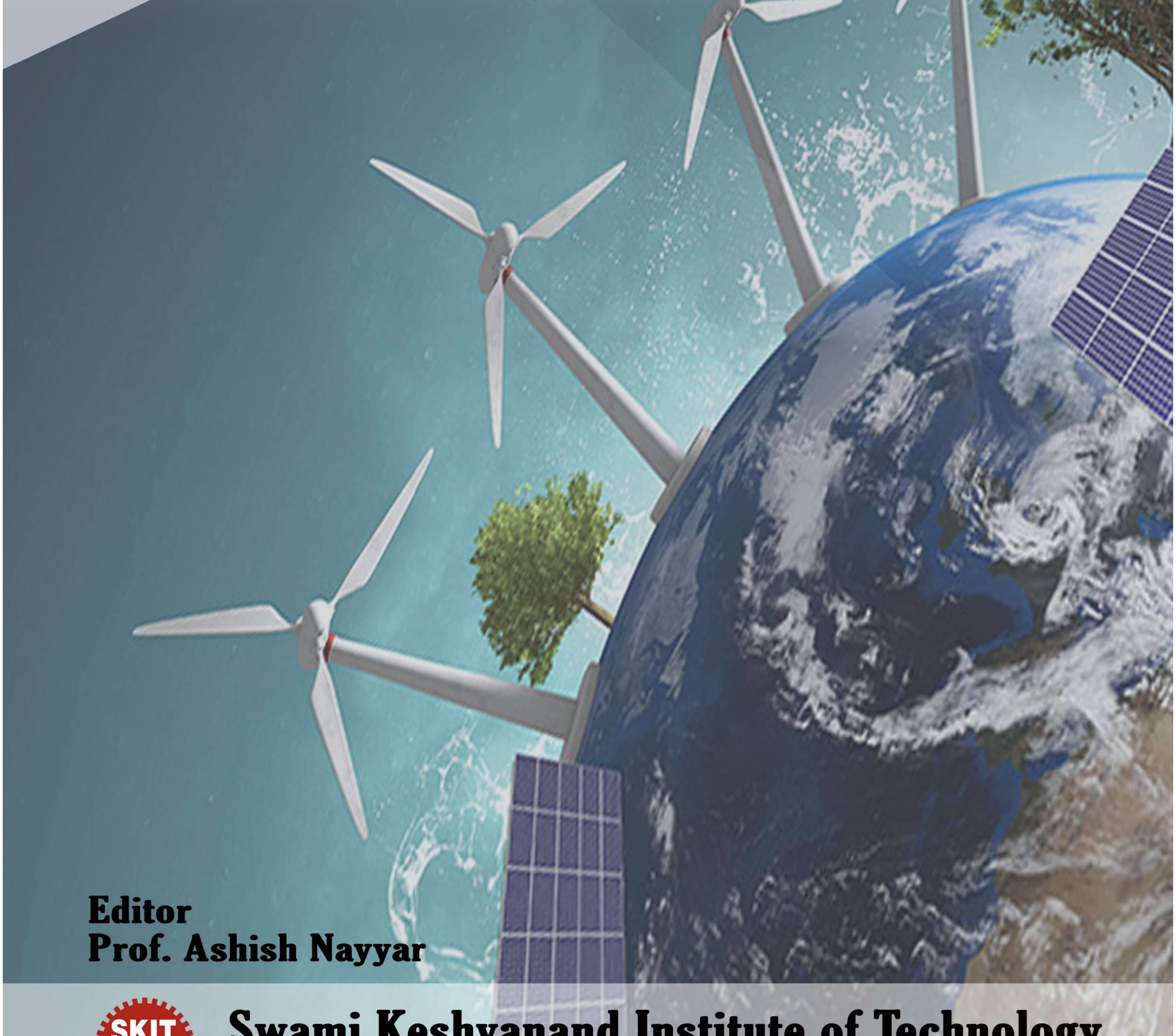
Proceedings of 3rd International Conference on New and Renewable Energy Resources for Sustainable Future

ICONRER-2021

February 11-13, 2021



Editor
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SELECTION OF OPTIMUM 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); Applied voltage (V); ECM; GA**

INTRODUCTION
There are some non-traditional machining processes i.e. laser beam machining (LBM), electron beam machining (EBM), electro-discharge machining (EDM), and electrochemical machining (ECM). Generally, they are used for removal of material [1]. The machining for most of the materials is not done by other conventional processes like LBM, EBM and EDM. Therefore, this types of materials are machined by ECM. ECM is one of nonconventional machining process applied to machine the harshest materials that difficult to machine in conventional process. This search has been used to study impact of different parameters on material removal rate (MRR) and to improve the MRR.

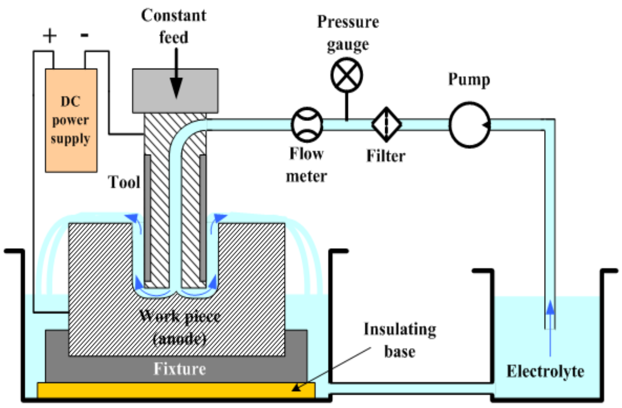

Fig.1. Working principle of ECM [3]

ECM works on electrolysis laws. The procedure of ECM is illustrated by Fig1[2]. In ECM, anode represents the work piece, while cathode represent the tool. Work piece 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 constant voltage difference is used across both work piece and tool. Thus this procedure removes the material from the work piece.

ECM is used to machine a large variety of materials. It may be designated by a higher material removal rate. Although, high initial investment, high power, and requirement of more space are the main limitations of the ECM[4]. Also, working principle of ECM is complicated and it is difficult to improve the material removal rate (MRR) by changing the process parameters. Therefore, the selection of the optimum process parameters is an effective method to improve MRR. The researchers have been focused on the optimization method to obtain the process parameters for ECM. Some literatures of optimization method are described as grey relational analysis and ANN model are used to optimize the MRR and surface finish [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 obtain the optimum process parameters for ECM. But, these conventional optimization techniques consider an initial start point to find the optimum result and provide the local solution near to start point [12].

In this paper, the optimization problem with the maximization of the material removal rate is formulated, and optimum process parameters i.e. electrolyte concentration, flow rate, applied voltage, and feed rate are considered as design variables. The Genetic Algorithm (GA) is used to solve the formulated optimization problem.

The structure of this paper is in the following sequence: formulation of optimization problem is presented in Section 2. Results are discussed in Section 3. Finally, Section 4 presents conclusions.

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

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

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

$Maximize$

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

$$L_n \le x_n \le U_n \qquad n = 1,\cdots 4 \qquad (3)$$

Where, U_n and L_n are the upper and lower limits on the nth design variable.

Results and Discussion

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

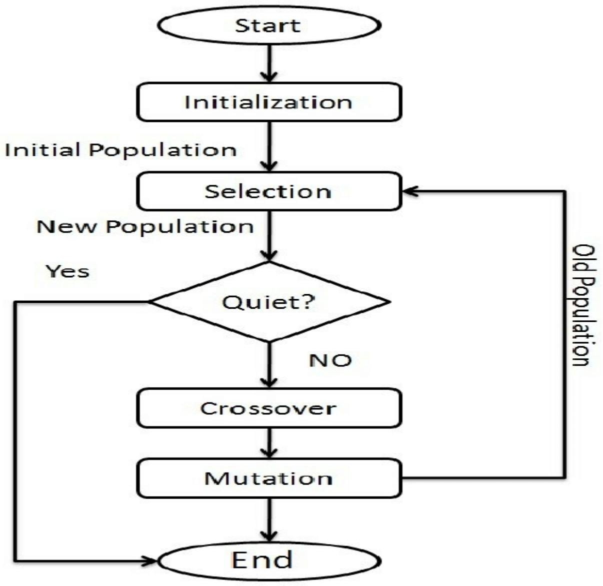

Fig.2. Flow chart of genetic algorithm [13]

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

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

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

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 Fig.3. The convergence efficiency is described in ref. [12].

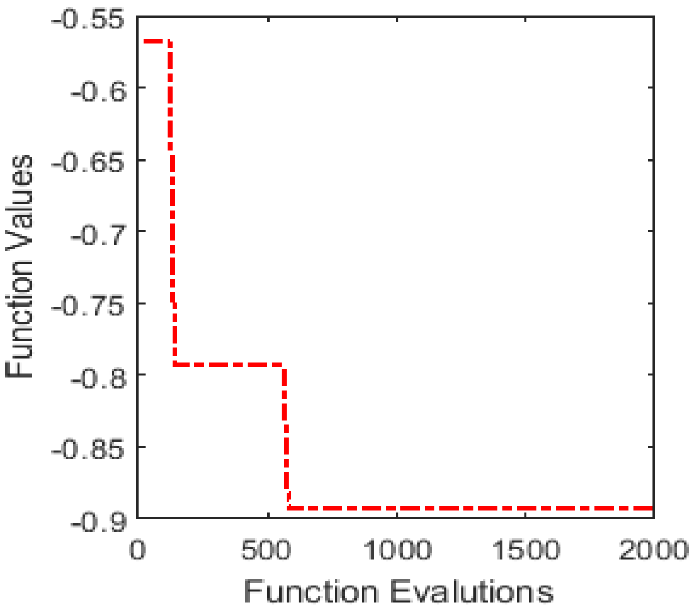

Fig.3. Convergence of best objective function value

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

CONCLUSIONS

This paper illustrates the selection of optimum process parameters for electrochemical machining (ECM). Therefore, the optimization problem is formulated 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 that coded in MATLAB gives the optimum values of process parameters for ECM. MRR can be increased using optimum values of these process parameters.

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ICONRER-2021

Renewable energy and sustainable development are the key technologies to offer solutions to the ever-increasing environmental pollutions and depleting conventional fuel reserves. With an aim to discuss the state of art technologies pertaining to the renewable energy domain, RTU (ATU) TEQIP III Sponsored 3rd International Conference on New and Renewable Energy Resources for Sustainable Future (ICONRER-2021) was organized by the Department of Mechanical Engineering, Swami Keshvanand Institute of Technology, Management and Gramothan, Jaipur in collaboration with Rajasthan Technical University and Department of Mechanical Engineering, Assiut University, Assiut (Egypt) from February 11 to 13, 2021. ICONRER is a series of the conference started in 2017 and it was 3rd event of that series.

असतो मा सद्गमय

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ISBN:978-81-954233-3-0

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