Literature Review on Electrical Discharge Machining (EDM)

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Abstract— By means of the improvement and growths in new machineries, low weight- high strength, high hardness and temperature resistant materials have been advanced for distinctive applications which include aerospace, medical, automobile and more. In the machining of hard and metal matrix composite materials, outdated manufacturing processes are being more and more changed by more non-traditional machining processes which include Electrical Discharge Machining (EDM). The work piece material designated in this experiment is Inconel 925 taking into interpretation its wide usage in industrial applications. In today's world stainless steel provides to nearly half of the world's production and consumption for industrial determinations. In this experiment the input variable factors are voltage, current and pulse on time. As we know that Taguchi method is functional to produce an L9 orthogonal array of input variables by means of the Design of Experiments (DOE). So, Taguchi method is used to analysis the output data. The consequence of the compliant parameters stated overhead upon machining characteristics such as Material Removal Rate (MRR) and Tool Wear Rate (TWR) is considered and examined. In this we are focused on to analysis minimum TWR and maximum MRR based on control factors and response parameters.

Key words: EDM, Electric Discharge Machining, Unconventional Manufacturing Process, TWR and MRR

I. INTRODUCTION

A. Electrical discharge machining

EDM is used to acquire the desired shape by means of electrical discharge operations. Material removal process has completed due to current discharge between two electrodes. In this operation dielectric liquid and electric voltage play very important role. As we know that electrical discharge machining operations come under non-conventional machining techniques. It is mostly used for machining operations on hard metals and for complex operations, which are nearly difficult with outdated techniques [1].

The EDM process is removing unwanted material in the form of debris and produce shape of the tool surface as of a metal piece via an electrical expulsion trapped between tool and work piece i.e. (cathode and work piece) in presence of dielectric fluid. In these machining process tool is attached to negative so it called cathode (polarized electrical device) and work piece is called the anode, because, it is attached to positive. Dielectric fluids are kerosene, transformer oil, distilled water, may be filled.

B. Die-sinking EDM process

This process was founded by two Russian scientists, B. R. Butinzky and N. I. Lazarenko in 1943 to find the ways of preventing the erosion of tungsten electrical contacts due to sparking. So many times, they were unsuccessful in this task but they found that the erosion was more precisely controlled if the electrodes were immersed in a dielectric fluid [2]. This led them to invent an EDM machine used for working difficult-to-machine materials such as tungsten.

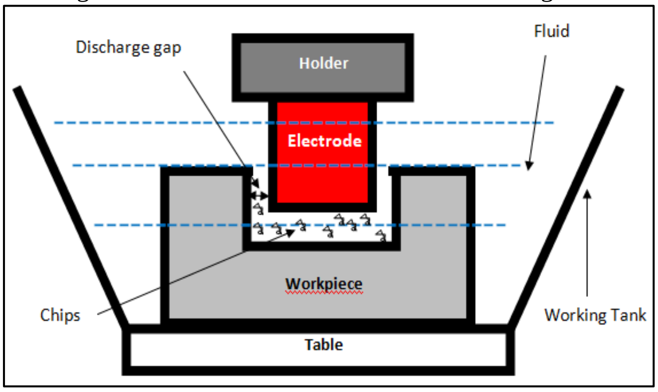

Fig. 1: Mechanism of Die-Sinker EDM

In this process two electrodes are fitted on their places on the machine parts which is work bench and the tool holder. Both the electrodes must be the electrically conductive. After that both the electrodes are immersed in an insulating liquid dielectric with the help of the pump. The dielectric is the EDM oil/ kerosene / transformer oil. Then set the machining parameters on the CNC controller for machining on the work piece to get required shape and the size.

C. Wire EDM Process

The wire-cut kind of machine founded in the 1960s for the purpose of making tools (dies) from hardened steel. In this process the tool electrode in form of wire. To avoid the erosion of material from the wire causing it to break, the wire is wound between two spools so that the active part of the wire is constantly changing.

The wire cut EDM process also called electric discharge wire cutting process. It is used for the producing two or three dimensional complex shapes using an electro thermal mechanism for eroding the material from a thin single stranded by guide metal wire surrounded by deionised water which is used to the conduct electricity.

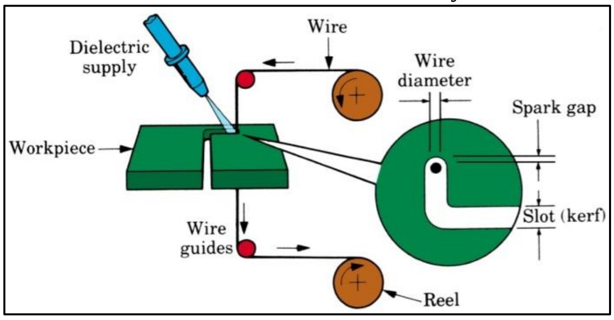

Fig. 2: Mechanism of Wire EDM

D. Dielectric Fluid

It is used as a coolant, flushing medium and also a catalyst conductor. It plays very important roles in EDM process. The requirements are:

1) The dielectric should have compulsory and constant dielectric strength to serve as insulation between tools and the work, till the breakdown voltage is reached.
2) It must be de-ionizing speedily afterwards the spark ejection has taken place.
3) It must need small viscosity and a polite moistening ability to provide effective cooling mechanism and remove the swerve particles from the machining gap.
4) It should flush out of the element produce during the spark out of the gap. This is the most important purpose of the dielectric fluid. Insufficient flushing can result in arcing decreasing the life of the electrode and increasing of the machining time.
5) It should be chemically in neutral, so as not to attack to the tool, job and the movable table or the tank.
6) Its flash point should be high so that there are no fire threats.
7) It should not release any toxic vapours.
8) It should sustain these properties with temperature variation, contamination by working residuals and products of the decomposition.
9) It should be economical and easily available in nature.

II. CURRENT RESEARCH DETERMINATIONS

Rao, P. Srinivasa et al.[3] have studied that have an effect on by means of design four factors such as current, servo control, duty cycle and open circuit voltage over the outputs on the MRR, TWR, SR and hardness on the die-sinker EDM process of machining AISI 304 SS. They have been hired the DOE technique with mixed degree layout and to analyze for appearing a minimal quantity of runs. They finished that for higher the MRR, the current, servo and duty cycle should be fixed as high levels and 95% confidence level with descending order in case of the TWR with equal elements.

S. H. Tomadi et al.[4] analyzed that impact of machining settings of the tungsten carbide on the outputs such as TWR, MRR and Surface finish. Confirmation check finished to assess errors between the predicted values and to experimental runs in terms of machining characteristics. They were found out copper tungsten tool use for better surface finishing of work piece. They were using full factorial DOE, to optimization and discovered out with greater pulse off time lesser tool wear of the tungsten carbide and with current, voltage and pulse on time increment with tool wear increased.

Zhao Wansheng et al.[5] have studied about surface machining process by EDM. Shows the consists of a series of discharge craters, and explain that there is no screw-like trail left on the hole's inside wall that would be formed by ordinary drilling. This can change the field of distribution condition when fluid or gas flows through the small hole. As there is no macroscopic force, it is easy to machine a half hole by using EDM.

Ulas Çaydas et al.[6] analyzed that the EW and WLT in die-sinking EDM process were modelled and analyzed through response surface methodology (RSM). A valuable central composite rotatable design (CCRD) in RSM consisting of three variables. Pulse on time, pulse off-time and pulse current have been employed to carry out the experimental study have a look at. Analysis of variance (ANOVA) was applied to study. Their predicted values match the experimental values reasonably nicely, with R2 of 0.99 for EW and R2 of 0.97 for WLT. Pulse current was found the most essential factor effecting the both EW and WLT, even as pulse off-time has no enormous impact on both responses.

H. Shen et al. [7] have studied in micro EDM, they defined about the discharge gap that is very small, and the dimensions of the electrode is just too small to use internal and/or outside flushing to dispose of debris. In their paper, a new method the usage of planetary movement of the electrode is proposed to lessen the particles concentration and enhance precision. The planetary movement of electrode provides extra area for particles elimination. Therefore, the material removal rate increases and the electrode wear reduce. This method has been confirmed through machining of micro holes with excessive element ratio and blind noncircular micro holes.

G. Appa Rao et al. [8] have studied the effect of normal heat treatment on the microstructure and mechanical properties of hot isostatically pressed superalloy inconel 718. In this, Inconel 718 was analyzed processed through powder metallurgy (P/M) hot isostatic pressing (HIP) route. In this study, they have led to better study of the property and structure relationships in HIP + heat treated analysis on alloy 718 and suggest that the standard heat treatment approved for wrought IN 718 is not convenient for HIPed alloy and has to be modified to realize optimum properties.

The stress rupture life and ductility of the alloy have also made better marginally after heat treatment and has got the minimum expected life for wrought heat treated IN 718, however, the rupture ductility was found to be much less than the specified value. This suggest that the recommended heat treatment for wrought alloy is not suitable for HIP processed alloy and has to be modified to realize optimum properties.

P. Kuppan et al. [9] shows the experimental analysis of small deep hole drilling of Inconel 718 using the EDM process. The parameters such as peak current, pulse on-time, duty factor and electrode speed were selected to study the machining components characteristics. In these experiments, they were prepared using central composite design (CCD) method. The output feedbacks measured were material removal rate (MRR) and depth averaged surface roughness (DASR). The process parameters are enhanced for the maximum MRR with the specified surface roughness value 3 µm and 3.5 µm using desirability function approach. The optimized parameters are fairly in good compliance with the experimental values. For Inconel 718, the outcome of pulse on-time is irrelevant on MRR but strongly effect the DASR. Hence to achieve better surface finish low value of pulse on-time to be selected.

T.A. Spedding et al. [10] analyzed the response surface methodology and artificial neural networks models. It have been developed for the wire EDM process, experiments showing that both of the models are able to predict the process performance, such as cutting speed, surface roughness, surface waviness within a reasonable large range of input factor levels. In the investigating area, the ANN model is found to fit the data better and have higher predictive capability to Ra and the cutting speed. From the results presented in this paper it can be concluded that these techniques can be extended to processes exhibiting similar stochastic character and complexity.

K. Salonitis et al. [11] studied about theoretical thermal model. It has been proposed for the simulation of the die-sinking EDM process. A number of experiments were conducted in order for the effect of the current and the discharge duration in the MRR and the average surface roughness to be studied. The MRR and average surface roughness can be decided with an average deviation of 8.2 % and 6.1 %, respectively. The deviations are attributed to the assumptions posed during the development of the model, i.e., the overlook of the recast layer's formation and the idea that the idling time is insignificant in comparison with the discharge duration.

III. Conclusion

In this conclusion, there are following major factors are reviewed:

1) Resulting foremost conclusions can be stated from review of work in this area that EDM performance is generally evaluated on the basis of TWR, MRR, Ra and hardness.
2) In Material removal rate (MRR) from all selected parameters, spark current (I) is the most significant input factor affecting the machining of workpiece.
3) The performance is affected by discharge current, pulse on time, pulse off time, duty cycle, voltage for EDM.
4) For tool wear rate (TWR) from the all selected parameters, spark current (I) is the most significant input factor affecting the machining of workpiece followed by spark time and voltage.
5) Innovative technology in the EDM is unceasingly progressing to make this procedure further appropriate for the Machining. In the field of manufacturing additional attention is on the optimization of the method by dropping the number of Electrode.

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