PARAMETRIC OPTIMIZATION OF ECM PROCESS PARAMETERS BY MOORA METHOD

Vedansh Chaturvedi*
Akshay Jain**
Arjun Bhadauriya**
Kuldeep Tomar**

ABSTRACT

The selection of optimum machining condition, during electro chemical machining process is of great concern in manufacturing industries these days the increasing quality demands, at higher productivity levels; require the electro chemical machining process to be executed more efficiently. Specifically, the MRR needs to be maximized while controlling the power consumption. In this study mild steel is used as a work piece, tool size is used 1.8×1.8 cm and distilled water is used as a dielectric fluid. For experimentation Taguchi's L_9*orthogonal array has been used. The input parameters selected for optimization are voltage, feed rate, electrolyte concentration. Parametric optimization technique is completed using MOORA method and found best parametric combination for both responses.*

Keywords*: MRR, Power consumption, Mild steel, ECM, MOORA*

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*Assistant Professor, Department of Mechanical Engineering, Madhav Institute of Technology & Science,Gwalior (Madhya Pradesh) INDIA

**Under-Graduate Student, Department of Mechanical Engineering, Madhav Institute of Technology & Science,Gwalior (Madhya Pradesh) INDIA

INTRODUCTION

Electro Chemical Machining (ECM) is process of removing the material conducting electricity by electrochemical by between two electrodes (work-piece electrode and tool electrode), electrolyte fluid being used in the process. The aim of the process is controlled removal of material from the work piece.

The physical principle of electrochemical machining (ECM) is based on high-speed anode dissolution of metals and alloys under the electrolysis current of high density in the flowing electrolyte at small inter-electrode gaps. Thus according to Faraday's law, weight of the material removed from the work piece is proportional to current density and processing time.

Electrochemical machining (ECM) has inaugurated itself as one of the major other possible way to conventional methods for machining hard materials and complicated outlines not having the residual stresses and tool wear. Electrochemical machining has vast application in automotive, Aircrafts, petroleum, aerospace, textile, medical and electronic industries. Studies on Material Removal Rate (MRR) are of extremely important in ECM Use of optimal ECM process parameters can significantly reduce the ECM operating, tooling, and maintenance cost and will produce components of higher accuracy. This paper investigates the effect and parametric optimization of process parameters for Electrochemical machining of Titanium based alloy. The process parameters considered are electrolyte concentration, feed rate and applied voltage and are optimized in consideration of material removal rate. Analysis of variance is performed to get contribution of each parameter on the performance characteristics and it was observed that feed rate is the significant process parameter that affects the ECM robustness [1].Electrochemical machining is one of the widely used non-traditional machining processes to machine complicated shapes for electrically conducting but difficult-to-machine materials such as super alloys, Ti-alloys, alloy steel, tool steel, stainless steel, etc. Use of optimal ECM process parameters can significantly reduce the ECM operating,tooling, and maintenance cost and will produce components of higher accuracy [2]. The Multi-Objective Optimization by Ratio Analysis (MOORA) was introduced by Brauers and Zavadskas (2006). Subsequently, these authors further developed the method (Brauers and Zavadskas, 2010a) thus presenting the MULTIMOORA (MOORA plusthe full multiplicative form). Numerous examples of application of MULTIMOORA a represent. The ULTIMOORA was applied as well as in a manufacturing and engineering environment (Kracka*et al.*, 2010; Chakraborty, 2011; Brauers*et al.*, 2008a, 2008b; Kalibatasand Turskis, 2008), as in regional evelopmentstudies (Brauers and Zavadskas,2010b, 2011b; Brauers and Ginevi˘cius, 2009, 2010; Brauers*et al.*, 2007). The theory of dominance (Brauers and Zavadskas, 2011a) enables to summarize the ranks obtained from different parts of MULTIMOORA. Moreover, MULTIMOORA has been updated with fuzzy number theory (Brauers*et al.*, 2011) [3]. Location selection problem in banking is an important issue for the commercial success in competitive environment. There is a strategic fit between the location selection decision and overall performance of a new branch. Providing physical service in requested location as well as alternative distribution channels to meet profitable client needs is the current problematic to achieve the competitive advantage over the rivalry in financial system. In this paper, an integrated model has been developed to support in the decision of branch location selection for a new bank branch. Analytic Hierarchy Process (AHP) technique has been conducted to prioritize of evaluation criteria, and multi-objective optimization on the basis of ratio analysis (MOORA) method has been applied to rank location alternatives of bank branch[4]. ECM emerges out to be one of the major non conventional machining techniques based on Faraday‟ s laws of electrolysis, highly efficient due to its zero tool wear characteristic. Occurrence of passivation is the major problem faced in ECM. In the present work, study of the flow pattern of electrolyte has been performed so that, the machining variable distribution can bepredicted accurately thus passivation can be minimized. A tool was modeled in Pro-E design modeler and study is considered under steady state with turbulence. The model was simulated for various inlet pressures. The results obtained showed that the flow velocity decreases when electrolyte moves towards the work piece and it increases at the outlet. Turbulent kinetic energy and turbulent eddy dissipation rate profile exhibits higher value of turbulence at pressure 1.0 kg/cm2 and 1.4 kg/cm2 whereas at 1.2 kg/cm 2 pressure, turbulence is almost negligible. The MRR is maximum affected by the tool feed rate followed by voltage and least by the electrolyte pressure. The optimize results A2B2C2 gives the best material removal rate (MRR).Hence, from the computational simulation and experimental results it was found that 1.2 kg/cm2 is a optimum value for pressure [5].Multi-objective analysis is a popular tool in many economic, managerial, constructional, etc. problems. The objective of this research is to develop and implement a methodology for multi-objective optimization of multi-alternative decisions in road construction. After a rough overview of multi-objective decision support for assessment of road design alternatives multi-objective optimization with discrete alternatives: MOORA (Multi-Objective

Optimization on basis of Ratio Analysis) was selected. This method goes for a matrix of responses of alternatives on objectives, on which ratios are applied. This methodology is applicable to the problems with large numbers of scenarios and objectives. A case study demonstrates the concept of multi-objective optimization of road design alternatives and the best road design alternative is determined[6]. Nowadays everyone likes a nation or a company until it tries to reduce energy losses in heating. This paper proposes the project to study energy losses in heating a building. Investigations and heating losses calculations were made and methods selected to optimize the results. These methods concern MOORA (Multi-Objective
Optimization by Ratio analysis) and MULTIMOORA (MOORA plus Full Multiplicative Form). Starting with a matrix of alternative responses on the objectives, three approaches come to an unambiguous result[7].Deburring is, to put it simply, a finishing method used in industrial settings and manufacturing environments. The raised particles and shavings that appear when metal blanks are machined are referred to as burrs, and the process by which they are removed is known as deburring. Deburring process with high efficiency and full automation is an extremely difficult task. Electrochemical deburring offers very cost effective and efficient solution[8]. ECM removes material without heat. Almost all types of metals can be machined by this process. In today‟ s high precision and time sensitive scenario, ECM has wide scope for applications[9]. Many researchers have presented experimental and analytical studies related to material removal mechanism and current density distribution in ECM using different tool shapes and different software, but they couldn‟ t predict the flow pattern accurately[10].

Figure: 1 closed setup of ECM

Figure: 2 open setup of ECM

Figure :3 control panel

Figure: 4 Tool for Operation

Figure: 5 machined work piece

THE MOORA METHOD

Multi objective optimization also known as multi-criteria or multi attribute optimization, is the process of simultaneously optimizing two or more conflicting attributes (objectives) subject to certain constraints. The MOORA method, first introduced [3]. Is such a multi objective optimization technique that can be successfully applied to solve various types of complex decision making problems in the manufacturing environment. The MOORA method [6].starts with a decision matrix showing the performance of different alternatives with respect to various attributes.

Step1: The first step is to determine the objective, and to identify the pertinent evaluation attributes.

Step2: The next step is to represent all the information available for the attributes in the form of a decision matrix. The data given in eq.(5) are represented as matrix $X_{m\times n}$ where X_{ij} is the performance measure of i^{th} alternative on j^{th} attribute, m is the number of alternatives, and n is the number of attributes. Then a ratio system is developed in which each performance of an alternative on an attribute is compared to a denominator which is a representative for all the alternatives concerning that attribute.

$$X=\begin{bmatrix} x_{11} & x_{12} & . & x_{1n} \\ x_{21} & x_{22} & . & x_{2n} \\ . & . & . & . \\ x_{m1} & x_{m2} & . & x_{mn} \end{bmatrix} \qquad \text{..} (1)$$

Step3: [17] concluded that for this denominator, the best choice is the square root of the sum of squares of each alternative per attribute. This ratio can be expressed as below:

$$x_{ij}^{*}=x_{ij}/\sum_{i=1}^{m} x_{ij}^{2} \qquad \text{.................................} (2)$$

(j=1, 2, 3,…….., n)

Where x_{ij} is a dimensionless number which belongs to the interval $[0,1]$ representing the normalized performance of i^{th} alternative on j^{th}attribute.

Step 4: For multi-objective optimization, these normalized performances are added in case of maximization (for beneficial attributes) and subtracted in case of minimization (for non beneficial attributes).then the optimization problem becomes:

$$y_i=\sum_{j=1}^{g} x_{ij}^{*}-\sum_{j=g+1}^{n} x_{ij}^{*} \qquad \text{..............................} (3)$$

n =no. of attributes

g=Beneficial attribute (MRR)

n-g= non-beneficial attribute (SRa)

Where ‘g’ is the number of attributes to be maximized, (n-g) is the number of attributes to be minimized, andy_i is the normalized assessment value of i^{th} alternative with respect to all the attributes. In some cases, it is often observed that some attributes are more important than the others. In order to give more importance to an attribute, it could be multiplied with its corresponding weight. When these attribute weights are taken into consideration, Eq. 3 becomes as follows:

$$y_i=\sum_{j=1}^{g} w_j\, x_{ij}^{*}-\sum_{j=g+1}^{n} w_j\, x_{ij}^{*} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

(j=1,2,3,……,n)

Where w_j is the weight of j^{th} attribute, which can be determined applying analytic hierarchy process (AHP) or entropy method.

Step 5: The y_i value can be positive or negative depending of the totals of its maxima (beneficial attributes) and minima (non-beneficial attributes) in the decision matrix. An ordinal ranking of $y_i$shows the final preference. thus, the best alternative has the highest y_i value, while the worst alternative has the lowest y_i value.

Decision-making problems

In order to demonstrate the applicability and potentiality of the MOORA method in solving multi-objective decision making problems in real-time manufacturing environment, the following example are considered.

Table :1 Parameters and their levels

Parameters	**Level 1**	**Level 2**	**Level 3**
Voltage (volt)	5	7	9
Feed Rate (mm/min)	0.16	0.19	0.23
Electrolyte Concentration(%)	20	25	30

Table :2 L_9 Orthogonal Array

Experiment no.	**Voltage (volt)**	**Feed rate (mm/min)**	**Electrolyte Concentration (%)**
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1

7	3	1	3
8	3	2	1
9	3	3	2

Table:3 Quantitative data of the ECM

Experiment no.	**Voltage (volt)**	**Feed rate (mm/min)**	**Electrolyte Concentration (%)**	**Material removal rate (mg/min)**	**Power consumption (watt)**
1	5	0.16	20	800	2.76
2	5	0.19	25	400	4.37
3	5	0.23	30	400	4.83
4	7	0.16	25	500	4.83
5	7	0.19	30	900	6.06
6	7	0.23	20	1000	6.96
7	9	0.16	30	1000	2.72
8	9	0.19	20	600	2.96
9	9	0.23	25	200	2.80

MRR is considered as beneficial attribute (higher values are desirable), and power consumption considered as non-beneficial attribute (lower values are desirable).

Table:4 Assessment values for theTable:3

Experiment no.	**Material removal rate mg/min.**	**Power consumption(watt)**	**Rank**
1	800	2.76	2
2	400	4.37	8
3	400	4.83	9
4	500	4.83	7
5	900	6.06	4
6	1000	6.96	5
7	1000	2.72	1

8	600	2.96	3
9	200	2.80	6

RESULTS AND DISCUSSIONS

The results from the MOORA method is found to get best parametric combination. It can seen that for a particular values of input parameter in experiment no. 7 is an optimal parameter combination for mild steel and ECM the corresponding range of occurrence of MRR and Power consumption.

CONCLUSION

Experimental investigation on electrochemical machining of Mild steel has been done. The following conclusions are made. Based on the MOORA method,the optimized input parameter combination to get best result parameters setting are at Voltage (9volt), feed rate (0.16 mm/min), electrolyte concentration (30%). This method is very reliable for solving multi-objective optimization problem, for continuous quality development of the process. In the forgoing it has been assumed that all response features are independent to each other.

REFERENCES

[1] Jadhav R. Baliram and Babar d. Pravin ”Experimental study on parametric optimization of titanium based alloy (ti-6al-4v) in electrochemical machining process”.

[2] Venu Gopaland Chakradhar D “Multi-Objective Optimization of electrochemical machining of en31 steel by grey relational analysis international journal of modeling and optimization” vol. 1, no. 2, june 2011

[3] Brauers M. K. Baležentis Tomas and BaležentiAlvydas” Multimoora-fg: a multi-objective decision making method for linguistic reasoning with an application to personnel informatica” 2012, vol. 23, no. 2, 173–190 173 □ 2012 vilnius university.

[4] GörenerAli and Dinçer Hasan and HacıoğluUmit “Application of Multi-objective optimization on the basis of ratio analysis (moora) method for bank branch location selection” vol.2 no.2, 2013 issn: 2147-4486.

[5]. Jadhav P. V. and Jadhav D V and Mishra Anamika “CFD Analysis of electrolyte flow pattern in pulse ecm and to optimize mrr for circular tool international journal of engineering research and general science” volume 2, issue 4, june-july, 2issn 2091-2730.

[6]. Brauers Willem Karel M and ZavadskasEdmundas Kazimieras and Peldschus Friedel and TurskisZenonas “Multi-objective optimization of road design alternatives with an application of the moora method” the 25th international symposium on automation and robotics in construction june 26, 29 2008.

[7]. Karel Willem and Kracka Modestas and Zavadskas Edmundas Kazimieras **“**Ranking heating losses in a building by applying the multimoora” *issn 1392 – 2785 inzinerineekonomika-engineering economics,* 2010, 21(4), 352-359.

[8]. Mishra Ashish and Gupta Sanchay and Mall R.N.. “Application of taguchi and anova to optimize the process parameter of electrochemical deburringinternal journal for technological research in engineering” volume 1, issue 12, august-2014 issn (online): 2347 - 4718 natio.

[9] Rao R.V. and Pawar P.J. and Shankar R. “ Multi objective optimization of electrochemical machining process parameters using a particle swarm optimization algorithm” doi:10.1243/09544054jem1158 proc. i mech e vol 222 (2008) part b.

[10] Baburaj, M**.** “CFD analysis of flow pattern in electrochemical machining for l-shaped tool”. m.tech project report (2012).