Optimization of Process Parameters in Finishing of Weld Bead using WEDM

Prakash Kumar[1] Mr. Parvesh Dahiya[2]
[1]M.Tech Scholar [2]Associate Professor
[1,2]Department of Mechanical Engineering
[1,2]Ganga Institute of Technology & Management, Jhajjar Haryana, India

Abstract— Accompanying the development of mechanical industry, the demand for alloy materials having high hardness, toughness and impact resistance are increasing. However, these materials are difficult to machine by traditional machining methods. Hence, non-traditional machining methods including electrochemical machining, laser beam machining and electrical discharge machining (EDM) are applied. Wire electrical discharge machining (WEDM) is widely accepted non-traditional material removal process used to manufacture components with intricate shapes and profile. It is a specialized thermal machining process capable of accurately machining parts with varying hardness and complex shapes, which have sharp edges that are very difficult to be machined by the main stream machining processes. This principal of the WEDM process is based on the conventional EDM sparking phenomenon utilizing the widely accepted non-contact technique of material removal. However, WEDM utilizes a continuously travelling thin wire electrode made of copper, brass or tungsten of diameter 0.05-0.30 mm, which is capable of achieving very small corner radii. The wire is kept under tension using a mechanical tensioning device, reducing the tendency of producing inaccurate parts. During WEDM process, the material is eroded ahead of the wire and there is no direct contact between the workpiece and the wire. In addition, WEDM process is able to machine exotic and high strength and temperature resistive materials.

Key words: WEDM, Weld Bead

I. Introduction

WEDM has evolved from a simple means of making tools and dies to the best alternative of producing micro-scale parts with the highest degree of dimensional accuracy and surface finish quality. WEDM has greatly altered the tooling and manufacturing industry, resulting in considerable improvements in accuracy, quality, productivity and profit. Over the years, the WEDM process has exists as a competitive and economical machining option fulfilling the demanding machining requirements imposed by the short product development cycles and the growing cost pressures. However, the risk of wire breakage and bending has undermined the full potential of the process dramatically reducing the efficiency and accuracy of the WEDM operation. A significant amount of research has explored the different approach of achieving the ultimate WEDM goals of optimizing the numerous process parameters analytically with the total elimination of the wire breakage thereby also improving the overall machining reliability.

II. Literature review

Williams and Rajurkar [1991] described that the main goals of WEDM manufacturers and users are to achieve a better stability and high productivity of the process i.e. higher machining rate with desired accuracy and minimal surface damage. Surface roughness profiles were studied with theoretical modeling and analysis methodology to better understand the process mechanism. Scanning electron microscopic examination highlighted important features of machined surfaces in WEDM.

Dauw and Albert [1992] reported an analysis of the six contributing factors. Attention is given in particular to one of these factors, the wire tool itself. Tine several types of wire are compared from their metallurgical aspect. Their physical composition and relative performance are analyzed and a cost to performance ratio is given for a series of wires considered. As a conclusion, it is shown that the wire tool, although often considered as an evident EDM accessory has influenced very substantially the EDM wire cutting performance. Since the commercial introduction of wire EDM on the market, end 1969 begins 1970, the overall performance of the wire EDM has undergone a tremendous evolution. Six major contributing components have been responsible for this important change. One of these, the wire tool electrode has been improving substantially yielding an enormous increase of the overall performance (cutting speed, cutting accuracy, precision, cost etc).

Prasad and Mishra [1993] determined the temperature distribution in the material of the wire in order to predict failure due to thermal load. In the present work, a simple computational model is developed which will give the temperature values for varying magnitudes of parameters, viz., input power, pulse-on time, wire velocity and wire diameter. It is reported that the optimum control of these parameters will help in preventing thermal failure, thus obtaining better utilization of the process. A finite-difference thermal model to predict the temperature distribution along the wire for the WEDM process in the zone of the discharge channel is proposed. The power is presumed to be vanish in a single spark through a volumetric heat source present within the wire over the discharge channel width, which in turn, is calculated from the available literature. The temperature distributions are calculated by varying the values of different pertinent parameters: input power (50–300 W), pulse-on time (10–200 μs), wire velocity (0.5–10 m/min) and wire diameter (0.1–0.3 mm).

Luo [1995] analyzed the technical requirements of fast-cutting WEDM. Based on a synthesis of experimental results and pulse energy analysis, an energy-distribution diagram concerning the correlation between cutting speed and comprehensive machining conditions has been established to determine a suitable parameter combination for a stable fast-cutting process. High power density and high pulse density are found to be two basic requirements for a constant high cutting speed. Harmful energy loss has to be reduced; otherwise the wire temperature becomes too high due to the dissipated heat. According to the energy-distribution diagram, machining conditions such as cutting width, wire diameter and wire travelling speed are also considered in increasing the cutting speed. After an optimization of the energy distribution in fast-cutting WEDM, a 4-fold improvement in cutting speed has been achieved whilst the wire service life remains almost unchanged. The achievements described have practical significance in enhancing die productivity as well as in transferring WEDM into a general cutting alternative.

Spedding and Wang [1997] made an attempt at modeling the process through Response Surface Methodology and Artificial Neural Networks. Wire electrical discharge machining (WEDM) technology has been used widely in production, aerospace/aircraft, medical and virtually all areas of conductive material machining. Its complexity and stochastic nature have stimulated numerous attempts to model it accurately. A response surface model based on a central composite rotatable experimental design, and a 4-16-3 size back-propagation neural network has 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.

III. Aims & objective

Welding is an important metal joining process which can join two metals or nonmetals with same strength as that of parent metals. Welding process generates a weld bead at the metal surfaces which need to be finished completely before assembling the welded components. In case of flat and external weld bead, it can be easily finished with the help of grinding operation. But weld bead on intricate parts are difficult to finish with fine surface finish. In present work, an attempt has been made to finish the weld bead using wire electrical discharge machining (WEDM) process. For the purpose of finishing the weld bead, specimens of mild steel were welded to generate weld bead with different current settings. Effects of various WEDM parameters were investigated on surface finish of weld bead. The objective of present work is as follows:

- To evaluate the influence of process parameters on cutting speed and surface roughness in finishing of weld bead on mild steel specimen.
- Optimize the process parameters for cutting speed and surface roughness of weld bead using Taguchi's L_{18} orthogonal array.
- Identification of the critical factors affecting the cutting speed and surface roughness.
- Predict the optimal value of each response characteristic corresponds to their optimal parameter setting.
- Compare the experimental results with the predicted optimal values.

IV. Conclusion

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, which are very difficult to machine by the main stream machining processes.

This practical technology of the WEDM process is based on the conventional EDM sparking phenomenon utilizing the widely accepted non-contact technique of material removal. The non-contact machining techniques have been continuously evolving from a mere tool and die making process to a micro scale application machining alternative attracting a significant amount of research interests.

In present work, a WEDM process has been performed to finish weld beads developed on mild steel specimens. Five process variables namely weld bead quality, discharge current (Ip), pulse-on time (Ton), servo voltage (SV) and wire feed rate (WF) have been investigated.

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