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A Review on Recent Research Trends in WEDM

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Abstract—*Wire-cut electrical discharge machining (WEDM) is one of the most emerging non conventional manufacturing processes for machining hard to machine materials and intricate shapes which are not possible with conventional machining methods. This paper reviews the effects of various WEDM process parameters such as pulse on time, pulse off time, servo voltage, peak current, dielectric flow rate, wire speed, wire tension on different process response parameters such as material removal rate (MRR), surface roughness (Ra), Kerf (width of Cut), wire wear ratio (WWR) and surface integrity factors. This paper also reviews various optimization methods applied by the researchers and finally outlines the recommendations and future trends in WEDM research.*

Keywords*: Optimization, Process parameters, Review, Wire-cut EDM.*

1. INTRODUCTION

Accompanying the development of mechanical industry, the demands for alloy materials having high hardness, toughness and impact resistance are increasing. Nevertheless, such materials are difficult to be machined by traditional machining methods. Hence, non-traditional machining methods including electrochemical machining, ultrasonic machining, electrical discharging machine (EDM) etc. are applied to machine such difficult to machine materials. WEDM process with a thin wire as an electrode transforms electrical energy to thermal energy for cutting materials. With this process, alloy steel, conductive ceramics and aerospace materials can be machined irrespective to their hardness and toughness. Furthermore, WEDM is capable of producing a fine, precise, corrosion and wear resistant surface. WEDM is considered as a unique adoption of the conventional EDM process, which uses an electrode to initialize the sparking process. However, WEDM utilizes a continuously travelling wire electrode made of thin copper, brass or tungsten of diameter 0.05-0.30 mm, which is capable of achieving very small corner radii. The wire is kept in tension using a mechanical tensioning device reducing the tendency of producing inaccurate parts. During the WEDM process, the material is eroded ahead of the wire and there is no direct contact between the work piece and the wire, eliminating the mechanical stresses during machining. The present study shows a literature review based on some important research papers shows different trends on WEDM

2. WORKING PRINCIPLE OF WEDM

A model of WEDM is shown in Fig I The electric discharge is caused to occur erratically in a pulse-like manner between an electrode wire and a work piece through a processing liquid so as to fuse-cutting the work piece in a desired configuration. A pulse voltage is applied between the wire electrode and workpiece in the processing fluid to melt the surface of the workpiece by the thermal energy of an arc discharge, while at the same time removing machining dust through a vaporizing explosion and recirculation of the processing fluid. The residue resulting from the melting of a small volume of the surface of both the workpiece and the EDM wire electrode is contained in gaseous envelope .The plasma eventually collapses under the pressure of the dielectric fluid. The liquid and the vapor phases created by the melting are quenched by the dielectric fluid to form solid debris. This process is repeated at nanosecond interval along the length of the wire in cutting zone.

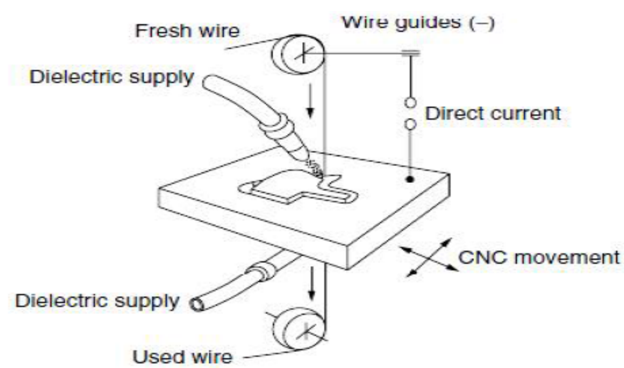

Fig. I: Wire electric discharge machining (WEDM)

The most important performance measures in WEDM are metal removal rate, surface finish, and cutting width. They depend on machining parameters like discharge current, pulse duration, pulse frequency, wire speed, wire tension and dielectric flow rate. Among other performance measures, the kerf, which determines the dimensional accuracy of the finishing part, is of extreme importance. The internal corner radius to be produced in WEDM operations is also limited by the kerf. The gap between the wire and work piece usually ranges from 0.025 to 0.075 mm and is constantly maintained by a computer controlled positioning system.

3. LITERATURE REVIEW

Speeding and Wang, 1997; Scott et al., (1991) have concluded that WEDM is an essential operation in several manufacturing processes in some industries, which gives importance to variety, precision and accuracy. Several researchers have attempted to improve the performance characteristics namely the surface roughness, cutting speed, dimensional accuracy and material removal rate. But the full potential utilization of this process is not completely solved because of its complex and stochastic nature and more number of variables involved in this operation [1].

R.Nagaraja, K.Chandrasekaran, S.Shenbhgaraj (2015) presents an investigation on the optimization of machining parameters in WEDM of bronze-alumina MMC. The main objective is to find the optimum cutting parameters to achieve a low value of Surface roughness and high value of material removal rate (MRR). The cutting parameters considered in this experimental study are, pulse on time (Ton), pulse off time (Toff) and wire feed rate. The settings of cutting parameters were determined by using Taguchi experimental design method. An L9 orthogonal array was chosen. Signal to Noise ratio (S/N) and analysis of variance (ANOVA) was used to analyze the effect of the parameters on surface roughness and to identify the optimum cutting parameters. The contribution of each cutting parameters towards the surface roughness and MRR is also identified. The study shows that the Taguchi method is suitable to solve the stated problem with minimum number of trails as compared with a full factorial design [2].

R.Pandithurai, I. Ambrose Edward (2014) illustrates that WEDM involves complex physical and chemical process including heating and cooling. The electrical discharge energy affected by the spark plasma intensity and the discharging time will determine the crater size, which in turn will influence the machining efficiency and surface quality. This paper presents an effective approach to optimize process parameters for Wire electro discharge machining (WEDM).WEDM is extensively used in tool and die industries. Precision and intricate machining are the strengths. While machining time and surface quality still remains as major challenges. The main objective of this study is to obtain higher material removal rate (MRR) and lower surface roughness (SR). Ton, T off, Gap voltage and wire feed rate are the four control factors taken each at various levels. The genetic algorithm optimization tool is used to find the factors level that create a low surface roughness in WEDM [3].

P. Abinesh , Dr. K. Varatharajan , Dr. G. Satheesh (2014) shows that the study exhibits that WEDM process parameters can be altered to achieve betterment of Material removal rate(MRR),Surface Roughness (SR) and Electrode Wear. The objective of our project is to investigate and optimize the potential process parameters influencing the MRR, SR and Electrode Wear while machining of Titanium alloys using WEDM process. This work involves study of the relation between the various input process parameters like Pulse-on time(Ton), Pulseoff time(Toff), Pulse Peak Current(IP), Wire material and Work piece material and process variables. Based on the chosen input parameters and performance measures L-16 orthogonal array is selected to optimize the best suited values for machining for Titanium alloys by WEDM [4].

Harshad kumar C. Patel et al (2012) found Process parameters affect different response in different ways MRR increase by increasing Pulse on Time, flushing pressure and reduces with increasing Pulse OFF Time. Increasing Pulse ON Time also increase Surface Roughness. Material Thickness has little effect on MRR but it has significant effect over surface finish. Increasing Thickness reduces Surface Roughness and increase surface finish. Little interaction effect found for Surface Roughness between wire tension and flushing pressure [5].

S.R.Nithin Aravind (2012) found five optimal control parameters input voltage, current, speed, pulse on/off time to maximize metal removal rate (MRR) and minimize surface roughness (SR) on wire edm (electrical discharge machining). For the purpose to get a best solution to maximize MRR and reduce SR, he optimize parameters using taguchi method. Also he compares experimental reading with taguchi optimum result to know the optimal solution [6].

Bijendra Diwakar (2012) researched the work, through the Taguchi methodology found the optimum process parameters for CNC wire electric discharge machining (WEDM). The research is to optimize the MRR and Surface Roughness of work piece high chromium high carbon (HCHC) die steel tool. This methodology based on Taguchi's, analysis of variance (ANOVA) and signal to noise ratio (S/N Ratio) to optimize the CNC WEDM process parameter. The design of experiment for machining process control parameter are Voltage(A), Discharge current(B), Pulse duration(C), Pulse frequency(D) and Wire Tension(E) L27 (3*5) standard orthogonal array design of experiment three level and five parameter A,B,C,D and E respectively for each combination we have conducted one experiment [7].

Jatinder Kapoor (2011) studied the results of the effect of Cryogenic treated brass wire electrode on the surface of an EN-31 steel machined by WEDM. Full factorial experimental design strategy is used in the experimentation. Three process parameters, namely type of wire electrode (untreated and cryogenic treated brass wire electrodes), Pulse width, and wire tension have been considered. The process performance is measured in terms of surface roughness (SR). Type of wire, pulse width and wire tension significantly affect the SR in WEDM ANOVA results indicated that all the process parameters have significant effect on SR [8].

Mustafa Ilhan Gokler and Alp Mithat Ozanozu (2000) present the experimental study to select the most suitable cutting and offset parameter combination for the wire electrical discharge machining process in order to get the desired surface roughness value for the machined workpieces. A series of experiments have been performed on 1040 steel material of thicknesses 30, 60 and 80 mm, and on 2379 and 2738 steel materials of thicknesses 30 and 60 mm [9].

Fuzhu Han, Jun Jiang and Dingwen Yu (2007) gives the journal on Influence of machining parameters on surface roughness in finish cut of WEDM, according to them Surface roughness is significant to the finish cut of wire electrical discharge machining (WEDM). This paper describes the influence of the machining parameters (including pulse duration, discharge current, sustained pulse time, pulse interval time, polarity effect, material and dielectric) on surface roughness in the finish cut of WEDM. Experiments proved that the surface roughness can be improved by decreasing both pulse duration and discharge current. When the pulse energy per discharge is constant, short pulses and long pulses will result in the same surface roughness but dissimilar surface morphology and different material removal rates. The removal rate when short pulse duration is used is much higher than when the pulse duration is long [10].

Nihat Tosun and Can Cogun (2003) carried out an investigation on wire wear in WEDM- In this study, the effect of cutting parameters on wire electrode wear was investigated experimentally in wire electrical discharge machining (WEDM). The experiments were conducted under different settings of pulse duration, open circuit voltage, wire speed and dielectric fluid pressure. Brass wire of 0.25 mm diameter and AISI 4140 steel of 10 mm thickness were used as tool and workpiece material. It is found experimentally that the increasing pulse duration and open circuit voltage increase the wire wear ratio (WWR) whereas the increasing wire speed decreases it. The variation of workpiece material removal rate and average surface roughness were also investigated in relation to the WWR. The variation of the WWR with machining parameters was modelled statistically by using regression analysis technique. The level of importance of the machining parameters on the WWR was determined by using analysis of variance (ANOVA) method [11].

Aminollah Mohammadi, Alireza Fadaei Tehrani, Ehsan Emanian and Davoud Karimi (2008) shows that Statistical analysis of wire electrical discharge turning on material removal rate was made. The application of wire electrical discharge machining (WEDM) for machining of precise cylindrical forms on hard and difficult-to-machine materials is presented. At first, the design of a precise, flexible and corrosion-resistant rotary spindle submerged is introduced. The spindle has been mounted on a five-axis wire EDM machine to rotate the workpiece in order to generate free form cylindrical geometries. The material removal rate (MRR) is an important indicator of the efficiency and cost-effectiveness of the process. Several experiments are conducted to consider effects of power, time-off, voltage, servo, wire speed, wire tension, and rotational speed (factors) on the MRR (response) [12].

Williams and Rajurkar performed experimental investigations on WEDM to study the wire electrical discharged machined surface characteristics. The main objective of research was to stochastically model and analyze WEDM surface profiles to gain a better understanding of the surface generating mechanism. Further scanning electron microscopy and energy dispersive spectrometry were also used to study WEDM surface characteristics [13].

Davies et.al (2007) reviewed several temperature measurement methods and used them in temperature monitoring during material removal in WEDM. There study outlines the physics of each method, detailing the sources and evaluation of uncertainty. Finally, using critical criteria in measuring material removal rate, methods were compared and the results were presented in guide-format for participants in this field of work [14].

Gao., Q., Zhang (2008) established the parameter optimization model and for the same they used artificial neural network (ANN) and genetic algorithm techniques (GA). ANN model was setup to represent the relationship between material removal rate and input parameters (pulse on time and pulse off time) and GA was used to optimize the input parameters .The suggested model was Found effective and material removal rate was improved after using optimized parameters [15].

4. CONCLUSIONS

From the papers referred above, many conclusions have been drawn. These are summarized below:

1. The surface roughness can be improved by decreasing both pulse duration and discharge current.
2. This indicates that a short pulse duration combined with a high peak value can generate better surface roughness, which cannot be achieved with long pulses.
3. Reversed polarity machining with the appropriate pulse energy can improve the machined surface roughness somewhat better compared with normal polarity in finish machining, but some copper from the wire electrode is accreted on the machined surface.
4. The hardness and strength of the work material are no longer the dominating factors that affect the tool wear and hinder the machining process.
5. The increasing pulse duration and open circuit voltage increase the wire wear ratio whereas the increasing wire speed decreases it.

REFERENCES

[1] Spedding, T. A., Wang, Z.Q. (1997), “Parametric optimization and surface characterization of wire electrical discharge machining process”, Precision Engineering, 20(1), 5-15.

[2] R.Nagaraja, K.Chandrasekaran, S.Shenbhgaraj (2015),” Optimization Of Parameter For Metal Matrix Composite In

WIRE EDM", International Journal Of Engineering Sciences & Research Technology, February, 2015.

[3] R.Pandithurai, I. Ambrose Edward," Optimizing surface roughness in Wire-EDM using machining parameters", International Conference on Innovations in Engineering and Technology (ICIET'14).

[4] P. Abinesh, Dr. K. Varatharajan , Dr. G. Satheesh Kumar," Optimization of Process Parameters Influencing MRR, Surface Roughness and Electrode Wear During Machining of Titanium Alloys by WEDM", International Journal of Engineering Research and General Science Volume 2, Issue 4, June-July, 2014.

[5] Harshadkumar C. Patel, Dhaval M. Patel, Rajesh Prajapati (July-August 2012), "Parametric Analysis And Mathematical Modelling Of MRR And Surface Roughness For H-11 Material On Wire Cut EDM By D.O.E Approach" Vol. 2, Issue4, pp.1919-1924.

[6] S.R.Nithin Aravind (March 2012) "Optimization of metal removal rate and surface roughness on wire edm using taguchi method".

[7] Bijendra Diwakar, Vedansh Chaturvedi and Jyoti Vimal (July 2012), "Application of taguchi approach for optimization of CNC wire electrical discharge machining process parameters".

[8] Jatinder Kapoor, Jaimal Singh Khamba, Sehijpal Singh (Oct. 7-8,2011) "Effects of cryogenic treated wire electrode on the surface of an EN-31 steel machined by WEDM" National Conference on Advancements and Futuristic Trends in Mechanical and Materials Engineering.

[9] Mustafa Ilhan ,Ozanozgu, Alp Mithat-Experimental investigation of effects of cutting parameters on surface roughness in the WEDM process, International Journal of Machine Tools and Manufacture, Volume 40, Issue 13, Pages 1831-1848, October 2000.

[10] Fuzhu Han, Jun Jiang and Dingwen Yu-Influence of machining parameters on surface roughness in finish cut of WEDM**,** The International Journal of Advanced Manufacturing Technology, 2007, Volume 34, Numbers 5-6, Pages 538-546.

[11] Nihat Tosun and Can Cogun- An investigation on wire wear in WEDM, Journal of Materials Processing Technology Volume 134, Issue 3, 20 March 2003, Pages 273.278

[12] Aminollah Mohammadi, Alireza Fadaei Tehrani, Ehsan Emanian and Davoud Karimi- *analysis of wire electrical discharge turning on material removal rate,* Journal of Materials Processing Technology Volume 205, Issues 1.3, 26 August 2008, Pages 283.289

[13] Williams, R. and Rajurkar., K.,(1991),Study of wire electrical discharge machined surface characteristics, Journal of Materials Processing Technology, 28, pp.127-138.

[14] Davies M. A., Ueda. T., Saoubi., and Mullany., B., (2007), On the measurement of temperature in material removal process, Annals of the CIRP vol. 56, pp. 581-604.

[15] Gao., Q., Zhang., Q., and Zhang., J., (2008), Parameter optimization model in electrical discharge machining process, Journal of Zhejiang University Science A, pp.104-108.