iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: VI Month of publication: June 2021

DOI: https://doi.org/10.22214/ijraset.2021.35850

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

An Investigation of Milling using a Combination of Electrical Discharge (ED) and Electrochemical (EC) Machining Techniques

Vishal Gandhi[1], Sanjeev Kumar Sarswat[2]
[1, 2]*Vivekananda College of Technology and Management, India*

Abstract: This study investigate the machining operation perform by the combination of EDM and ECM process. Since in case of EDM the surface finish obtain is not as good as required so next machining operation is done by ECM. As we have, in EDM metal is removed from the workpiece through spark erosion and in ECM metal removed by anodic dissolution in the electrolyte. Both the process is done simultaneously in single machine changing the potential on anode and cathode and the medium. The EDM surface of 1µ mm Ra is improved to 0.2µ mm Ra by applying ECM. The surface roughness of a machined hole is improved to 0.07 mm Ra by applying 2 min of ECM lapping. Both the process is done simultaneously.

I. INTRODUCTION

More than 60 years have passed since Russian scientists "Lazarenkos and Zolotykh utilised the impact of electrical discharges to remove material from a metallic component with the assistance of a young researcher named Zolotykh. Electrical discharge machining (EDM) is by far the most common nonconventional material removal method today, having applications in a wide range of sectors including die and moldmaking, aerospace, automotive, medical, micromechanics, and more. Electric discharge machining (EDM) is a nontraditional manufacturing method that utilises the heat energy of a spark to mill both electrically conductive and non-conductive components, independent of work material hardness. In the meso and micro production of difficult to process complicated shaped dies and moulds, as well as essential components for automotive, aerospace, medical, and other industrial applications, EDM has therefore become an important machining alternative. The same tool is utilised for work material in combined EC and ED machining. EDM offers a number of benefits when it comes to creating tiny holes and micro moulds. Due to the random distribution of spark, the EDM surface is typically rough, with a heat-affected layer and many tiny fractures. The research's ultimate goal is to build an automated system that can provide a flawless EDM surface finish. Small components and moulds will be used with the system. In addition, the designed machine tool includes five cutting heads that may be switched out when the machining technique is changed [1]. These heads minimise work piece setup errors by performing several machining techniques on the same machine tool, from rough machining to finishing. Second, sophisticated machining technique has been created using EDM and electrochemical machining (ECM) [2]. Because ECM has features that may create smooth and stress-free surfaces without onerous monitoring and/or regulating of the machining condition [3,4]", it is used to complete an EDM surface, as illustrated in set up fig.1. Furthermore, EDM and ECM utilise the same machining fluids and electrode [5].

II. EXPERIMENTAL SETUP

This study uses the experimental setup shown in Fig. 1.

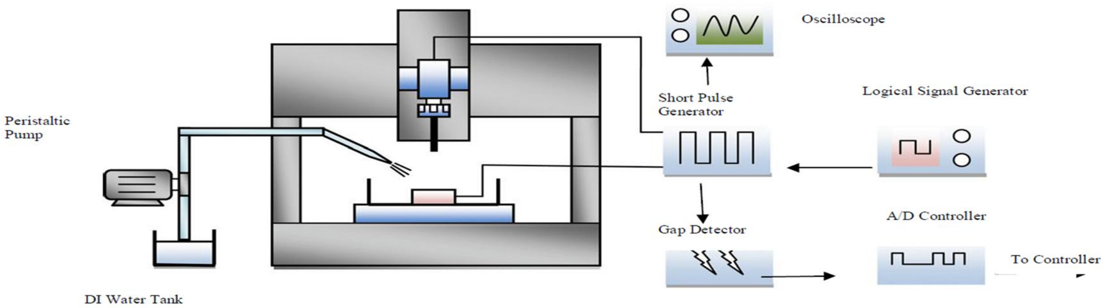

Figure 1.Experiment apparatus used in ED/EC combine machine

A. *Machine Tool*

The tests were carried out using the "DT-110, a specifically designed integrated multi-process machine tool. It has a maximum travel length of 200 mm (X-axis) by 100 mm (Y-axis) by 100 mm (Z-axis) (Z-axis). For all axes, the solution is 0.1 mm and the repeatability is 1 mm".

B. *Deionised Water Supply*

The deionised water utilised in this research has a low resistivity "(from 0.1 to 0.5M cm) to aid electrochemical reactions in the combined ED/EC machine. It was kept in a plastic tank to keep its quality from deteriorating. A peristaltic pump was used to pump it to the milling zone during the operation". The Alpha RES-1000 resistivity metre was used to monitor the pump and the resistivity of deionized water.

C. *Electrode And Work Piece Material*

To reduce electrode wear, "the cylindrical electrode was constructed of tungsten, which has a high melting point and strong heat conductivity. There are two sizes used: 500 and 75 mm. The tests were carried out on SUS304 stainless steel with a thickness of 100 mm". Table 1 lists the characteristics of electrode and workpiece materials.

D. *In-House Developed Short Pulse Generator*

To localise material disintegration, "the pulse generator must be capable of producing brief voltage pulses. Although most commercial pulse generators can produce high frequencies in the tens of megahertz range, the output voltage is restricted to approximately 15V and only for 50 impedance. As a result, a specifically built brief pulse generator was created. The pulses supplied to the micro-EDM process are controlled by a high frequency switching MOSFET". The logic signal from the Tabor WW2571 function generator powers it.

III. MACHINING PROCEDURES AND CONDITIONS

Table1. Basic machining condition in micro-EDM.

Open voltage	250V
Servo reference voltage	180V
Discharge current	0.21A
Discharge duration	5μs
Pulse interval time	10μs
Capacitance(1000pF)	71
Polarity	Positive
Diameter of electrode	Φ 0.11mm
Rotation of electrode	2000rpm

Table.2. Basic machining condition in micro-ECM.

Pulse-on time	580ns
Duty ratio	1:2
Frequency	1MHz
Average current density	12.7 A/mm^2
Tool feed rate	1-20μm/s
Initial machining gap	10-20μm
Electrolyte concentration	13 wt% $NaClO_3$, 1 wt% EDTA
Polarity	Positive

IV. RESULT AND DISCUSSION

The machining voltages in the "micro-ECM finishing process were set at 8 V, 9 V, and 10 V, respectively, to study the impact of machining voltage on machining performance. The tool feed rate is 10 m/s, and the machining gap between electrode and workpiece is maintained at 10 m. SEM images of a micro-EDM shaped and micro-ECM completed cavity at various voltages are shown in Fig. 2. Figure 3 shows the MRR of micro-EDM roughing and ECM polishing. Micro-EDM roughing and ECM finishing take 80 minutes and 8 minutes, respectively. Under 10 V, 9 V, and 8 V, the depth of the EDMed square cavity is 0.185 mm, while the depth of the ECM completed is 0.197 mm, 0.189 mm, and 0.185 mm, respectively.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

After micro-EDM roughing, the cavity length and breadth are 0.55 mm and 0.565 mm, respectively. The square cavity's objective width is 0.5 mm, and its depth is 0.2 mm. The electrode has a diameter of 0.11 mm. As a result, the micro-EDM single-side discharge gap is about 25 m. In addition, micro-ECM finishing will eliminate 15 m of machining allowance in depth". It clearly demonstrates that the micro-ECM final surface is extremely smooth while cutting at 10 V.

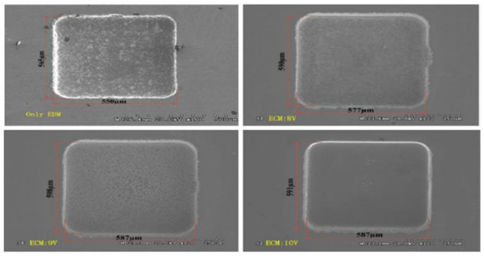

Figure2. SEM photos of EDMed and combined milled cavity under different voltages.

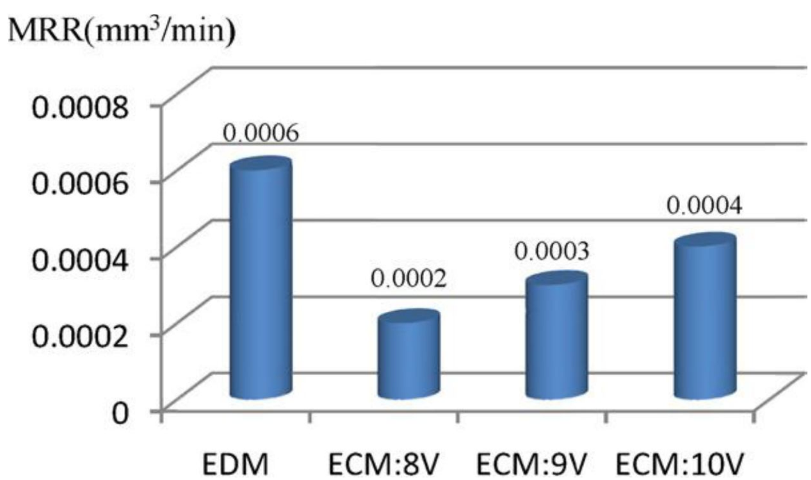

Figure.3.Material removal rate (MRR) for micro-EDM and ECM finishing.

A. Effect Of Electrode Feed Rate On Machining Performance

The tool feed rate was varied from 1 to 20 m/s to see how it affected machining performance. The initial bottom machining gap is 10 m, and the machining voltage is 10 V. Figure 4 shows the size of each cavity in the X, Y, and Z directions after micro-ECM completion.

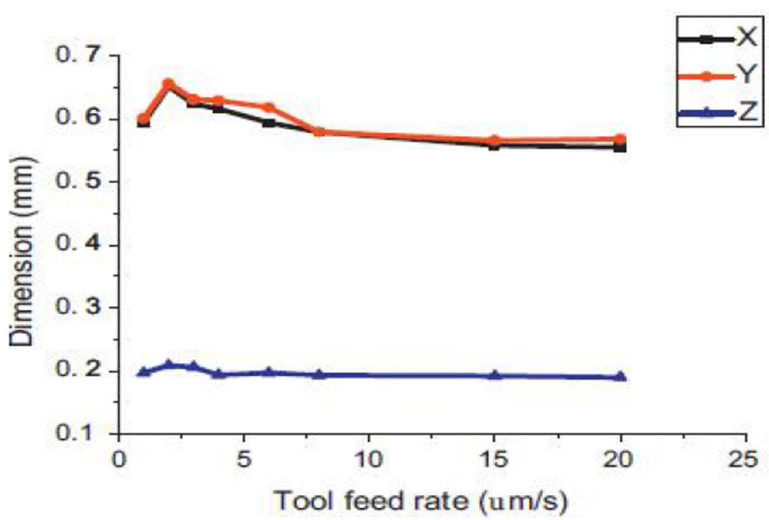

Figure 4. Size of micro-ECM finished cavity (voltage: 10 V, machining gap: 10 μm).

B. Tool Path Model

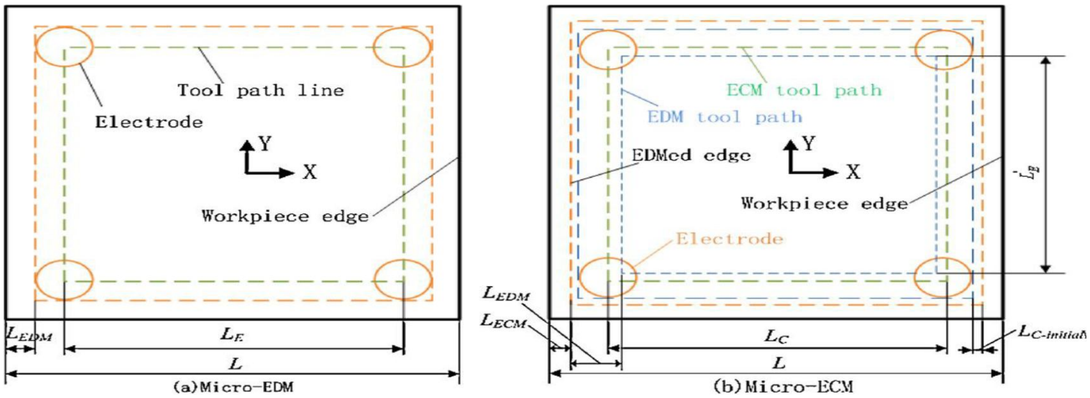

Figure 5. Tool path model for micro-EDM and micro-ECM

The electrode tool feeding length for “micro-EDM and combined milling is varied in order to achieve the same component size. The discharge gap of micro-EDM and ECM, according to the aforementioned tests, is 50 m and 31.5 m, respectively. Thus, for micro-EDM, the electrode feeding length in the X and Y directions may be given as Eq (4)

LE = L - 2LEDM (4)

Where LE denotes the electrode feeding length in both X and Y directions; L is the goal workpiece width, which is 0.5 mm; LEDM denotes the single side EDM discharge gap, which is 25 m based on the previous tests; and is the electrode diameter, which is 0.115 mm. In the combined milling process”, the electrode feeding length in X and Y directions for micro-EDM roughing and micro-ECM finishing may be stated as eqs. (5) and (6):

LE’ = L – 2LEDM - 2LECM (5)

LC= L – 2LEDM – 2LC-initial (6).

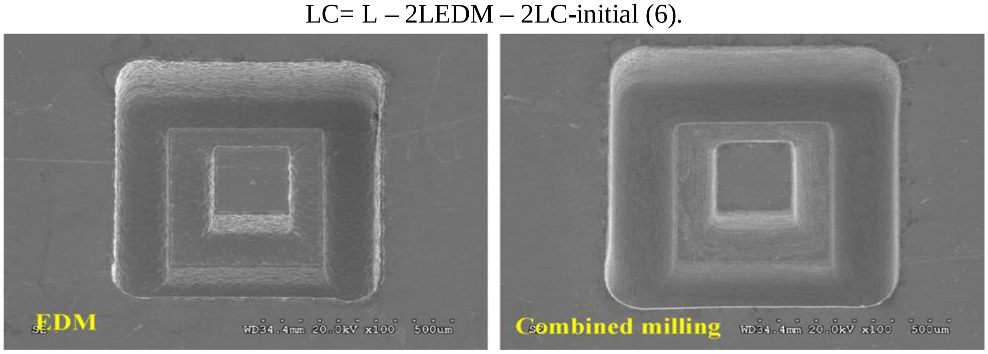

Figure 6. SEM photos of two-layer square column

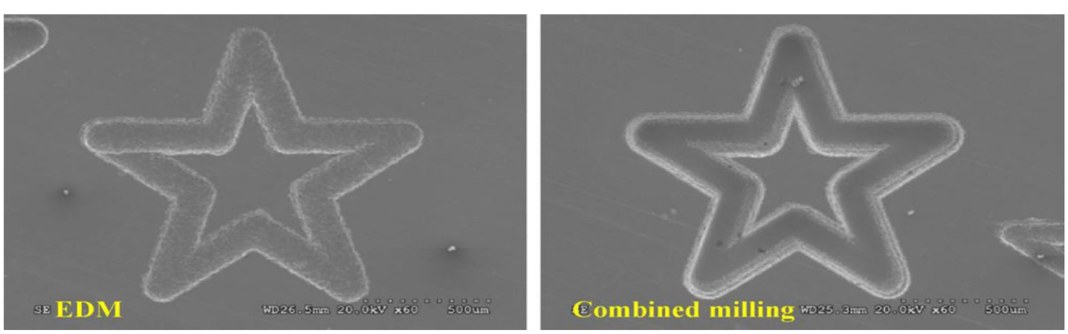

Figure7. SEM picture of the five-pointed star.

where LE is the electrode feeding length for micro-EDM roughing, LECM is the ECM machining gap, which is 15.75 m, LC is the electrode feeding length for micro-ECM finishing, and LCinitial is the initial electrochemical machining gap, which is 10 m, and LCinitial is the initial electrochemical machining gap, which is 10 m.

V. CONCLUSION

The combined micro-EDM roughing and ECM finishing milling was shown and successfully completed on the same machine tool with the same electrode. “The best machining settings are 10 m, 10V, and 10 m/s for initial machining gap, voltage, and tool feed rate, respectively.

Firstly The roughness shaped surface, which was 0.707 m Ra before micro-EDM, was reduced to 0.143 m Ra after micro-ECM completion. All burrs, the recast layer, craters, and micropores are removed from the surfaces using the Micro-ECM procedure. As a result, the workpiece's surface quality and mechanical characteristics are both enhanced at the same time. The greater the surface quality and the form and size of the workpiece, the quicker the electrode feed rate. Machining conditions and a proper tool path are in charge of dimensional accuracy.

Because of the high processing energy and high tool feed rate, machining efficiency is significantly enhanced as compared to traditional micro-ECM. This technique of accurate combined milling is helpful for cutting 3D metallic microstructures”. It expands the scope of micro-electrochemical machining while also improving the workpiece's machining performance and mechanical properties.

REFERENCES

[1] Tsuneo Kurita, Mitsuro Hattori, A study of EDM and ECM/ECM-lapping complex machining Technology, International Journal of Machine Tools & Manufacture 46 (2006) 1804–1810.
[2] T. Kurita, S. Watanabe, M. Hattori, Study of Electrodischarge and Electrochemical Micro Machining Technology— Environmentally Conscious Machining with Hybrid Micro Machine Tool, in: Proceedings of the International Workshop on Environment Benign Manufacturing, 2001, pp.65–72
[3] T. Sato, Electrochemical machining and chemical machining, Asakura Publishing Company, 1970 (in Japanese).
[4] K. Chikamori, Possibilities of Electrochemical Micromachining, International Journal of Japan Society for Precision Engineering 32 (1998) 37–42.
[5] Zhaoqi Zeng, Yukui Wang, Zhenlong Wang, Debin Shan, Xiaolong He,A study of micro-EDM and micro-ECM combined milling for 3D metallic micro-structures, Precision Engineering 36 (2012) 500– 509.
[6] M.P. Jahan, M.Rahman, Y.S.Wong, A review on the conventional and micro-electrodischarge machining of tungsten carbide, International Journal of Machine Tools & Manufacture 51(2011)837–858.