EDUZONE: International Peer Reviewed/Refereed Multidisciplinary Journal (EIPRMJ), ISSN: 2319-5045
Volume 12, Issue 2, July-December, 2023, Available online at: www.eduzonejournal.com

Multi-Response Optimization of EDM Parameters on Inconel 600 and Inconel 718 using Rotary Brass Electrode by Modified Taguchi Method

Pramod Kumar[1], Umesh[2]

[1]Assistant Professor, Department of Mechanical Engineering, Rattan Institute of Technology and Management, Haryana, India
[2]Research Scholar, Department of Mechanical Engineering, Rattan Institute of Technology and Management, Haryana, India

ABSTRACT

Taguchi method is a conventional method to improve the quality of manufactured goods and more recently also applied to engineering with its most of applications limited to single response optimization. In the present study, the optimization of EDM parameters with multi disciplinary mannerism has been strive based on OA with new re-fashion Taguchi Methodology. Thus flawless of process parameters their created by assuming SNR and Performa using the ANOVA. Thus, the dynamic characteristics namely pulse current, gap voltage, pulse duration, pulse off time, pulse rise time , pulse hold time and dielectric were advance by considering the accomplishment for Inconel 600 and Inconel 718 using rotary brass hollow tubular electrode of 1mm diameter with through hole center flushing technique. The sight of this review is to recognize the conclusion of specification on output response and revamp the consummation characteristics of EDM process. The confirmation experiment was conducted to validate trials that indicate the retaliation characteristics of EDM mechanism should be enhance successfully through this mechanism. The experimental results further revealed that maximizing MRR, while minimizing EWR, OC and TA can be achieved simultaneously at a particular combination of control parameters setting. HIGHLIGHTS Multi-response optimization of EDM parameters for Inconel 600 and Inconel 718 has been proposed. Experimental results were normalized to optimize the multi-response based on the basic underlying philosophy of Taguchi methodology. Improvement in multi-response SNR shows the effectiveness of the modified Taguchi method. Confirmation experiment validates the experimental result that is very productive.

Keywords: Multi-response SNR, Control Parameter, Response parameter, ANOVA

INTRODUCTION

Electric discharge machining (EDM) is a non-traditive electro-thermal machine process commonly used for machining of electrical conductive components. Sometimes it also referred to as spark machining, spark eroding and die sinking machining process. Material is removed from the workpiece by a series of rapid, repetitive and control electrical effect between same electrodes, differentiates by a di-electric liquid field and reliazation to a high potential difference.

EDM is now become the most important accepted technologies widely used in automotive, aerospace, tool and die making industries since precise, complex and irregular 3D shapes can be machined using a simple shaped tool electrode. Very fine holes, delicate sections and weak materials can be machined without any distortion because there is no direct contact between the tool electrode and the workpiece.

Scenario of Edm

The scenario of EDM machine tool technology as earlier 1960's where it bring to light by an English researcher. However, EDM were not as unreservedly under-taken benefit of until 1941

When Russian researcher experiment that the biting effect of the style should maintained and practice for multi-machining processes. Firstly this was researched by Joseph Priestly ar early's 1770, wire EDM introduce to a work ability methods were assist to structure the metalworking fabrication as present scenario . At mid-1981s, EDM approach was maintaining shifted to a tool

This changeover helped EDM much effectively mechanism and presenting traditional machining [1].

Principle of Edm

Electrical Discharge Machining is a effectively material elimination mechanism that is used in order to remove metal by means of electric spark erosion. In this process an electrical spark is employed because the cutting tool to chop (erode) the work piece to supply the finished part to the specified shape. The local temperature rise during the spark is around 10000ºC.

A thin gap about 0.025mm is constantly managed for both tool and work material by a servo mechanism presented in Fig 1.1.As work material and tool are aligned during a dielectric field. Oil and De-ionized H2O are examples of liquid di-electric even gaseous di-electric are also useful at mostly area .Typically, tool placed at cathode and work-piece is placed at anode position. At Situation Where the voltage fills difference becomes enough high it required discharges maintained at gap spark attime-interval of 10-12 μs.

Characteristics of Edm

The EDM process can be used to machine any work material if it is electrically conductive. Material removal depends on mainly thermal properties of the work material instead ofits strength and hardness. The local temperature rise is quite high, still thanks to very small pulse on time, there's not enough time for the warmth to diffuse and thus almost no increase in bulk temperature takes place. Thus the warmth affected zone is restricted to 2 – 4 μm of the spark crater. Rapid heating and cooling and native heat result in surface hardening which may be desirable in some applications There is an opportunity of taper cut and overcut in EDM, they will be controlled and compensated.

Dielectric Fluid

In EDM process the workpiece and electrode are submerged in the dielectric fluid, which is an electrical insulator9 helps to control the arc disengaged. The dielectric fluid, that provides a way of flushing, is pumped through the arc gap. In EDM, material removal mainly occurs due to thermal evaporation and melting. The thermal processing is required to be carried out in the absence of oxygen in order these process are commonly handled to avoid oxidation process which causes improper surface electrical conductivity.

The characteristics of di-electric fluid are:

Maintaining discharge by feeding when ionized, and passes on the spark.

It helps in quenching the spark, cooling the work-piece, tool electrode and enables arcing to be prevented.

It removes corrode metal.

It provides coolant significantly for quenching.

Flushing Method

Flushing is very important function in any EDM operation. For successful EDM operation, it is most important to remove the metal particles from the working gap. Therefore, a clean filtered dielectric fluid is introduced into the spark gap to prevent them from forming bridges that cause short circuits. There are varieties of flushing methods wont to remove the metal particles efficiently. Too much pressure of fluid will remove chips before they Can assist within the cutting action, leading to slower metal removal. Too little pressure will not remove the chips quickly enough and should end in short-circuiting the erosion process. Therefore, an optimum dielectric pressure needs to be maintained to achieve desired performance.

LITERATURE SURVEY

This chapter introduces the review of research work which is closely related to this thesis work. We first give an overview of the various techniques used for the optimization of manufacturing processes. Then the overview of EDM process optimization based on different dielectric fluid, different geometry of the electrode and workpiece material with their conclusion has been discussed. Finally, the problem has been formulated with the critical finding of literature survey.

A literature review is an evaluative report of the knowledge found within the literature associated with the selected area of study. It gives the theoretical base for research and helps to figure out nature of your research. Its aim to review the critical points of current knowledge including substantive found also as theoretical and therefore the methodological contributions to a specific topic. When radius of electrode significantly increases, the MRR increases but EWR decrease [6]. Among the various dielectric fluids used in EDM process, water based dielectric fluid oils as they have good performed and green

environmentally friendly [7]. During EDM of Inconel 718 material, typical geometry of the machining holes and solidified material near the hole entry have been observed to achieve the feasibility of micron size hole manufacturing [8].

The pulse current has more effect on EDM multi-performance feature instead of pulse duration. Due to the higher energy density during EDM on Inconel 721 [9]. The experimental investigation of EDM parameters on Inconel 721 using the different geometry of the tungsten carbide electrode with kerosene as dielectric fluid reveals that pulse when required are significantly. characteristic that is required to MRR and reverse to EWR and surface roughness [10]. A comparative analysis of mild steel & aluminium material in the EDM process reveals that low MRR occurs in case of mild steel due its high melting temp. causes poor removal of work material. Electrode undergoes more wear in case of mild steel than aluminium and the wear rate of copper electrode is a smaller amount than that of brass electrode. [11].

Critical Findings of Literature Survey

Concluding research , it observed there a easy work that which provided with the objective to optimize the multi-response characteristic of EDM process using rotary brass hollow tubular electrode for Inconel 600 and Inconel 718 based on the basic underlying philosophy of Taguchi methodology.

Most of the study of EDM process was done to increase MRR and reduced EWR, OC but there was only limited work on tapers of the drill hole using an EDM process. There was no significant work is available for Electrical Discharge Machining using Rotary brass hollow tubular electrode. Several methods were adopted by the researchers to design the experiment and optimization of process parameters of EDM namely desirability approach, gray relational analysis, response surface methodology, Taguchi methodology and hybrid optimization technique but there is only limited work on the optimization technique based on the basic underlying philosophy of Taguchi methodology.

Problem Formulation

Today's manufacturing industries are facing challenges of more strenuous to machine materials such as hard alloys, composites and ceramics This improved thermal, chemical, and mechanical properties of the material such as improved strength, heat resistance, wear resistance and corrosion resistance are used in machining processes unable to machine them suitable. This phenomenon because traditional machining is valued helped in removing material using tools.

In previous decade, EDM has achieved a significant machining process, artily used in the automobile industry having ability to produce typical and complex shapes. Drilling when considered as machining operation for robust materials to rednecks the applications. The optimum parameter of control set of instructions during the EDM mechanism is significant views in manufacturing and automobile and sheet metal industries now adays. hence, the selection c r i t e r i a of machining metal for parameters is not at all depent on on machine
controls rather dependency of material.

METHODOLOGY

The experimentation is as systematic and scientific approach to manipulate one or more output variables and control or measure the input variables. Data obtained through the experiment are used to calculate the output variables. Every researcher try to conduct trials to obtain maximum and useful data respect to behind the significantly approached.

Experimental Workpiece and Their Specification

Modern industry promotes the use of alternative advanced materials (composites, super alloys and ceramics) for establishing design and manufacturing.

Therefore, an experiment was performed on Inconel 600 and Inconel 718 that is most widely used Aerospace alloy due to having some typical properties- Silvery shiny appearance High toughness and ductility Good high and low temperature strength High oxidation resistance Good corrosion resistance Inconel 600 is a High nickel alloy having good resistance to oxidation and corrosion at high temperature, extensively used widely different industries.

Inconel 718 is a super alloy having excellent Mechanical properties at elevated temperatures and excellent oxidation resistance up to 980°C typically used in Gas turbine component, Nuclear reactors & pumps, Spacecraft, Cryogenic tanks and liquid fuel Rocket motor components.

The typical properties and chemical composition of Inconel 600 and Inconel 718 is given below.

Workpiece Preparation

Before going to start the experiment, A Rockwell hardness test was conducted on both the specimen i.e. Inconel 600 and Inconel 718. G scale was considered to characterize the nickel based superalloy. The Hardness for Inconel 600 and Inconel 718 were found to be 135 HRG and 145 HRG respectively.

The magnetic base surface grinder was used to achieve the almost same thickness for both the specimen with an accuracy of 0.05 mm. After the grinding operation, thickness of both the specimen was found to be 11.1 mm that was measured using the digital vernier caliper.

Experimental Electrode with Their Specification

Single hole brass tubular electrode of diameter of 1 mm and length 400mm was used as a tool that was Brass is one of the most commonly used material because of the high degree of stiffness, high tensile strength, easy mach inability, and comparatively cheaper.

Taguchi Philosophy

Taguchi espoused a superb philosophy for internal control within the manufacturing industries. Taguchi method is a scientifically disciplined mechanism for evaluating and implementing improvements in products, processes, materials, equipment, and facilities. Taguchi method is an engineering approach of quality improvement that seeks to obtain a low cost solution to the product design specification based on the requirement of the customer. These improvements are aimed at improving the specified characteristics and simultaneously reducing the amount of defects by studying the key variables controlling the method and optimizing the procedures or design to yield the best results. The method is applicable over a good range of engineering fields that include processes that manufacture raw materials, subsystems, products for professional and consumer markets. In fact, the method can be applied to any process like engineering fabrication computer-aided-design, banking and service sectors etc. Taguchi method is useful for 'tuning' a given process for 'best' results.

Taguchi method divides all problems into 2 categories – Static or Dynamic. While the Dynamic problems have a sign factor, the Static problems don't have any signal factor. In Static problems, the optimization is achieved by using 3 Signal to Noise ratio (SNR) – smaller the better, larger the better and nominal the best. In Dynamic problems, the optimization is achieved by using 2 SNR - Slope and Linearity. The objective of Taguchi approach is to determine the optimum setting of process parameters or control factors, thereby making the method insensitive to the sources of variations thanks to uncontrollable or noise factors. In this method, main process parameters which influence process results are taken as control parameters and the experiment is performed as per specifically designed orthogonal array.

CONCLUSION

An application of the modified Taguchi method to improve the multi-response parameter i.e. MRR, EWR, OC and TA in EDM process of Inconel 600 and Inconel 718 using rotary brass hollow tubular electrode has been reported in this thesis work. The experimental result confirms that this approach is simple, effective and efficient for simultaneous optimization of multiresponse characteristics. From the results of confirmation experiment, it was concluded that the for Inconel 600 MRR is slightly reduced by 4.62% but EWR, OC and TA are reduced by 28.70%, 8.33%, 6.61% respectively. In case of Inconel 718 MRR was improved by 9.86% and EWR, OC and TA reduced by 5.16%, 10.00%, 18.18% respectively, therefore enhancing the quality characteristics of the holes and reducing the EWR. It was evident from the above study that optimization of difficult various performance characteristics can be simplified by this approach. The experimental error for Inconel 600 and Inconel 718 were found to be 8.64%, 5.10% respectively. The experimental error can be reduced further by increasing the number of experiments or increasing the number of repetitions or considering the interaction among the control parameters. The experimental results are very productive and therefore confirm the success of the experiment. The optimization of EDM process is concerned with maximizing MRR while minimizing EWR, OC and TA that can be achieved simultaneously with a particular combination of control parameters setting. The experimental results obtained can be used in industry in favour of select the highly suitable parameter combination to get the needed quality characteristics of the product. Therefore, the present work successfully evaluated the feasibility of EDM process for Inconel 600 and Inconel 718.From the comparative graphical analysis it was concluded that multi-performance characteristic of Inconel 600 is greatly improved as comparing to Inconel 718. For the same level of control parameters, MRR of Inconel 600 is comparatively higher than that of Inconel 718 because Inconel 718 has low thermal conductivity compare to Inconel 600 that cause the poor heat absorption. For the same level of control parameters, the EWR in case of Inconel 718 is more than that of Inconel 600 because Inconel 718 has low electrical conductivity compare to Inconel 600 that restrict the flow of electrical current during the spark.

REFERENCES

[1]. Jameson EC, Electrical Discharge Machining, Society of Manufacturing Engineers: USA 2001.
[2]. Choudhury IA and El-Baradie MA, "Mach inability of nickel-base super alloys: a general review", Journal of Material Processing Technology, 77 (1998) 278–284.
[3]. Patel, M., Parikh, H., & Dave, G. (2023), "Chitosan flakes-mediated diatom harvesting from natural water sources", Water Science and Technology, 87(7), 1732-1746.
[4]. Parikh, H. (2021), "Diatom Biosilica as a source of Nanomaterials", International Journal of All Research Education and Scientific Methods (IJARESM), Volume 9, Issue 11
[5]. Gurule NB and Nandurkar KN, "Effect of tool rotation on material removal rate during powder mixed electrical discharge machining of die steel", International Journal of Emerging Technology & Advance Engineering, 2 (2012) 328–332.
[6]. Patel VD, Patel CP and Patel UJ, "Analysis of different tool material on MRR and surface roughness of mild steel in EDM", International Journal of Engineering Research & Application, 1 (2012) 394–397.
[7]. Yilmaz O and Okka MA, "Effect of single and multi-channel electrode application on EDM fast hole drilling performance", International Journal of Advance of Manufacturing Technology, 51 (2010) 185–194.
[8]. Purohit R, Verma CS and Shekhar P, "Electric Discharge Machining of 7075 Al-10 Wt.% Sicp composites using rotary tube brass electrodes", International Journal of Engineering Research & Application, 2 (2012) 411–423.
[9]. Leao FN and Pashby IR, "A review on the use of environmentally friendly dielectric =fluids in Electrical discharge machining", Journal of Material Processing Technology, 149 (2004) 341–346.
[10]. Manikandan R and Venkatesan R, "Optimizing the machining parameters of Micro- EDM for Inconel 718", Journal of Applied Science, 12 (2012) 971–977.
[11]. Mustafa A, Caydas U and Hascalik A, "Optimization of Micro-EDM drilling of Inconel718 super alloy", International Journal of Advance Manufacturing Technology, 38(2012) 1–9.
[12]. Sengottuvel K, Satishkumar S and Dinakaran D, "Optimization of Electrical Discharge Machining Parameters using Desirability Approach", Journal of Applied Mechanics & Material, 159 (2012) 176–180.
[13]. Khan AA, "Electrode wear and material removal rate during EDM of aluminium and mild steel using copper and brass electrodes", International Journal of Advance Manufacturing Technology, 39 (2008) 482–487.
[14]. Janmanee P and Muttamara A, "A Study of Hole Drilling on Stainless Steel AISI 431 by EDM Using Brass Tube Electrode", International Transaction Journal of Engineering, Management, & Applied Science Technologies, 2 (2011) 471–481.
[15]. Natarajan N and Arunachalam RM, "Optimization of micro EDM with multiple performance characteristics Using Taguchi of method and gray relational analysis", Journal of Science & Industrial Research, 70 (2011) 500–505.
[16]. Hewidy MS, El-Taweel TA and El-Safty MF, "Modelling the machining parameters of wire electrical discharge machining (EDM) of Inconel 601 using of RSM", Journal of Materials Processing Technology, 169 (2005) 328–336.
[17]. Bharti PS, Mashewari S and Sharma C, "Experimental investigation of Inconel 718 during die sinking electrical discharge machining", International Journal of Engineering Science & Technology, 2 (2010) 6464–6473.