A Review Paper on EDM and ECM of Stainless Steel

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***Abstract* - Electric Discharge Machining (EDM) is one of the most efficiently employed non-traditional machining process for cutting hard-to-cut materials & to cut geometrically complex shapes that are difficult to machine by conventional machines. In the present paper reviews is conducted of experimental investigations carried out to study the effect of EDM parameters on material removal rate (MRR), electrode wear (EWR), surface roughness (Ra) and diameteral overcut in corrosion resistant stainless steels. The non-contact machining technique has been continuously evolving from a mere tool and die making process to a micro-scale application machining alternative attracting a significant amount of research interests and Electrochemical machining (ECM) offers several special advantages including higher machining rate, better precision and control, and a wider range of materials that can be machined.This paper reviewswork related to EDM and ECM processes applied to stainless steel materials such as AISI 304, AISI 302B, 316 L and 17-4 PH.**

***Keywords* - EDM, ECM, Stainless steel materials**

I. INTRODUCTION

Electrical discharge machining (EDM)

EDM is most widely and successfully applied process in machining of hard metals or those that would be very difficult to machine with traditional techniques. The material is removed from the work piece by the thermal erosion process, i.e., by a series of recurring electrical discharges between a cutting tool acting as an electrode and a conductive workpiece in the presence of a dielectric fluid. This discharge occurs in a voltage gap (Vg) between the electrode and work piece. Heat from the discharge vaporizes minute particles of work piece material, which are then washed from the gap by the continuously flushing dielectric fluid [1].

This technology is increasingly being used in tool, die and mould making industries, for machining of heat treated tool steels and advanced materials (super alloys, ceramics, and metal matrix composites) requiring high precision, complex shapes and high surface finish. Traditional machining technique is often based on the material removal using tool material harder than the work material and is unable to machine them economically. EDM is one of the most popular non-traditional material removals process and has become basic machining method for the manufacturing industries of aerospace, automotive, nuclear and medical [2].

With the increasing demands of high surface finish and machining of complex shape geometries, conventional machining process are now being replaced by non-traditional machining processes. Electrical discharge machining utilizes rapid, repetitive spark discharges from a pulsating direct current power supply between the workpiece and the tool submerged into a dielectric liquid [3].

Electrochemical Machining (ECM)

ECM is developed on the principle of Faradays and Ohm. In this process, an electrolyte cell is formed by the anode (work piece) and the cathode (tool) in the midst of a following electrolyte. The metal is removed by the controlled dissolution of the anode according to the well known Faradays law of electrolysis [4].

In this paper MRR is an important aspect on an electrochemical machining. Because its process relies on chemical process, its rate of machining depends only upon its atomic weight, its valence, the current density, and the time of machining [5].

ECM removes material without heat. In today’s high precision and time sensitive scenario, ECM has wide scope of applications [6].

II.EXISTING RESEARCH EFFORTS

P. SRINIVASA RAO et. al. [1]studied the influence of the most relevant EDM factors over MRR, tool wear rate (TWR), Ra and hardness of ss 304 by copper tool electrode. In order to achieve this, 3*24-1 mixed factorial design of experiments and multiple regression analysis techniques have been employed to model the previously mentioned response variables by means of equations in the form of polynomials. In the case of MRR, all the design factors are influencing for a confidence level of 95% and arranged in descending order of importance, servo voltage, dutycyle, current and voltage.In order to obtain the high value of MRR the workinterval of current, servo and dutycycle (t) should be fixed as high as possible. The influential design factorsin case of TWR in the descending order of importance were: current, servo and dutycycle for a confidence level of95%.

Singh Jaspreetet. al. [2] studiedthe effect of EDM parameters such as pulse-on time (TON), pulse-off time (TOFF), and current (I) on MRR inss 202 and results were analyzed using analysis of variance and response graphs. They found that different combinations of EDM process parameters are required to achieve higher MRR and greater surface finish. They used Signal to noise ratio (S/N) and analysis of variance (ANOVA) to analyze the effect of the parameters on MRR and also to identify the optimum cutting parameters. The contribution of each cutting parameter towards the MRR was also identified.

MunmunBhaumiket. al. [3] investigated the influence of EDM parameters on TWR,MRR, Rawhile machining of ss304 material by TungstenCarbide and concluded that MRR is mainly affected bypeak Current (IP). TON and gap Vg have considerable effect on MRR. The effect of t on MRR is negligible. EWR is mainly affected by IP. TON and t haveconsiderable effect on MRR. The effect of Vg on electrode wear is very negligible. Ra is mainly influenced by IP and TON. Vg and t have less influence on Ra.

Pradeep Kumar P. [4] investigated the improvement in the MRR of electrochemical machining. Experimental MRR was calculated for different electrolytes conditions on ss 302B and aluminium by copper electrode. The experimental results indicated that by using sea water as anelectrolytein electrochemical machining on aluminium alloyand steel alloy gave better MRR.

AndiSudiarsoet. al. [5] Experimental work had conducted experiments on brass, ss 204, and aluminium 1100 workpiece materials by using brass electrode through ECM and the machining time is kept constant for all materials. So, they were concluded the average MRR of brass is 2.96 x 10-4 g/s, ss has MRR 2.54 x 10-4 g/s, and MRR aluminium is 7.9 x 10-5 g/s. For 6 mm of brass electrode, the MRR is 5.74 x 10-4 g/s and 2.53 x 10-4 g/s for 1 mm thickness of ss and aluminium respectively.

S. S. Uttarwaret. al. [6] studied the effect of ECM process parameters ofss302B by brass tool electrode on machining criteria such as MRR and with gradual increase in voltage MRR increases. IEG (Inter Electrode gap) variable is maintained constant during the whole experimentation. The machining voltage 45V (0.33A) gives the appreciable amount of MRR.

S. S. Uttarwaret. al. [7] studied that MRR in ECM with ss 304 material and copper electrode was remarkably affected by variation in current and Surface Roughness decreased with increase in current. Hence, it was apparent that irregular MRR was more likely to occur at high currents. They concluded that MRR increased with increasing electrical voltage, molar concentration of electrolyte, time of electrolysis and feed rate. However, the time of electrolysis was the most influential parameter on the produced surface finish.

AsifIqbalet. al.[8] established empirical relations regarding machining parameters and the responses in analyzing the machinability of the ss AISI 304 using copper electrode. The machining factors used were voltage, rotational speed of electrode and feed rate over the responses MRR, EWR and SR. The response surface methodology was used to investigate the relationships and parametric interactions between the three control variables on the MRR, EWR and SR. The developed models show that the voltage and rotary motion of electrode are the most significant machining parameters influencing MRR, EWR and SR.

S.Gopalakannanet. al. [9] investigated the effect of pulsed current on material removal rate, electrode wear, surface roughness and diameteral overcut in corrosion resistant stainless steels viz., ss316 L and 17-4 PH. They observed that the output parameters such as MRR, EWR and Ra of EDM increase with increase in pulsed current. The results reveal that high MRR have been achieved with copper electrode whereas copper-tungsten yielded lower electrode wear, smooth surface finish and good dimensional accuracy.

R Thanigaivelanet. al. [10] investigated the effect and parametric optimization of process parameters for electrochemical micromachining (EMM) ofss 304 using grey relational analysis, by using machining voltage, pulse on-time, electrolyte concentration and tool tip shapes as typical process parameters.The experimental results revealed that, the conical with rounded electrode, machining voltage of 9V, pulse on-time of 15ms and electrolyte concentration of 0.35mole/l was the optimum combination for higher machining rate and lesser overcut. The experimental results for the optimal setting showed that there was considerable improvement in the process.

Chen Huiet. al. [11]was studied experimental results and indicated that EDTA-Na2 can avoid the short circuit and not increase the side gap of electrochemical machining. They Concluded EDTA-Na2 can form complex compound with ions of anode and dissolved in electrolyte. It is a kind of effective complexing agent in electrochemical machining of stainless steel. EDTA-Na2 complexing agent avoids the formation of insoluble precipitation on the electrode surface and in the electrolyte solution and it is helpful to machining stability.

Viral B. Prajapatiet. al. [12] studied that most effective parameters for cutting condition arepulse on time, pulse off time and discharge current and they are easily controlled by operatorat the machine at same time. Experimental work was performed on EDM with ss410 work piece and copper electrode, inwhich input parameters are pulse on time, pulse off time and discharge current and theresponse parameters are Ra and MRR.For experimental design they were used full factorial method to find out number of readings. To find out percentage contribution of each input parameter for obtaining optimal conditions, ANOVA methodwas used.

III. CONCLUSION

Following major conclusions can be drawn from review of work in this area over the past two decades reveals that EDM and ECM performance is generally evaluated on the basis of TWR, RWR, Ra, hardness.

The performance is affected by discharge current, pulse on time, pulse off time, duty cycle, voltage for EDM.

Electrolyte concentration, current, feed rate, inter electrode gap, pulse duration for ECM.

From the above review paperswe have also studied stainless steel materials which are AISI 304, AISI 302B, 316 L and 17-4 PH machined by mainly copper tool electrode.AISI 304 iswidely use almost in all industrial applications and accounts for approximately50% of the world's stainless steel production and consumption.

Some work has been done for identifying parameters for optimization and also suitable techniques for EDM and ECM mechanisms, but further investigations for precise control are desirable.

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