DEVELOPMENT OF ECDM SETUP AND STUDYOF MACHINING PARAMETERS ON DENTAL IMPLANTS AND NON-CONDUCTIVE MATERIALS

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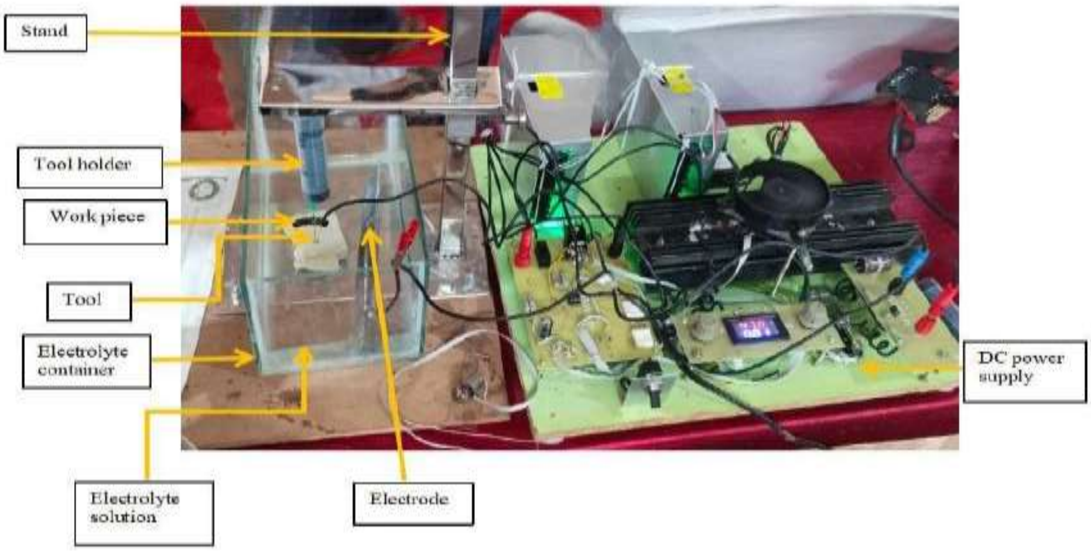
Introduction:

1. Electrochemical Discharge Machining (ECDM) is an advanced hybrid manufacturing process that combines the principles of Electrical Discharge Machining (EDM) and Electrochemical Machining (ECM). In this project, the focus is on the development of an ECDM setup and the investigation of machining parameters for processing dental implants and other non-conductive materials.
2. ECDM is particularly suitable for machining materials such as bioceramics, glass, and composite biomaterials, which are widely used in dental implant applications but are difficult to machine using conventional methods due to their hardness and brittleness. The process integrates electrochemical reactions with spark discharge phenomena, enabling effective material removal even from electrically non-conductive surfaces.
3. When a high voltage is applied between the tool electrode and the workpiece immersed in an electrolyte, a gas film is formed around the tool. This leads to spark generation, which produces localized thermal energy (similar to EDM), while simultaneous electrochemical reactions (similar to ECM) contribute to material removal. This hybrid mechanism allows precise machining with controlled surface characteristics.
4. In this project, the developed ECDM setup is used to study the influence of key machining parameters such as applied voltage, electrolyte concentration, tool feed rate, and inter-electrode gap on performance measures like Material Removal Rate (MRR), surface finish, and dimensional accuracy. Special emphasis is given to machining features required in dental implants, such as micro-holes, slots, and surface texturing, which are critical for implant performance and biocompatibility.
5. The ability of ECDM to machine complex geometries with minimal tool wear makes it highly suitable for biomedical applications, especially in the fabrication and modification of dental implants. This study contributes to optimizing process parameters and improving machining efficiency for advanced non-conductive biomaterials.

Figure 1:. EXPERIMENT CONDUCTED ECDM PROCESS



Objectives:

1. Design and develop an Electrochemical Discharge Machining (ECDM) setup integrated with an XY positioning table for controlled micro-machining operations.
2. Investigate the machining behavior of Dental Implants and non-conductive materials. (Such as glass, ceramics, etc.) using the developed ECDM system.
3. To analyze the influence of major process parameters (voltage, electrolyte concentration, inter-electrode gap, feed rate, tool material) on material removal rate (MRR) and surface quality.

Methodology:

PREPARATION

- Cut borosilicate glass into equal-sized specimens.
- Clean with distilled water and dry.
- Prepare electrolyte solution at various concentrations.

SET UP CONFIGURATIOIN

- Mount the tool electrode.
- Immerse the tool slightly into the electrolyte.
- Set voltage and tool feed rate as per experimental design.

CONDUCT MACHINING

- Apply DC voltage and initiate machining.
- Record **machining time** and **electrolyte temperature** (if needed).
- Repeat for various parameter settings.

MEASURE MATERIAL REMOVAL RATE

- Measure **initial and final weight** of the workpiece using a precision balance.
- Calculate **MRR** using:

MRR = W1-W2/t

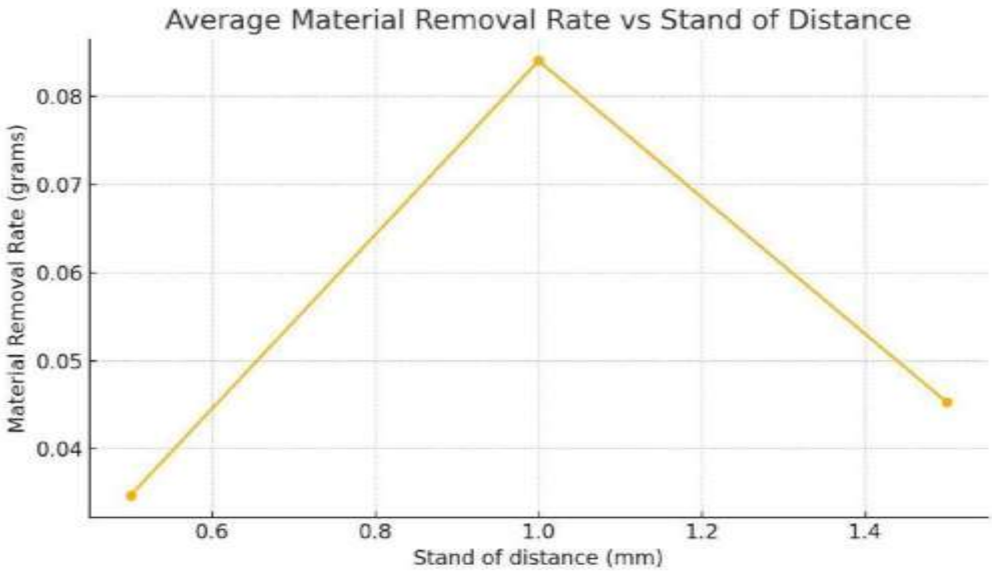
Where, W1 = Initial weight (grams) W2 = After machining (grams)

t = time taken for machining (minutes or seconds)

Result and Conclusion:

SPECIMEN NUMBER	VOLTAGE (V)	STAND OF DISTANCE (mm)	INITIAL WEIGHT (grams) W1	AFTER MACHINING WEIGHT(grams) W2	DIFFERENCE (W1-W2)/time (grams)
MS 45	40	1	5.7824	5.6882	0.0942
MS 47	50	1.5	5.8003	5.7845	0.0158

FIG.2. Material Removal Rat



SPECIMEN NUMBER	VOLTAGE (V)	STAND OF DISTANCE (mm)	INITIAL WEIGHT (grams) W1	AFTER MACHINING WEIGHT (grams) W2	SPECIMEN	TESTED SPECIMEN IMAGE
MS 45	40	1	5.7824	5.6882		
MS 47	50	1.5	5.8003	5.7845		

CONCLUSION

100X MICROSCOPE:

Fig.3, 100x Microscope

SPECIFICATIONS:

SPECIFICATIONS	TYPE
Magnification	100x
Total Magnification	1000x
Numerical Apperture	1.25 - 1.4
Working Distance	0.13 mm or less
Immersion Type	Oil immersion
Cover glass Thickness	0.17 mm
Parfocal Distance	45 mm
Field of view	0.18 mm

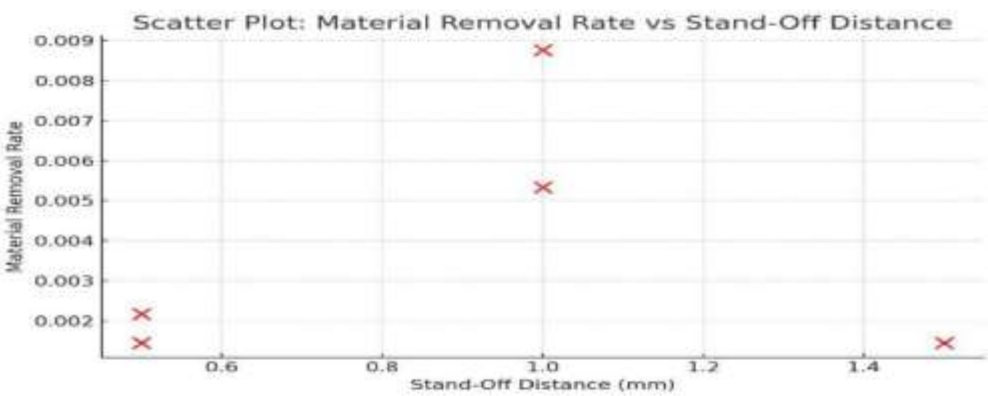
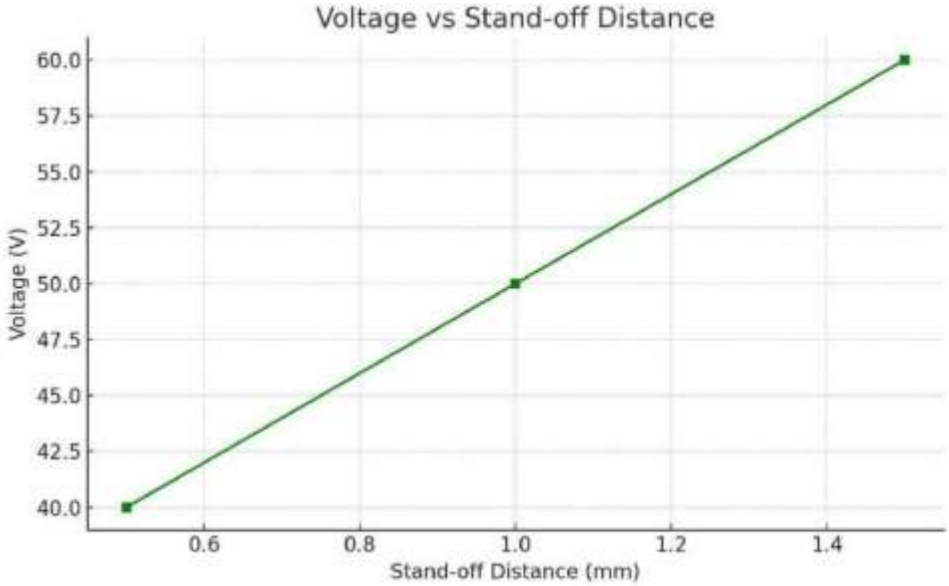


Fig.4. Material Removal Rate Vs Stand Off Distance

Fig.5. Voltage Vs Stand Off Distance



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Future Scope:

The developed setup is used to machine selected non-conductive materials such as glass, ceramics, or similar materials relevant to dental applications. The project also analyzes the relationship between process parameters and machining outcomes to determine optimal operating conditions.

The scope is limited to laboratory-scale experimentation and performance evaluation of the ECDM process. Industrial-scale implementation, commercial production, and long-term clinical testing of dental implants are outside the scope of this project.

The future scope of this project includes:

1. Design and fabrication of an ECDM setup.
2. Machining of dental implant-related and non-conductive materials.
3. Study of machining parameters (voltage, electrolyte concentration, feed rate, etc.).
4. Measurement of MRR, surface roughness, dimensional accuracy, and overcut.
5. Optimization of machining conditions for improved performance.
6. Analysis and comparison of experimental results.
7. Validation of ECDM as a suitable process for machining non-conductive materials.