International Journal of Innovative Research in Science and Engineering
Vol. No.3, Issue 06, June 2017
www.ijirse.com
ISSN (O) 2454-9665
ISSN (P) 2454-0663

EFFECTS OF VARIOUS PROCESS PARAMETERS OF WEDM ON PERFORMANCE CHARACTERISTICS : A REVIEW

Prateek[1], J.P.Misra[2]

[1]M.Tech. Scholar,Mech. Engg. Deptt . NIT Kurukshetra, (India)
Assistant professor Mech. Engg. Deptt.NIT Kurukshetra, (India)

ABSTRACT

Since last decades wire electric discharge machining (WEDM) is emerging as a unique machining technique employed to manufacture components with intricate shapes and complex profiles. Various experimental investigations have been carried out to study the effect of process parameters on process performance characteristics of WEDM: material removal rate (MRR), wire wear rate (WWR), surface roughness (Ra) and wear ratio during WEDM of different alloys. It is evident from the present study that the process parameters have significant influence on process performance characteristics.This paper reviews the various notable works in the field of WEDM and emphasis is made on optimization of machining parameters.

Keywords: Material Removal Rate (MRR), Surface Roughness (Ra),WEDM, Wear Ratio (WR), Wire Wear Rate (WWR).

I .INTRODUCTION

Wire electrical discharge machining (WEDM) is a widely used nontraditional machining process to machine intricate shapes and profiles. It is a thermo-electrical process in which material is removed by generating a series of discrete sparks between electrode and work piece immersed in a liquid dielectric medium. The discrete spark discharges melt and vaporize the minute amounts of work piece. A thin electrically conductive wire acts as the electrode. Wire is fed continuously and pulled by an automatic take-up mechanism. The movement of the wire is numerically controlled to get required shape and accuracy of workpiece. The dielectric fluid is continuously injected to flush away minute amounts of removed material as shown in figure 1 (Schematic diagram of WEDM). WEDM finds extensive applications in various fields like tool and die manufacturing industries, space applications, and automotive industries. The selection of machining parameters in a machining process significantly affects production rate and quality of machined components. The selection of these parameters in WEDM is primarily dependent on the operator's experience and machining parameter tables provided by the machine-tool manufacturers. However, such criterion does guarantee neither high production rate nor good surface quality.

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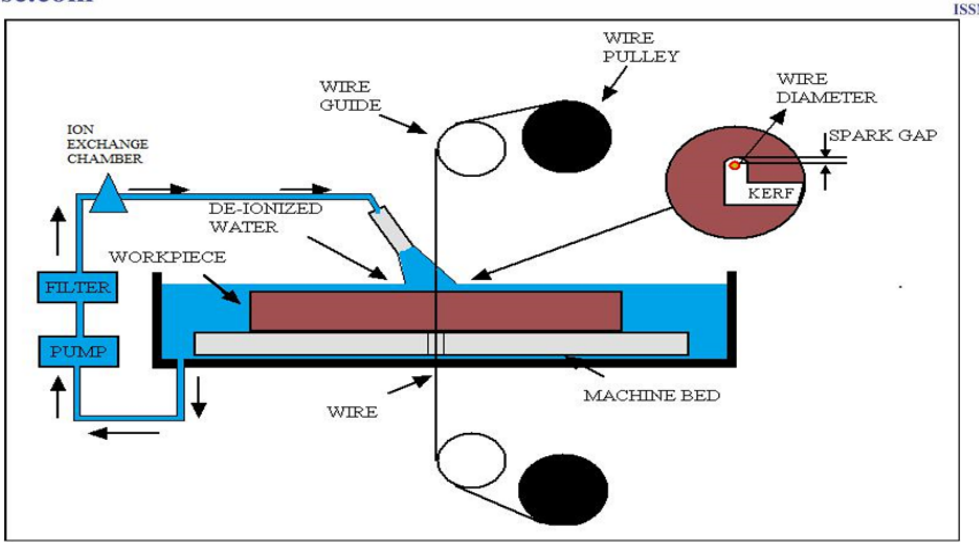

Figure 1. Schematic diagram of WEDM

II LITERATURE REVIEW

D.F. Dauw and I. Beltrami (1994) This paper deals with a technical realization to improve the Wire EDM accuracy. The system which is readily available on commercial wire EDM machines is based on the on-line tracking and control of the wire position. The deviation of the wire position relative to the programmed wire path position is continuously measured and corrections are being made during the machine cutting. This technique allows to cut complex shapes, arc paths and contours at a much faster cutting speed as compared to conventional wire EDM machines. Practical examples are discussed and the economical relevance is emphasized.

T.A. Spedding and Z.Q. Wang (1997) This paper presents an attempt at modeling the process through Response Surface Methodology and Artificial Neural Networks. A response surface model based on a central composite rotatable experimental design, and a 4-16-3 size back-propagation neural network have been developed. The pulse-width, the time between two pulses, the wire mechanical tension and the injection set-point are selected as the factors (input parameters), whilst the cutting speed, the surface roughness and the surface waviness are the responses (output parameters). The two models are compared for goodness of fit. Verification experiments have been carried out to check the validity of the developed models. It is concluded that both models provide accurate results for the process.

N. Tosun, C. Cogun, and A. Inan (2003) In this study, the variation of workpiece surface roughness with varying pulse duration, open circuit voltage, wire speed and dielectric fluid pressure was experimentally investigated in Wire Electrical Discharge Machining (WEDM). Brass wire with 0.25 mm diameter and SAE 4140 steel with 10 mm thickness were used as tool and workpiece materials in the experiments, respectively. It is found experimentally that the increasing pulse duration, open circuit voltage and wire speed, increase the surface roughness whereas the increasing dielectric fluid pressure decreases the surface roughness. The variation of workpiece surface roughness with machining parameters is modeled by using a power function. The level of importance of the machining parameters on the workpiece surface roughness is determined by using analysis of variance (ANOVA).

ISSN (O) 2454-9665
ISSN (P) 2454-0663

K.H. Ho, S.T. Newman, S. Rahimifard and R.D. Allen (2004) This paper reviews the vast array of research work carried out from the spin-off from the EDM process to the development of the WEDM. It reports on the WEDM research involving the optimization of the process parameters surveying the influence of the various factors affecting the machining performance and productivity. The paper also highlights the adaptive monitoring and control of the process investigating the feasibility of the different control strategies of obtaining the optimal machining conditions. A wide range of WEDM industrial applications are reported together with the development of the hybrid machining processes. The final part of the paper discusses these developments and outlines the possible trends for future WEDM research.

A. Manna and B. Bhattacharyya (2006) This paper present a reliable set of parameters that demonstrate versatility, and numerous and diverse range based on experience and technology. We offer an experimental investigation to determine the parameters setting during the machining of aluminium-reinforced silicon carbide metal matrix composite (Al/SiC-MMC). The Taguchi method, a powerful tool for experimental design, is used to optimize the CNC-wire cut-EDM parameters. According to the Taguchi quality design Concept, a L_{18} ($2^1 \times 3^7$) mixed orthogonal array was used to determine the S/N ratio, and an analysis of variance (ANOVA) and the F-test values were used to indicate the significant machining parameters affecting the machining performance. From experimental results and through ANOVA and F-test values, the significant factors are determined for each machining performance criteria, such as the metal removal rate, surface roughness, gap current and spark gap (gap width). Considering these significant CNC wire cut-EDM parameters, verification of the improvement in the quality characteristics for machining Al/SiC-MMC was made with a confirmation test with respect to the chosen initial or reference parameter setting. Mathematical models relating to the machining performance are established using the Gauss elimination method for the effective machining of Al/SiC-MMC. Yet again, confirmation test results also show that the developed mathematical models are appropriate for the effective machining of Al/SiC-MMC. The determined optimal combination of CNC-wire cut-EDM parameters obtained from the study satisfy the real requirement of quality machining of Al/SiC MMC in practice.

Haddad and Tehrani (2008) explored the effect of power supply, pulse-off time, servo voltage, wire tension, wire speed, rotational speed on surface roughness and roundness of machined part during WEDT of cemented steel of 10 mm diameter using L_{18} orthogonal array as design of experiments technique. It is evident that power has significant influence on surface roughness while, none of the factors have significant effect on roundness. Moreover, a regression model has been proposed for future researchers for proper selection of machining conditions.

PujariSrinivasaRao, KoonaRamji (2011) The effects of pulse on time, pulse off time, peak current, flushing pressure of dielectric fluid, wire feed rate setting, wire tension setting, spark gap voltage setting and servo feed setting are experimentally investigated in machining of Aluminum BIS-24345 alloy using CNC Wire-cut EDM process. Analysis of variance and S/N ratios determined the importance of parameters and optimum parametric combination respectively for the response of surface roughness. Improved S/N ratio values and confirmation test results showed the possibility of improvement in surface finish using Taguchi‟ s method. From the present analysis it is evident that the optimal parametric combination will be beneficial for the people working on low

ISSN (O) 2454-9665
ISSN (P) 2454-0663

rigid, high thermal conductivity and low melting point materials of aluminum alloys. The proposed regression model (with high correlation co-efficient) successfully predicted the parametric values in the machining of aluminum BIS-24345 alloy.

H. Eivazi-Bagheri1, M.R. Shabgard (2011) The experimental study of the EDM of AISI H13 workpiece steel provided important quantitative results for obtaining possible high plasma flushing efficiency. The leading conclusions are as follows: 1. Increasing pulse-on time at both tool polarity, the pulse efficiency is increased. 2. In case of positive polarity, most of spark pulse occurs at a higher duty cycle while in negative polarity the highest percentage of spark pulse occurs in less duty cycle. 3. While increasing the pulse-on time in positive polarity, the plasma flushing efficiency is increased 4. In case of negative polarity, plasma flushing efficiency is initially increased but at higher pulse-on times with increasing pulse-on time, is declined. 5. Increasing duty cycle, plasma flushing efficiency at both tool polarities is increased.

E. Weingartnera, K. Wegenera, F. Kustera (2013) Wire electrical discharge dressing uses relative speeds that are typically not found in other EDM applications. Dressing is usually performed at grinding speeds, so that erosion can take place at speeds around 100 m/s. It was found that for the types of erosion pulses used in this work, the plasma channel easily slides over the anode, creating elongated craters. Not only the size of the craters is influenced by the relative speeds but also the material removal per single discharge is considerably affected. The material removal was found to increase as relative speeds are increased. Based on simulation results using a thermo-electrical model to describe the EDM process, it was found that higher melting efficiencies can be achieved when higher relative speeds are applied. In this case, the energy available in a single discharge can be better used to warm up and melt more material rather than to overheat the melting pool, and thus more material can be removed by a single discharge as the relative speed is increased.

R.Pandithurai and Ambrose Edward (2014) GA's are derivative-free calculations and therefore, are neither bound to assumptions regarding continuity, nor limited by required prerequisites. As Goldberg stated, Gas are blind. They can handle any kind of objective function and any kind of constraints (e.g., linear or nonlinear) defined on discrete, continuous or mixed search spaces. In addition, as stated earlier, they are robust in producing near-optimal solutions, with a high degree of probability to obtain the global Optimum. A genetic algorithm was proposed for optimizing the machining parameters. The main advantage of this approach is that it can be used for any objective function, which was most clearly demonstrated in this example, where the objective function was the minimization of surface roughness

S.SivanagaMalleswaraRaouthor and Ch.V.S.ParameswaraRao (2014) The influence of parameters, like power input, job thickness, on the machining criteria such as cutting power, cutting width, surface finish, material removal rate are determined. The results are useful in setting the parameters required for quality cuts on HSS. Suitable parameters can be selected for machining with the wire available. The mathematical relations developed are much more beneficial for machine settings, to estimate the cutting time, cost of machining and accuracy of cutting for any size of the job within machine range. The maximum error obtained in the calculated values and experimental values are less than 2%. These results will be useful to make the Wire EDM system to

ISSN (O) 2454-9665
ISSN (P) 2454-0663

be efficiently utilized in the modern industrial applications like die and tool-manufacturing units for parametric setting, machining time and cost calculations and also for process planning.

RupeshChalisgaonkar and Jatinder Kumar (2014) In this paper, issues of process capability and surface integrity have been investigated for WEDM of pure titanium. Following conclusions may be drawn from this work- 1. The optimized process parametric setting for process capability index (MWD) was found to be: TON-0.7µs, TOFF-7 µs, IP-140 A, WF-10 m/min, WT- 1200 gm, SV-30 V. For Surface roughness, the optimal setting is different (TON- 0.5µs, TOFF-9.5 µs, IP-200 A WF-10 m/min, WT- 1200 gm, SV-70 V).2. The optimal values of the Cpi(MWD) and Cpi(SR) have been found to be much higher than unity (26.8 and 20.8 respectively), which reflects the high process capability of WEDM process for the selected machining operation for the Ti work material. Enormous improvement in the capability index was realized by using the optimal process setting in both cases. 3. Surface integrity evaluation of samples machined under the optimal parametric setting revealed that sample machined under parametric setting for optimal SR (Cpi) exhibits smoother surface and better microstructure aspects in terms of craters, debris, spherical deposits and cracks. 4. Further, the mechanism of crater, debris, debris, and spherical deposits and cracks formation on machined surface has been found to be related with the pulse discharge energy.

Manjaiaha et al. (2015) The effects of process parameters such as pulse on time, pulse off time, servo voltage, wire speed and servo feed on performance characteristics, namely, MRR and surface roughness of machined components by WEDM of Ti50Ni50−xCuxSMA with brass and zinc coated brass wires have been studied. The experiments were planned as per L27orthogonal array (OA) to explore the effects of machining parameters on the proposed characteristics. The influence of brass wire on the performance of WEDM (MRR, Ra, surface topography and metallographic changes) has been compared with zinc-coated brass wire. Based on the experimental results and sub-sequent analysis, the following conclusions are drawn within the ranges of the process parameters selected

G.Ugrasen, H.V.Ravindra, G.V.NaveenPrakashc and R.Keshavamurthy (2014) This paper has presented an investigation on optimization and the effect of machining parameters on accuracy, surface roughness and VMRR in WEDM operations. The level of importance of the machining parameters on accuracy, surface roughness and VMRR is determined by using ANOVA. Based on the ANOVA method the highly effective parameters on surface roughness, VMRR and accuracy were found as current. The control factors considered for the studies are Pulse-on, Pulse-off, Current and Bed speed. Process parameters were selected based on Taguchi's L'16 orthogonal array. ANN is used to predict the response variable viz., surface roughness, VMRR and accuracy. Back propagation feed forward neural network (BPNN) and Leven berg–Marquardt algorithm (LMA) are used to build and train the network. It is observed that neural network trained with 70% of the data in training set gives good prediction results when compared to the 50% and 60% of data in training set. Thus, predicted response variables of 70% training set correlates well with the measured response variables.

T Singh, J.P Misra , B Singh (2017) In this paper an attempt has been made to carry out experimental investigation to study the effect of process parameters: pulse-on time, pulse-off time, servo voltage, peak current on measure of process performance, i.e. material removal rate (MRR) during WEDM of Al6063 alloy. It is evident from present study that input process parameters have significant influence on process performance

ISSN (O) 2454-9665
ISSN (P) 2454-0663

characteristics as Al 6063 alloy has vast application area which includes aerospace industry, medical implants, electronic industry, automobile industries, etc. owing to its unique characteristics: high strength to weight ratio, high wear resistance, improved stiffness, compatibility of operating at elevated temperature and low thermal expansion coefficient.

III CONCLUSION

Depend upon experimental investigations to study the effect of various process parameters namely wire feed rate,peak current, servo voltage wire tension on measures of process performance: material removal rate, wire wear rate, wear ratio and average surface roughness of machined surface during WEDM. From the literature review, it may therefore be concluded that wires with greater tensile strength can be made but they face adverse effects in terms of increase in resistance to breakage. Coated wires can perform better in the present scenario where surface finish and tool life is most preferred. The zinc coated brass wires performs better when compared to simple brass wire because of its low wear rate and low breakage at increased currents. Due to high precision and good quality of surface finish, WEDM is potentially an important process. The research is on for the development of the WEDM as Micro WEDM, where it can be used for the fabrication of micro components, more efficiently and more effectively on industrial scale. Some work has been done with Cryogenic treatment on the different types of work pieces; this area can play a vital role in the development of WEDM. More compositions may be developed and used for the new multi layered electrodes; fine finish power supply can explore more zones to achieve good quality of surface finish as well as enhanced tool life. To sum up we can say enormous research has been done in the past and large amount of work can still be done in the future on the topic, so that WEDM can serve the purpose of high speed machining with good quality products in short time period and at reduced costs. The future research could include the study of effect of other process parameters on process capability and surface integrity aspects of wire electric discharge machined parts after optimization.

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