A Comprehensive Review on Impact of Machining Parameters on MRR and SR

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Abstract: **The electrical discharge machining (EDM) process is a non-conventional machining process that is utilized to create high caliber and exact dimension items. This machining (EDM) is used to machine the smallest to complex geometrical shapes. Thermal energy helps to evaporate and melt the material from a work piece. Circulation of dielectric fluid removes out the debris from working zone and maintains the stability of machining process. EDM process is generally used for machining with different applications such as automobile, aircraft, aerospace, tools and dies, etc. This paper provides a review on the effect of different input parameters of EDM such as current, pulse off time, pulse on time, etc. on material removal rate (MRR) and surface roughness (SR).**

Keywords*: EDM, WEDM, SR, MRR.*

I. Introduction

Metal matrix composites are materials with two or more components, one of which is a metal composition called a matrix and the other hard materials such as ceramic or organic compounds called reinforcement. MMCs are obtained by dispersing the reinforcing material in the metal matrix. In structural applications, lighter metals such as aluminum, magnesium or titanium are used to provide a suitable medium for reinforcement. Cobalt and cobalt-nickel alloy molds are common in high temperature applications. Reinforcement generally improves stiffness and greatly hinders crack propagation. The strength of the composite generally depends on the diameter of the particles, the distance between the particles and the volume fraction of the reinforcement. Some of the commonly used reinforcements are Al 2 O 3, SiC, TiC, B 4 C, etc., which give the matrix in composite materials a high level of hardness.

The presence of these hard and abrasive reinforcements makes it difficult to produce complex shapes with conventional processing methods. Among the various unconventional practices, WEDM plays a leading role in various manufacturing industries and is mainly used in the aerospace, defense and military sectors. WEDM is a typical heat treatment technique that can be used to accurately process parts of different hardness and complex shapes.

This is an EDM machining process that can create complex 2D and 3D parts where the wire does not touch the part, resulting in reduced physical pressure on the part. Compared to other conventional machining methods such as milling and milling end mills, where significant tool wear occurs due to the existing reinforcement, WEDM is considered an effective non-contact machining method.

While other unconventional processes such as beam grinding, electron beam machining and laser cutting are limited to linear cutting, WEDM offers advanced options for cutting complex 3D shapes with high precision. Despite these advantages, the WEDM process is limited in terms of removal speed due to poor surface quality and the risk of wire breakage.

This requires studying the parameters of the WEDM process to achieve a maximum removal rate with a better surface quality. This article mainly introduces the main WEDM research activities related to MMC, which include the different process parameters such as on time, off time, servo voltage, peak current, wire feed speed, dielectric flux and wire speed. These process parameters have a great influence on performance characteristics such as material removal rate, surface quality, width of cut, dimensional deviation and wire wear rate.

A. Electrical Discharge Machining (EDM)

Electric discharge processing (EDM) is an unusual form of processing in which electrical vitality generates electrical sparks and converts them into warm vitality. Warm vitality will help remove unreasonable material from the room. Unusual machining is used not only on low alloy steels, but also on high strength hardened alloy steels and difficult machining with conventional techniques. EDM is used to process electrically conductive material with complex shapes, complex 3D geometries and sensitive sections.

The different types of processing techniques are illustrated in Fig. 1. [5-8].

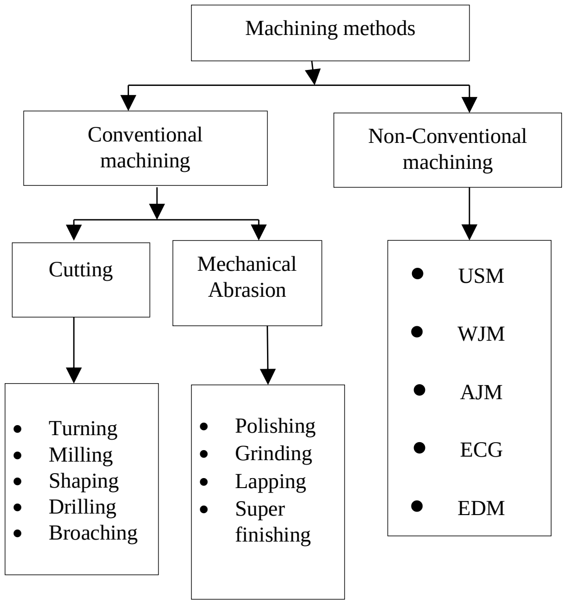

Fig. 1. Types of Machining Methods [5-8]

B. *Benefits of EDM Machining*

- Cutting extremely hard conductive materials that can be difficult to use with traditional processing methods.
- EDM machining provides a very smooth finish with no burrs or rough spots. Therefore, EDM is an excellent choice when the finish or appearance of the final product is an issue.
- Drastic reduction of production times and unit costs as well as greater machine efficiency.
- The precision of the EDM process enables cost-effective processing of complex projects.
- EDMs have built-in precision and precision that allow you to machine complex projects economically.

II. Literature Review

M. Prabhua et al. [1] In this thesis, the influence of the machining parameters of electric discharge machining (EDM) and waterjet grinding (AWJM) on the material removal rate, tool wear rate and on the surface roughness of composite materials. A Vitallium composite material reinforced with titanium nitride and tantalum carbide particles was synthesized using agitation casting processes. Processing properties were analyzed using Taguchi and ANOVA methods. The Taguchi optimization technique was used to find the optimal level of parameters when calculating the percentage contribution for each input parameter to the ANOVA responses. A scanning electron microscope (SEM) was used to examine the surface morphology.

Aharwal et al. [2] Optimization of machining parameters on the electric discharge machine (EDM) with AlSiC as the workpiece and pure copper as the electrode. The machining parameters examined in this thesis are the material removal rate (MRR) and the surface roughness. The control parameters used are discharge voltage (v), discharge current (Ip), pulse charge factor (Tau), pulse activation time (ton). The Taguchi technique (L16b orthogonal matrix) was used for the experimental design and the genetic algorithm for optimization. Material removal rate analysis provides optimal values when current is high and voltage is low, while surface roughness is best when both are low.

Mohan et al. [3] investigated the influence of the rotating tubular electrode on the processing properties of Sic / 6025 aluminum composite materials. In his study, he found the positive effect of peak current on surface roughness (SR), the removal rate (MRR) and the tool wear rate (TWR). TWR, MRR, and SR were higher when treated with positive or negative polarity. Pulse duration was inversely proportional to TWR, MRR and SR. The speed and diameter of the electrode hole have a great influence on the material removal rate and on the decrease of SR and TWR. The genetic algorithm was used to achieve an optimal stock removal rate, better surface quality and minimal tool wear.

Khan et al. [4] evaluated the wear of the tool along the length of the tool versus wear along its cross section. Wear on brass and copper tools increased with increasing current and voltage, but wear along its cross section was greater than that along its length. As the current wear rate increases, this has also increased, showing that as the current increases both material removal and tool wear increase, but tool wear increases relatively more. The highest wear rate was found for steel when brass was used as an electrode for tools.

III. EDM Parameter

Four input parameters based on literature search were selected to perform experiments.

Pulse ignition time (spark ignition time or ton): The time during which current flows through the spark gap per cycle is called the pulse activation time. It is measured in microseconds (μs).

Duty Factor: Duty Factor can be defined as a percentage of the ratio of duty cycle to total cycle time. Mathematically, it is expressed as,

$$\text{Duty factor} = \frac{T_{on}}{Ton+Toff} \times 100$$

Power / Servo Voltage: This is the voltage that is supplied between the tool electrode and the work piece while DC current is supplied to the circuit. It is measured in volts and labeled V. It affects MRR, TWR and surface roughness.

Discharge current (peak current or Ip): is defined as the power consumed in the erosion machine. The discharge current also has a great influence on MRR, TWR and surface roughness. It is measured in amperes (A).

IV. PERFORMANCE PARAMETER

A. Material Removal Rate (MRR)

It may be calculated by using equation (1) given below: MRR = (Initial weight in gms –Final weight in gms) / Machining Time (in min.) (1)

B. Surface Roughness (SR)

Component failure in industry begins with surface structure degradation or other production limitations. The important parameter of the surface texture is the roughness or quality of the surface. The manufacturing industry requires roughness within certain limits. A high roughness value is undesirable in the manufacturing area because it promotes adhesion and is difficult to control. A rougher surface wears out quickly and creates higher friction than a smooth, rough surface. In the technical field, average surface roughness measurements are generally used because they allow a better description of the height variation of the measurement surface. Surface hardness assessment can be predicted by a contact type and a non-contact discomfort analyzer. Surface roughness is possible using contact and non-contact roughness gauges.

V. CONCLUSION

This paper provides an overview of electric discharge machining, material removal rate, and surface roughness. Despite the various studies and improvements in EDM that have emerged from numerous research papers, ongoing efforts must be made to optimize performance measurement with respect to process variables such as voltage, pulse current, and pulse width in EDM machining. Special attention is needed to monitor and control the EDM process.

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