

INVESTIGATION OF MICRO-ELECTRO DISCHARGE MACHINING OF STAINLESS STEEL

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ABSTRACT

In micro-electro discharge machining (micro-EDM), electrodes plays important role during machining operation. The tool electrode should possess the desirable properties like easy machinability, low wear rate, good conductor of electricity and heat, cheap and readily available. Present paper deals with comparative investigation of machining characteristics such as MRR, TWR, OC, MT and Taper during microhole drilling in micro EDM on AISI 304 stainless steel material using copper and brass electrodes using de-ionized water as dielectric.

Furthermore, surface characteristics and entry and exit diameter of machined microholes have also been investigated through SEM micrographs. Results from a thermal finite element analysis are also presented to show how the thermal action of the micro-EDM process affected the surface integrity of machined workpiece. The results of the thermal finite element analysis show high temperature gradient zones in a machined workpiece. Thermal is performed in this study using the commercial FEM package ANSYS 11.0.

Key Words: Micro EDM, SS – 304, MRR, TWR, OC, MT

INTRODUCTION

Non conventional machining processes are now gaining in popularity, since these processes can machine many complex and precise 3D shapes using simple shaped tools. In non conventional machining processes, work piece surface modifications can be well controlled and highly accurate geometric predictions can also be made. Therefore, in the area of precision engineering, many components for the manufacturing, telecommunications and information industries can be fabricated with high accuracy using Non Conventional methods.

- **NON-CONVENTIONAL MANUFACTURING PROCESSES**

Non conventional manufacturing processes are defined as a group of processes that remove excess material by various techniques involving mechanical, thermal, electrical or chemical energy or combinations of these energies but do not use a sharp cutting tools as it needs to be used for tradi

tional manufacturing processes.

MICRO ELECTRICAL DISCHARGE MACHINING (MEDM)

Whenever sparking takes place between two electrical contacts a small amount of material is removed from each of the contacts. This fact was realized and the attempts were made to harness and control the spark energy to employ it for useful purpose, say, for machining of metals. It was found that the sparks of short duration and high frequency are needed for efficient machining. Further, it was also observed that if the discharge is submerged in dielectric, the energy can be concentrated into a small area. A relaxation circuit was proposed in which electrodes are immersed in the dielectric like kerosene, and are connected to the capacitor.

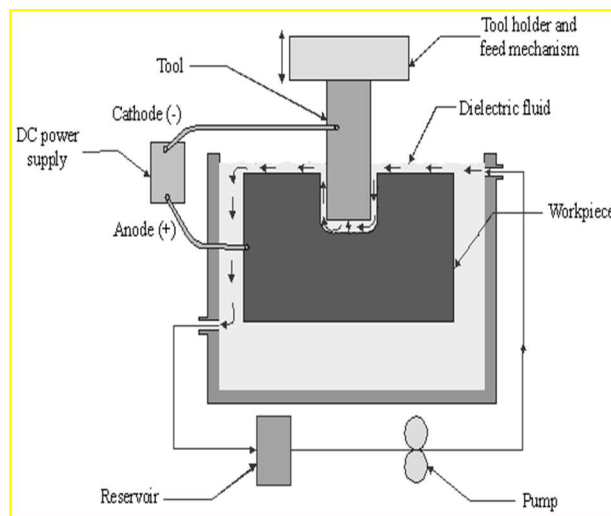


Fig.1 Schematic Representation of an EDM machine arrangement

WORKING PRINCIPLE OF MEDM:

Micro EDM is a thermoelectric process in which heat energy of a spark is used to remove material from the workpiece. The workpiece and tool should be made of electrically conductive materials. A spark is produced between the two electrodes (tool and workpiece) and its location is determined by the narrowest gap between the two. Duration of each spark is very short. The entire cycle time usually few micro-seconds (μs). The frequency of the sparking may be as high as thousands of sparks per second. The area over which a spark is effective (or spark radius) is also very small. However, temperature of the area under the spark is very high. As a result, the spark energy is capable of partly melting and partly vaporizing material from localized area on the both the electrodes. The material removed in the form of craters which spread over the entire surface of the workpiece. Finally, the cavity produced in the workpiece is approximately replica of the tool. To have machined cavity as replica of the tool, the tool wear should be zero. To minimize wear of the tool the operating parameters and polarity should be selected carefully.

EDM MACHINE:

EDM is one of the most popular non-traditional machining process used in various industries. Any micro EDM machine tool has four major components, viz power supply, dielectric system, tool (electrode) and workpiece, and servosystem.

- 1 Power Supply
2. Dielectric System
3. Electrodes
4. Servo Mechanism

- **PROCESS PARAMETERS**

1. Pulse on time (Ton):
2. Pulse off time (Toff):
- 3 Inter Electrode Gap (IEG):
4. Duty cycle:
5. Intensity (I):

METHODOLOGY

MACHINING CONDITIONS AND EXPERIMENTAL METHOD:

Experimentations have been performed on a traditional drilling EDM set-up (manufactured by ELECTRONICA, India). The following Figure shows the photographic view of micro-EDM set-up. As the micro-EDM performances are affected mostly by peak current (I_p) and pulse-on time (T_{on}) [2] during machining of stainless steel AISI 304, so influence of these predominant parameters were considered as varying parameters. To machine through-hole drilling of diameter 500 μm on a stainless steel plate, The experimental scheme has been designed based on two input factors, i.e., peak current (I_p), and pulse-on-time (T_{on}) having three levels, and the corresponding machining performances were recorded and used for analysis.

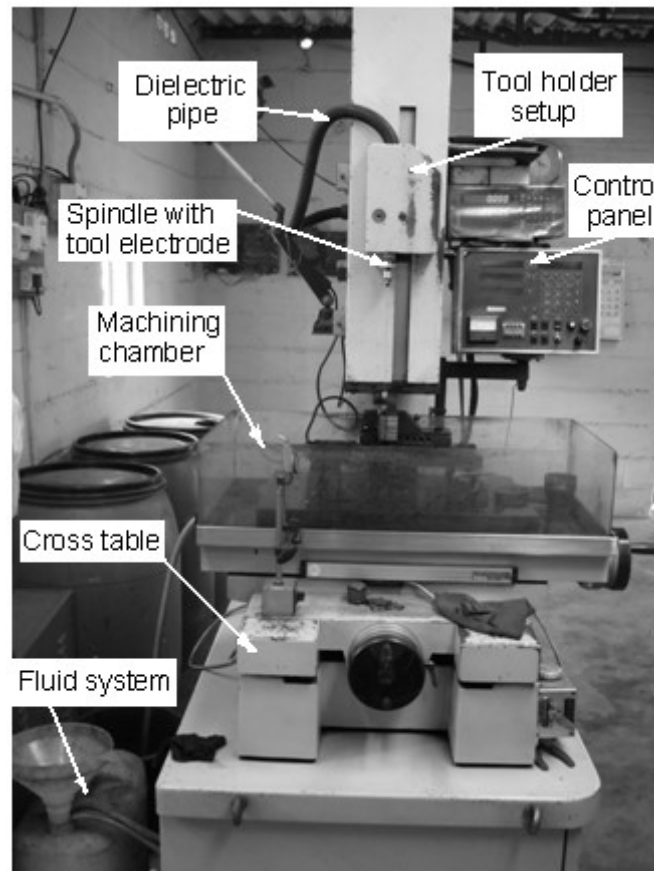


Fig.2 EDM machine installed at the A1 EDM TOOLS

RESULTS AND DISCUSSIONS:

Micro-EDM process criteria during micro-hole generation on AISI 304 were measured after each set of experimental run based on planning. The measured performances criteria of the micro-EDM were metal removal rate (MRR), tool wear rate (TWR), overcut (OC) and taper. According to methodology, the characteristic that has a larger value represents the better machining performance, such as metal removal rate (MRR) is termed as “larger-the-better” type problem. On the other hand, for better economy and precision manufacturing. The objective is to minimize the TWR, OC, and taper. So, their smaller values indicate the better machining performance and they are referred to as “smaller-the-better” type problems.

CONCLUSION:

The influence of machining process parameters such as peak current, pulse-on-time, and gap voltage on performance criteria like MRR, TWR, overcut (OC), and taper while machining AISI 304 stainless steel by EDM machining technique have been examined. From the set of experimental investigations, the following outcomes are observed during micro-hole generation on AISI 304 stainless steel.

- I. Pulse on time (T_{on}) is the most influencing factor of micro-EDM process and has the maxi

imum percentage of contribution on MRR, OC, and taper whereas peak current (I_p) has the maximum percentage of contribution on TWR during micro-drilling of stainless steel by electro discharge phenomenon.

- II. In case of MRR, the brass tool exhibits better machinability than copper, though it consumes more amount of electrode materials due to its high melting point. Metal removal rate (MRR) and tool-wear rate (TWR) are found to increase monotonically with the increase in peak current (2 A to 4 A) due to higher discharge energy at higher value of peak current (I_p). Also they (MRR and TWR) are found to increase when pulse on time (T_{on}) increases from 100 μ s to 200 μ s.
- III. Brass electrode was found to be better capable of producing burr-free and less heat affected microholes with good surface quality and lower taper compared to copper electrode with low peak current. At the same level of discharge energy, the copper was found to produce relatively broader craters on the machined surface. At high discharge energy, deeper and larger discharge craters are induced in the workpiece surface, which piles up and causes unusual secondary sparking.
- IV. It has been found that with the increase of discharge energy (100 μ s to 200 μ s and 2 A to 4 A), the overcut increases in both tool materials. At lower discharge energy, smaller amount of material is removed per discharge producing smaller craters, which in turn results in low overcut.
- V. In this research study, the authors have studied the time required to drilling a particular thickness of the workpiece (5mm) by varying two most effective process parameter, i.e., peak current and pulse on time. It has been found that using copper electrode results in longer machining time than using brass electrode.
- VI. Based on the finite element analysis procedure, the temperature distributions in stainless steel AISI 304 were obtained. It has been found that with the increase of peak current (I_p) and pulse on time (T_{on}), the temperature increases in workpiece. It has been observed that at increases of pulse on time, the temperature increases. The maximum temperature is observed near spark area is 8550 K.

In this project, the comparative investigation of machining characteristics such as MRR, TWR, OC, MT and Taper during microhole drilling in micro EDM on AISI 304 stainless steel material using copper and brass electrodes using de-ionized water as dielectric and the thermal finite element analysis shows high temperature gradient zones in a machined workpiece. It can be concluded from this investigation that there is a great influence of using brass electrode for drilling performance characteristics in micro-EDM during microhole generation on AISI 304 stainless steel.

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