Optimization Techniques used in Electric Discharge Machining – A Technical Review

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Abstract— Optimization is a technique to finding the maximum and minimum value. Optimization is the mathematical discipline which is concerned with finding the maxima and minima of functions, possibly subject to constraints. Optimization is the act of achieving the best possible result under given circumstances. In design, construction, maintenance, engineers have to take decisions. The goal of all such decisions is either to minimize effort or to maximize benefit. The effort or the benefit can be usually expressed as a function of certain design variables. Hence, optimization is the process of finding the conditions that give the maximum or the minimum value of a function. It is obvious that if a point corresponds to the minimum value of a function f(x), the same point corresponds to the maximum value of the function -f(x). Thus, optimization can be taken to be minimization. There is no single method available for solving all optimization problems efficiently. Hence, a number of methods have been developed for solving different types of problems.

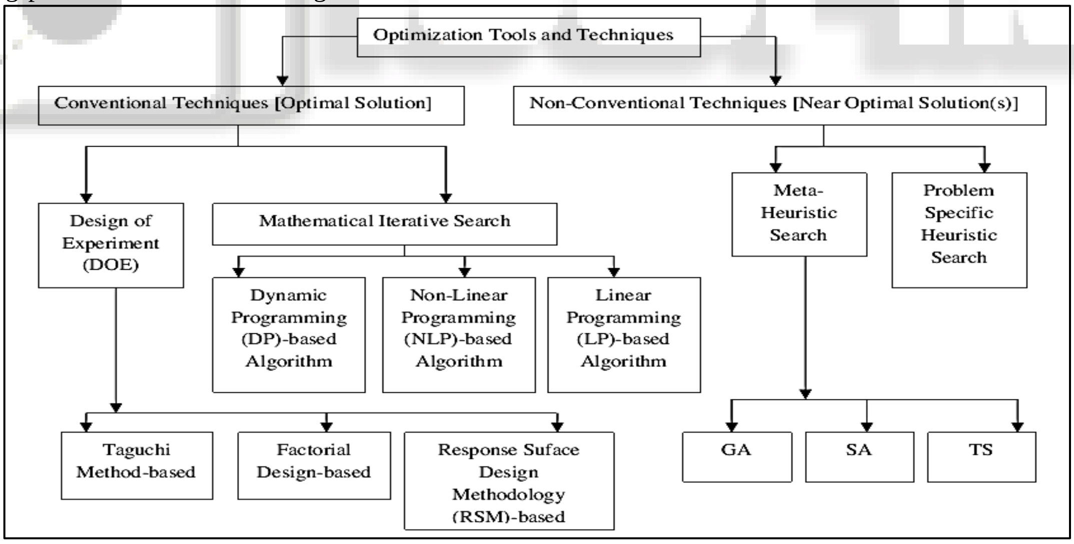
Key words: Electric Discharge, EDM, Traditional Method

I. INTRODUCTION

Electrical Discharge Machining (EDM) is a nontraditional manufacturing process based on removing material From a part by means of a series of repeated electrical Discharges (created by electric pulse generators at short intervals) between a tool, called electrode, and the part being machined in the presence of a dielectric fluid. Electrical discharge machining (EDM) is a process for shaping hard metals and forming deep complex shaped holes by arc erosion in all kinds of electro-conductive materials. Electric discharge machining is one such industrial application for material remover, where electric pulse generators at short intervals between a tool.

II. TECHNIQUES OF OPTIMIZATION

There are various types of optimization techniques used in EDM. In highly competitive manufacturing industries nowadays, the manufactures ultimate goals are to produce high quality product with less cost and time constraints. To achieve these goals, one of the considerations is by optimizing the machining process parameters. Optimization is the act of obtaining the best results under given circumstances. The various methods that used in optimization can be described as below.



III. DIFFERENT OPTIMIZATION METHODS

A. *Traditional Method:*

The classical optimization techniques are useful in finding the optimum solution or unconstrained maxima or minima of continuous and differentiable functions. These are analytical methods and make use of differential calculus in locating the optimum solution. The classical methods have limited scope in practical applications as some of them involve objective functions which are not continuous and/or differentiable.

B. *Non-Traditional Optimization Algorithms:*

In recent years, some optimization methods that are conceptually different from the traditional mathematical programming techniques have been developed. These methods are labelled as modern or non-traditional methods of optimization. Most of these methods are based on certain characteristics and behavior of biological, molecular, swarm of insects, and neurobiological systems. The following methods are comes under non-traditional optimization methods:

1) Genetic algorithms

2) Simulated annealing
3) Particle swarm optimization
4) Ant colony optimization
5) Artificial bee colony algorithm (ABC)
6) Sheep flock algorithm (SFA)
7) Biogeography-based optimization (BBO)
8) Fuzzy optimization
9) Neural-network-based methods.

Where would we use optimization-

- Architecture
- Nutrition
- Electrical circuits
- Economics
- Transportation etc.

IV. VARIOUS OPTIMIZATION METHODS USED IN ELECTRIC DISCHARGE MACHINING

Rajneesh Kumar Singh [1] studied on Surface roughness and MRR with GA and RSM evolutionary techniques on WEDM. The present research work optimizes the desired responses and control parameters by writing .M-files and then solved by GA using the MATLAB software. Figure 1 shows the GA output of best measured response of maximum MMR. GA was run for 50 generations as the result remained stagnant even after increasing the number of generations further. Three different initial population sizes were considered while running the GA. Test of 20 runs were conducted for each population size and the results have been conduct.

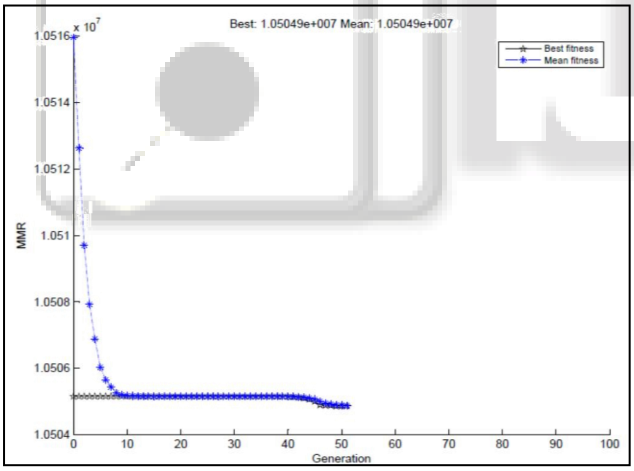


Fig. 1: Plot of GA Predicted Result for MMR

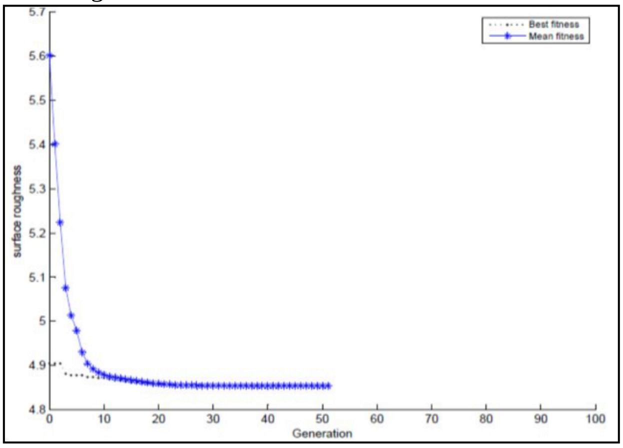


Fig. 2: Plot of GA Predicted Result for Surface Roughness

GA provides a cost effective soft computing technique for optimizing machining operations. Based on the test results predicted using GA, this technique can be accommodated within an intelligent manufacturing system for automated process planning.

S S Mahapatra & Amar Patnaik.[2] in 2006 studied on WEDM using Genetic Algorithm for MMR & SR. D2 steel is the material Genetic algorithm was used to obtain the optimum machining parameter for multi objective outputs by using the several combinations of the weights. The values of the weights are assigned randomly, that the sum should be one. The larger weighting factor, the greater the improvement in the machining performance outputs. The computational algorithm was implemented in c++ code. GA mainly works on three types of operators: Reproduction, Crossover, and Mutation. In GA population size, probability of crossover and mutation are set at 50%, 75%, and 5% respectively for all the case. Below table shows the optimum conditions of the machining parameter for multi-performance outputs with different combination of the weighting factor.

Results saws that when current is 32 A, pulse duration is12.8micro sec, frequency is 60Hz & wire speed is 9.2 Rpm than max. MRR is 0.19119 mm3/min and SF is 149.86 micro inch.

Ko-Ta Chiang, Fu-Ping Chang [3] studied on Al2O3 particle reinforced material (6061 alloy) on Grey relational analysis.

The grey means the primitive data with poor, incomplete and uncertain information in the grey systematic theory, the incomplete relation of information among this data is called the gray relation. Grey relational analysis is to compare quantitative analysis to the development between every factor in the grey system dynamically, describes the relation degree among main factor and other factors in the grey system. The space of grey message relation is expressed as following:

$$\{Q(X), r\}$$

Where Q(X) is the set of factor of grey message relation and r is influencing relation for each other. The set of sequence XI in the set of Q(X).

From the value of grey relational grade r, the relational degree between main factor and other factors is computed concerning of all performance characteristic. The average value of the grey relational grade for each level of the operating parameters is shown in the response table and response graph in order to select the composition of optimal factors.

During the manufacture in WEDM process, the value of grey relational grade r for each operating factor concerning the cutting rate and surface roughness is the greater the better.

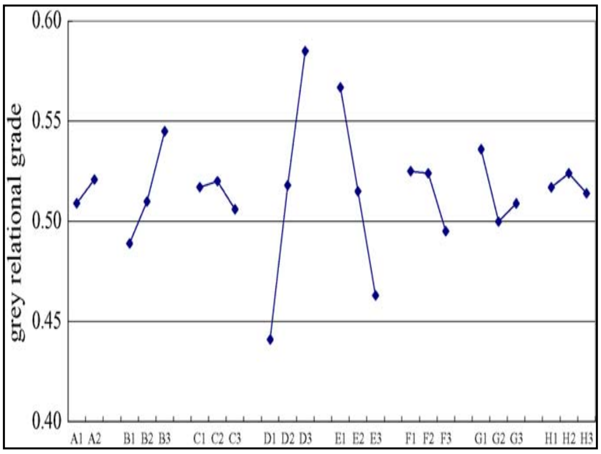


Fig. 3: The Response Graph for Each Level of the Machining Parameters.

From this research paper obtain that the grey relational analysis to optimize the WEDM process with the multiple performance characteristics such as the cutting removal rate and the maximum surface roughness. The response table and response graph for each level of the machining parameters are obtained from the grey relational grade, and select the optimal levels of machining parameters.

Hsien-Ching Chen Jen Chang Lin, Yung-Kuang Yang Chih-Hung T[4] in 2010studied on optimization of Tungsten is done with ANN on WEDM. The use of neural network (NN) has been well accepted in the arenas of telecommunication, signal processing, pattern recognition, prediction, and process control and financial analysis. Most of the literature adopts back-propagation neural network (BPNN) because it has the advantages of fast response and high learning accuracy. The proposed approach can effectively assist engineers in determining the optimal process parameter settings for WEDM process under multi-response consideration. According to the implementation results obtained in the illustrative example, are summarized as follows:

1) The BPNN could be utilized successfully to predict cutting velocity (CV), roughness average (Ra) and roughness maximum (Rt) properties for WEDM process during manufacture of pure tungsten profiles after being properly trained. At the same time, the BPNN prediction models yield smaller MSE after training, namely, the BPNN was gave reasonable prediction in the experimental runs based on the BPNN approach.
2) The combining BPNN/GA optimization method is proposed in this paper that optimal setting can be obtained for the appropriate combinations of the WEDM process parameters. Additionally, the proposed algorithm of SAA approach is also by confirmation experiment carried out to check the validity within 3% error.

Reza Atefi, Ali Razmavar, Farhad Teimoori, Farshad Teimoori[5] studied on EDM Parameters in Finishing Stage on Surface Quality Using Hybrid Model. In this paper Hot Work Steel: DIN 1.2344 Composition—C: 0.39 %; Cr:5.15%;Mo: 1.25%; V: 1%;Si: 1%; Mn: 1%; rest iron Dimension: cylindrical shape with a diameter of 25mm (25mm×25mm×5 mm) is use with ANN method. By using a hybrid model, mean error of ANN has been reduced to 0.3 percent and has been reached to 0.8 percent. The experiment results show good performance of proposed method in optimization of such a complex and non-linear problems. Using hybrid model caused mean error reach to 0.8 percent which showed 0.3 percent less error in compared to the experiments that ANN was used. The results show good performance of proposed model when we optimize such a complex and non-linear problems. Finally for reducing the error in ANN, a hybrid model (a combination of statistical analysis and ANN model) has been designed and following results has been obtained:

1) Application of ANN to predict surface roughness is a scientific method which makes industries free from complex traditional trial and error methods
2) By using ANN, proper training of network and giving values for current, pulse on-time, pulse off-time and arc voltage, accurately predict the surface roughness
3) Designed ANN has mean error of 1.1 percent and maximum error of 2.2 percent. This error level is a good accuracy for surface roughness measurement.

S. Murugesan, K. Balamurugan, C. Sathiya Narayanan, P. G. Venkatakrishnan[6] Studied on EDM of Al-15%SiC MMC using Solid and Multi hole Electrodes- A Taguchi Approach. In this paper a comparison of performance of a multi hole electrode with a solid electrode in blind hole drilling of Al-15% SiC Metal Matrix Composite (MMC) using Electrical Discharge Machining (EDM) is reported. Results of ANOVA indicate that the pulse on time is the most significant factor affecting the machining time with a percentage contribution of 64.97%. The next significant factor is discharge current with a percentage contribution of 27.86% whereas pulse off time with 5.91% contributes the least.

Pradhan, Das, Biswas M.K. R. C.K.[7] studied on predictive modelling and analysis of surface roughness in electro-discharge machining of d2 tool steel using regression and neural networks approach. Surface roughness (Ra) is a significant upshot in the manufacturing process and it materializes a major part in the manufacturing system. It depends on different machining parameters and its prediction and control is a query to the researchers. The following is the outcome of this study:

1) The regression model is quite comparable to the ANN models for prediction of Ra and they can provide a satisfactory prediction. The predicted process parameters on validation are found to be close correlation with the actual experimental results. It is seen that ANN provides the better prediction capability with coefficient of correlation 0.988 and 0.995 respectively for BPN and RBFN, while 0.978 for regression model. Though the proposed regression model is adequate and accepted, neural network models yield better prediction
2) The evidence of correct prediction is also proved by the mean prediction error is as low as 3.06%., 9.01% and 20.21% for RBFN, BPN and regression model respectively.
3) The surface roughness is found to increase with the increase in discharge current, however it increases

to optimum value and then start decreasing with the increase in pulse on time.

Prof. P. R. Cheke, Prof. D. S. Khedekar, Prof. R. S. Pawar, Dr. M. S. Kadam[8] studied on comparative performance of wet and near-dry EDM process for machining of oil hardened non sinking material. This paper investigates wet and near-dry electrical discharge machining to achieve the high material removal rate (MRR) on oil hardened non shrinking steel. The following conclusions are drawn for the effective machining of oil hardened non shrinking steel in wet and dry EDM process:

1) For wet and near-dry EDM process, discharge current (Ip) was the most influencing factor for in wet EDM followed by pulse off time(Toff), discharge voltage(Vg) and pulse on time(Ton). So, to achieve the maximum material removal rate in wet and near dry EDM, employ high discharge current of 20 ampere, moderate pulse on time of 400 µs with low pulse off time of 10 position and high gap voltage of 40 volts.
2) A comparison of process performance of near-dry EDM with wet EDM has provenless beneficial for roughing process in a given range of input variable because stable machining conditions were established at low discharge energy (When Ip is in the range of2 to 4 ampere) resulting in high spark frequency which is beneficial for finishing operation .At high energy input (When Ip is in the range of 10 - 20 Ampere) low spark frequency were obtained with wet EDM which improve the flushing condition resulting higher MRR and rough surface as compared to near-dry EDM. Thus wet EDM proven to be beneficial for roughing operation.

Mane S.G., Hargude N.V. [9] studied on dry electrical discharge machining process.EDM has achieved a status of being nearly indispensable in the industry because of its ability to machine any electrically conductive material which is difficult-to-machine irrespective of its mechanical strength. In this study, different levels of these electrical parameters are selected to study both the roughing and finishing, and dry and near dry EDM processes. Statistical analysis using ANOVA for dry EDM drilling reveals that discharge current I, is the most significant parameter due to the highest F value. With a variation in current from12 to 15 A, and further increase up to 18 A, a linear increase in average MRR has been observed. From ANOVA table for MRR, a very higher indicates that discharge current i is more significant than gap voltage V. The gap voltage (V) is also a significant parameter at 95 % confidence level. An increase in voltage appears to cause a decrease in MRR. An increase in gap voltage from 50 to 65 V causes a decrease in average MRR by 1.69 %. As the voltage changes from 65 to 80 V, further reduction in MRR 18.26 % has been observed.

Sourabh K. Saha*, S.K. Choudhury[10] studied on Multi–objective optimization of the dry electric discharge machining process. Experiments were conducted with air as dielectric to develop polynomial models of MRR and Ra in terms of the six input parameters: gap voltage, discharge current, pulse–on time, duty factor, air pressure and spindle speed.Multi–objective optimization revealed that high air pressure and high spindle speed combination is favorable for obtaining both a high MRR and a low Ra. Such a combination of these input parameters leads to a higher flushing efficiency. Finish machining region (low Ra) was obtained for low current, high pulse–on time and low duty factor values. Rough machining region (high MRR) was obtained for high current, low pulse–on time and high duty factor values. Best Ra value of 1.60 µm and best MRR value of 6.83mm3/min was obtained experimentally in the finish and rough regions, respectively.

V. CONCLUSION

Different Models were used to predict the response parameters i.e. cutting speed, surface finish and dimensional deviation for all possible combination of level of the input factors. Then the optimal combinations were searched out from all these combinations.

REFERENCE

[1] Rajneesh Kumar Singh* and D.K. Singh (2013) control parameters optimization of wire – EDM by using genetic algorithm, vsrd International Journal of Mechanical, Civil, Automobile and Production Engineering, Vol. III Issue IX September 2013 / 327e-ISSN : 2249-8303, p-ISSN : 2319-2208 © VSRD International Journals : www.vsrdjournals.com
[2] SS Mahapatra and Amar Patnayik, (2006), Optimization of wire electrical discharge machining process parameters using GA, 13 December 2006,pp,494-502
[3] Ko-Ta Chiang, Fu-Ping Chang (2006), Optimization of the WEDM process of particle-reinforced material with multiple performance characteristics using grey relational analysis Journal of Materials Processing Technology 180 (2006) 96–101
[4] Hsien-Ching Chen a, Jen-Chang Lin b, Yung-Kuang Yang b, Chih-Hung Tsai c,(2010),Optimization of wire electrical discharge machining for pure tungsten using a neural network integrated simulated annealing approach, Expert Systems with Applications 37 (2010) 7147–7153
[5] Reza Atefi, Ali Razmavar, Farhad Teimoori, Farshad Teimoori (2012), The Investigation of EDM Parameters in Finishing Stage on Surface Quality Using Hybrid Model . Basic. Appl. Sci. Res., 2(3)3061-3065, 2012
[6] S. Murugesan, K. Balamurugan, C. Sathiya Narayanan, P. G.Venkatakrishnan(2012), Study on EDM of Al-15%SiC MMC using Solid and Multihole Electrodes- A Taguchi ApproachEuropean Journal of Scientific ResearchISSN 1450-216X Vol.68 No.2 (2012), pp. 161-171© EuroJournals Publishing, Inc. 2012 http://www.europeanjournalofscientificresearch.com
[7] Pradhan , Das , Biswas ,M.K. R. C.K., (2004), predictive modelling and analysis of surface roughness in electro-discharge machining of d2 tool steel using regression and neural networks approachol.3, no.2, july 2009

Journal of Materials Processing Technology 148 (2004) 362–367

[8] Prof. P. R. Cheke, Prof. D. S. Khedekar, Prof. R. S. Pawar,Dr. M. S. Kadam (2008), COMPARATIVE PERFORMANCE OF WET AND NEAR-DRY EDM PROCESS FOR MACHINING OF OIL HARDNED NON SINKING STEEL MATERIAL (2008)37:523-533,DOI 10.1007/s00170-004-1002-3.

[9] Mane S.G., Hargude N.V. (2008) AN OVERVIEW OF EXPERIMENTAL INVESTIGATION OF NEAR DRY ELECTRICAL DISCHARGE MACHININGPROCESS Journal of Manufacturing Science & Engineering (Feb2008), Vol.130 / 011002-1- 011002-8.

[10] Sourabh K. Saha*, S.K. Choudhury(2009) Multi–objective optimization of the dry electric discharge machining process. Indian Institute of Technology Kanpur Kanpur 208016, India January 15, 2009