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A REVIEW ON OPTIMIZATION OF PROCESS PARAMETERS ON DRY ELECTRIC DISCHARGE MACHINING FOR AL-SIC MMC MATERIAL USING HYBRID MODELLING

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ABSTRACT

Dry EDM is a modification of oil EDM Machining process were liquid dielectric is replaced by gaseous dielectric medium. The main aim is to study the effect of Percentage of Silicon carbide particles, Gap voltage, discharge Current, Pulse on time, Spindle speed, air pressure on response such as Material Removal rate (MRR), Tool Wear Rate (TWR) and Surface Roughness (Ra).Influence of Silicon Carbide Particles, Gas Pressure, Spindle speed are also discussed resulting in Finding the optimum conditions of machining parameters using Genetic Algorithm (GA) and Artificial Neural Network (ANN) called as Hybrid Modelling.

KEYWORDS: Dry EDM, % SiC, MRR, Ra, TWR, GA, ANN

INTRODUCTION

In recent era development of manufacturing techniques and process with increasing the of need accuracy, quality of machining and quality of surface layer of machining required so there is demands on creating machining methods not harmful for environment. Effective way of reduction of hazardous effects on environment is elimination of liquids used as working media or coolants during machining processes.try to eliminate by changing working medium which is not much more affect the environment. [1].

Figure 1: Benefits of Dry Electro Discharge Machining

The Figure 1 shows the benefits of dry machining processes, now era companies and research centres involved in development of electro discharge machining are aiming towards reduction of organic based dielectric fluids and exchanging them with pure water or low concentration water solutions. [2]

Dry EDM is a 'green' environment friendly machining technique in which instead of mineral oil based liquid dielectric, gas at high pressure was used as the dielectric medium. This method has many advantages in process performance, like lower tool wear, lower residual thermal stresses and higher precision. Practical application of the Dry EDM process would bring a lot of advantages for machine makers and machine end users. Main factor is the simplicity of the machine construction, not requiring sophisticated and spacious dielectric circulation and cooling system. The main advantage that same design, manufacturing and material cost can be reduced. Due to the lack of oils (which are usually flammable), the risk of fire hazards is also reduced.

WORKING PRINCIPLE OF DRY EDM

Dry electro Discharge Machining (Dry EDM) is a modification of the oil EDM process in which the liquid dielectric is replaced by a gaseous dielectric. In which High velocity gas flowing through the inter electrode gap substitutes the liquid dielectric. The flow of high velocity gas into the gap facilitates removal of debris particle and also prevents excessive heating between the tool and work piece at the discharge spots. Providing rotation or planetary motion to the tool has been found to be essential for maintaining the stability of the dry EDM process. The dry EDM process schematic is shown in Figure 2.

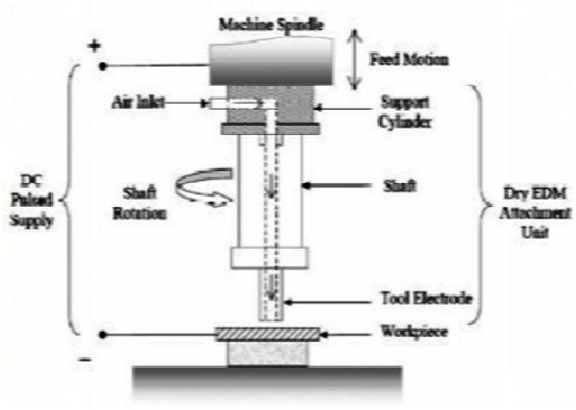

Figure 2: Schematic Diagram of DEDM [3]

Here tubular tool is used and as the tool rotates, high velocity gas is supplied through it into the discharge gap. Gas in the gap plays vary important role of the dielectric medium required for electric discharge. Tool rotation during machining is not only facilities flushing but also improves the process stability by reducing arcing between the electrodes.

HYBRID MODEL

In this an initial population of individuals is generated at random. Then related neural network model is developed using Neuro solutions package. This package gives ANN models with and without the application of GA tool. ANN models are developed for to find out the advantage of using GA for optimizing the weights of ANN. Lastly the three operators of GA: selection, crossover and mutation were applied to produce a new generation. The above operations was repeated until the given limitation number N of generations was reached. Combining the capabilities of ANN and GA, a methodology have been developed using an input-output pattern of data from an DRY EDM process to solve both the modeling and optimization problems. To implement this hybrid model GA and ANN approach, the capability of neural networks to model and predict the structured data is exploited together with the power of GAs for optimization. The functional optimization problem for this hybrid system can be expressed as bellows:

Optimize Y = f(X, W)

Where, Y represents the performance parameters; X is a vector of the input variables to the neural network, and W is weight matrix that is evaluated in the network training process. F (.) shows the model for the process that is to be built through neural network training.

LITERATURE REVIEW

The first reference to DRY EDM can be found in a 1985 NASA Technical report [4].It is briefly reported that argon and helium gas were used as dielectric medium to drill holes using tubular copper electrode. Further details are not available.

Later in 1991, Kunieda et. Al. [5] showed that introducing oxygen gas into the discharge medium. Later in 1997, that the feasibility of using air as the dielectric medium was first demonstrated by Kunieda et al. [6]. High velocity gas jet through a thin walled tubular electrode was used to serve the purpose of a dielectric.

R.Karthikeyan, P.R.LakshmiNarayanan, R.S. Naagarazan et. Al. [7] studied that Mathematical modelling for electric discharge machining of aluminium–silicon carbide particulate composites. In this an attempt has been made to develop mathematical models for optimizing electric discharge machining (EDM) characteristics such as the metal removal rate (MRR), the tool wear rate (TWR) and the surface roughness (SR). The process parameters taken into consideration were the current (*I*), the pulse duration (*T*) and the percentage volume fraction of SiC (25 m size) present in LM25 aluminium matrix. In this 3- level full factorial design was chosen for experimentation and mathematical models with linear, quadratic and interactive effects of the parameters chosen were developed. Finally the significance of the models was checked using the analysis of variance technique (ANOVA). MRR, TWR and the surface roughness are greatly influenced by the percentage volume of SiC present in MMCs, by the current and by the pulse duration. As Current (I) increased the MRR, TWR, SR increased. As %SiC increased TWR and SR increased but MRR decreased. As Pulse Duration decreased TWR and MRR increased but SR decreased.

G.KrishnaMohanaRao, G.Ranga Janardhana et.al [8] studied on Optimizing the metal removal rate (MRR) of die sinking electric discharge machining by considering the affect of all various input parameters. The experiments were carried out on Ti6Al4V, HE15, and 15CDV6and M-250. An experiment was conducted by varying the peak current and voltage and the corresponding values of MRR were measured. Multi perceptron neural network models was developed using Neuro solutions package (MATLAB) Almost negligible electrode wear occurred when machining was performed in air or sulfur hexafluoride(SF_6) results from the fact, that during machining process particles of molten material attach to the electrode, creating thin layer on its surface, which prevent electrode from being worn. To solve this task an attempt is made to relate the input variables to metal removal rate of EDM Process for different materials with the help of Artificial Neural Network (ANN) and optimizing the weights of the network using GA. A software package Neuro solutions has been used for the purpose of forming the ANN and optimizing it with GA.

Ramezan Ali, Mahdavi Nejad et. Al. [9] studied that silicon carbide (SiC) machining by traditional methods with regard to its high hardness is not possible. Among non-traditional machining methods, EDM is used for machining of SiC. Here try to optimize the surface roughness and material removal rate of electro discharge machining of SiC parameters simultaneously. As the output parameters are varying in nature, so there is no single combination of machining parameters, which provides the best machining performance. ANN with back propagation algorithm is used to model the process.

If two or more response are optimize than used a multi objective optimization method, non-dominating sorting genetic algorithm-II is used to optimize the process parameter are discharge current, pulse on time, pulse off time on electric discharge machining of SiC. Experiments have been conducted over a wide range of considered input parameters for training and verification of the ANN model. A Pareto-optimal set has been predicated in multi objective GA. Various ANN architectures have been studied, and from that 3-5-5-2 is selected. Material removal rate and surface roughness have been optimized as objectives by using a non dominating sorting Genetic algorithm-II and finally Pareto-optimal sets of material removal rate and surface roughness are obtained.

R. Rajesh and M. DevAnandet. al. [10] studied on the optimization of the Electro-Discharge Machining Process using Response Surface Methodology and Genetic Algorithms. Selection of machining parameters for the EDM process is dependent on operator's experience and technologies because there is numerous and diverge range. Also Machining parameters provided by machine tool expert cannot meet operator's requirement. To solve this problem, Multiple regression model with modified GA model are developed as efficient approaches to determine the optimal machining parameters in EDM. In this working current, working voltage, oil pressure, spark gap, Pulse on Time and Pulse off Time are taken as input parameter on Material Removal Rate (MRR) and Surface Finish (Ra) has been studied. Using Grey Relational Analysis the Empirical models was developed for MRR and Ra according to designed experiment. In this work Genetic Algorithm (GA) based multi objective optimization used for maximization of MRR and Minimization of Ra.MRR and Ra are combined to have a single objective as grey relational grade by the application of grey relational analysis. Linear regression model has been developed to correlate the relationship between machining parameters and output responses. Finally the optimal conditions obtained from GA are i.e., current at 3 A, Voltage at 78 V, gap at 0.35mm, Flow rate at 1 mm^3/s, Pulse on as 1µs and Pulse OFF as 8µs for maximizing MRR and minimize the surface roughness simultaneously among the experimental data.

Reza Teimouri, Hamid Baseri [11] studied on improvement of DRY EDM characteristics using artificial soft computing methodologies.Artificial neural network was developed as an estimator to forecast process characteristic against variation of input variables. Here the inputs were gap voltage, pulse current, pulse on time, duty factor, air intake pressure and rotational speed of tool, and also the main outputs were material removal rate (MRR) and surface roughness (SR).Predictive model based on back propagation neural network has been applied to correlate the inputs and outputs of dry EDM process and ABC algorithm was used for optimization. From the optimum parameter concluded that lowest value of pulse on time the surface is smoother, when the value of pulse off time is lower due to that inappropriate renewal of dielectric, the debris aren't removed properly, so leads to lower MRR. Higher air pressure, expulsion of debris from machining gap improved and leads to desired MRR and SR.

Shandilya, Pragya & Jain, Pramod Kumar [12] studied on the optimization of process parameters by using Response Surface Methodology (RSM) and genetic algorithm for WEDM for machining of Metal matrix composite. In this work RSM and GA are used together to establish parameter optimization model. RSM with CCD model has been established to represent the relationship between surface roughness (SR) and input variables (Voltage, Pulse-on time, Pulse-off time and Wire feed rate). GA was used to obtain an optimal combination of parameters. As different input process parameters namely Servo voltage , pulse-on time, pulse-off time and wire feed rate affect Wire EDM process performance and hence were chosen as input variables to investigate their effects on surface roughness during machining of SiC_p/6061 aluminium MMC as response parameters. The developed mathematical model was further coupled with a

developed GA to find out the optimum conditions so that the minimum surface roughness value. The predicted optimum cutting condition was validating with an experimental measurement.

S.N.Mehta et al.(2013) [13] investigated that conductive ceramic like cobalt bonded tungsten carbide which is categorized as with high mechanical and physical properties are usually known to create major challenges during conventional and non conventional machining. This work was undertaken to study the machining performance of EDM with tungsten carbide using Copper and graphite as electrodes. The effect of varying the machining parameters on the machining response such as MRR, EWR was investigated. Taguchi methodology was employed in evaluating the machining performance of the EDM process and the mathematical models for MRR, EWR were developed. For verification of model results, conformation runs have been conducted. Results show that peak current was the most significant parameter that influenced the machining response on EDM. ANN and GA based multi objective optimization implemented for maximization of MRR and Minimization of EWR has been done by using the developed empirical models. Optimization results have been used for identifying the effect of control parameters on response that developed data sets which give the performance of EDM on conductive ceramics. He concluded that the GA developed based on neural network is good at automatically selecting an optimal process parameters set in accordance with the desired machining performances. Also there is considerable reduction in data error when the network is optimized with GA tool.

G.Ugersen, H.V.Ravindra, G.V.NaveenPrakash [14] studied on optimization of machining performance using artificial Neural network (ANN) in Wire EDM. Here Experimentation was performed as per Taugchi's L16 orthogonal array. Process parameters are pulse on time, pulse off time, current, bed speed and response parameters are accuracy, surface roughness, MRR and ANOVA is performed to determine the relative magnitude of each factor on the objective function. Estimation and comparison was done using ANN. In neural network the training data set used with higher percentage of data in training set, results in better predications. In this research 70% more training dataset exhibit better correlation with Surface Roughness than 50% and 60% of data set. Back propagation feed forward neural network (BPNN) and Levenberg-Marguardt algorithm (LMA) are used to build and train the network.

Ranjan Kumar Ghadai, RashmiRanjanBehera, Subash Chandra Mondal [15] studied on ANN model used to established relationship between variables such as input and output and a feed forward back propagation ANN is used to model the influence of current and time on MRR & Surface roughness. Multilayer perception Model has been constructed with feed forward back propagation algorithm using current and time as input parameter and MRR and average surface Roughness as output parameters. After modelling it was found that predicated results based on the ANN model are found to be in a very close agreement with the unexposed experimental dataset. Also the effect of Mean square error, epochs, weights, learning rate, Network architectures affects the ANN predicated results.Modelling results confirm the feasibility of the ANN and its good correlation with the experimental results. Here bathch mode of training data is taken as i/p to get the o/p data. Tan sigmoid function was used for hidden layer and log sigmoid function for o/p layer.

N.Pragadish, M.Pradeep Kumar [16] studied on optimization of EDM process parameter using Grey Relational Analysis. Here modified tool design was adopted to drill holes so that MRR can be increased. Experiments were conducted on AISI D2 steel using copper electrode tool. Discharge current, pulse on time, voltage, pressure and tool rotational speed was chosen as the various input parameters.Taguchi's L27 orthogonal array was used to design the experiments. ANOVA test also carried out and then perform the gray relational analysis was used to determine the optimal level of parameters to achieve better results. It is observed that current as most influence parameter followed by the pressure. It was found that

better surface characteristics were exhibited on the surface machined using the optimal level of parameters. MRR can increase as current increase but electrode wear occurred more.

CONCLUSIONS

- When performing experiment on DRY EDM and EDM the most i/p parameter are voltage, pulse on time, pulse off time, speed & current which affect MRR, Surface Roughness (SR), Tool wear rate (TWR). Ra values decrease with an increase in the values of air pressure and spindle speed.
- Also for optimization of non-traditional machining process, the advance level optimization technique selected as SA, GA, PCA, ANN, Ant colony algorithm and for mathematical modeling the various techniques used as Taguchi method, ANN, Response surface methodology.
- When doing experiment with DRYEDM machining the MRR increased slightly compared to EDM and SR also improved, TWR is decreased. This shows that DRYEDM is best suitable for making most intricate shape component with high accuracy and surface finish.
- Genetic Algorithm (GA) based multi-objective optimization for maximization of MRR and minimization of Ra has been done by using the developed empirical models.
- Material removal rate and surface roughness have been optimized as objectives using a multi –objective optimization method.
- For optimization using Genetic Algorithm and ANN it was found that Gradient Descent Method and Back propagation feed forward neural network (BPNN), Levenberg-Marguardt algorithm (LMA) are best to build and train the network.

REFERENCES

1. K. Weinert, I. Inasaki, J. W. Sutherland, T. Wakabayashi “Dry Machining and Minimum Quantity Lubrication,” CIRP Annals, Manufacturing Technology, Vol. 53, 2004, Issue 2, pp. 511-537.
2. F. N. Leao, I. R. Pashby, “A review on the use on environmentally-friendly dielectric fluids in electrical discharge machining,” Journal of Material Processing Technology, Vol. 149, 2004, Issues 1-3, pp. 341-346.
3. Govindan, P. and Joshi, S.S., 2010, ” Experimental characterization of material removal in dry electrical discharge drilling, International Journal of Machine Tools & Manufacture, vol. 50 ,pp. 431–443
4. Ramani, V., Cassidenti, M. L., Inert-Gas Electrical Discharge Machining (1985) NASA, National Technology Transfer centre (NTTC), Wheeling, WV.
5. M. Kunieda, S. Furuoya and N. Taniguchi, Improvement of EDM efficiency by supplying oxygen gas into gap (1991) CIRP Annals-Manufacturing Technology 40, pp. 215-218.
6. M. Kunieda, M. Yoshida and N. Taniguchi, Electrical discharge Machining in gas, (1997) CIRP Annals-Manufacturing Technology 46, pp. 143-146
7. R.Karthikeyan, P.R.Lakshmi Narayanan, R.S. Naagarazan, “Mathematical modelling for electric discharge

machining of aluminium–silicon carbide particulate composites" Journal of Materials Processing Technology 87 (1999) 59–63

8. G.KrishnamohanaRao, G.RangaJanardhana, D.HanumanthaRao and M.SrinivasaRao, "Development of Hybrid Model and Optimization of Metal Removal Rate in Electric Discharge Machining using Artificial Neural Networks and Genetic Algorithm" ARPN Journal of Engineering and Applied Science VOL.3, NO.1, FEBRUARY(2008)
9. Ramezan Ali, MahdaviNejad, "Modeling and Optimization of Electrical Discharge Machining of SiC Parameters, Using Neural Network and Non-dominating Sorting Genetic Algorithm (NSGA II)" Materials Sciences and Applications, 2011, 669-675, June 2011.
10. R. Rajesh and M. DevAnand, "The Optimization of the Electro-Discharge Machining Process Using Response Surface Methodology and Genetic Algorithms" International Conference on Modelling, Optimization and Computing (ICMOC), 2012 Published by Elsevier Ltd
11. Reza Teimouri, Hamid Baseri, "Improvement of dry EDM process characteristics using artificial soft computing methodologies" Prod. Eng. Res. Devel. (2012) 6:493–504DOI 10.1007/s11740-012-0398-2
12. Shandilya, Pragya & Jain, Pramod Kumar, "Genetic algorithm based optimization during Wire Electric Discharge Machining of Metal Matrix Composite", Annals of DAAAM for 2012 & Proceedings of the 23rd International DAAAM Symposium, Volume 23.
13. S.N.Mehta, Investigation of optimum Process parameters Using Genetic Algorithm Based Neural Networks during EDM of 64WC-9Co, International Journal of Engineering Research and technology, ISSN 0974-3154 volume 6, Number 5 (2013), pp. 701-708.
14. G.Ugersen, H.V.Ravindra, G.V.NaveenPrakash, "Process optimization and estimation of machining performances using Artificial neural Network in Wire EDM" 3rd International Conference on Materials Processing and Characterisation (ICMPC2014)
15. Ranjan Kumar Ghadai, RashmiRanjanBehera, Subash Chandra Mondal, "Modeling Electerical Discharge machining process using Artificial Neural Network for the Machining of Special steel WP7V"5th International & 26th All India Manufacturing Technology, Design and Research Conference, IIT Guwhti Assam (AIMTDR2014).
16. N.Pragadish, M.Pradeep Kumar, "Optimization of Dry EDM Process Parameter Using Grey Relational Analysis" Arab J Sci Eng, Springer (2016) (DOI 10.1007/s13369-016-2130-6).