

# Selection of Parameters for Electro-Chemical Machining (ECM) using Genetic Algorithm

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**Abstract** - The parameters influence the metal removal rate of any process. The selection of parameters plays a vital role in the process. Therefore, the selection of optimum parameters for electrochemical machining (ECM) is illustrated in this paper. The optimization problem is formulated with the maximization of the material removal rate (MRR) and optimum parameters i.e. electrolyte concentration (C), flow rate (Q), applied voltage (V), and feed rate ( $f$ ) are considered as design variables. The formulated optimization problem is solved using Genetic Algorithm (GA). GA algorithm is coded in MATLAB. Optimum parameters are applied to obtain maximum MRR for ECM process.

**Keywords:** MRR, Flow rate (Q), Design variables, ECM, GA.

## I. INTRODUCTION

There are a few non-traditional machining techniques, including electrochemical machining, laser beam machining, electron beam machining, and electron discharge machining (ECM). They are typically used to remove material [1]. Most materials cannot be machined using more traditional techniques like LBM, EBM, or EDM. As a result, ECM is used to process these types of materials. ECM is one of the non-traditional machining techniques used to work the hardest materials that are challenging to work conventionally. The goal of this search is to better understand the effects of various parameters on material removal rate (MRR).

ECM works on electrolysis laws. The procedure of ECM is illustrated in Figure 1 [2]. In ECM, the anode represents the workpiece, while the cathode represents the tool. The workpiece and tool are immersed in an electrolyte as NaCl and located closely with a gap of about 0.5 mm [3]. The cathode moves towards the anode when a constant voltage difference is used across both the workpiece and tool. Thus, this procedure removes the material from the workpiece.

Various types of materials are machined using ECM. A greater rate of material removal could serve as a marker. The main restrictions of the ECM, however, are its expensive initial cost, high power requirements, and need for extra space [4]. Changing the process parameters to increase the material

removal rate (MRR) is challenging due to the intricate nature of ECM's operating principle. Therefore, choosing the ideal process parameters is a useful way to raise MRR. The optimization approach to obtaining the ECM process parameters has been the attention of the researchers. The MRR and surface finish are optimized using ANN models and grey relational analysis, according to certain research on optimization techniques [5]. Based on the required response criteria, the ideal settings and their impacts are assessed [6].

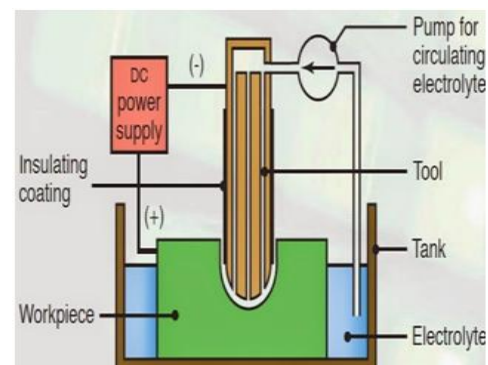


Figure 1: Working principle of ECM [3]

Additionally, tool feed rate and electrolyte flow velocity are regarded as the design factors and MRR is viewed as an objective function with design limitations. The optimization problem is suggested to be solved using a two-dimensional inter-electrode gap model [7]. It is created as a cost optimization model that is formed from the process parameters [8]. Additionally, costs associated with labour, electrolyte, and power usage has been examined. Based on the fundamental concepts, the choice of an appropriate electrochemical machine is also assessed [9]. Low-frequency vibrations are employed to improve ECM performance using an analytical technique [10]. However, the ideal process parameters for ECM have been obtained using traditional optimization techniques. However, these traditional optimization methods take into account a starting point to discover the best outcome and offer a local solution close to the starting point [12].

The optimal process parameters, such as electrolyte concentration, flow rate, applied voltage, and feed rate, are taken into account as design variables in this work to

maximize the material removal rate. The optimization problem is resolved using the Genetic Algorithm (GA).

This paper's structure is organized as follows: In Section 2, the formulation of the optimization issue is presented. Section 3 discussion of the results. Section 4 concludes with conclusions.

## II. FORMULATION OF OPTIMIZATION PROBLEM

In this section, the optimization problem with the maximization of the material removal rate is formulated. Electrolyte concentration (C), flow rate (Q), applied voltage (V), and feed rate (f) are the process parameters for ECM treated as design variables. The design variables are stated in vector form as

$$x = [C \ Q \ V \ f]^T \quad (1)$$

The optimization problem is finally proposed under the appropriate bound constraints of design variables by taking MRR as objective functions [11] as:

Maximize

$$MRR = -0.5256 + 0.00028C + 0.0459Q + 0.0419V + 0.1029f - 0.000028C^2 + 0.000023Q^2 - 0.000036V^2 + 0.00244f^2 + 0.000354CQ - 0.000079CV + 0.00019Cf - 0.00323QV - 0.00596Qf - 0.1002Vf \quad (2)$$

$$L_n \leq x_n \leq U_n \quad n = 1, \dots, 4 \quad (3)$$

Where,  $U_n$  and  $L_n$  are the upper and lower limits on the  $n$ th design variable.

## III. RESULTS AND DISCUSSIONS

In this section, the formulated problem is solved using GA. GA is coded in MATLAB. The flow chart of GA algorithm is shown in Figure 2.

The upper bound and lower bound of the design variables are chosen as:

$$10 \leq C \leq 20 \text{ (g/l)} ; 5 \leq Q \leq 10 \text{ (l/min)} ;$$

$$15 \leq V \leq 20 \text{ (Volt)} ; 0.9 \leq f \leq 1.0 \text{ (mm/min)}$$

The number of iterations and population size are taken as 100 and 20, respectively for GA. 10 independent run is considered to find out the best objective function value concerning the design variables corresponding to the best run. The convergence efficiency of the algorithms is shown in Figure 3. The convergence efficiency is described in ref. [12].

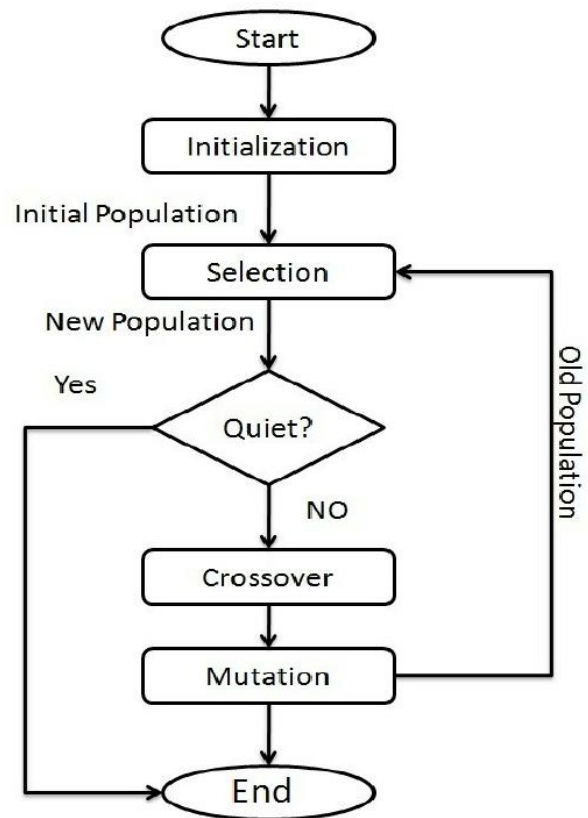


Figure 2: Flow chart of genetic algorithm [13]

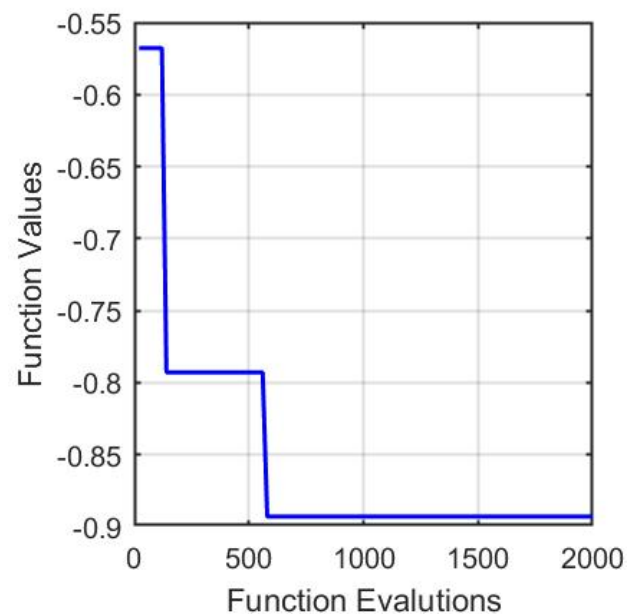


Figure 3: Convergence of best objective function value

The optimal process parameters for ECM are presented in Table 1.

Table1: Optimal process parameters for ECM

Parameters of ECM	Optimum values
Electrolyte concentration (C) in g/l	18.3
flow rate (Q) in l/min	5
applied voltage (V) in Volt	15
feed rate (f) in mm/min	0.9
MRR in g/min	0.8927

#### IV. CONCLUSIONS

This paper provides to choose the optimum ideal process parameters for electrochemical machining (ECM). Therefore, the electrolyte content, flow rate, applied voltage, and feed rate are taken as design variables and the optimization problem is framed with the goal of maximization of the material removal rate.

The GA that was programmed in MATLAB provides the ideal settings for the ECM process parameters.

Using the ideal settings for these process parameters, MRR can be raised.

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