# ECM PROCESS CHARACTERISTICS

**A PROJECT SUBMITTED IN PARTIAL FULFILLMENT**

**OF THE REQUIREMENT FOR THE DEGREE OF**

**Bachelor of Technology**

**In**

**Mechanical Engineering**


**Submitted by:**

**ANIL KUMAR MEHER**

**ROLL NO. : 10503046**



**Department of Mechanical Engineering**

**National Institute of Technology**

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# CERTIFICATE

This is to certify that the thesis entitled, "**Electrochemical Machining (ECM) Process Characteristics**" submitted by Mr. Anil Kumar Meher, Roll No: 10503046, in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Mechanical Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance .

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma.

Date: 12.5.2009

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2009

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Date: May 12, 2009



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## Abstract:

This paper intends to deal with the process characteristics of ECM and how it is affected by the process parameters. This work shows a study of the intervening variables in electrochemical machining (ECM) of mild steel (C=0.08%, Mn=0.35%, P=0.014%, S=0.018%, Si=0.017%, Fe= rest). The material removal rate (MRR) was studied. Two parameters were changed during the experiments: feed rate and voltage. Sodium chloride solution was taken as electrolyte (100gm/lt). The results show that feed rate was the main parameter affecting the MRR.

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# Chapter 1

## Introduction

# 1. INTRODUCTION –

Electrochemical machining (ECM) is among the well recognized non-traditional manufacturing processes in industry. It is the controlled removal of metal by anodic dissolution in an electrolytic medium in which the work piece is the anode & the tool is the cathode. Different from the other machining processes, in ECM there is no contact between tool and work-piece. The main components of ECM system are a low voltage and high current power supply and an electrolyte. The electrolyte is normally solutions of inorganic salts, like sodium chloride (NaCl) or sodium nitrate ($NaNO_3$).

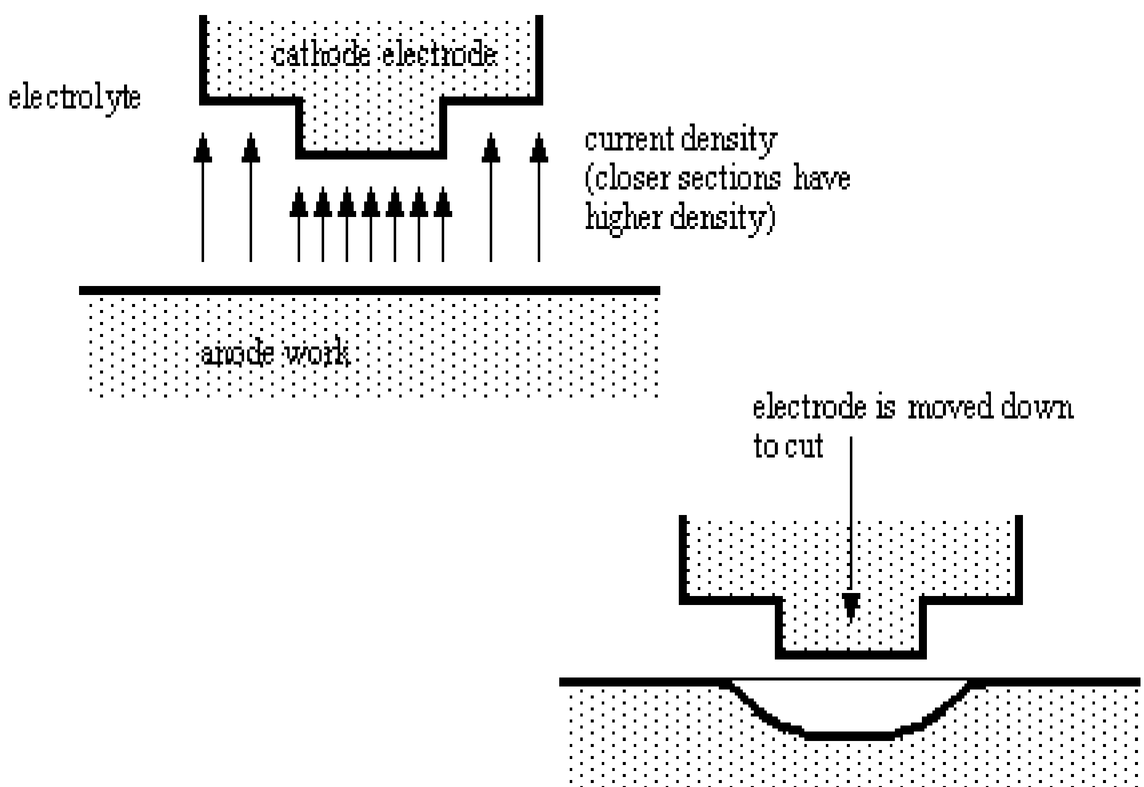


Fig. 1.1.

The chemical reaction between an electrode and the electrolyte leads to electrons being added, or removed from the electrode metal. This addition/subtraction leads to a voltage

potential.

For Iron

$$Fe \Leftrightarrow Fe^{2+?} + 2e^{-?} \qquad V_2 = -0.409V$$

For Copper

$$Cu \Leftrightarrow Cu^{2+?} + 2e^{-?} \qquad V_1 = 0.304V$$

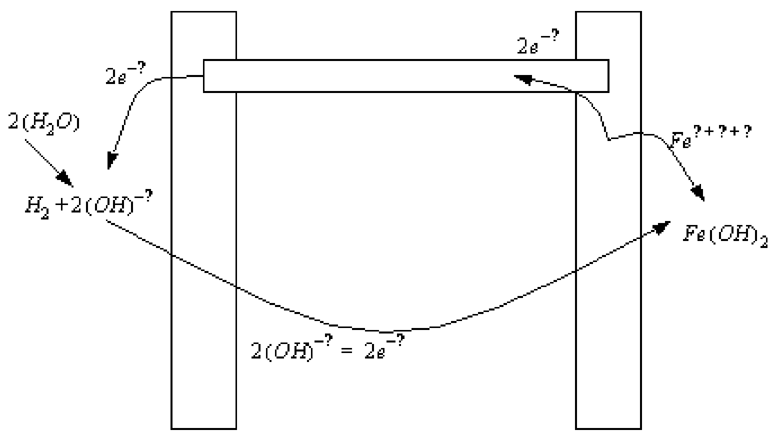


Fig. 1.2

The main purpose of this work is to_show the process characteristics of ECM and how it is affected by the process parameters. This work shows a study of the intervening variables in electrochemical machining (ECM) of mild steel (C=0.08%, Mn=0.35%, P=0.014%, S=0.018%, Si=0.017%, Fe= rest). The material removal rate (MRR) was studied. Two parameters were changed during the experiments: feed rate and voltage. Sodium chloride solution was taken as electrolyte (100gm/l). The results show that feed rate was the main parameter affecting the MRR.

# Chapter 2

## ECM Process Characteristics

## 2. ECM PROCESS CHARACTERISTICS

### 2.1 Material removal rate:

It depends chiefly on feed rates. The feed rate determines the current passed between the work & the tool. As the tool approaches the work, the length of the conductive current path decreases & the magnitude of current increases. This continues until the current is just sufficient to remove the metal at a rate corresponding to the rate of tool advance. A stable cut is then made with a fixed spacing between the work and the tool, termed as the equilibrium-machining gap. If the tool feed rate is reduced, the tool advance will momentarily lag behind, increasing the gap and thus resulting in a reduction of current. This happens until a stable gap is once again established.

### 2.2 Accuracy:

Under ideal conditions & with properly designed tooling, ECM is capable of holding tolerance of the order of .02 mm & less. Repeatability of the ECM process is also very good. This is largely due to the fact that the tool wear is virtually non-existent on a good machine; tolerance can be maintained on a production basis in the region of .02-.04 mm. As a general rule, the more complex the shape of the work, the more difficult is to hold tight tolerances and the greater is the attention required for developing a proper tooling and electrode shape.

### 2.3 Surface Finish:

ECM under certain conditions can produce surface finishes of the order of 0.4µm. This can be obtained by the frontal cut or the rotation of the tool or the work. The important variables affecting the surface finish are feed rate, gap dimension, electrolyte composition, viscosity, temperature & flow. Any defect on the tool will cause machining defects on the surface of the work.

# Chapter 3

## Operating Parameters

## 3. OPERATING PARAMETERS [2]

**The operating parameters which are within the control of the operator and which influence ECM process capabilities can be described as follows:**

i. Feed Rate: A high feed rate results in higher metal removal rate. It decreases the equilibrium machining gap resulting in improvement of surface finish and tolerance control.

ii. Voltage: Low voltage decreases the equilibrium-machining gap and results in better surface finish and tolerance control.

iii. Nature of power supply and machining pulse: The nature of applied power supply may be of two types, such as DC (full wave rectified) and pulse DC. A full wave rectified DC supplies continuous voltage where the current efficiency depends much more on the current density. The efficiency decreases gradually when the current density is reduced, whereas in pulse voltage (duration of 1 ms and interval of 10 ms) the decrease is much more rapid. With decreasing current density the accuracy of the form of the work-piece improves.

iv. Electrolyte type, concentration and flow: ECM electrolyte is generally classified into two categories: passivity electrolyte containing oxidizing anions e.g. sodium nitrate and sodium chlorate, etc. and non-passivity electrolyte containing relatively aggressive anions such as sodium chloride. Passivity electrolytes are known to give better machining precision. This is due to their ability to form oxide films and evolve oxygen in the stray current region. From review of past research, in most of the investigations researchers recommended $NaClO_3$, $NaNO_3$, and NaCl solution with different concentration for electrochemical machining (ECM). The pH value of the electrolyte solution is chosen to ensure good dissolution of the work-piece material during the ECM process without the tool being attacked.

**v.** Size, shape and material of the tool: The tool must match the required shape of the work-piece depending on the material and the profile to be produced. Tool materials used in ECM must have good thermal and electrical conductivity; corrosion resistance must be highly machinable and should be stiff enough to withstand the electrolytic pressure without vibrating.

# Chapter 4

## Experimental Procedure

# 4. EXPERIMENTAL PROCEDURE :

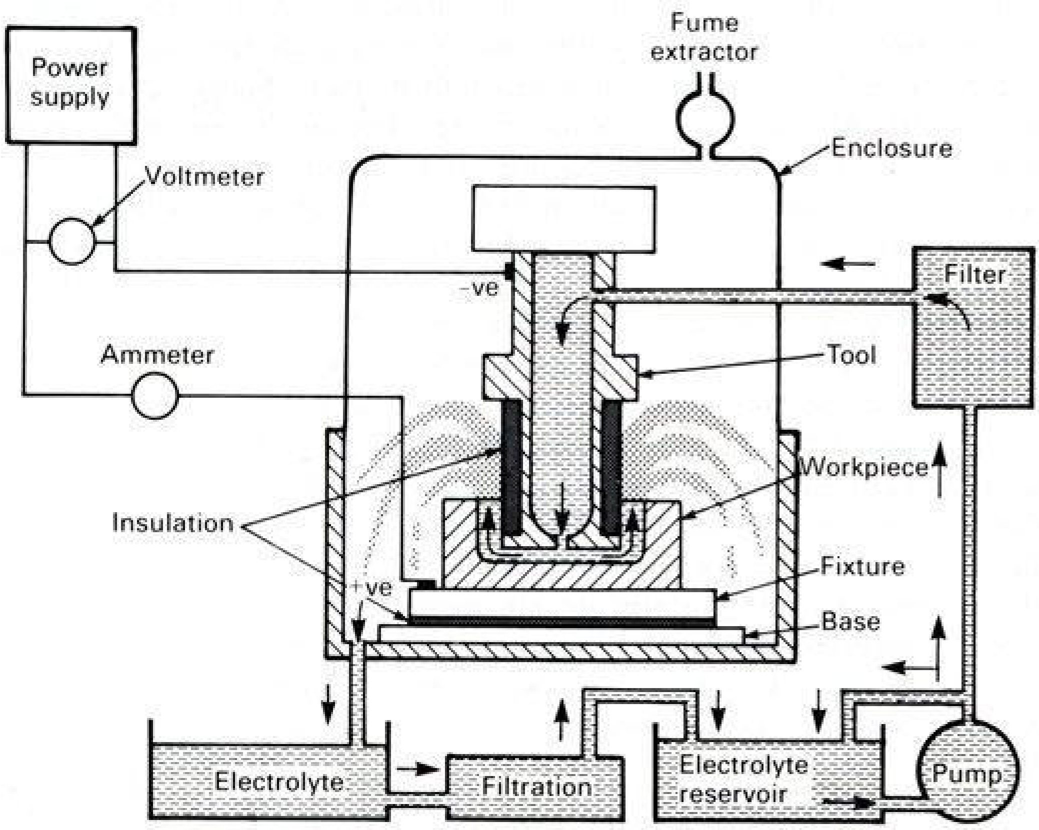


Fig. 4.1 [1]

Fig. 4.1 shows a schematic diagram of the electrochemical machining system used in this work. The work-piece was fixed between two metal sacrifice plates to minimize the over-cut at both sides of the machined hole. During the process, the electrode (tool) makes the feed movement while the work-piece is stationary. The tool material used was copper. The work-piece material was mild steel with the following chemical composition:

(C=0.08%, Mn=0.35%, P=0.014%, S=0.018%, Si=0.017%, Fe= rest).

It was used in sodium chloride solution (NaCl at concentration of 100 g/l). The following equation was used for calculation of the material removal rate (MRR), considering a work-piece density of 7.8 g/cm3.

MRR =

$$Q = \frac{AI}{\rho Z F}\left(\frac{cm^3}{sec\ ?}\right) = \underbrace{\frac{0.1035\times 10^{-2}}{\rho}\left(\frac{1}{\sum_i \frac{x_i Z_i}{A_i}}\right)\left(\frac{cm^3}{A sec\ ?}\right)}_{\text{for alloys}}$$

# Chapter 5

## Results and Discussions

# 5. RESULTS and DISCUSSIONS

| S. no. | Tool feed rate(mm/min) | Voltage (V) | Weight of work-piece(gm) | | MRR |
|---|---|---|---|---|---|
| | | | Initial | Final | |
| 1 | .03 | 10 | 162.045 | 158.935 | 0.3110 |
| 2 | .02 | 10 | 158.935 | 156.847 | 0.2080 |
| 3 | .03 | 15 | 153.335 | 149.798 | 0.3537 |
| 4 | .02 | 15 | 149.798 | 147.145 | 0.2653 |

**Table 5.1**

## 5.1. Analysis of MRR

Table 5.1 shows the general results for MRR, in all cutting. It shows that the MRR was influenced by feed rate. This result was expected because the material removal rate increases with feed rate because the machining time decreases. For this condition, the voltage was 10V and the flow rate of the electrolyte was 250 $h^{-1}$. The electrochemical reactions did not produce the necessary and compatible effects with the increasing feed rate. According to the results, feed rate and the voltage control the MMR.As we can deduce from the graphs, the MRR increases with the Tool Feed Rate as well as the Voltage but it depends mainly on the tool feed rate.

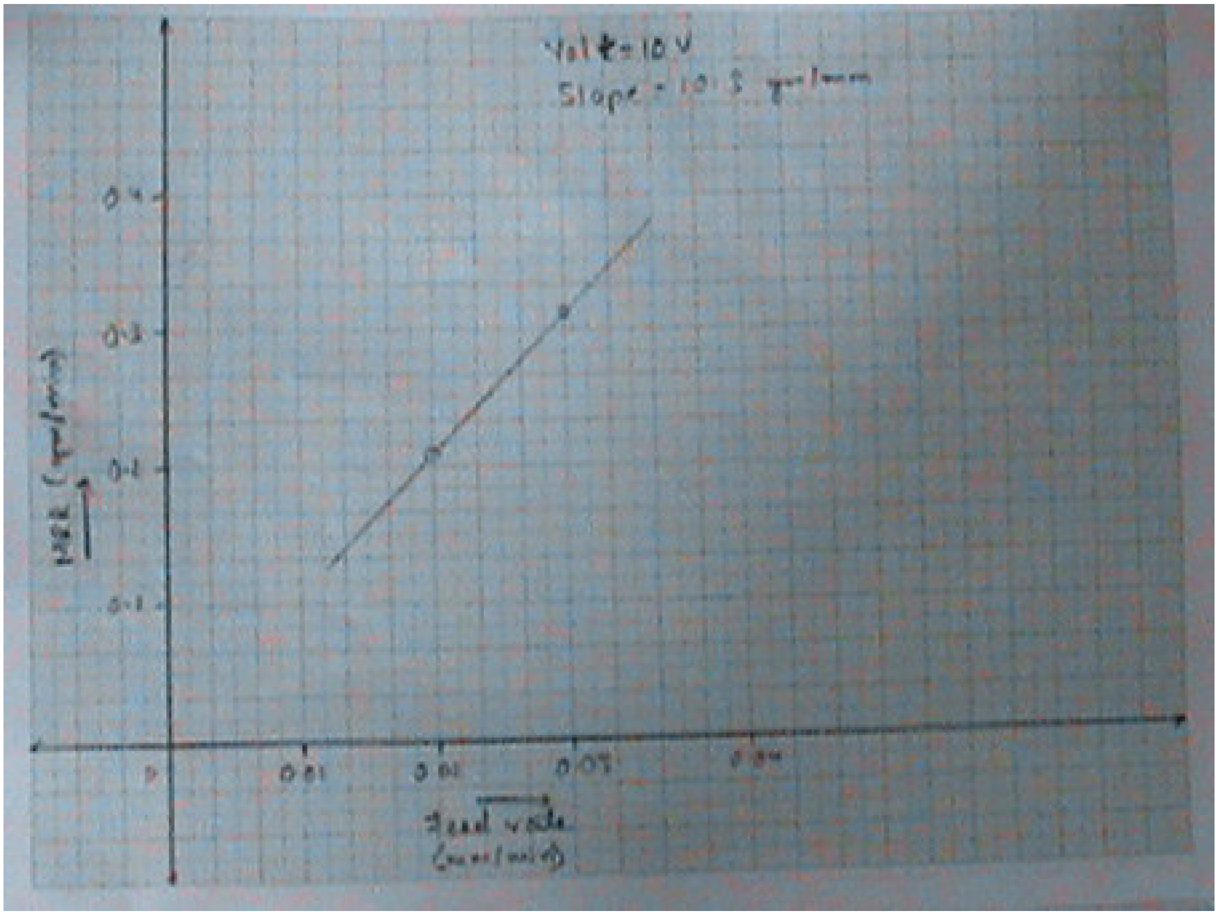

Fig. 5.1 [MRR vs. Tool feed rate (at voltage=10)]

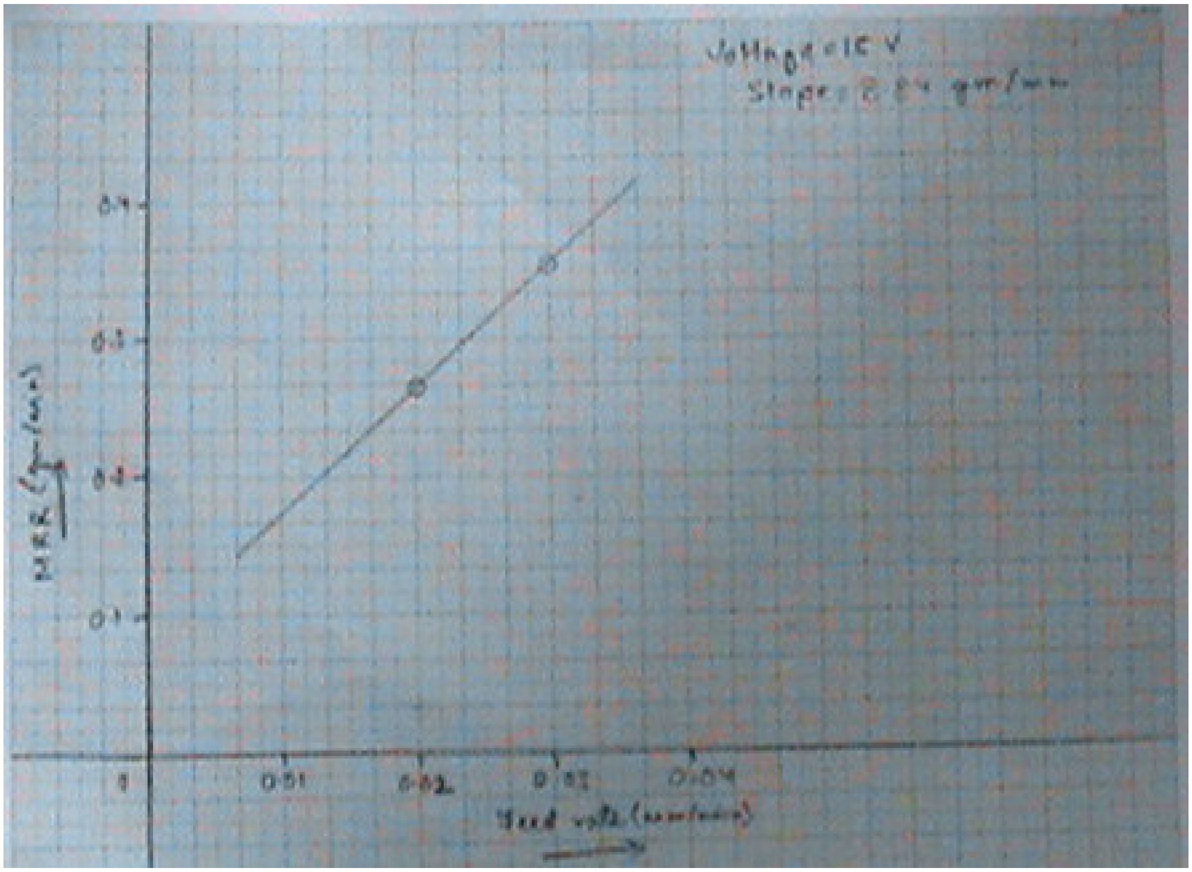

Fig. 5.2 [MRR vs. Tool feed rate (at voltage=15)]

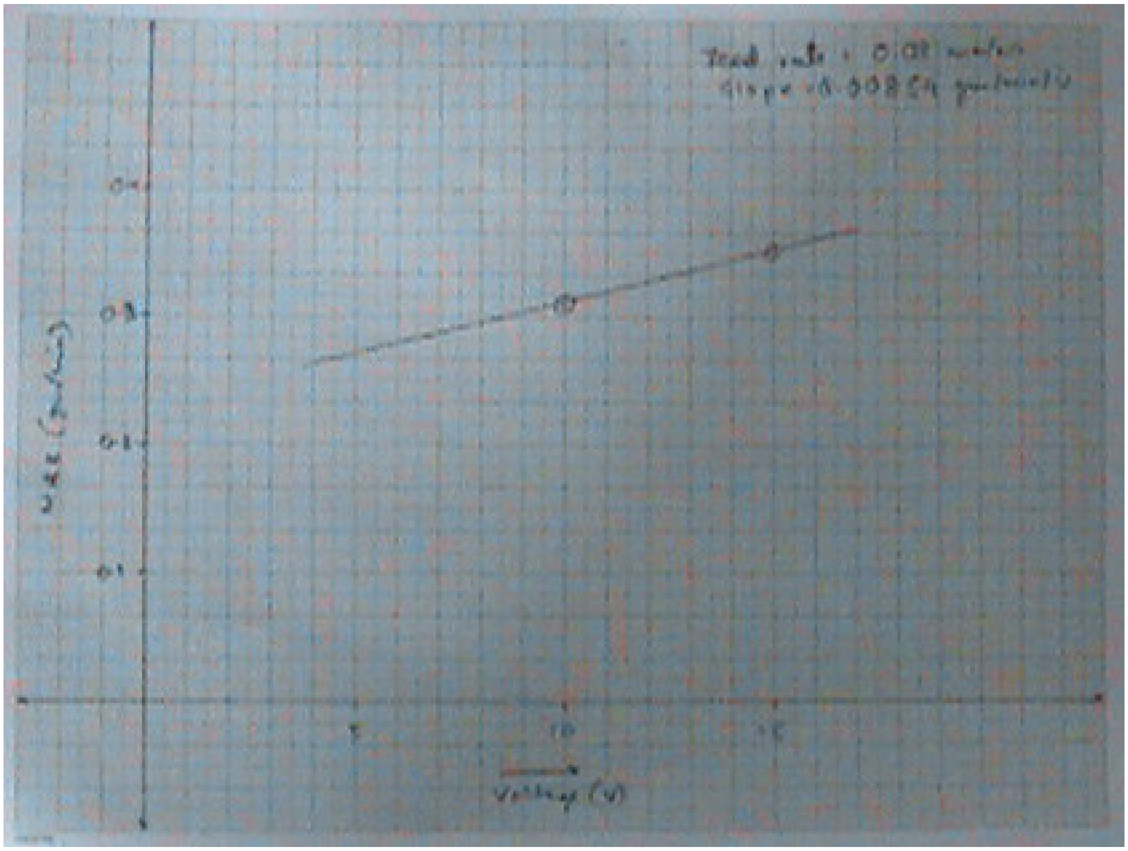

Fig. 5.3 [MRR vs. Voltage (at Tool feed rate=0.02)]

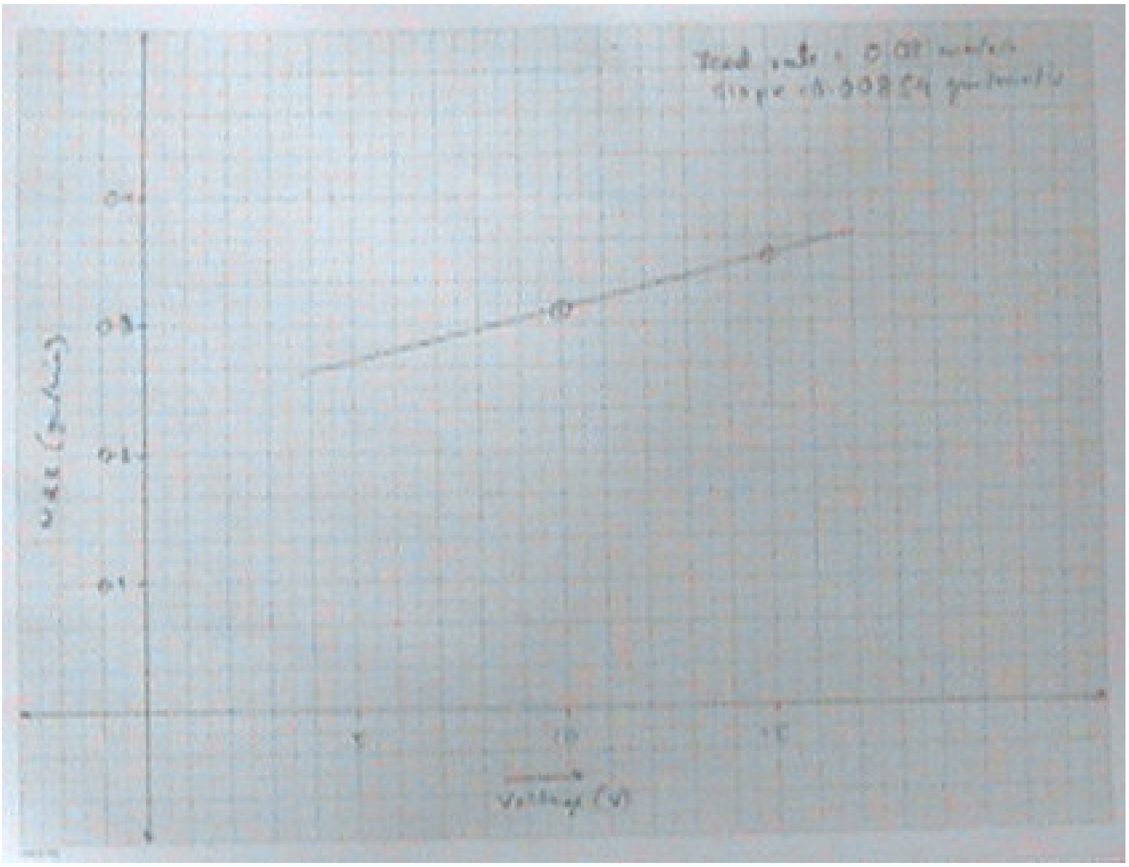


Fig. 5.4 [MRR vs. Voltage (at Tool feed rate=0.03)]

## 6. Conclusions

According to the results obtained in this work, main conclusions that can be withdrawn are:

- The MRR increases with tool feed rate.
- MRR is also related with voltage.

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