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Evaluation of Process Parameter Variations in Wire Electric Discharge Machining

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Abstract: *The incorporation of non-traditional machining techniques has become a benchmark in contemporary manufacturing processes. WEDM, or wire electrical discharge machining, is among the most sophisticated non-conventional manufacturing techniques used to machine materials that are notoriously difficult to machine. Critical components of precision manufacturing sectors including aerospace, automotive, and sheet metal are machined using non-traditional machining techniques like wire electric discharge machining (WEDM) and electro discharge machining (EDM). The majority of the time, machine tool tables supplied by the manufacturer fail to satisfy the machining specifications of a given material. The objective of this manuscript is to provide a comprehensive synthesis of the contributions made by numerous researchers to the WEDM process. This literature review elucidates the WEDM process by analyzing the correlation between various input process parameters and output metrics, including wire attrition ratio, material removal rate, surface roughness, and kerf width. The conclusion of this paper describes the function of various wire materials and diameters in the WEDM process.*

Keywords: Wire Electric Discharge Machining (WEDM), Process Parameters, Cutting Speed.

I. INTRODUCTION

Wire-EDM is a non-traditional machining technique that is extensively employed in the automotive, aerospace engineering, tool, die, and mold manufacturing, and metalworking sectors due to the utilization of wire. EDM is a highly efficient method for machining rigid materials into complex geometries. In wire-EDM, however, the selection of cutting parameters to achieve greater cutting precision or efficiency. WEDM is a thermoelectric procedure in which a series of shocks between the work piece and wire electrode decompose the material.

A work piece bears the opposite side of an electrical charge that is carried by the wire during the procedure. The attraction of electrical charges generates a regulated spark as the wire approaches the component, causing microscopic particles of material to dissolve and vaporize. A minuscule portion of the wire is also eliminated by the spark. In accordance with the Creative Commons Attribution Non-Commercial License, which grants unrestricted non-commercial use, distribution, and reproduction in any format, provided that the original work is appropriately cited, the machine automatically advances new wire and discards the used wire after it has passed through the workpiece once. A conductor electrode comprised of a thin copper, brass, or tungsten wire with a continuous travel distance of 0.05–0.30 mm. The principal research activities of WEDM, including wire material, wire diameter, pulse on time, pulse off time, peak current, wire tension, wire feed rate, servo voltage, dielectric fluid, and cleansing pressure, are the subject of this article. Material removal rate, surface irregularity, wire attrition rate, and kerf width are among the performance metrics most significantly impacted by these process parameters.

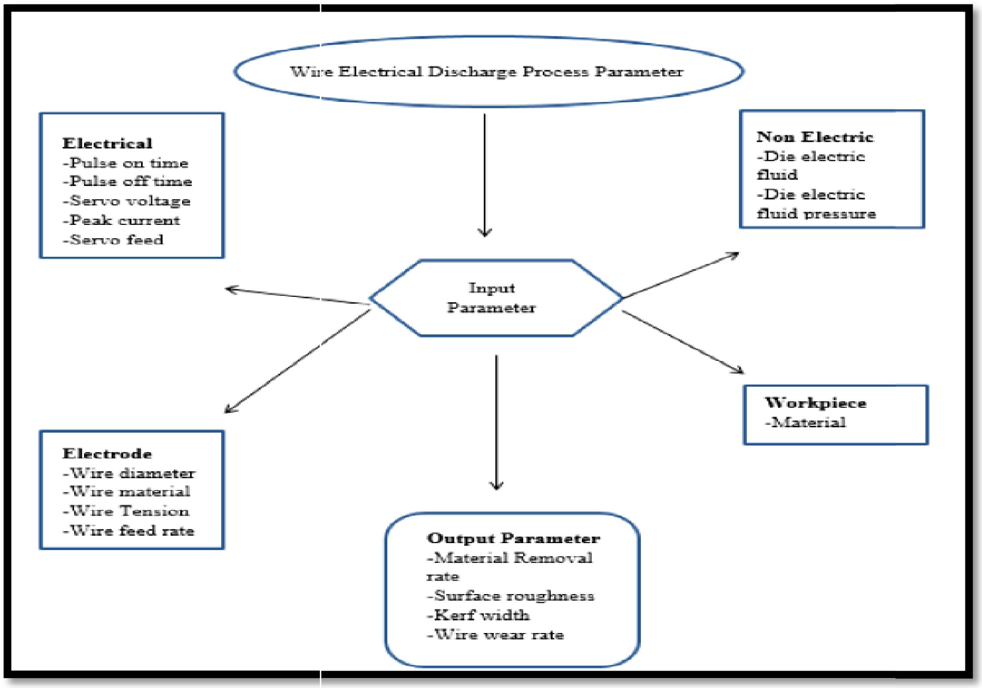

Fig.1: WEDM process and respond parameter

II. LITERATURE REVIEW

The literature review section contains details regarding the machining parameters and characteristics of the WEDM process. It also contains information regarding the machining of the most recent composite materials utilized in the aerospace, automotive, and tooling industries.

The machining characteristics of a SiC/6025 Al composite were examined by Mohan et al. via rotary electro-discharge machining (EDM) with a tube electrode. As the electrode material for EDM SiC/6025 Al composites, brass was utilized. Electrode wear rate (EWR), machinability (SR), and MRR are the three observed values utilized to assess machinability. Input variables utilized to evaluate machinability included peak current, polarity, volume fraction of SiC-reinforced particles, pulse duration, opening diameter of the tube electrode, and speed of electrode rotation.

The impact of surface modifications and machining characteristics on low-carbon steel (S15C) during EDM procedures utilizing semi-sintered electrodes was examined by Yuan-Feng Chen et al. An endeavor was made by Pradhan et al. to optimize the process parameters of micro-EDM for the machining of Ti-6Al-4V superalloy. As observed performance criteria, metal removal rate (MRR), tool-wear rate (TWR), overcut (OC), and taper were selected to validate the micro-EDM process parameter settings.

The Taguchi method for optimizing machining parameters in steel turning operations was introduced by Abhang et al. For the purpose of their research, EN-31 steel alloy was turned utilizing tungsten carbide inlays. In an effort to maximize the MRR while optimizing the micro-wire electro discharge grinding process, Periyanan et al. have concentrated on the Taguchi technique, which takes into account the cutting parameters of capacitance, voltage, and input rate. The aim of the study by Milan Kumar Das et al. is to determine the optimal material removal rate (MRR) and surface roughness (SRR) combination of process parameters for electro discharge machining (EDM) of EN31 tool steel. Pujari Srinivasa Rao et al. investigate the impact of wire EDM parameters on aluminum alloy due to the expanding industrial applications of this material. The current study employed the Taguchi method to conduct a parametric analysis of wire EDM parameters, specifically material removal rate (MRR) and surface roughness (SR). Muthu Kumar et al. have utilized the Grey-Taguchi method to optimize the WEDM process parameters of Inconel800 superalloy.

Gap voltage, pulse on-time, pulse off-time, and wire feed have been selected as process parameters that influence various performance characteristics, including kerf, MRR, and SR. Hsien-Ching Chen et al. have utilized the Taguchi method and grey relational analysis to forecast the optimization of WEDM parameters for machining Ti-6Al-4V with multiple quality characteristics. As process parameters, they selected discharge current, open voltage, pulse duration, and duty factor; as performance characteristics, they considered electrode wear ratio, material removal rate, and surface roughness. The impact of machining parameters on the efficacy of the wire electro discharge turning process was examined by Janardhan et al. The aim of the research conducted by Venkata Ramaiah et al. is to enhance the rate at which material is removed, the surface irregularity, and the spark gap. Grey relational theory was implemented in order to ascertain the optimal process parameters that would maximize the response measures.

III. DISCUSSION AND FUTURE TRENDS

Following an exhaustive review of the published works in this field, the following conclusions can be reached: WEDM is a highly precise manufacturing process that can create intricate shapes from any hardness of conductive material. For a rapid removal of materials, the development of cost-effective wire electrodes with high conductivity and durability. The investigation of electrode materials in terms of their thermal properties as they relate to cutting speed has received minimal attention. The machining of composite materials through the utilization of assisting electrodes to facilitate sparking in materials with extremely high electrical resistance has been the subject of few studies.

Utilizing effectively for gear cutting, grinding, turning, step turning, and taper turning, this method has the capacity to significantly supplant conventional procedures.

It has been observed that the following input process parameters have a significant impact on process performance characteristics in WEDM: wire material, pulse-on time, pulse-off time, servo voltage, peak current, wire feed rate, wire tension, wire offset, water pressure, servo feed, surface roughness, material removal rate, kerf width, wire wear rate, surface integrity aspects, and so forth.

Several modeling and optimization techniques are implemented in an effort to enhance the efficacy of the process. The impact of wire material and diameter on material removal rate and surface irregularity has received limited attention in research. Further investigation is necessary to improve the performance of wire electrodes utilized in high-speed cutting applications, such as the production of dies and automobile components, by incorporating high conductivity alloy materials.

IV. CONCLUSION

The primary objective of this paper was to develop wire EDM wire electrodes tools using molybdenum wire, which has been selected for its low melting point and high thermal conductivity. These electrodes effectively meet the demands of users for optimum productivity and quantity. By augmenting the silicon carbide content of an aluminum silicon carbide composite (Al/SiCp), both the cutting speed and material removal rate are enhanced. It has been noted that the majority of researchers at the time focused on optimizing a limited number of process parameters in order to achieve diverse responses. The potential for efficient multi-objective optimization is substantial. In the current investigation, we emphasize the effects of input process parameters on process performance characteristics, including wire feed, wire speed, pulse on and pulse off times, and so forth. In order to optimize the process parameters for these composites, the authors noted that WEDM manufacturers are consistently engaged in the development of wire EDM wire electrodes that are machinable, environmentally favorable, and possess high conductivity.

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