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Effects of Powder Mixed Electrolytes on Surface Finish and Material Removal Rate in Electrical Discharge Machining: A Brief Review

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Abstract—*Electrical discharge machining is a non-conventional machining process which is adopted in machining work-pieces that are too difficult to work upon using existing machining technologies and/or require high tolerance levels in the finished product. EDM is essentially an "electro-sparking method" of machining. Although an innovative machining method, it is not used extensively due to low efficiency. To overcome these problems, powder-mixed electrolytes are used. PHEDM is an experimentally proven method to improve machining efficiency, tool wear, surface finish and material removal rate. This paper reviews the existing experimental results for material removal rate and surface finish using PHEDM indicating the success in adoption of the said method in achieving improved performance.*

Keywords*: EDM, Powder mixed EDM, PHEDM, Machining efficiency, Material removal rate, Surface roughness, Surface finish*

1. INTRODUCTION

Electrical discharge machining finds its applications in making a wide variety of dies, moulds, aerospace products and in surgical equipment (Ho and Newman, 2003). Machining is achieved by removing material from a part by a series of repetitive electrical discharges between the electrode and the work-piece in the presence of a dielectric medium (Luis et. al, 2005). When the gap between the electrode and the work-piece is small enough, the voltage becomes sufficient to ionize the dielectric (Bojorquez et. al 2002). The desired material removal is achieved with the eroding effect achieved from the electrical discharges between the tool and the work-piece (Marafona and Chousal. 2005).

2. POWDER MIXED EDM

Although EDM process is being adopted for manufacturing; low efficiency and poor surface quality have restricted wider adoption of this process and hence it's further development (Meng et. al, 2002). Like other machining methods, EDM machining is achieved in two phases, rough machining and finish machining. The finish machining phase requires high surface finish quality where as rough machining requires higher efficiency at a lower surface finish quality. Many experimental researches in the past have shown that PHEDM can distinctly and effectively improve the surface roughness and surface quality in the finish machining phase.

In powder mixed EDM, fine abrasive particles are mixed with the electrolytes in the dielectric fluid surrounding the work-piece. This electrically conductive powder acts as a reducing agent that reduces the insulating strength of the surrounding dielectric medium, which increases the spark gap between the tool and the work-piece. PHEDM process hence attains more stablity and enhances machining efficiency, material removal rate and surface quality. The physical characteristics of the powder such as size, concentration and type influences the performance of the dielectric used (Pecas and Henriques, 2003).

3. EFFECT OF POWDER MIXED ELECTROLYTES ON MATERIAL REMOVAL RATE

(Jeswani, 1981) highlighted that adding 4 g of fine graphite powder per litre of kerosene not only increases the material removal rate by 60% but also the tool wear rate by 15% in EDM. These results were found in the lower spark energy range, i.e., between 1mJ to 500mJ. The addition of graphite powder also resulted in a reduction of breakdown voltage by 30% of kerosene at a spark gap of 50μm. This reduction in breakdown voltage results in higher discharge frequency which in turn increases the material removal rate.

Use of Aluminium powder with 40g per l volume and a grain size of 10mm improved machining efficiency from 2.06mm^3/min to 3.4mm^3/min; an increment of 70% (Meng et. al, 2002). The machining efficiency can be greatly elevated by electing proper discharge parameters such as increasing peak current values and reducing pulse width with improved surface finish as compared to conservative EDM machining.

Table 1: Additives and Corresponding Effects on the Finished Product

S. No.	Additives/Dielectric Fluid Used	Corresponding Effect
1	Conductive powders	Lowers surface finish and leads to the formation of cracks
2	Inorganic oxides	No effect on surface finish or material removal rate
3	Silicon, Aluminum, crushed glass Molybdenum Sulphide and Silicon Carbide with varying grain sizes.	Mirror-like surface finish
4	Powder-suspension dielectric oil containing Aluminum, Silicon, Copper and Silicon Carbide powder	Major improvements in surface finish characteristics
5	Powder particles (Silicon) in suspension in the dielectric fluid	High surface quality
6	Graphite powder in kerosene as dielectric fluid	Up to 60% increase in the material removal rate
7	Chromium in dielectric fluid with varying grain sizes	Larger material removal rate

(Lee and Tzeng, 2001) stated that the greatest material removal rate can be achieved by using Chromium of 70-80mm grain size. (Pec, 2008) evaluated the surface quality by measuring roughness and analysis of the diameter and depth of craters and the dimensions of the white formed in the process. It indicated that the use of PHEDM conditions endorses the reduction in surface roughness, crater diameter, crater depth and the thickness of white layer.

(Kansal, 2005) suggested ideal process conditions for PHEDM in the rough machining phase using "Taguchi method" with Graphite powder and discovered that addition of Graphite powder in appropriate amounts into dielectric fluid causes recognizable improvement in material removal rate and reduction in tool wear and surface roughness.

4. EFFECT OF POWDER MIXED ELECTROLYTES ON SURFACE FINISH

(Ming and He, 1995) found through their experiments that several additives can elevate productivity of EDM when they are supplemented with kerosene. Moreover, certain conductive powders and lipophilic agents effectively reduce the surface roughness and the propensity of formation of cracks in mid-finish machining and finish machining, whereas inorganic oxides, when employed as additives, have no such effect. Some type of powders, such as Silicon and Graphite powders have been registered to dispense the discharges in the spark gap to generate fair to lustrous finish surfaces even at relatively greater pulse currents up to 2A (Wong et. al, 1998). (Wong et. al, 1998) also suggested that a correct combination of work-piece material and powder additives are important to achieve near mirror finish. (Fu-Chen, 2005) investigated that Aluminium, Chromium, Copper and Silicon Carbide particles of small grain sizes (70-80mm) generate best surface finish on a SKD-11 work-piece.

5. RESULTS

The following Table 1 summarizes various additives in the dielectric fluids and their respective effects on surface finish quality and material removal rate of the machined product.

6. CONCLUSION

From the review it can be concluded that PHEDM can successfully produce better surface finish and significantly increase the material removal rate. The extent of the above characteristics depend upon various physical characteristics such as the grain size of the additive, nature of the work-piece, spark gap, pulse current and various other operating conditions. Although the review highlights potential in this area for research, a considerable drop is noticed from research point of view for the same. In future, more research emphasis can bring dramatic change in industrial application of PHEDM with improved results.

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