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A REVIEW ON RESEARCH TRENDS IN ELECTROCHEMICAL DISCHARGE MACHINING

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ABSTRACT:- The concept of electrochemical discharge machining (ECDM), also known as electro-chemical spark machining (ECSM), was first time presented in 1968. This technology emerges as research topic since then and never worked on for industrial applications. The ECDM is a non-traditional machining process used for machining of non-conducting materials. The emerging requirements of very hard to machine materials in modern industries results in working on nonconventional methods of machining which can work on such materials with higher material removal rate as well as good surface quality. ECDM is one of the non-conventional machining processes which can be used to machine newer materials with higher surface quality required by Industries.

Key Words:-Electrochemical Discharge Machining, Material Removal Rate, Surface Finish, Tool Wear Rate.

1. INTRODUCTION

Electrochemical discharge machining is based on discharge in material removal process which can be potentially used as a micro-machining technique. This process is especially useful for machining materials like glass, ceramics which are non-conducting. In this process multiple parameters including tool-electrode material, electrode size and shape, feed-rate, workpiece material, applied Voltage, current, electrolyte, gap in between tool and workpiece, distance between tool and workpiece, etc. are involved. In ECDM, the workpiece is dipped in electrolyte. A DC voltage is supplied between the tool (cathode) and the counter electrode (anode).

Reverse polarity may be possible, but it is not preferred, as it have disadvantages than direct polarity. The tool-electrode tip is dipped few mms in electrolyte. The counter electrode is fixed a few cms apart from the tool-electrode. Electrolysis occurs at lower voltage than the critical voltage, typically between 20 and 30 V and then, formation of hydrogen bubbles generates at the tool-electrode and oxygen bubbles at the counter electrode [1]. As the voltage increases, the formation of hydrogen and oxygen bubbles and their radius increases with increase in current density. This results in a layer of gas bubbles around the tool-electrode. If critical applied voltage exceeds, the bubble coalesce and formation of a gas film results around the tool-electrode. The gas film works as a dielectric and creates sufficient resistance to create high difference in potential in between the electrodes. As this difference becomes higher enough for a given set pair of tool-electrolyte, electrical discharge does occurs between electrode and electrolyte. If the workpiece placed in the discharge zone, material removal does take place in the form of melting, vaporization and thermal erosion due to the heat created by the discharges. Chemical etching also contributes to material removal process. The ECDM process can be used for making very small channels, and very small holes in micro sizes [2–6].

1.1 Basics of ECDM Process

ECDM can be used to machine for no conducting materials such as glass and ceramics due to fast chemical reaction by the effect of electrical discharge heat created by electrolytically-generated heat. The chemical reaction between workpiece and electrolyte is initiated by heat. Consequently, the material from surface of workpiece is removed. The diagram of ECDM is shown in Fig. 1, the tool-electrode (cathode) and auxiliary-electrode (anode) are immersed in an electrolytic solution (normally NaOH or KOH). Electrodes are connected to DC supply, causing hydrogen bubbles to be produced on both electrodes due to electrochemical reactions.

The bubbles comes closer and makes a gas film on the tool-electrode. The gas film permits sparking between the tool-electrode and electrolyte by covering the tool from the surrounding electrolyte. If the workpiece is brought closer to the tool, material removes. The material removal process of ECDM is a combination of melting and chemical dissolution.

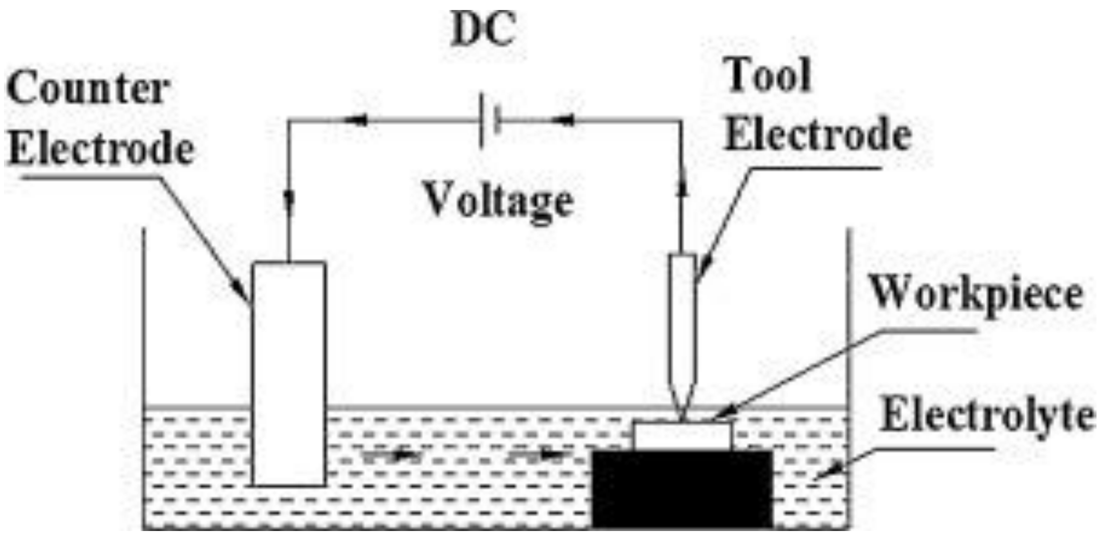

Fig. 1 Electrochemical Discharge Machining

2. LITERATURE REVIEW

2.1 Affecting Parameters of different materials used in ECDM

Sarkar et. al. [7] authors studied that, the ECDM process is used in machining of silicon nitride ceramics. The machining results in that as voltage is more important factor on MRR, ROC and HAZ.

Doloi et. al. [8]. Authors studied that, in ECDM the machining parameters for hole drilling operation on insulating material zirconium oxide ceramic work piece material. The applied voltage, concentration of electrolyte and gap between electrodes are the three main parameters which affect the MRR as well as ROC of ECDM process.

Mitra et. al. [9] investigated that the Travelling Wire Electrochemical Discharge Machining (TW-ECDM) process can be used for cutting of insulating materials for making complicated profiles, authors suggested that it is very useful for working on various advanced ceramics and composite materials using TW-ECDM.

Chavoshi and Behagh [10] investigated that the hole depth variation were taken into two cases (1) hole depth is known and (2) hole depth is not known, by using these factors investigation was carried out. The voltage, electrolyte density and electrode-tool diameter are the most significant parameters on the wear along axis and hole depth in that case material taken was AISI 4140 which is hard to drill.

Laio et. al. [11] authors used new technique of added Sodium Dodecyl Sulfate surfactant in to electrolyte for machining of quartz in ECDM, findings obtained that, a small taper and a good quality but a small over size hole can be drilled with a higher engraving speed when current density is increased.

Leszek [12] author make micro holes in borosilicate glass and partly in diamond crystals by using electrochemical discharge machining, which are difficult to machine using conventional or even other techniques, the tool material used in this case were tungsten or tungsten carbides.

Lijo et. al. [13] authors investigated the effect of process parameters of ECDM on MRR is studied on borosilicate glass of 0.5mm thick plate & tool of tungsten carbide. Findings are obtained as MRR improves with duty factor, concentration of electrolyte and voltage also, TWR decreases with increase in concentration similarly ROC decreases with voltage increase, electrolyte concentration and duty factor.

Chaka and Rao [14] authors used to machine electrically insulating HSHTR ceramics, such as aluminium oxide (Al_2O_3).This investigation resulted in that the deep holes in ceramics can be drilled by using pulsed DC and with abrasive rotary electrode. Results received as overall improvement in holes quality produced.

Manna and Narang [15] authors investigated that micro machining of electrically insulating e-glass–fibre–epoxy composite during electrochemical spark machining using specially designed square cross section with centrally micro hole brass tool and different diameter round-shaped micro tools made of IS-3748 steel. The generation of a special contour on e-glass–fibre–epoxy composites is possible by ECDM.

2.2 Research on Internal Behaviour of ECDM

Debasish et. al. [16] authors studied bubble's behaviour around the electrodes in ECDM process as a factor of spark initiation. Factors affecting bubbles formed is Voltage- Current, with this analyzed factors are combinations of electrolytes, diameter of tool and depth of tool. So, result was that this local turbulence has small effect on critical voltage or critical current, linear increased tool depth in electrolyte and increased tool diameter. It was found that contact area and total resistance dependency is non-linear.

Liu et. al. [17] authors studied that the G-ECDM process is better than the ECDM process for machining particulate reinforced metal matrix composites; the tool electrode is coated with a hard reinforcement phase of diamond particles. Higher efficiency of machining and better surface quality can be obtained.

2.3 New Technology Developed in ECDM Machining Process

Chak and Rao [14] the authors investigated that to dril deep holes in ceramics pulsed DC and abrasive rotary electrode is used, which is resulted in improved quality of holes produced.

Coteata et. al. [18] the authors designed crank mechanism which is attached to ECDM process in short explaining that some geometrical considerations which permit to conclude that the material removal rate depends on the motion and on dimensions of crank mechanism elements.

The influence of the input parameters on the axial electrode, tool wear and on the drilling speed are controlled, a device for electrochemical discharge drilling was designed and made.

Chih et. al. [19] the authors used magneto hydrodynamic (MHD) convection to enhance electrolyte circulation, applied to the ECDM process to upgrade the accuracy and efficiency of machining. The MHD convection made the electrolyte to move, thus increasing circulation of electrolyte by using MHD authors achieve micro-holes in glass with a depth of 450 μm are drilled in less than 20 sec.

Mochimaru et. al. [20] the authors studied about feedback circuit for machining stop system and two-step machining which were developed to reduce the smallest diameter of micro hole. This system detects signal of electrical current and after penetration it stops machining immediately. The smallest diameter and the exit diameter were reduced by using this system in ECDM device. Initially ECDM process is stopped in the middle depth of the workpiece, and in second step the penetration is completed. From these results, the smallest diameter of micro hole was reduced.

2.4 Optimization Technique Used to Optimized ECDM Parameters

Chenjun et al. [21] in this the authors used a finite element based model of ECDM drilling in less than 300-μm depth, referred to as discharge regime. The fraction of thermal power transferred to the workpiece found 29.1% and machinable depth were found 303 μm.

Phipon and Pradhan [22] the authors used Genetic Algorithm (GA) as optimization technique. . Mathematical models using Response Surface Methodology are used to correlate responses to control parameters. The required responses are minimum radial overcut and minimum heat affected zone while the control parameters are electrolyte concentration, applied voltage and inter electrode gap.

Lijo et al [23] the authors studied the effect of process parameters of ECDM on material removal rate on borosilicate glass. As MRR is found to be nonlinear, RSM is used for optimization of process parameters.

3. CONCLUSIONS

The review of investigation of different authors reveals that, many researchers have attempted primarily glass as the workpiece material the processes are also used for machining of ceramic material also. The review found that the voltage is the most important factor for Material removal rate and which follows electrolyte concentration affecting the MRR and Tool wear and lest important is inter electrode gap factor. The researchers put lots of effort to design and develop different ECDM set ups for getting better machining results & also investigated behaviour of internal structure of ECDM process. The researchers used various optimization techniques to optimize parameters for better performance of ECDM.

4. FUTURE SCOPE

The present work of different authors is an attempt at investigating the research trends in Electro chemical discharge machining. In future the study can be extended for various combinations of tool materials, by changing different electrolytes, with different combinations of optimization tools. The work can also be extended by using different setups of experimentation.

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