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A review paper on Optimization of process parameter of EDM for air hardening tool steel

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Abstract
EDM is now more economical non convectional machining process. It is used widely used on small scale as well major industries. EDM process is affect by so many process parameter which are electrical and non electrical. In this project work the rotating tool is used to improve the Metal removal rate (MRR) and to observe its effect on surface finish. I am using Taguchi's method as a design of experiments and response surface methodology for analysis and optimization. The machining parameters selected as a variables are pulse off time, pulse on time, servo voltage. The output measurement include MRR and surface roughness.
Index Terms—MMR, EDM, Process Parameter.

I. INTRODUCTION

In traditional machining processes the tool is harder than the work-piece. however, Some materials are too hard to be machined by conventional machining methods. The use of very hard nickel-based and titanium alloys by the aircraft engine industry, for example, has stimulated non conventional machining methods. By conventional methods their machining is not only costly but also results into poor surface finish and shorter tool life. To overcome these difficulties, a number of Newer Machining Methods have been developed. These methods are known as non-conventional method where the tool material should not harder than the work piece material. These methods are base on electro-chemical Metal Removal Processes, Thermal Metal Removal Processes and Mechanical Metal Removal Processes. In specific applications, the non conventional methods become economical than conventional method.

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II. LITERATURE REVIEW

[1]K.H. Ho and S.T. Newman had published a paper titled a State of the art electrical discharge machining (EDM) in June 2003. They summarized Electrical discharge machining (EDM) as a well-established machining option for manufacturing geometrically complex or hard material parts that are extremely difficult-to-machine by conventional machining processes. The non-contact machining techniques have been continuously evolving in a mere tool and die making process to a micro-scale application machining alternative attracting a significant amount of research interests. In recent years, EDM researchers have explored a number of ways to improve the sparking efficiency including some unique experimental concepts that depart from the EDM traditional sparking phenomenon to improve material removal rate. This paper reviews the research work carried out from the inception to the development of die-sinking EDM within the past decade. It reports on the EDM research relating to improving performance measures, optimizing the process variables, monitoring and control the sparking process, simplifying the electrode design and manufacture. A range of EDM applications are highlighted together with the development of hybrid machining processes. The final part of the paper discusses these developments and outlines the trends for future EDM research.

[2]Anand Pandey and Shankar Singh do a review on Current research trends in variants of Electrical Discharge Machining. He wrote that Present manufacturing industries are facing challenges from these advanced materials viz. super alloys, ceramics, and composites, that are hard and difficult to machine, requiring high precision, surface quality which increases machining cost. To meet these challenges, non-conventional machining processes are being employed to achieve higher metal removal rate, better surface finish and greater dimensional accuracy, with less tool wear. Electric Discharge Machining (EDM), a non-conventional process, has a wide applications in automotive, defense, aerospace and micro systems industries plays an excellent role in the development of least cost products with more reliable quality assurance. They have discuss different type of EDM processes like Die sinking EDM, Rotating pin electrode (RPE), Wire electrical discharge machining (WEDM), Micro- EDM, Dry EDM, Rotary disk electrode electrical discharge machining (RDE-EDM). They had summarized the paper as EDM has resulted out as most cost effective and precision machining process in recent years. The capacity of machining hard and difficult to machine parts has made EDM as one of the most important machining processes.

The contribution Variants of EDM has brought tremendous improvements in the surface finish of machined advanced engineering materials. Powder mixed EDM and Ultrasonic assisted EDM has not only reduces tool wear but also increases material removal rate. Modeling and optimization of various electrical and non electrical parameters in EDM improved in precision machining of work materials The review of the research trends in EDM on rotary EDM, dry EDM machining, EDM with powder additives, Ultrasonic assisted EDM ,WEDM and Micro EDM performances is presented. In each topic, the development of the methods for the last 50 years is discussed.

[3]This paper aims to show the prospects of electrical discharge machining (EDM) technology by interrelating recent achievements in fundamental studies on EDM with newly developed advanced application technologies. Although gap phenomena in EDM are very complicated and hence not yet very well understood, recent improvements in computers and electronic measuring instruments are contributing to new discoveries and inventions in EDM technology. Such newly acquired insight sometimes raises questions on the validity of the established theories of EDM phenomena, and EDM processes once believed to be impossible or unrealistic are now becoming practical. EDM processes involve transient phenomena occurring in a narrow space (order of micrometers) and in a short period of time (order of microseconds). These EDM phenomena are not in thermal equilibrium, but include transitions between solid, liquid, gas, and plasma, chemical reactions, mass transfer, and displacement of boundaries. Hence, compared to other discharge phenomena such as glow discharge in dry etching processes and arc discharge in welding processes, physics involved in EDM processes are obviously most complicated, rendering observation and theoretical analysis extremely difficult. Although it is a long way to fully understand the EDM phenomena, thanks to advancements of various surface analyzing equipments, microscopes, high-speed imaging devices, and software tools for numerical analysis, fundamental studies are progressing step by step, and some of the common EDM knowledge which have been accepted for a long time are being modified. On the other hand, given that numerous discharge gap phenomena have yet to be fully understood, the potentials of EDM technology may not be fully realized. Undoubtedly, continuous efforts are expected to lead to further developments of the EDM technology in the future.

[4]Michael F.W. Festing publishes a paper in 2001 as Guidelines for the Design and Statistical Analysis of Experiments. An experiment is a procedure for collecting scientific data in order to answer a hypothesis, or to provide material for generating new hypotheses, and differs from a survey because the scientist has control over the treatments that can be applied. Most experiments can be classified into one of a few formal designs, the most common being completely randomized, and randomized block designs.. Some experiments involve a single independent (treatment) variable, whereas other "factorial" designs simultaneously vary two or more independent variables, such as drug treatment and cell line. Factorial designs often provide additional information at little extra cost. Experiments need to be carefully planned to avoid bias, be powerful yet simple, provide for a valid statistical analysis and, in some cases, have a wide range of applicability. Virtually all experiments need some sort of statistical analysis in order to take account of biological variation among the experimental subjects. Parametric methods using the t-test or analysis of variance are usually more powerful than non-parametric methods, provided the underlying assumptions of normality of the residuals and equal variances are valid.

[5]J.L. Lin and C.L. Lin used grey-fuzzy logic for the optimization of the manufacturing process in 2003. In this paper, the use of the grey-fuzzy logic based on orthogonal array for optimizing the electrical discharge machining process with multi-response has been reported. An orthogonal array, grey relational generating, grey relational coefficient, grey-fuzzy reasoning grade and analysis of variance are applied to study the performance characteristics of the machining process. The machining parameters (pulse on time, duty factor and discharge current) with considerations of multiple responses (electrode wear ratio, material removal rate and surface roughness) are effective. The grey-fuzzy logic approach can help to optimize the electrical discharge machining process with multiple process response. The paper has presented the use of the grey-fuzzy logics based on orthogonal array for the optimization of the electrical discharge machining process with the multiple process responses. Grey relational coefficient analyzes the relational degree of the multiple responses (electrode wear ratio, material removal rate and surface roughness). Fuzzy logic is used to perform a fuzzy reasoning of the multiple performance characteristics. As a result, these approaches can greatly improve the process responses such as the electrode wear ratio, material removal rate and surface roughness in the electrical discharge machining process.

[6] Prof. Dr.-Ing. A. Behrens and Dipl.-Ing. M.P. Witzak had present a paper under the title "New arc detection technology for highly efficient electro-discharge machining". Control of Electro-discharge machining is aimed at a stable process, with

maximum removal rate in combination with high quality surfaces. Electro discharge machining is known for its high statistic and non-linear nature and is therefore difficult to control. Furthermore there does not exist a complete mathematical model for the physical varieties related to the removal process. Therefore it is impossible to go through a classical identification procedure to find a transfer function permitting a controller design for stable process control. Consequently, EDM control requires multiple modules accomplished in hardware sensors and computer systems in combination with so-called technology tables. These technology tables that are created by the manufacturer contain users experience and deliver a great spectrum of basic machining parameters. Modern EDM plants contain so-called adaptive control optimization "which leads to on-line adjustment of an ensemble of working parameters. This paper will present a strategy that belongs to overall process stability control and contains a new arc detection technology. The resulting system enables the user to drive the EDM process under all circumstances near its physical limit i.e. maximum removal rate with regard to a defined surface quality.

[7]C. K. Biswas and Shailesh Dewangan investigate Optimisation of EDM Process with Fuzzy Logic Techniquein in December 26-27, 2012 Dubai (UAE). In this analysis, the optimisation of multiple responses of Electric discharge machining (EDM) using Fuzzy logic coupled with Taguchi method is attempted. The work piece material was AISI P20 tool steel and a cylindrical copper electrode was used with side impulse flushing. The influence of machining parameters, i.e., pulse current (Ip), pulse duration (Ton), work time (Tw), lift time (Tup) and Inter Electrode Gap (IEG) on the Material Removal Rate (MRR) and Surface Roughness(SR) in EDM are examined. L27 orthogonal array was used to design the experiment and the effect of the factors on the responses were studied. Experimental data has been analysed using analysis of variance (ANOVA). As the responses are conflicting in nature, a single combination of factors cannot be treated as best machining performance for all responses. Fuzzy logic is used to convert multiple responses into a single characteristic index known as Multi Performance Characteristic Index (MPCI). Finally, MPCIs were optimised by using robust Taguchi design. This paper has presented the use of fuzzy logic for optimization of the EDM process with multiple performance characteristics. The following factor settings have been identified as to yield the best combination of process variables: Factor Ip= 2A, Ton= 500 μs, Tup= 1.4s, Tw= 1s and IEG= 90 μm. The performance characteristics such as MRR and SR can be improved through this approach.

[8]Samar Singh and MukeshVerma had do A Parametric Optimization of Electric Discharge Drill Machine Using Taguchi Approach published in Journal of Engineering, Computers & Applied Sciences (JEC&AS), ISSN No: 2319-5606, Volume 1, No.3, December 2012. Electric Discharge Drill Machine (EDDM) is a spark erosion process to produce micro holes in conductive materials. This process is widely used in aerospace, medical, dental and automobile industries. As for the performance evaluation of the Electric discharge drilling machine it is very necessary to study the process parameters of machine tool. In this research paper a brass rod 2 mm diameter was selected as a tool electrode. The experiments generate output responses such as material removal rate (MRR). The best parameters such as pulse on-time, Pulse off-time and water pressure were studied for best machining characteristics. This investigation presents the use of Taguchi approach for better MRR in drilling of Al-7075. A plan of experiments, based on L27 Taguchi design method, was selected for drilling of material. From the analysis of variance (ANOVA) shows the percentage contribution of the control factor in the machining of Al-7075 in EDDM. The optimal combination levels and the significant drilling parameters on MRR were obtained. The optimization results showed that the combination of maximum pulse on-time and minimum pulse off-time gives maximum MRR. Influences of EDDM process parameters on MRR of Al 7075 were investigated in this paper. ANOVA shows that Pulse on time has the maximum contribution i.e. 94% on MRR and Pulse off time has 4 % contribution on MRR. It is also concluded from this research that with increase of pulse on time MRR increases and with the increase of Pulse off time MRR decreases.

[9] Yih-fong Tzeng and Fu-chen Chen, "Multi-objective optimisation of high-speed electrical discharge machining process using a Taguchi fuzzy-based approach" Materials and Design 28 (2007) 1159–1168, science direct. The paper describes the application of the fuzzy logic analysis coupled with Taguchi methods to optimise the precision and accuracy of the high-speed electrical discharge machining (EDM) process. A fuzzy logic system is used to investigate relationships between the machining precision and accuracy for determining the efficiency of each parameter design of the Taguchi dynamic experiments. From the fuzzy inference process, the optimal process conditions for the high-speed EDM process can be easily determined. In addition, the analysis of variance (ANOVA) is also employed to identify factor B (pulse time), C (duty cycle), and D (peak value of discharge current) as the most important parameters, which account for about 81.5% of the variance. The factors E (powder concentration) and H (powder

size) are found to have relatively weaker impacts on the process design of the high-speed EDM. Furthermore, a confirmation experiment of the optimal process shows that the targeted multiple performance characteristics are significantly improved to achieve more desirable levels. Here Comparing to the initial trial, the MPCIs of the optimal parameter design are increased by 54.21%. The dimensional precision and accuracy are improved by 25.8% and 0.8%, respectively.

[10] J.L. Lina, K.S. Wangb, B.H. Yan and Y.S. Tarng do Optimization of the electrical discharge machining process published in Journal of Materials Processing Technology 102 (2000) 48-55. In this paper, the application of the Taguchi method with fuzzy logic for optimizing the electrical discharge machining process with multiple performance characteristics has been reported. A multi-response performance index is used to solve the electrical discharge machining process with multiple performance characteristics. The machining parameters (the workpiece polarity, pulse-on time, duty factor, open discharge voltage, discharge current and dielectric fuid) are optimized with considerations of the multiple performance characteristics (electrode wear ratio and material removal rate).

[11]M.P. Jahan, M.Rahman and Y.S.Wong do “A review on the conventional and micro-electro discharge machining of tungsten carbide” published in International Journal of Machine Tools & Manufacture 51(2011)837–858. The capability of machining intricate features with high dimensional accuracy in hard and difficult-to- cut material has made electro discharge machining (EDM) process as an inevitable and one of the most popular non-conventional machining processes. In recent years, both EDM and micro-EDM processes are being used extensively in the field of mould making, production of dies, cavities and complex 3D structures using difficult-to-cut tungsten carbide and its composites. The objective of this paper is to provide a state of the art in the field of EDM and micro-EDM of tungsten carbide and its composites. The review begins with a brief introduction on the EDM and micro-EDM processes. The research and developments in electrodischarge machining of tungsten carbide are grouped broadly into conventional EDM of tungsten carbide, micro-EDM of tungsten carbide and current research trends in EDM and micro-EDM of tungsten carbide. The problems and challenges in the area of conventional and micro- EDM of tungsten carbide and the importance of compound and hybrid machining processes are discussed. A summary of the future research directions based on the review is presented at the final section.

[12] Vishnu D Asal and Prof.R.I.Patel did A Review on Prediction of EDM Parameters using Artificial Neural Network in IJSR Volume : 2 | Issue : 3 | Mar 2013 • ISSN No 2277 - 8179. ANNs can identify and learn correlated patterns between input data sets and corresponding target values. After training, ANNs can be used to predict the outcome of new independent input data. Interest in using Artificial Neural Networks (ANNs) for forecasting has led to a tremendous surge in research activities in the past decade. While ANNs provide a great deal of promise, they also embody much uncertainty. Researchers to date are still not certain about the effect of key factors on forecasting performance of ANNs. This paper presents a Literature survey of ANN applications in forecasting of EDM parameters which controls the MRR, TWR, Surface Roughness, Radial overcut etc. The important findings are summarized as follows :- The unique characteristics of ANNs adaptability, nonlinearity and arbitrary function mapping ability make them quite suitable and useful for forecasting tasks. The findings are inconclusive as to whether and when ANNs are better than classical methods. It is observed that there is a considerable reduction in MSE for the developed network of ANN with GA. It was found that the neural models could predict the process performance with reasonable accuracy, under varying machining conditions. RBFN is faster than the BPNs and the BPN is reasonably more accurate.

[13]Kapil Banker1, Ujjval Prajapati2, Jaimin Prajapati3, Paras Modi “Parameter optimization of Electro Discharge Machine of AISI 304 Steel by using Taguchi Method” International Journal of Application or Innovation in Engineering & Managemen, Volume 3, Issue 8, August 2014 ISSN 2319 – 4847. Electrical discharge machining (EDM) is one of the non-traditional machining processes, based on thermo electric energy between the work piece and an electrode. In this process, the material removal is occurred electro thermally by a series of successive discrete discharges between electrode and the work piece. The optimization of the parameters of the EDM machining has been carried out by using the taguchi’s method for design of experiments (DOE). In recent years many ways has been found for improving the MRR of the WORK PIECE. Taguchi method has been used for design of experiments with three input parameters and their three levels using L9 array. In the research nine experiment had been done along with copper tool material as well as AISI 304L material had been used as a work piece. The dielectric used is kerosene diluted with water. The main objective of the research is the analysis to optimize the process parameters of EDM with the help of taguchi method and using Minitab software in terms of MMR. The different parameters considered while carrying out the experiments on EDM would be the current, Ton, Toff, Time required, Depth of cut etc,. The research

findings show that the copper having high material removal rate with respect to other material such as aluminum, gun metal, brass, etc.

[17]The Response Surface Methodology (RSM) is a collection of mathematical and statistical techniques useful for the modeling and analysis of problems in which a response of interest is influenced by several variables and the objective is to optimize this response. Nuran Bradley's thesis puts emphasis on designing, modeling, and analyzing the Response Surface Methodology. The three types of Response Surface Methodology, the first-order, the second-order, and three- level fractional factorial, will be explained and analyzed in depth. The thesis will also provide examples of application of each model by numerically and graphically using computer software. A first-order model uses low-order polynomial terms to describe some part of the response surface. This model is appropriate for describing a flat surface with or without tilted surfaces. Usually a first-order model fits the data by least squares. Once the estimated equation is obtained, an experimenter can examine the normal plot, the main effects, the contour plot, and ANOVA statistics (F-test, t-test, R2, the adjusted R2, and lack of fit) to determine adequacy of the fitted model. Lack of fit of the first-order model happens when the response surface is not a plane. If there is a significant lack of fit of the first-order model, then a more highly structured model, such as second-order model, may be studied in order to locate the optimum. When the first-order model shows a significant lack of fit, then an experimenter can use a second-order model to describe the response surface. There are many designs available to conduct a second-order design. The central composite design is one of the most popular ones. An experimenter can start with 2q factorial point, and then add center and axial points to get central composite design. Adding the axial points will allow quadratic terms to be included into the model. Second-order model describes quadratic surfaces, and this kind of surface can take many shapes. Therefore, response surface can represent maximum, minimum, ridge or saddle point. Contour plot is a helpful visualization of the surface when the factors are no more than three. When there are more than three design variables, it is almost impossible to visualize the surface. For that reason, in order to locate the optimum value, one can find the stationary point. Once the stationary point is located, either an experimenter can draw a conclusion about the result or continue in further studying of the surface

III. RESEARCH GAP

I found in literature survey that nobody did a process parameter investigation for Air hardening tool steel. Air hardening tool steel has its own properties those may be best for some particular application than other tool steel. It can be use as a forming tool for low duty cutting application. It is comparatively cheaper than HSS tool steel. So I decide to optimize and analyze the process parameter of EDM for any famous grade of Air hardening tool steel.

REFERENCES

[1] K.H. Ho and S.T. Newman, *"A State of the art electrical discharge machining (EDM)"* International Journal of Machine Tools & Manufacture 43 (2003) 1287–1300

[2] Anand Pandey and Shankar Singh *"review on Current research trends in variants of Electrical Discharge Machining"* International Journal of Engineering Science and Technology Vol. 2(6), 2010, 2172-2191

[3] M. Kunieda, B. Lauwers, K. P. Rajurkar, B. M. Schumacher4 *"Advancing EDM through Fundamental Insight into the Process"*

[4] Michael F. W. Festing "*Guidelines for the Design and Statistical Analysis of Experiments"* ATLA, 2001

[5] J.L. Lin and C.L. Lin *"grey-fuzzy logic for the optimization of the manufacturing process"* Journal of Materials Processing Technology 160 (2005)

[6] Prof. Dr.-Ing. A. Behrens and Dipl.-Ing. M.P. Witzak *"New arc detection technology for highly efficient electro-discharge machining"* Universität der Bundeswehr Hamburg Laboratorium Fertigungstechnik (LFT)- Holstenhofweg 85 - 22043 Hamburg

[7] C. K. Biswas and Shailesh Dewangan investigate Optimisation of EDM Process with Fuzzy Logic Technique, International Conference on Metallurgical, Manufacturing and Mechanical Engineering (ICMMME'2012) December 26-27, 2012 Dubai (UAE)

[8] Samar Singh and Mukesh Verma had do A Parametric Optimization of Electric Discharge Drill Machine Using Taguchi Approach published in Journal of Engineering, Computers & Applied Sciences (JEC&AS), ISSN No: 2319-5606, Volume 1, No.3, December 2012

[9] Yih-fong Tzeng and Fu-chen Chen, *"Multi-objective optimisation of high-speed electrical discharge machining process using a Taguchi fuzzy-based approach"* Materials and Design 28 (2007) 1159–1168, science direct.

[10] J.L. Lina, K.S. Wangb, B.H. Yan and Y.S. Tarng *"Optimization of the electrical discharge machining process"* Journal of Materials Processing Technology 102 (2000) 48-55

[11] M.P. Jahan, M.Rahman and Y.S.Wong *"A review on the conventional and micro-electrodischarge machining of tungsten carbide"* International Journal of Machine Tools & Manufacture 51(2011)837–858

[12] Vishnu D Asal and Prof.R.I.Patel did A Review on Prediction of EDM Parameters using Artificial Neural Network in IJSR Volume : 2 | Issue : 3 | Mar 2013 • ISSN No 2277 - 8179

[13] Kapil Banker1, Ujjval Prajapati2, Jaimin Prajapati3, Paras Modi *"Parameter optimization of Electro Discharge Machine of AISI 304 Steel by using Taguchi Method"* International Journal of Application or Innovation in Engineering & Managemen, Volume 3, Issue 8, August 2014 ISSN 2319 – 4847

[14] Marcel Proust, Design of Experiments Guide, version 9, JMP, A Business Unit of SAS, SAS Campus Drive Cary, NC 27513

[15] George E. Dieter, Linda C. Schmidt, ENGINEERING DESIGN, 4th edition, Copyright © 2009 by The McGraw-Hill Companies

[16] Rohit Garg. Ph.D. Thesis, *"Effect of Process Parameters on Performance Measures of Wire Electrical Discharge machining",* National Institute of Technology, Kurukshetra, May 2010

[17] Nuran Bradley, M.E Thesis*, "The Response Surface Methodology",* Department of Mathematical Sciences, Indiana University of South Bend, 2007