece and its composition were obtained in duration of about 3-5 seconds. The INCONEL 718 disc and Convex electrodes of R4, R6 and R8 as shown below in figure 2.

Figure.2.INCONEL 718 disc and Convex electrodes of R4, R6 and R8

Selection of Tool Electrode: Electrodes for Electric discharge machine, being used are prepared from brass rods of 8mm diameter. For achieving precision of dimensions of the electrode, it was done in CNC lathe machine. Three different types of electrodes were formed. The convex electrodes were made of different radius of curvature as 4mm, 6mm and 8mm.

Selection of Di-Electric Medium: In this present work, Kerosene has been chosen as its dielectric fluid, controlling its resistivity and other electrical properties with filters and de-ionizer units. Flushing is an important factor in determining the maximum feed rate for a given material thickness. The essential requirements of dielectric fluid are should remain electrically non-conductive until the required breakdown voltage is reached. Kerosene was used as dielectric fluid with pressure of 0.2kg/cm2, side flushing technique was used to conduct all experiments.

Selection of Input Process Parameters: Basically, machining time, material removal rate, Electrode wear rate are strongly correlated with machining parameters such as Peak Current, Pulse ON Time and Pulse OFF Time. Proper selection of the process parameters can obtain a nominal machining time, higher material removal rate, lower electrode wear rate. In this present study, to select the most influence parameters such as Peak Current, Pulse ON Time and Pulse OFF Time.

Selection of Process Variables: The essential steps include identification of factors that are to be included in the study and for determining the factor levels. It was decided to study the effect of the parameters viz., Peak Current (Amps), Pulse on Time (µs) and Pulse off Time (µs) on the responses viz. Machining time, Electrode wear rate, Material removal rate. The Table 2 shows three levels and three parameters list.

Table.1.Chemical composition of the work piece

Element	Sn	Mo	Nb	Zn	Ni	Co	Fe	Cr	Sb	Ti	Al
Weight%	0.030	3.06	5.69	0.050	53.23	0.071	19.78	17.02	0.022	1.18	0.41

Table.2.Optimal parameters used for experimentation

Machining Parameter	**Unit**	**Level 1**	**Level 2**	**Level 3**
Peak Current	Amps	4	8	12
Pulse ON Time	µs	200	400	600
Pulse OFF Time	µs	10	20	40

3. EXPERIMENTAL AND METHODS

The experiment is carried out by taking optimal parameter values, which were obtained by conducted experiments on INCONEL 718 as work piece using brass as electrode by using *L1*8 orthogonal array. The EDM experiments were conducted in SPARKONIX – Electric Discharge machine, having a maximum of 15 Amps current. The schematic Diagram of the process is shown in Figure 1. The result of experiment of L18 orthogonal array is shown.

4. RESULT AND DISCUSIONS

Common methods of evaluating machining performance in an EDM process are based on the performance characteristics like machining time, material removal rate, and Electrode wear rate. Hence, the optimized values of machining parameters based on the grey relational analysis is adopted in this work to improve the machining time, material removal rate, electrode wear rate of EDM process.

Machining Performance Measurement:

1. Measuring the Machining Time*:* Machining has been carried out on an EDM machine for INCONEL disc using the brass electrodes with convex and concave bottom surface radius of curvature vary as 6mm, 8mm and 10mm. The experiments contributing to make 8mm throw holes on the 3mm thick work piece has been carried out and machining time is noted down.

Table.3.Result of experiment of L18 orthogonal array

Current	T_{on}	T_{off}	Grey relational grade	
			4mm Electrodes	3mm Electrodes
4	200	10	0.4469606	0.4697318
4	400	20	0.5541256	0.5967309
4	600	40	0.5315167	0.4892998
8	200	10	0.5189446	0.4403739
8	400	20	0.6540739	0.6118145
8	600	40	0.6189374	0.5659062
12	200	20	0.4694444	0.5015943
12	400	40	1	0.7819467
12	600	10	0.7754541	0.4599196
4	200	40	0.4195545	0.4225645
4	400	10	0.5053624	0.5348503
4	600	20	0.5233681	0.5137385
8	200	20	0.5419711	0.4574577
8	400	40	0.6817489	0.605298
8	600	10	0.6341089	0.5326297
12	200	40	0.7359126	0.5033708
12	400	10	0.7164971	0.6336474
12	600	20	0.7310356	0.5445356

From the results, it is observed that the Machining time is decreased while using convex tool electrode over flat tool electrode but the Machining time is increased with increasing in diameter of convex tool electrode.

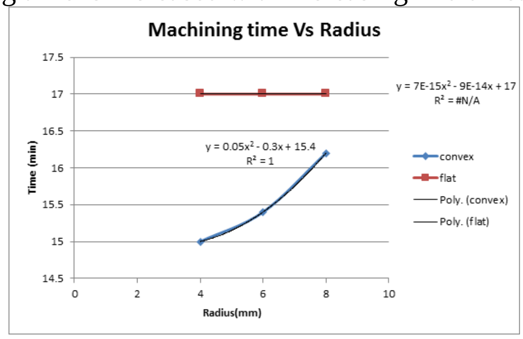

Figure.3.Machining time variation with respect to electrode radius

Convex shape electrode less machining time compare to flat and flat electrode has disadvantage that eroded INCONEL is deposit on the electrode machining surface So machining is not done on the uniformly in the cross section area of the hole still some surface left out the left out surface will not able to machine until the deposited metal in the electrode is removed. The time for removing electrode, time for removing the deposited metal in the electrode and time for resetting the electrode is avoided in the case of the convex surface.

Analysis of Experimental Data in Relation to Machining Time and Tool Wear: Machining time is more in flat the peripheral area that allowed faster heat loss to the surroundings. As a result less heat is available for material removal compared to the convex electrodes in convex shape that peripheral area is avoided so heat loss is reduced the convex surface is round face to the lice on Y-axis. According to the data convex surface of radius of curvature R4 electrode is the optimal for making hole of 12mm diameter in INCONEL 718. By this graph we come to know that machining time of the convex electrode is less than flat electrode as radius of curvature increase from radius 4mm to radius 8mm the convex surface is change towards flat surface thus convex electrode machining time value increase towards flat electrode machining time value. The figure 4 shows that Tool wear variation with respect to electrode radius. Electrode wear is also reduce when electrode chance from flat to convex thus electrode wear is increase when radius of convex tool electrode increase that can be seen in the graph because the small diameter convex tool electrode has been produced less spark compare to large diameter convex tool electrode.

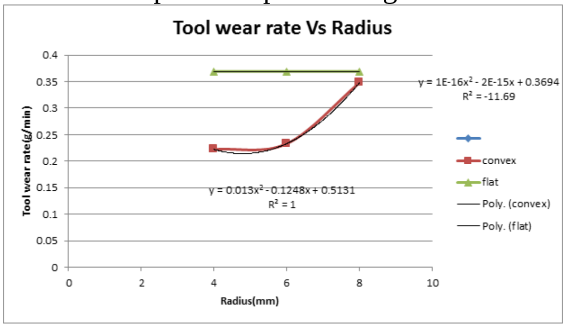

Fig.4.Tool wear variation with respect to electrode radius

Topology Analysis: EDM was carried out on cylindrical segment which is cut into eight piece each combination is each different electrode like (1,2) for flat, (2,3) for convex R4 and so on for observing surface topography, and the extent of possible surface damage and material removal mechanisms was obtained using a Scanning Electron Microscope (SEM) as shown in figure 5 (a), (b), (c) and (d).

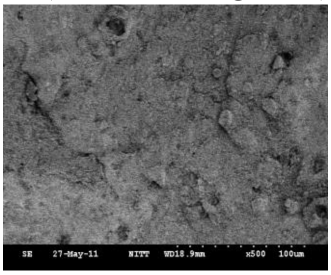

Figure.5(a) R4 W=10µm L = 100 µm

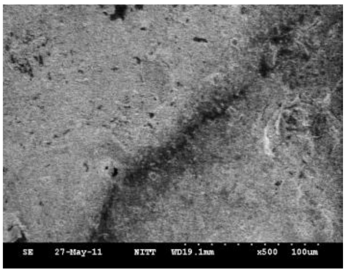

Figure.5.(b) R6 W=20µm L = 150µm

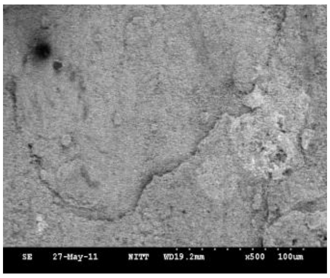

Figure.5(c) R8 W=10µm L = 90 µm

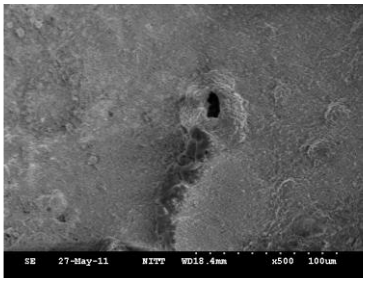

Figure.5(d).Flat W=25µm L = 80 µm

Crack formation can be attributed to the presence of residual stresses induced during the machining process. Bombarding the work piece with a succession of electrical discharges causes a dramatic increase in the surface temperature, which then induces thermal stresses within the specimen. The molten material which is not removed by the dielectric material subsequently re-solidifies as a white layer upon the surface of the component. Due to the rapid cooling effect, residual stresses are induced within the white layer, and when these stresses exceed the material's ultimate tensile strength, cracking of the surface takes place thermal sapling effect is related to the formation of cracks and observed at high energy EDM.

Measurement of Form Tolerances: This graph shows that work piece cylindricity factor increases with increase in the radius of curvature of convex tool electrode. Cylindricity factor is also reduce when electrode chance from flat to convex tool electrode. Finally, it is observed that the small diameter of convex tool electrode has been achieved lower cylindricity factor as shown in figure 6.

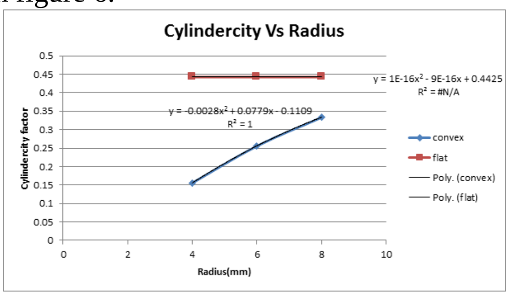

Figure.6.Cylindricity ratio varies with radius

5. CONCLUSION

A study on machining Inconel 718 with brass tool electrodes having different bottom shape like Flat and Convex ends using the EDM process is to studied and analyzed the effects of different bottom shape tool electrodes on response in the thermal erosion process. The conclusions of the experimental results could be summarized as follows:

The Machining time is decreased while using convex tool electrode over flat tool electrode but the Machining time is increased with increasing in diameter of convex tool electrode.

Electrode wear is also reduce when electrode chance from flat to convex thus electrode wear is increase when radius of convex tool electrode increase.

The cylindricity factor increases with increase in the radius of curvature of convex tool electrode. Finally, it is observed that the small diameter of convex tool electrode has been achieved lower cylindricity factor.

The peak current and pulse off time significantly affects the machining characteristics in the EDM process

REFRENCES

Altin A, Nalbant M and Taskesen A, The effects of cutting speed on tool wear and tool life when machining Inconel 718 with ceramic tools, Mater. Design, 28, 2007, 2518-2522.

Aspinwall DK, Soo SL, Berrisford AE and Walder G, Workpiece surface roughness and integrity after WEDM of Ti–6Al–4V and Inconel 718 using minimum damage generator technology, CIRP Annals. – Manuf. Technol, 57, 2008, 187-190.

Huang MF and Lin TR, Application of grey –Taguchi method to optimize drilling of aluminium alloy 6061 with multiple performance characteristics, Mater. Sci. Technol, 20, 2004, 528-532.

Kaebernick H, Jeromin A and Mathew P, Adaptive Control for Laser Cutting Using Striation Frequency Analysis, School. Annals of the ClRP, 47(1), 1998.

Lin JL and Lin CL, The use of the orthogonal array with grey relational analysis to optimize the electrical discharge machining process with multiple performance characteristics, Inter. J. Machine. Tool. Manuf, 42, 2002, 237–244.

Ming Zhou and Fuzhu Han, Adaptive control for EDM process with a self-tuning regulator, A time-varied predictive model for EDM process, International Journal of Machine Tools and Manufacture, 2009, 49(6):462-469

Narender Singh P, Raghukandan K and Pai BC, Optimization by Grey relational analysis of EDM parameters on machining Al–10%SiCP composites, Journal of Materials Processing Technology 155–156 (2004) 1658–1661

Nian CY, Yang WH and Tarng YS, Optimization of EDM operations with multiple performance characteristics Journal of Materials Processing Technology 95 (1999) 90-96.

Nihat Tosun, Determination of optimum parameters for multi-performance characteristics in drilling by using grey relational analysis, Inter. J. Adv. Manuf. Technol, 28, 2006, 450-455.

Tosun N and Ozler L, Optimization for hot EDM operations with multiple performance characteristics, Inter. J. Adv. Manuf. Technol, 23, 2004, 777–782.

Wang WM and Rajurkar KP, Modeling and Adaptive Control of EDM Systems, University of Nebraska-Lincoln, J. Manuf. Sys, 1(5), 2005.