Scientific Journal of Impact Factor(SJIF): 3.134
e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 11, November -2015

Research work on Wire Electical Discharge Machining: A Review

N G Parmar[1], B.D.Parmar[2]

[1]*Mechanical Engg Deptt. Govt.Polytechnic, Kheda*
[2] *Mechanical Engg Deptt. Govt.Polytechnic, Junagadh*

Abstract : *Wire EDM machines are used to cut all conductive material of any hardness or toughness or those are difficult or impossible to cut with conventional methods. Wire electrical discharge machining process is a highly complex, time varying & stochastic process. Electrical discharge machining has been extensively used for cutting intricate contours or delicate cavities that would be difficult to produce with a conventional machining methods or tools.*

A review of the research work on Wire EDM is presented in this paper. Some important research work of the recent years has been discussed. The review revealed that majority of the researchers have focused research work on performance parameters of the wire EDM process, multi objective optimization of the input and performance parameters, dimensional accuracy of the WEDM, development of mathematical model of the process. Researchers have used different types of statistical methods for the analysis of the experimental results. Grey Relation analysis is used in some research work for the multi objective optimization. Taguchi method in combination with ANOVA is used to analyze the result data and significant effect of parameters on performance characteristics.

The review relies on notable academic publications and recent conference proceedings.

Keywords-*WEDM, Cutting speed, MRR, Spark gap, Surface finish, Kerf width, Taguchi Method*

I. INTRODUCTION

The beginning of EDM came during the Second World War, when two Russian physicists B.R. and N.I. Lazarenko published their study on The Inversion of the Electric Discharge Wear Effect. Later on this technology is used for the application in the field of manufacturing technology of the capacity of electrical discharges, under controlled distribution, to remove metal [11]. EDM was being used at that time to remove broken taps and drills. The early "Tap- Busters" disintegrated taps with hand fed electrodes, burning a hole in the center of the tap or drill, leaving the remaining fragments that could be picked out. This saved workpieces and very expensive parts from being scrapped and having to be made over again. This process opened the birth of Vertical EDM, also called: Sinker, Conventional, Ram, Plunge or Diesinker EDM's. These machines were, and still are primarily used to make precision cavities in metal primarily for the mold industry [11].

II. WIRE ELECTRICAL DISCHARGE MACHINING

Wire EDM (Vertical EDM's kid brother), is not the new kid on the block. It was introduced in the late 1960s', and has revolutionized the tool and die, mold, and metalworking industries. It is probably the most exciting and diversified machine tool developed for this industry in the last fifty years, and has numerous advantages to offer [11]. WEDM is a thermo-electrical process in which material is eroded from the workpiece by a series of discrete sparks between the workpiece and the wire electrode (tool) separated by a thin film of dielectric fluid (de-ionized water) that is continuously fed to the machining zone (fig. 1, 2) to flush away the eroded particles[12].

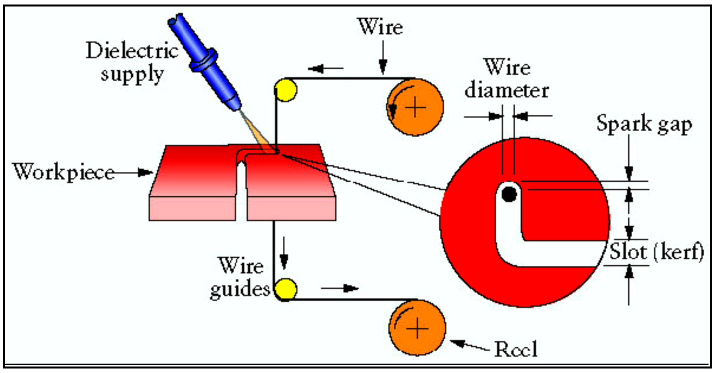

Figure1. Working Mechanism of WEDM

Wire electrical discharge machining (WEDM) is a specialized thermal machining process capable of accurately machining parts with varying hardness or complex shapes, which have sharp edges that are very difficult to be machined by the main stream machining processes.

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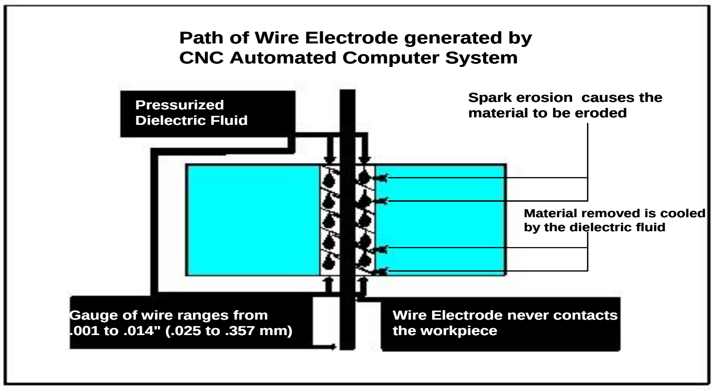

Figure 2. Material removal in Wire EDM

At present, WEDM is a widespread technique used in industry for high-precision machining of all types of conductive materials such as metals, metallic alloys, graphite, of any hardness [13]. It can machine anything that is electrically conductive regardless of the hardness, from relatively common materials such as tool steel, aluminum, copper, and graphite, to exotic space-age alloys including hastaloy, waspaloy, inconel, titanium, carbide, polycrystalline diamond compacts and conductive ceramics [1].

2.1 Process Parameters in Wire EDM

2.1.1 Spark On-time (pulse time or T-on): It is the duration of time measured in micro seconds. During this time period the current is allowed to through the electrode towards the work material within a short gap known as spark gap [11].

2.1.2 Spark Off-time (pause time or T-off): The duration of time (µs) between the sparks. It is the duration of time in which no machining takes place (idle time period) and it allows the melt material to vaporize and to remove from setting [11].

2.1.3 Discharge current (current Ip): Current is measured in amp allowed per cycle. Discharge current is directly proportional to the Material removal rate [11].

2.1.4 Kerf Width and Over Cut:
Kerf is the width of material removed by wire in WEDM. It is the slot that is created when wire passes through a workpiece. The difference between the size of the electrode and the size of the cavity is created during machining [11].

Over cut is expressed as half the difference of diameter of the hole produced to the tool diameter that is shown in the equation.

$$OC = \frac{(D_j - D_t)}{2}$$

Where, = Diameter of hole produced in workpiece.
= Diameter of electrode.

III. REVIEW OF RESEARCH WORK IN WIRE EDM

M. N. Islam, N. H. Rafai, and S. S. Subramanian [2] studied on "An Investigation into Dimensional Accuracy Achievable in Wire-cut Electrical Discharge Machining" in 2010, found that (1) the linear dimensional accuracy by WEDM performed poorly and its precision level is far less than CNC end milling. (2)The Surfaces produced by WEDM have flatness errors about ten times higher compared to surfaces produced by CNC end milling. In a vertical plane, the surface errors for WEDM and CNC end milling are comparable.
(3)The surfaces produced by WEDM have about five times higher perpendicularity errors compared to surfaces produced by CNC end milling. They also concluded that out of the six input parameters considered Discharge current, Pulse

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duration, Pulse gap frequency, Wire speed, Wire tension, Dielectric flow rate, wire tension showed the greatest overall affect on three dimensional accuracy characteristics, therefore, its value should be chosen carefully.

C V S Parmeshwara Rao / M.M.M. Sarcar [3] in 2009 published paper " Evaluation of optimal parameters for machining brass with wire cut EDM ", concluded that cutting speed decreases as job thickness increases. Roughness value decreases with increase in thickness. Wire with 90 % Cu gives best results.

Vishal Parashar, A. Rehman, J.L. Bhagoria, Y.M. Puri[4] experimented on Kerfs width analysis for wire cut electro discharge machining of SS 304L using design of experiments in 2010. They proposed statistical and regression analysis of kerf width using design of experiments. Results showed that, pulse on time and dielectric flushing pressure are the most significant factors, while gap voltage, pulse off time and wire feed are the less significant factor to the kerf width of wire EDMed SS304L.

Ricky Agarwal [5] National Institute of Technology, Rourkela experimented on optimization of process parameters of micro wire EDM in 2010. He concluded that (1) for all electrode materials, the material removal rate increases with increasing peak current. Graphite electrodes give the highest material removal rate followed by copper tungsten & then copper. (2) For all the three electrode materials the machined w/p surface roughness increases with increasing peak current. Copper exhibits the best performance with regard to surface finish followed by copper tungsten while graphite shows the poorest. (3) With the electrode as cathode & the workpiece as anode in EDM of tungsten carbide better machining performance can be obtained. (4) The material removal rate generally decreases with the increase of open circuit voltage whereas the relative wear ratio and machined workpiece surface roughness increase with the increase of open-circuit voltage. (5) The material removal rate decreases when the pulse interval is increased .both the relative wear ratio & the surface roughness have minimum values when varying the pulse interval, the minimum values occurring at the same value of pulse interval. (6) There is a maximum material removal rate with pulse duration at all current settings. The relative wear ratio increase with increase in pulse duration for all peak current settings. The increase is very pronounced at low pulse duration. The machined workpiece surface roughness increases steadily with increasing peak current.

Vishal Parashar, A. Rehman, J.L. Bhagoria, Y.M. Puri [6] experimented on Investigation and Optimization of Surface Roughness for Wire Cut Electro Discharge Machining of SS 304L using Taguchi Dynamic Experiments Thy concluded that The effect of various machining parameters such as gap voltage, pulse on time, pulse off time, wire feed speed and flushing pressure were studied while machining of SS 304L. Pulse On time is the most influencing machining parameter for surface roughness. The gap voltage, pulse-off time and flushing pressure has the little effect on surface roughness. The wire feed has the lowest effect on the surface roughness.

Chang-Ho Kim [9] of Dong-Eui University, Korea conducted experiments on Influence of the Electrical Conductivity of Dielectric Fluid on WEDM Machinability. He concluded that increasing the fraction of cobalt in carbides improves the metal removal rate, but the surface quality is degraded as a greater quantity of solidified metal deposits on the eroded surface. Lower electrical conductivity of the dielectric results in a higher metal removal rate as spark gap reduced.He also found that (1) the grade of the cemented carbide has an influence on the machining results. Low cobalt concentration yields a higher removal rate, however the micro cracks will be somewhat longer. (2) It is important to have good quality water in the work tank. Higher electrical conductivity of water yields a higher removal rate but poorer surface smoothness. It is recommended that the ideal conductivity vary from 5-10 µS/cm to prevent from corrosion and electrolytic wash for fine surface and precision machining. (3) The presence of mixed carbides (TiC, TaC) has no influence on the erosive process. Cobalt wash along edge is present in all alloys. (4) Study reveals that some of the wire electrode material from the WEDM gets deposited onto the workpiece surface. Some elements of workpiece material can also be seen on the wire electrode surface during EDM.

Niladri Mandal1, P Saha2, K Ramesh Kumar1, DR Yadav [8] Studied on Machining Parameter Optimization for WEDM of Nimonic C263 - A Taguchi Approach in 2010. They noticed that factor gap voltage (VG) and peak current (IP), capacitance (C) has the largest contribution. While pulse-on time (T-ON) has some contribution but pulse off time (T-OFF) has very little contribution towards the total sum square compared to the other parameters. So for certain critical machining condition pulse off time (T-OFF) can be varied to get stable machining without affecting the surface roughness significantly. Influence of cutting parameters of pulse on time, peak current, capacitance and gap voltage is found to be most significant on machining performance measure cutting speed, kerf width and surface roughness. It is evident that pulse off time is having very less effects on surface roughness. Pulse off time can be varied as per

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requirement to achieve better machining stability and accuracy in critical application without affecting the surface roughness significantly.

Er. Navneet Singh Virk, Er. Mandeep Chahal [7] published paper in International Journal of Advance Engineering and Research Development, 2015, on Evaluation of Process parameter ranks in WIRE-Electric Discharge Machining on Surface Roughness for INCONEL X750 using Brass Electrode. They studied the effects of input parameters such as Pulse-On time, Pulse-Off time and Peak current, on performance parameter Surface Roughness. The experiments were performed with different combination of values of input parameter. Optimization of the machining conditions for SR was carried out based on Orthogonal Array and Taguchi method. Experiments were carried out under varying process parameters pulse-on time, pulse-off time, and peak current. They concluded that surface roughness increases as the pulse ON time and peak current increases where as it decreases with increasing values of pulse OFF time.

Mr. Rahul M. Chaudhari1, Mr. Vimal P. Salot[10] conducted research on parametric optimization on die steel using wire cut EDM, in 2015 concluded that the analysis of variance resulted that the voltage has major influence on the surface roughness (µm) and kerf width (mm) in both the Taguchi optimization method and Grey relational analysis. The pulse-on time has significant effect on the material removal rate.

IV. SUMMARY

A review of the research work on WEDM is presented in this paper. Some important research work of the recent years has been discussed. For each and every method introduced and employed in WEDM process, the objectives are the same: to enhance the capability of machining performance, to get better output product, and to have better working conditions.

Important finding of these research work are as follows.

- Material removal rate increases with increasing peak current. Graphite electrodes give the highest material removal rate followed by copper tungsten & then copper.
- Surface roughness increases as the pulse ON time and peak current increases where as it decreases with increasing values of pulse OFF time.
- Pulse on time and dielectric flushing pressure is the most significant factors for kerf width. The pulse-on time has significant effect on the material removal rate.
- Cutting speed decreases as job thickness increases. Roughness value decreases with increase in thickness.

Majority of the researchers have focused their research on following aspects.

1. Performance parameters of the wire EDM process.
2. Multi objective optimization of the input and performance parameters.
3. Dimensional accuracy of the WEDM and comparison of the same with other recent manufacturing processes.
4. Development of Mathematical model of the process to predict performance based on input parameters.
5. Analysis of the experimental results using different types of statistical regression methods. Statistical technique like design of experiments is used by few researchers to study multiple variables (factors or parameters) simultaneously.
6. Effects of the process parameters on the material removal rate, surface finish, kerf width.
7. Effect of wire material on the process performance.
8. Significance of wire tension.
9. Input parameters are Current, T-on, T-Off, Wire tension, Wire feed speed, Electrical Conductivity of Dielectric Fluid.
10. Performance parameters are cutting speed/ MRR, Kerf width, Surface roughness.
11. Taguchi method in combination with ANOVA is used to analyze the result data and significant effect of parameters on performance characteristics.
12. Grey Relation analysis is used for multi optimization.

V. COMMENT

The reviews revealed that majority of the researchers have focused their research on the performance parameters of the wire EDM process and multi objective optimization of the input and performance parameters. The optimization allows us to get the most out of a given system. In a way it is the minimization of unwanted effects and maximizing the desired performance parameters. Considering the more number of control parameters and similarly more number of performance (output) parameters and complicated nature of the working mechanism of the wire EDM, multi objective optimization is the best technique to enhance performance of the WEDM process.

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VI. REFERENCES

[1] Ch. V. S. ParameswaraRao, M. M. M. Sarcar "Experimental Investigation and Development of Mathematical Correlations of Cutting Parameters" Journal of Mechanical Engineering, Vol. ME 40, No. 1, June 2009, mechanical engineering division, the Institution of Engineers.

[2] M. N. Islam, N. H. Rafai, and S. S. Subramanian, "An Investigation into Dimensional Accuracy Achievable in Wire-cut Electrical Discharge Machining" Proceedings of the World Congress on Engineering 2010 Vol III WCE 2010, June 30 - July 2, 2010, London, U.K.

[3] C V S Parmeshwara Rao / M.M.M. Sarcar "Evaluation of optimal parameters for machining brass with wire cut EDM" journal of Scientific & Industrial research Vol – 68 , Jan-2009 pp 32-35.

[4] Vishal Parashar, A. Rehman, J.L. Bhagoria, Y.M. Puri "Kerfs width analysis for wire cut electro discharge machining of SS 304L using design of experiments " Indian Journal of Science and Technology Vol. 3 No. 4 (Apr. 2010) ISSN: 0974- 6846.

[5] Ricky Agarwal "optimization of process parameters of micro wire EDM" National Institute of Technology, Rourkela research thesis in May 2010.

[6] Vishal Parashar, A. Rehman, J.L. Bhagoria, Y.M. Puri "Investigation and Optimization of Surface Roughness for Wire Cut Electro Discharge Machining of SS 304L using Taguchi Dynamic Experiments" International Journal of Engineering Studies ISSN 0975- 6469 Volume 1, Number 4 (2009), pp. 257–267.

[7] Er. Navneet Singh Virk, Er. Mandeep Chahal "Evaluation of Process parameter ranks in WIRE-Electric Discharge Machining on Surface Roughness for INCONEL X750 using Brass Electrode" International Journal of Advance Engineering and Research Development, Volume 2,Issue 6, June -2015 e-ISSN(O): 2348-4470.

[8] Niladri Mandal1, P Saha2, K Ramesh Kumar1, DR Yadav "Study on Machining Parameter Optimization for WEDM of Nimonic C263 - A Taguchi Approach" International Conference on Advances in Mechanical Engineering, 2010 S.V. National Institute of Technology, Surat

[9] Chang-Ho Kim of Dong-Eui University, Korea, "Influence of the Electrical Conductivity of Dielectric Fluid on WEDM Machinability"

[10] Mr. Rahul M. Chaudhari1, Mr. Vimal P. Salot "parametric optimization on die steel using wire cut EDM" International Journal of Advance Engineering and Research Development, Volume 2,Issue 5, May -2015 e-ISSN(O): 2348-4470

[11] Production technology by HMT, Bangalore, 2005, Tata McGraw-Hill Publishing Company Limited.

[12] N.G.Parmar, B.D.Parmar, B.C.Khatri "An Experimental Study on Reusable type Wire EDM of HcHcr steel based on Taguchi Methodology" Proc. of the 4th National Conference on Emerging Trends in Mechanical Engineering, 2011.

[13] H. Singh, R. Garg, "Effects of process parameters on material removal rate in WEDM of Achievements in Materials and Manufacturing Engineering - (2009) Volume 32 Issue 1 – page-70.

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