International Organization of Research & Development (IORD)
ISSN: 2348-0831
Vol 10 Issue 01 | 2022

Review on Recent Development in the Wire EDM Process

Dipak P Kharat[1] Dr.M P Nawathe[2]
[1] Research Scholar Dept of Mechanical Engg. Prof.Ram Meghe Institute of Technology and Research Badnera –Amravati-444701(MS)
kharatdipak18@gmail.com
[2]Associate Professor Dept of Mechanical Engg. Prof.Ram Meghe Institute of Technology and Research Badnera –Amravati-444701(MS)
mpnawathe1968@gmail.com

DOI: 10.5281/zenodo.7162552

ABSTRACT

The optimum selection of process parameters is essential for advanced machining processes as these processes incur high initial investment, tooling cost, operating and maintenance cost. This report shows the consideration of Modelling and Optimization aspect of Wire Electric Discharge Machining. Wire electrical discharge machining is a widely accepted non-conventional machining process for advanced material removal and profile cutting. It is based on material removal through a series of electrical discharges applied between two electrically conductive electrodes i.e. work piece and wire. Dielectric fluid is injected into the gap, which is the space between electrodes. Thus, there is no contact between tool and work piece during the process.Each discharge is generated as follows the WEDM machine power supply applies a voltage between work piece and wire. It starts the ionization period of the dielectric fluid, which is known as ignition delay time. Dielectric ionization induces the discharge that vaporizes all the material around. One of the main challenges in wire electrical discharge machining is to eliminate wire breakage. The present work highlights the development of mathematical models using response surface modeling (RSM) for correlating the inter-relationships of various Wire Electric Discharge Machining parameters such as Pulseon time, Pulse off time, Peak voltage, Water pressure, Wire feed, Machine speed , Cutting speed override, etc.

Keywords— Optimization, cutting rate, deviations, WEDM, Response surface modeling

1. INTRODUCTION

Wire electric discharge machining (WEDM) is a widely accepted non - traditional material removal process used to manufacture the components with intricate shape and profiles [1]. Due to many parameters and the complex and stochastic nature of the process, achieving the optimal performance of very difficult task. The objective of this present work is therefore to discover the relationship between the performance measures of the process and its controllable input parameters and subsequently to find the optimal combination of the input parameters to achieve the maximum process performance [1, 2]. A mathematical model using response surface modeling (RSM) approach is developed for correlating the interrelationship of various wire electric discharge machining (WEDM) parameters with performance measure [2,3].

WEDM is an innovative modification on traditional EDM technique in which an electrode is employed to trigger the sparking process immediately after start-up [5]. A continuously travelling wire electrode composed of thin copper, brass, or tungsten wire with a diameter of 0.05-0.30 mm is used in WEDM, whereas a thin copper or brass wire electrode is used in WEDM. WEDM can produce extremely small corner radii when used in conjunction with thin copper, brass, or tungsten wire electrode. Because the wire is held in tension by way of a mechanical tensioning device, there is a lower chance of incorrect parts being manufactured [6]. In the course of the WEDM process, the material erodes ahead of the wire and there is no direct contact between the work piece and the wire, resulting in the elimination of mechanical stresses that would otherwise develop throughout the machining procedure.

1.1. OVERVIEW AND RECENT STATUS OF PROCESS

The Wire Electric Discharge Machining (WEDM) is a variation of EDM and is commonly known as wire-cut EDM or wire cutting [1]. In this process, a thin metallic wire is fed on-to the work piece, which is submerged in a tank of dielectric fluid such as deionized water. This process can also cut plates as thick as 300mm and is used for making punches, tools and dies from hard metals that are difficult to machine with other methods. In the wire-cut EDM process, water is commonly used as the dielectric fluid. Filters and de-ionizing units are used for controlling the resistivity and other electrical properties. Wires made of brass are generally preferred [3]. The water helps in flushing away the debris from the cutting zone. The selection of process parameters is very crucial [4]. For machining newly developed high strength alloys with high degree of dimensional accuracy and lower cost of production, EDM (electrical discharge machining) is a very successful, practical and profitable non-conventional machining process as compared to conventional machining. These materials are generally useful for many commercial and industrial applications like aircraft, automotive, aerospace, tool and die making, medical & surgical equipment etc. where high strength, hardness, high wear resistance and thermal stability are essential. We have selected the third generation Al-alloy (Al-2050) for machining, which finds wide applications in aerospace industry. EDM is broadly used in producing complex dies, tools and other components of hard and electrically conductive materials. EDM is very useful for Al-2050 alloy because it is Li-based complex hard alloy, which is electrically conductive. A considerable study has been carried out in the context of EDM of advanced materials and optimization of the process parameters of EDM by various optimization techniques. But relatively less investigation has been conducted in the area of EDM machining and drilling of Al-2050 alloys. In recent years, requirements of "High value-added" has increased to the wire-cut EDM under the situation of the high precision requirement of industrial products or the high labor cost. For corresponding to them, focusing on "Improvement of performance being helpful for the practical cutting in factories", we have developed advanced cutting technologies, various effective functions and a management tool for productions and quality data on our wire-cut EDM, ROBOCUT.

2. LITERATURE REVIEW

Various researchers had tried to optimize efficient process parameters of WEDM methods using various approaches discussed in this section. Lee and Li [1] carried out the study of influence of operating parameters of WEDM on tungsten carbide for the material removal rate (MRR) and surface finish using gap voltage, discharge current, pulse duration, dielectric flushing pressure as an operating parameters. Electric discharge machine is a process for shaping hard metals and forming deep and complex shape holes by arc tension in all kind of electro - conductive materials. An extensive experimental study has been conducted to investigate the effect of process parameters. The machining parameters are wire material, open circuit voltage, peak current, pulse duration. The machining characteristics are material removal rate, surface roughness. For wire, the material removal rate increases with increasing peak current. The material removal rate generally decreases with the increase of open circuit voltage, whereas the relative wear ration and machined work piece surface roughness increases with increase of open circuit voltage. The material removal rate decreases when the pulse interval is increased and the material removal rate decreases gradually with the flushing pressure, and becomes constant at high values of flushing pressure.

Puri and Bhattacharya [2] used Taguchi with orthogonal array with average cutting speed, surface finish characteristics and wire lag as a machining criteria. The optimum parametric setting for wire lag based on machining criteria. An extensive study of the wire lag phenomenon in Wire-cut Electrical Discharge Machining (WEDM) has been carried out and the trend of variation of the geometrical inaccuracy caused due to wire lag with various machine control parameters has been established in this work. The Taguchi methodology is employed to find out the main parameters that affect the different machining criteria, such as average cutting speed, surface roughness values and the geometrical inaccuracy caused due to wire lag in the present set of research study. Almost all the control factors have been studied simultaneously to establish the trends of variation of a few important machining criteria with various control parameters. A rough cut followed by a trim cut has been considered as a machining operation. Based on the constraints of the present set of experimentation. The average cutting speed (*Vc*) is mostly effected by pulse on time, pulse off time and pulse peak current during rough cutting; and pulse on time and the constant (not proportional as in rough cutting) cutting speed during trim cutting. The surface roughness values (*Ra*) are influenced mostly by pulse peak current during rough cutting and pulse on time, pulse peak voltage, servo spark gap set voltage, dielectric flow rate, wire tool offset and constant cutting speed during trim cutting. The significant factors for geometrical inaccuracy due to wire lag (*g*) are pulse on time, pulse off time and pulse peak current during rough cutting and pulse peak voltage, wire tension, servo spark gap set voltage, wire tool offset and constant cutting speed during trim cutting,

Tosun and Cogun [4] used regression analysis for mathematical modeling and the optimal search is based on the established mathematical model. The pulse duration, open circuit voltage, wire speed and dielectric flushing pressure were used as a process parameter to find the optimal result of kerf and material removal rate. The experimental studies were conducted under varying pulse duration, open circuit voltage, wire speed and dielectric flushing pressure. The settings of machining parameters were determined by using Taguchi experimental design method. The level of importance of the machining parameters on the cutting kerf and MRR is determined by using analysis of variance (ANOVA). The variation of kerf and MRR with machining parameters is mathematically modeled by using regression analysis method. The optimal search for machining parameters for the objective of minimum kerf together with maximum MRR is performed by using the established mathematical models. The level of importance of the machining parameters on the kerf and the MRR is determined by using ANOVA. Based on ANOVA method, the highly effective parameters on both the kerf and the MRR were found as open circuit voltage and pulse duration, whereas wire speed and dielectric flushing pressure were less effective factors. The results showed that open circuit voltage was about three times more important than the second ranking factor (pulse duration) for controlling the kerf, whereas open circuit voltage for controlling the MRR was about six times more important than the second ranking factor (pulse duration).

Ho et al [5] reviews the vast array of research work carried out from EDM to development of WEDM. It reports on the WEDM research involving the optimization of the process parameters surveying the influence of the various factor affecting the machining performance and productivity. The ultimate goal of the WEDM process is to achieve an accurate and efficient machining operation without compromising the machining performance. This is mainly carried out by understanding the interrelationship between the various factors affecting the process and identifying the optimal machining condition from the infinite number of combination. The adaptive monitoring and control system have also been extensively implemented to tame the transient WEDM behavior without the risk of wire breakage.

Luis et al [6] used a fractional factorial design to determine the most effective combination of wire EDM. In this work five process parameters namely intensity, pulse time, duty cycle, open - circuit voltage and dielectric flushing pressure are considered as a significant controllable factors, which directly affect the Material removal rate (MRR) and electrode wear. The selection of the above-mentioned conductive ceramic was made taking into account its wide range of applications in the industrial field: high-temperature gas turbines, bearings, seals and lining of industrial furnaces. This study was made only for the finish stages and has been carried out on the influence of five design factors: intensity supplied by the generator of the EDM machine (*I*), pulse time (*ti*), duty cycle (η),open-circuit voltage (*U*) and dielectric flushing pressure (*P*), over the two previously mentioned response variables. This has been done by means of the technique of design of experiments (DOE), which allows us to carry out the above-mentioned analysis performing a relatively small number of experiments. Study on the influence of the most relevant EDM factors over material removal rate (MRR) and electrode wear (EW) has been carried out. The study has been made for a conductive ceramic such as siliconised silicon carbide (SiSiC) and only for the finish stages. In order to achieve this, DOE and multiple linear regression statistical techniques have been employed to model the previously mentioned response variables by means of equations in the form of polynomials. The design finally chosen to accomplish the present study was a fractional factorial one of type 25−1 and whose resolution is V. The design factors selected in this case were intensity (I), pulse time (ti), duty cycle (η), open-circuit voltage (U) and flushing pressure (P), where all of them, except for the last one, are parameters widely used by the machinists to control the EDM machine generator.

Shandilya et al [16] used analysis of variance (ANOVA) and response surface methodology (RSM) for study the effect of process parameters on response parameters. The process parameters considered servo voltage, pulse on time, pulse off time and wire feed rate while the response is kerf. In this work, an attempt was made to study the effects of voltage, pulse-on time,pulse-off time and wire feed rate on kerf separately in WEDM of SiCp/6061 Al MMC. Input process parameters have been found to play a significant role in the minimization of kerf. ANOVA results show that voltage and wire feed rate are highly significant parameters and pulse-off time is less significant. Pulse-on time has insignificant effect on kerf. For targeted value of kerf the optimized values of servo voltage is 70.06 V, pulse-on time is 2.81 s, pulse-off time is 7.79 s and wire feed rate is 8.90 m/min. SEM images of the cut surfaces have revealed that the fine surface finish was obtained when machining was doneat a combination of lower levels of input process parameters. When machining was done at combination of higher levels of input process parameters, craters and black patches arise on the machined surface. AFM analysis of machined surfaces showsthat there is considerable decrease in surface roughness with decrease in voltage and this reduction is of the magnitude of approximately 59.27% in the taken range of voltage. The results of the present study based on WEDM of SiCp/6061 Al MMCs can be used for effective and economical machining of SiCp/6061 Al MMCs by WEDM. The present work is focused on the WEDM of SiCp/6061 Al MMCs having SiC particles upto 10%. In future the study can be extended for various percentages ofSiC particles in MMCs. The present work is an attempt at investigating the machinability studies in WEDM of SiCp/6061 Al MMCs. The work can be extended by using other matrix material like Mg alloys and titanium alloys as well as different typesof reinforcing material such as graphite, Al2O3 etc.

However, these traditional methods of optimization do not fare well over a broad spectrum of problem domain. Moreover traditional techniques may not be robust and they also tend to obtain a local optimal solution. Considering the drawbacks of traditional optimization technique, attempts are being made to optimize the machining problem using non- conventional optimization techniques such as particle swarm optimization. These methods use the fitness information instead of the functional derivatives making them more robust and effective. Efforts are continuing to use more recent optimization algorithm, which are more powerful, robust and able to provide accurate solution. Various researchers had tried to optimize efficient process parameters of WEDM. Sixteen research papers have been studied and pie charts are formulated.

3. FUTURE SCOPE

On the basis of the literature review, several significant future scopes for research are derived and provided in the following sections.

- According to an earlier researcher, only a limited number of studies have been conducted on the impact of process parameters on the machining characteristics and the heat affected zone; thus, further study is needed to improve the process.
- For obtaining good performance metrics and the adjustable parameters, there are no precise mathematical formulae to be found, that can be explored.
- There are no handbook recommendations or manufacturing guidelines available for defining the parameters to cut the material as a result of this situation.
- As a result, the challenge is considered to be an investigation of the influence of process parameters on machining characteristics with the goal of minimizing wire breakage while also optimizing the process.
- Only few researches have been done to determine if the mechanical characteristics and surface integrity of WEDM worked material have changed.
- There have only been a few research on multi response optimization using response surface methods.
- Identifying electrode materials while considering their thermal qualities from the standpoint of cutting speed has only beenattempted in a limited number of cases.

4. CONCLUSIONS

In this paper, the recent studies and development in the WEDM process are discussed. In this study, new studies and developments in the WEDM process, as well as their implications were discussed. The research includes a thorough examinationof relevant literature, which is made available in its entirety in the report. It also discusses the numerous tactics that have been identified in the literature to date. A study of the literature has been carried out in order to address the approaches and research in the field of environmental decision making (WEDM). There is now ongoing research into a wide range of steels and alloys as substrate materials, with the goal of enhancing their overall performance. Numerous approaches and procedures, as well as contemporary techniques, standards, and process elements, were uncovered during the investigation. Other than achieving the objectives specified in the presentation, the RSM may be used to accomplish other goals as well.

5. REFERENCES

[1] Lee, S. H., & Li, X. P. (2001). Study of the effect of machining parameters on the machining characteristics in electricaldischarge machining of tungsten carbide. *Journal of materials processing Technology*, *115*(3), 344-358.

[2] Puri, A. B., & Bhattacharyya, B. (2003). An analysis and optimisation of the geometrical inaccuracy due to wire lagphenomenon in WEDM. *International Journal of Machine tools and manufacture*, 43(2), 151-159.

[3] Tosun, N., & Cogun, C. (2003). An investigation on wire wear in WEDM. *Journal of materials processing technology*, *134*(3),273-278.

[4] Tosun, N., Cogun, C., & Tosun, G. (2004). A study on kerf and material removal rate in wire electrical discharge machiningbased on Taguchi method. *Journal of materials processing technology*, *152*(3), 316-322.

[5] Mandal, A., & Dixit, A. R. (2014). State of art in wire electrical discharge machining process and performance. *InternationalJournal of Machining and Machinability of Materials*, *16*(1), 1-21.

[6] Luis, C. J., Puertas, I., & Villa, A. G. (2005). Material removal rate and electrode wear study on the EDM of siliconcarbide. *Journal of materials processing technology*, *164*, 889-896.

[7] Mohammadi, A., Tehrani, A. F., Emanian, E., & Karimi, D. (2008). Statistical analysis of wire electrical discharge turning onmaterial removal rate. *Journal of materials processing Technology*, *205*(1-3), 283-289.

[8] Haddad, M. J., & Tehrani, A. F. (2008). Material removal rate (MRR) study in the cylindrical wire electrical discharge turning(CWEDT) process. *Journal of Materials Processing Technology*, *199*(1-3), 369-378.

[9] Singh, H., & Garg, R. (2009). Effects of process parameters on material removal rate in WEDM. *Journal of Achievements inMaterials and Manufacturing Engineering*, *32*(1), 70-74.

[10] Rao, R. V., & Pawar, P. J. (2009). Modelling and optimization of process parameters of wire electrical discharge machining. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, *223*(11), 1431-1440.

[11] Rao, R. V., & Pawar, P. J. (2010). Process Parameters Modeling and Optimization of Wire Electric Discharge Machining. *Advances in Production Engineering & Management*, *5*(3).

[12] Islam, M. N., Rafai, N. H., & Subramanian, S. S. (2010, June). An investigation into dimensional accuracy achievable in wire-cut electrical discharge machining. In *Proceedings of the world congress on Engineering* (Vol. 3, pp. 19-20).

[13] Jatinder, K., & Rupesh, C. R. (2011). Effect of Process Parameters on Machining Characteristics of Pure Titanium (ASTM Grade 2) Using WEDM. *International Journal of Advanced Engineering Technology*, *2*(5).

[14] Mevada, J. R., Shah, C. D., & Khatri, B. C. (2012). A wear investigation of repeatedly used wire in wire cut electrical dischargemachine. *International Journal of Emerging Technology and Advanced Engineering*, *2*(12).

[15] Srivastava, V., & Pandey, P. M. (2012). Effect of process parameters on the performance of EDM process with ultrasonic assisted cryogenically cooled electrode. *Journal of Manufacturing Processes*, *14*(3), 393-402.

[16] Dwivedi, A.P., Choudhury, S.K., (2016). Increasing the Performance of EDM Process Using Tool Rotation Methodology forMachining AISI D3 Steel. Procedia CIRP, 46, pp. 131 – 134.

[17] Gohil, V., Puri, Y.M., (2018). Optimization of Electrical Discharge Turning Process using Taguchi-Grey Relational Approach.Procedia CIRP, 68, pp. 70 – 75

[18] Kachhap, S., Singh, A., Debnath, (2018). Electric Discharge Drilling of Hybrid Meta Matrix composites using different toolelectrode. Journal of Scientific & Industrial Research, 77, pp. 325-329.

[19] Kumar, D., Mondal, S., (2019). A Fuzzy-TOPSIS Method for Optimizing of Forging Problems. International Journal ofInnovative Technology and Exploring Engineering, 8(12), pp. 3306-3314.