A Review of Experimental Investigation of WEDM to find out performance parameter with powder mix dielectric fluid on Molybdenum High Speed Steel

Mr. Makarand V. Deshpande, Mr. D. A. Deshmukh
SYCET, Aurangabad

Abstract: The demands of high surface finish and machining of complex shape geometries, conventional machining process are now being replaced by non-conventional machining processes. Wire EDM is one of the non-conventional machining processes. MRR and Surface roughness are of crucial importance in the field of machining processes. This Dissertation optimize the TWR in WireEDM for Steel material. The aim of optimization is to attain the maximum MRR and minimum surface roughness and Accuracy. In this study Molybdenum High speed tool Steel is going to use as a work piece, brass wire of 0.25mm diameter is going to use as a tool and distilled water is used as dielectric fluid. As per Literature survey the input parameters have to be pulse on time, pulse off time and Duty cycle, CNT concentration for optimization. Dielectric fluid pressure, wire speed, wire tension and resistance etc suppose to be fixed parameters. The optimal value will be obtain for surface roughness and MRR by using optimization technique, optimized value is obtained separately. Additionally, the analysis will be useful to identify the most important factor. The exponential growth of manufacturing industries and production and the increased need of accuracy and precision throws the spotlight on the nontraditional machining processes.

I. INTRODUCTION

Electrical Discharge Machining is commonly known as EDM is a non-traditional machining process used to remove material through a number of repetitive electrical discharges of short duration and high current density between the work piece and the tool. WEDM is an important and cost-effective method of machining extremely tough and brittle as well as electrically conductive materials. In WEDM, since there is no physical contact between the work piece and the electrode tool, hence there are no mechanical forces existing between them. Any type of conductive material can be machined by using WEDM according of the hardness or toughness of the material.

In Wire EDM is cut with a special metal wire electrode that is programmed by NC to travel along a programmed path. A Wire EDM generates spark discharges between a wire electrode and a work piece with deionized water as the dielectric medium and erodes the work piece to production of complexive two- and three dimensional shapes according to a numerically controlled (NC) programmed path.

The Wire EDM uses electrode as a very thin wire 0.02 to 0.3 mm in diameter, an electrode and a work piece mounted on machine tool with electrical discharge machine like a band saw is moving either the work piece or wire. Erosion to the metal by using the phenomenon of spark discharge that is the very similar to the conventional EDM. The prominent feature of a moving wire is that a complicated shape cutout can be easily machined without using a forming electrode Wire cut EDM machine basically combination of a machine proper composed of a work piece contour movement control unit (NC unit), work piece mounting table and wire driven section using for accurately
moving the wire at constant tension; a machining power supply which is applies electrical energy to the wire electrode and a system which is supplies a dielectric fluid with constant specific resistance. The progress of wire is handling numerically to acquire the required three dimensional shapes and the high rate of accuracy of the work piece. WEDM consists of different number of process parameters, so it is difficult to get a best combination of optimum parameters which gives higher accuracy. By using Taguchi method optimization of a single response is often carried out. This method results in the solution which gives best value of each response, the general application of the wire EDM cutting process. Wire EDM, is not a new type of machining, it was invented in the latish 1970s’, and has done revolution changed in the tools and dies industries. This is the important wide range cutting machine formulated for this sector in the past years. In that process, no physical connection between work piece and tool, so the materials of any hardness can be easily cut if they are electrically conductive. Since the wire not strike the workpiece, so that no pressure apply on the work piece and clamping pressure required to maintain the workpiece is less. The electrical conductivity is an important factor in this type of machining few methods are used to increase the effectiveness of the machining of less electrical conductive materials. The Spark Theory on the wire EDM is identical to the vertical EDM process. Many sparks can be analyzed at one time. The temperature of each electrical sparks is expected near about 15,000° to 21,000° Fahrenheit. This process help in many applications like in aerospace, nuclear and automotive industries, to machine accuracy and improper shapes in the different electrically conductive materials. These characteristics make Wire EDM is a process which remained as a competitive and economic machining option fulfills the demands of machining requirements of the short product development cycles.

II. LITRETURE SURVEY

As per the T. Muthuramalingam et al. have Studied about the review of the contribution of electrical process parameters for efficient EDM process in different aspects such as state of art, modeling of EDM process parameters, influence of the discharge energy, pulse genera-tors, pulse shape, monitoring the parameters and optimization of EDM process parameters. The following conclusions are made:

1) It has been found that the peak current and pulse duration are affected the performance measures in the EDM process.
2) It has been found that only less attention has been given for improving the electrical process parameters in EDM process in terms of pulse modification, monitoring and adaptive controlling of process parameters.

Another researcher Ms. Shalaka Kulkarni et al. Studied to determining the optimum settings of the process parameters for single as well as multi response optimization during EDM of high carbon high chromium steel on the basis of taguchi method and utility concept. The L25 OA was used for experimental design. In the first stage (single response) best settings of process parameters were obtained one by one to obtain optimum values for MRR, SR and KW. It is found that TON is the most important factor for both KW and MRR, while TOFF has less significant effect on SR. In second stage (multi response) response table establishes the combination of higher levels of pulse on time, pulse off time, wire feed and lower flush and lower level of wire tension and upper flush is essential for obtaining optimal value of multiple performances for the predefined weightages.

Also Ashok Kumar Choudhary et al. have studied on material removal rate kerf width, surface roughness, gap current, and the kerf width. The experiments were performed under different parameter setting. Minitab software is used for analyze L27 orthogonal array experimental data. Following conclusion is obtained after analysis.
1) The Kerf width increases with increasing of pulse on time and peak current and decrease with the increase of pulse off time.
2) The surface roughness increases with increasing of pulse on time and peak current and decrease with the increase of pulse off time and spark gap voltage.

When the increase of pulse on time and peak current the material removal rate increase and MRR decrease with the increase of pulse off time, spark gap voltage and wire feed rate. Some researcher M. Durairaja *et al.* studied on the cutting parameters in wire Edm for SS-304. The purpose of optimization is to obtain the best surface quality and minimum kerf width. In this study stainless steel 304 is used as a workpiece, brass wire of 0.25mm diameter used as a tool. The following conclusions are made.

1) Based on the taguchi optimization method, the best combination for input parameter get the minimum kerf width are 50v gap voltage, 2mm/min wire feed, 4 μs Pulse on time, 6 μs pulse off time and to get the minimum Surface roughness are 2mm/min wire feed, 40v gap voltage, 10 μs pulse off time 6μs pulse on time.
2) Based on the grey relational analysis, the best combinations for input parameter are 50v gap voltage, 2mm/min wire feed, 4 μs pulse on time and 4 μs pulse off time.

Conclusion of Kode Jaya Prakash *et al.* are that wires with greater tensile strength can be produced but they faced adverse effects in terms of increase in resistance to breakage. Coated wires may work better in the present situation when surface finish and tool life is most preferred. The zinc coated brass wires works better when compared to simple brass wire because of its low rate of wear and low breakage at increased currents. Due to high accuracy 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 production of micro components, more efficiently and more effectively on industrial scale.

A researcher F. Klocke *et al.* studied on the Titanium alloys such as Ti6Al4V are frequently used in turbine industry components due to their excellent mechanical properties. These properties make it tough to machine with formal processes like that broaching, milling or grinding. The main conclusion of this paper is that eroded surfaces are visually better to inspect than ground surfaces.

The non-destructive inspections of the sample allowed the estimation, that the ground specimens have an increased fatigue life. In addition to the main conclusion about the surface integrity analysis it can be emphasized that the process instabilities, which occur during Wire EDM of Ti6Al4V can directly be seen on the surface as black marks. The need for complex destructive inspection is not necessary. Process of unreliability which impacts the failure criteria of a WEDM part can easily be found by visual inspection. This provides the operator an opportunity to tune his process for a better and safer.

Another Jaharah A.G. *et al.* have also studied about the performance of the copper electrode when EDM used AISI H13 tool steel. The various parameters considered are the peak current, pulse off-time and pulse on-time. The effect of peak current settings (1, 2 and 4 A), pulse off time (1, 2 and 4 μs) and pulse on time (3, 6 and 12 μs) are investigated on the machining performance of the surface roughness (Ra), electrode wear rate (EWR) and material removal rate (MRR). Following conclusion made base on the result:

1) The optimal condition for the surface roughness was observed at low peak current, low pulse-on and pulse-off time.
2) High MRR is obtained when setting at high peak current, medium pulse-on time, and low pulse-off time. Therefore the peak current is observed the major factor affected the MRR and surface finish for the finishing and roughing operations.

As per the Ramakrishna et al. have proposed a multi objective optimization method in WEDM process by using parametric design of Taguchi method. The effect of various machining parameters such as delay time, pulse on time, wire tension, wire feed rate, and ignition current intensity has been studied through machining of heat-treated tool steel. It is found that the pulse on time and ignition current intensity have affected more than other parameters taken in this study.

In 1981 Jaswani investigated the performances of kerosene and distilled water over the pulse energy range 72–288 mJ. Machining in distilled water resulted in a higher MRR and a lower tool wear rate than in kerosene when a high pulse energy range was used. He also noticed that with distilled water, the machining accuracy was poor but the surface finish was better. Tariq Jilani and Pandey in the year 1984 measures the performance of water as dielectric fluid in EDM using distilled water, tap water and a mixture of 25% tap and 75% distilled water. The best machining rates have been achieved with the tap water and machining in water has the possibility of achieving zero TWR when using copper tools with negative polarities.

As per the research of Koenig and Joerres in 1987 perform by taking aqueous glycerine solution as additive in water. He reported that a highly concentrated aqueous glycerine solution has an advantage as compared to hydrocarbon dielectrics when working with long pulse durations and high pulse duty factors and discharge currents, i.e. in the roughing range with high open-circuit voltages and positive polarity of tool electrode.

As per the Konig and Siebers in 1993 explained the influence of the working medium on the metal removal process. They indicated that working medium has a sustained influence on the metal removal process. The erosion process in which water is used as dielectric consequently possesses higher thermal stability and much higher power input can be achieved especially under critical conditions, allowing much greater increases in the MRR. A considerable difference between conventional oil based dielectrics and aqueous media is specific boiling energy of aqueous media is some eight times higher and boiling phenomena occur at a lower temperature level. Another study on surface modification of aluminum was done by Tsunekawa in 1994 using powder compact electrodes having 64% Ti and 36% Al and they obtained fine dendritic precipitates of titanium carbide on the machined surface. The electrode was connected to negative polarity and kerosene was used as the working fluid. The average diameter and alloyed depth of discharge craters increased with increase in pulse width, the other important factor being the discharge current. It was found that the forming pressure of the powder metallurgy electrodes did not affect material transfer. Another research by Kruth in 1995 also succeeded in depositing aluminium on steel and TiC on aluminium using Al and Ti–Al green compact electrodes respectively with a traditional EDM machine. This was obtained by using porous electrodes with negative polarity favoring high tool wear. During investigating on white surface layer, the use of an oil dielectric increases the carbon content in the white layer and appears as iron carbides (Fe3C) in columnar, dendritic structures while machining in water causes a decarbonization. While investigating the influence of kerosene and distilled water as dielectric on Ti–6Al–4V work pieces. Chen found that carbide is formed on the work piece surface while using kerosene while oxide is formed on the work piece surface while using distilled water. The debris size of Ti–6Al–4V alloy in distilled water is greater than that in kerosene and compared with kerosene, the impulsive force of discharge in distilled water is smaller but more stable.
III. CONCLUSION AND SCOPE OF WORK

The contribution of WEDM to industries such as cutting new hard materials make WEDM technology remains indispensable. The review of the research trends in WEDM in water and WEDM with powder additives is presented. Powder mixed dielectric is a good research promising area. Most of the research work has been with Al, Si, and graphite powders and Less work with other types of powder like Cr, Ni, Mo, etc., but only a few has touched the introduction of using Nano powders in to WEDM. Most of the available research works on powder-mixed dielectric have studied the impact of such machining on MRR, Surface Roughness & TWR etc. with normal polarity. Many types of research and experimental work have been carried out contributes to the use of different dielectrics and mixture of additives which improve the performance of dielectrics which are cheaper and eco-friendly and have quite impressive Material removal rate. The literature review shows that dry EDM can be a substitute for hydrocarbon oil based EDM due to low cost, simple operation and no pollution. So, more research is needed for powder mixed WEDM regarding using essential alloying elements such as manganese, molybdenum, vanadium, etc. in the form of powder for machining of materials which have not been tried yet. Effect of size, shape, and concentration of powder particles on the performance of WEDM can also be investigated. More Research work is needed in the field of sustainable manufacturing and sustainable WEDM processes. The effect of discharge current and pulse duration has been taken into consideration in various research works but variation in pulse interval has not been investigated or it has been taken into consideration in conjunction with pulse duration by way of duty factor.

The study of the impact of this method on surface modification has been taken up by very few researchers. Likewise, some of the important die steel materials such as OHNS die steel, molybdenum high speed tool steels and water-hardening die steels (W-series) have not been tried as work materials.

REFERENCES


IV. M. Durairaja, D. Sudharsunb, N. Swamynathan,(20135) Analysis of Process Parameters in Wire EDM with Stainless Steel using Single Objective Taguchi Method and Multi Objective Grey Relational Grade. Procedia Engineering 64, pp. 868-877


**Author Details:**

1. Mr. Makarand Vithalrao Deshpande received B.E from JNEC Aurangabad. He is now pursuing Master in Mechanical Engineering from SYCET Aurangabad.

2. Mr. D.A. Deshmukh is Assistant professor at SYCET Aurangabad. Department of Mechanical Engineering.