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Experimental Study on Machining Parameter of Hard and Brittle Materials using ECDM Setup

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Abstract: **The concept of electrochemical discharge machining (ECDM), also known as electrochemical spark machining (ECSM), was presented for the first time in 1968. Since then, this technology remains a research topic. In the domain of non-conventional machining methods, the electrochemical discharge machining (ECDM) process is emerging as a potential contender for machining of nonconductive, hard, and brittle materials. In the general ECDM process, the gas film forms, and electrical discharge appears at the tool end that is exposed to the electrolyte. In this research work, the ECDM experimental setup was fabricated for machining non-conducting materials. This machining process was used for the machining of silicon carbide which is very brittle and hard in nature. The input parameters considered for the process were selected as voltage, electrolyte concentration, inter-electrode gap whereas MRR, tool surface geography, and heat-affected zone were obtained as response parameters.**

Keywords: **Electrochemical discharge machining (ECDM), silicon carbide, voltage, electrolyte concentration, inter electrode gap, MRR, tool surface geography, heat affected zone.**

I. INTRODUCTION

In modern industries, the technological growth and devolvement of harder machining materials, which discover wide application in automobile, aviation, medical, nuclear reactor, and missile. It is very difficult to find adequate strong and hard tools to machine such hard materials. Therefore, there is a necessity to develop innovative machining technologies to machine these difficult-to-machine materials more precisely. Silicon carbide (SiC) is one of the hardest materials in the world. Due to the various properties of SiC, it is very challenging to machine with the conventional machining process. Hence, the electrochemical discharge machining process can be used to machined SiC material. The electrochemical discharge machining (ECDM) technique is the combination of two manufacturing processes viz. electrochemical manufacturing process (ECM) and electro-discharge manufacturing (EDM) used to machine non-conducting materials. This process at higher electrolyte concentration and higher machining voltage conditions can produce micro-holes with maximum precision. In the present work, an innovative study has been made to improve the effect of process parameters such as voltage, electrolyte concentration, and standoff distance (SOD) of ECDM on material removal rate (MRR), Tool surface geography, and heat-affected zone (HAZ) while machining a silicon carbide work piece.

II. OBJECTIVE

The main objectives of the system are

- To conduct the experiments with different voltage, electrolytes concentration and inter electrode gap by machining silicon carbides.
- Optimization of various process parameters like material removal rate, tool surface geographyand heat effected zone.
- To study the characteristics of machined surfaces and to improve the qualitycharacter of ECDM process.
- To achieve high material removal rate and to reduce tool wear rate and heat effectedzone by using optimization technique.

III. METHODOLOGY

Working: The system consists of a two electrode i.e., tool as cathode (HSS) and an auxiliaryelectrode anode (Graphite) and the workpiece (Silicon Carbide) is kept below the tool electrode.A regulated DC power is supplied between the cathode and anode. Anoptimum gap is maintainedbetween the workpiece (Sic) and the tool (HSS) and electrolyte (NAOH) is passed through the gap. Arduino is programed in such a way that it can machine in X Y and Z direction.

BLOCK DIAGRAM

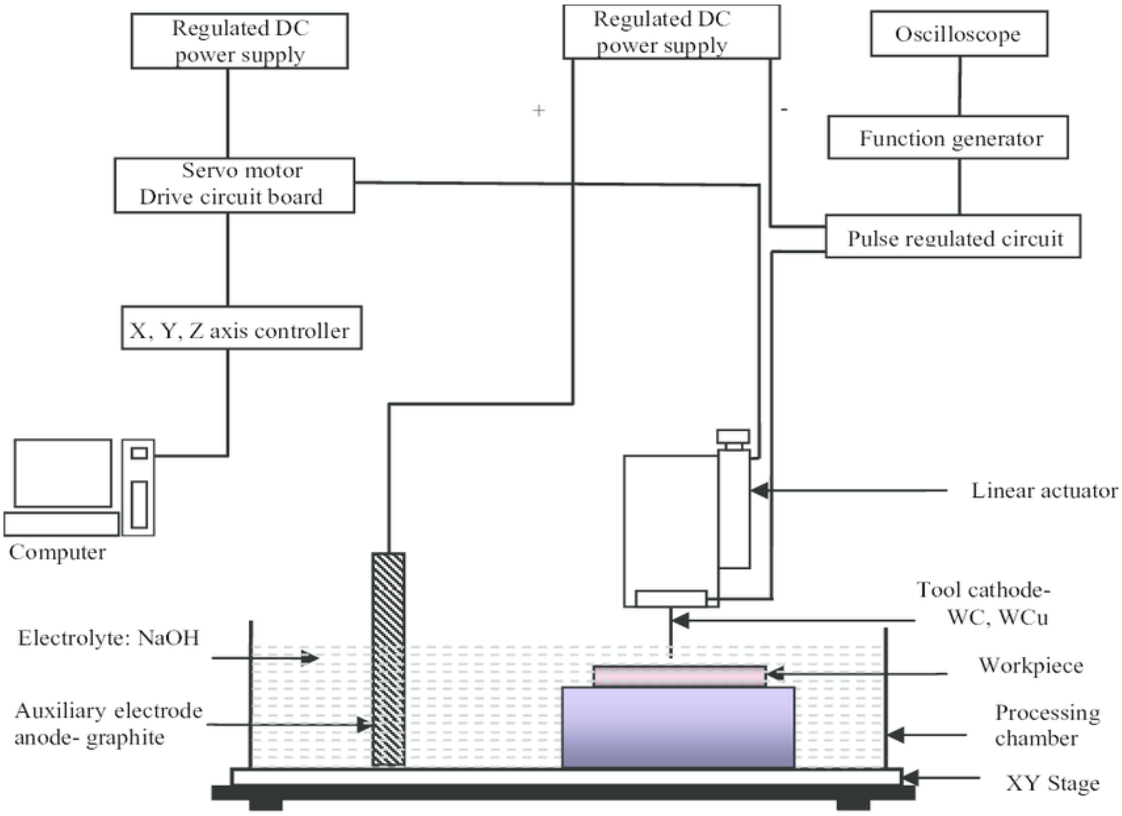

Fig.1 Block Diagram

When theDC voltage supply is applied,electrolysis happens and the insulating layer of the gas bubbles are formed at the tool electrode and the oxygen bubbles at the counter electrode. Material getsremoved due to intensive heating of the workpiece surface in the discharge zone that leads to melting and even vaporization. The local high temperature accelerates the contribution ofchemical etching in this sparking/discharge zone. The electrochemical reaction on the cathode leads to hydrogen gas generation and theelectrochemical reaction on anode electrode leads to oxygen gas generation. These reactions areas below:

$$2H_2O+2e^- \longrightarrow 2(OH^-)+H_2\uparrow \quad \text{(OnCathode)}$$

$$4(OH^-) \longrightarrow 2H_2O+O_2\uparrow+4e^- \quad \text{(OnAnode)}$$

Enhancement of metal removal: Performing of a machining process can be primarily defined by its “metal removal rate”. In ECDM the process performance is dependent on various important parameters they are as follows

1. Enhancing of chemical etching
2. Effect of tool electrode shape
3. Effects of tool electrode rotation
4. Effect of voltage
5. Effect of electrolyte concentration
6. Effect of tool feed rate

IV. OUTCOMES

1. The removal of the work material is high i.e., high MRR.

2. Due to the difference in the ratio of electrolyte and voltage feed drilling tool surface geography of the tool reduces.

3. Use of analyzed electrolyte concentration along with tool feed rate improvement in the surface finish can be obtained.

4. Analysing stand of distance (SOD), use of abrasive tool electrode reduction in the Heat effected zone area at hole entrance and exit, improve the surface quality and roundness of the hole can be obtained.

V. CONCLUSION

The ECDM setup was built, designed, and manufactured for machining non-conducting materials. In this work, two output responses are investigated viz. Material Removal Rate (MRR), Tool face Geography and Heat Affected Zone by` considering the three input factors such as voltage, electrolyte concentration, and Stand of Distance. The experimental work was carried out using the ECDM process on silicon carbide material using High-Speed Steel as a cathode electrode. From the current experimental observations, it can be concluded that the electrolyte concentration was the most significant factor for the Material removal rate and Heat affected zone followed by voltage and inter-electrode gap.

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