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Optimal Parameters of Electro-Chemical Machining

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Abstract – This paper describes the selection of optimal parameters of electrochemical machining (ECM). Therefore, the optimization problem is stated with the maximization of the material removal rate and optimal parameters i.e. electrolyte concentration, flow rate, applied voltage, and feed rate are taken as design variables. The Genetic Algorithm (GA) from the MATLAB optimization toolbox is applied to the optimization problem.

Key Words: Flow rate; Applied voltage; ECM; GA

1.INTRODUCTION

Non-traditional machining i.e. electro-discharge machining (EDM), laser beam machining (LBM), electron beam machining (EBM), and electrochemical machining (ECM) are applied for removal of material [1]. The material is not machined by conventional processes. ECM is applied to machined that material. The ECM is based on electrolysis laws. The working principle of ECM is described by Fig1[2]. coating. In ECM, the work piece and tool act as anode and cathode, respectively. Two electrodes as work piece and tool

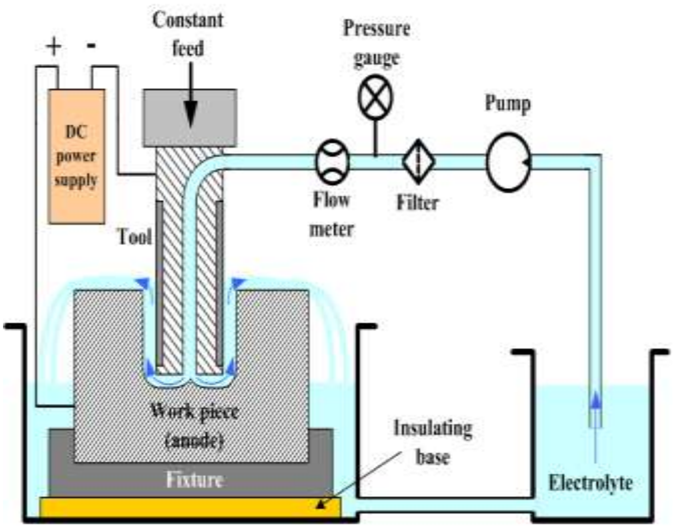

Fig.1. ECM Schematic diagram [3]

are immersed in an electrolyte as NaCl and placed closely with a gap of about 0.5 mm[3]. As constant voltage difference is applied across them, the cathode moves towards the anode. Thus material removes from the work piece.

A large variety of materials can be machined by ECM. It can be designated by a higher material removal rate. although, high initial investment, high power, and requirement of more space are the main drawbacks of the ECM[4]. Also, ECM is a complicated procedure and it is difficult to improve the material removal rate (MRR) by changing the process parameters. Therefore, the optimal selection of the parameters is an efficient approach to improve MRR. The researchers have been focused on the optimization of process parameters of ECM. MRR and surface finish are optimized using grey relational analysis and ANN model [5]. The optimal parameters and their effects are evaluated based on desired response criteria [6]. Further, MRR is considered as an objective function with design constraints and tool feed rate and electrolyte flow velocity are treated as the design variables. A two-dimensional inter electrode gap model is proposed to solve the optimization [7]. The optimization model of cost is developed that is derived in terms of the process parameters [8]. Furthermore, costs of power consumption, machining, electrolyte, and labor with the objective have been analyzed. The selection of a suitable electrochemical machine based on the basic principles is also evaluated [9]. An analytical approach is used to assist the performance of ECM by low-frequency vibrations [10].

Although, the conventional optimization techniques have been used to find out the optimal parameters of ECM. But, these convention optimization techniques require an initial start point to find the optimum solution and give the local solution near to start point.

In this paper, the optimization problem with the maximization of the material removal rate is stated, and optimal parameters i.e. electrolyte concentration, flow rate, applied voltage, and feed rate are taken as design variables. The Genetic Algorithm (GA) from the MATLAB optimization toolbox is applied to the optimization problem.

2. FORMULATION OF OPTIMIZATION PROBLEM

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

$$\boldsymbol{x} = [C\ Q\ V\ f]^T \tag{1}$$

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

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

$$L_r \le x_r \le U_r \qquad r = 1,\cdots 4 \quad (3)$$

Where, U_r and L_r are the upper and lower bounds on the rth design variable.

3. RESULTS AND DISCUSSIONS

In this section, the formulated problem is solved using GA from the MATLAB optimization toolbox.

The upper limit and lower limit of the design variables are taken as:

$10 \le C \le 20\ (g/l)\,;\ 5 \le Q \le 10\ (l/min)\,;$

$15 \le V \le 20\ (Volt);\ \ 0.9 \le f \le 1.0\ (mm/min)$

The number of iterations and population size are chosen as 100 and 20, respectively for GA. 10 independent run is chosen to find out the best objective function value concerning the design variables corresponding to the best run. The computational efficiency of the algorithms is shown in Fig.2. The computational efficiency is described in ref. [12].

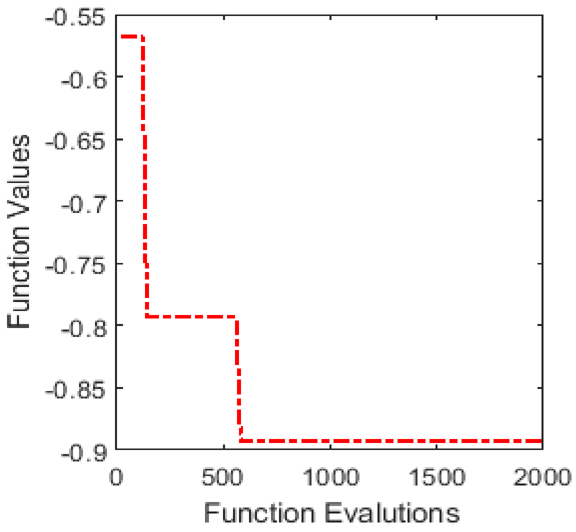

Fig.2. Convergence of best objective function value

The optimum results of process parameters of ECM is presented in Table 1.

Table1: Optimal parameters of 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

4. CONCLUSION

This paper describes the selection of optimal parameters of electrochemical machining (ECM). Therefore, the optimization problem is stated with the maximization of the material removal rate and optimal parameters i.e. electrolyte concentration, flow rate, applied voltage, and feed rate are taken as design variables. The GA from the MATLAB optimization toolbox gives the optimal values of process parameters of ECM. MRR can be increased using these optimum values of parameters.

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