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Assessment of Powder Mixed EDM: A Review

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Abstract. This project research undertakes the assessment of powder added electrical discharge machining (PMDM) with focus on effect of additive powders and circulation systems. In PMEDM process, powder can be mixed with dielectric fluid either in the main EDM tank or in a separate tank in order to improve EDM machining performance. Different designs of powder mixed EDM circulating systems such as closed and opened systems with different sizes of tank are described in literature. Various devices such as stirrer, circulating pump etc. are placed in the tank in order to ensure the uniformity of powder mixed dielectric. Each design has its advantages and disadvantages and it might affect the EDM output results. Therefore, there is a need to review the PMEDM with respect to additive powders and circulation systems in order to identify the gap and propose an alternative for improving process.

1 Introduction

Conventional machining processes require the tool to be harder than workpiece material and some materials are too hard or too brittle to be machined by conventional machining process. Electrical discharge machining (EDM) is widely used to machine various conductive materials including “hard to cut materials” with complex and smallest shapes and it is an alternative machining process.

Low material removal rate (MRR), relative poor surface quality and high tool wear ratio (TWR) are the disadvantages of EDM [1, 2]. To address the above problem mentioned, powder mixed electrical discharge machining (PMEDM) is reliable for improving the EDM performance. Applications of powder mixed with dielectric include EDM and micro-EDM. In PMEDM the use of powder lower the dielectric strength creating early and uniform electric discharge at low energy improving surface roughness (Ra), MRR, TWR and machined surface properties [3].

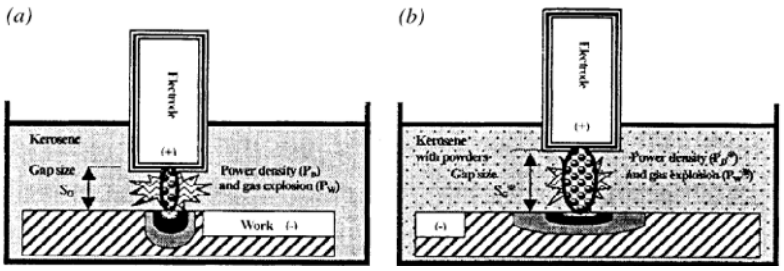

Figure 1: Single discharge (a) without powder and (b) with powder [3].

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The addition of powders increase the discharge gap and reduce discharge power density [3]. In PMEDM, powder is mixed with dielectric fluid in the tank or operating tank. Literature described two types powder mixed dielectric circulating systems which are closed and opened systems. In a closed system, the operating tank is isolated from the dielectric circulation system. In opened system, the powder mixed dielectric circulates continuously. This research aims to review powder mixed EDM circulation system.

EDM is a process applied in many areas including biomedical engineering, mould and dies automotive, aerospace, etc.

2 Review

Some investigations have been carried out to improve the electrical discharge machining (EDM) performance by modifying the EDM process without changing its working principle. The modification of the system includes powder mixed with dielectric EDM, dry EDM, ultrasonic EDM. This study focused on powder mixed dielectric EDM (PMEDM).

PMEDM method involves the use of different types of powder such as silicon, nickel, titanium, manganese, tungsten, chromium etc. mixed with the dielectric during EDM process resulting in improvement of EDM performance [4, 5].

From the literature it can be understood that PMEDM is a technique for improvement of EDM performance. Mixing powder with dielectric during EDM process reduces dielectric strength creating early electric discharges, enlarges discharge gap, disperses discharge points evenly, and stabilizes discharge process thus improves EDM performance and machined surface properties. PMEDM is a promising technique but still not well understood and it deserves more investigation to improve the techniques for satisfactory use.

Review of the previous works shows a promising improvement in PMEDM but some issues have not been considered with satisfaction. In this research project, focus is on powder and circulation design systems which are closed and opened systems.

2.1 Closed PMEDM System

In the literature available, couple of researchers used closed system during EDM process to investigate the effect of powder mixed dielectric electrical discharge machining (PMEDM) on various materials. The test-rig consists of a small container called operating tank and can be equipped with or without stirrer and circulating pump. The machining is performed in this operating tank as shown in Figure 1. The use of stirrer and circulating pump is to ensure the uniformity distribution of powder.

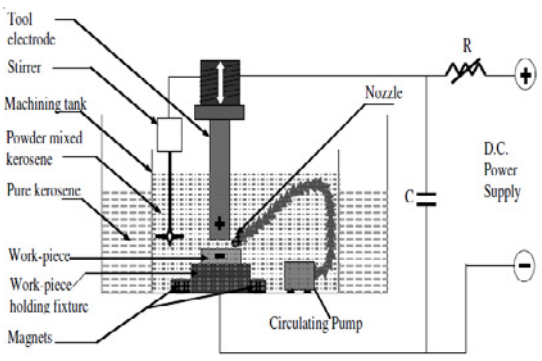


Figure 2: PMEDM closed system [9]

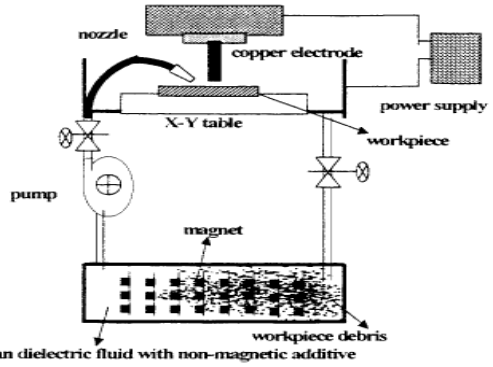
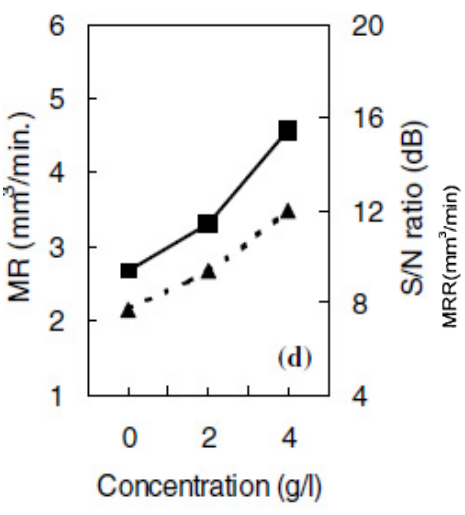


Figure 3: PMEDM opened system [3]

Kansal et al. analyzed the effect of silicon powder on EDM of machining rate of AISI D2 steel [6]. Powder-mixed dielectric circulation system was developed for the experiment. A circulating pump

and stirrer were placed in the small tank. They identified the significant process parameters which are peak current and powder concentration and optimized the machining conditions. Adding silicon powder in the dielectric maximize the machining rate (MR) when PMEDM machining AISI D2 steel compared to traditional EDM (Figure 4). The circulating pump placed in the small tank helps to circulate and flush the dielectric. The concern is the renewal of dielectric since the small is not connected to an extra tank for fresh dielectric renewal.

Singh and Yeh did research on optimization of aluminum and graphite powders mixed EDM when machining aluminum matrix composites using copper and graphite powders [7]. A small tank equipped with stirrer was placed in the main tank.



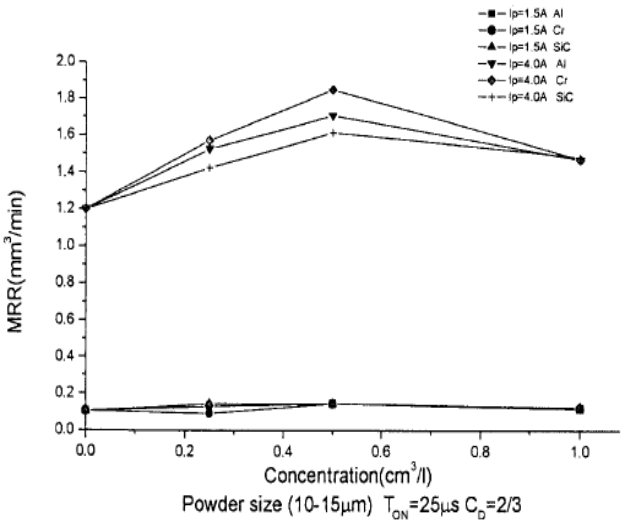


Figure 4: Effect of powder concentration on MR [7] **Figure 5**: Effect of powder concentrations on MRR [1]

The results reveal that adding aluminum powder in dielectric during EDM of Aluminum composite using copper maximized the material removal rate. Graphite powder improved surface finish but lower the MRR. Their finding shows some improvement in EDM when employing powder. The concern is the renewal of dielectric since the small tank placed in the main tank is not connected to any dielectric circulation system. Maybe the results would be much improved if renewal of dielectric system was designed. No evidence showing the uniform distribution of powder mixed with dielectric, maybe the concentration is not same all points in the operating tank.

Sanjeev et al. have investigated the machined surface properties in EDM of OHNS steel using manganese powder [8]. Authors designed a small tank which is placed in the actual tank and it is equipped with stirrer only. They observe the transfer of material from the powder suspended in dielectric to the machined surface improving its properties. Use of stirrer only without any powder mixed circulating system is a concern in evenly distribution of powder in dielectric, powder might settle down at the operating tank corner. The results would be also much improved if the experimental set up system was equipped with a dielectric renewal system.

Uno et al. worked on surface modification of electro discharge machined surface with nickel powder [9]. They designed a small tank equipped with stirrer and placed in the actual tank. They observed from the results that the surface roughness is lower when using PMEDM than that in conventional EDM. The hardness of the layer containing TiC is much higher than that of the base material, which leads to higher surface wear resistance. The result is improved but as mentioned earlier, the renewal and circulation of dielectric might improve much better the results.

Pecas et al. did researches on the influence of silicon powder EDM [10]. Small tank equipped with powder mixed dielectric circulating pump. They observed the reduction in crater and white-layer dimensions by the use of silicon powder added to the dielectric. Since no stirring system used in

experimental set up, the powder might be settled down at the bottom of operating tank. Stirring powder mixed dielectric continuously during EDM process would improve more the results.

2.2 Opened PM- EDM System

In powder mixed EDM (PMEDM) the opened system is a dielectric circulation system for the renewal and reuse of powder as shown in Figure 3. Little documentations on opened systems are available in literature. In opened system, mainly a dielectric circulation system is used to circulate and renew the dielectric.

Tzeng explored the effects of aluminum, chromium, copper and SiC powders on electro discharge machining focusing on multi-objective optimization [3]. A filter is placed in circulating system to filter the debris (Figure 5). They found that the most important parameters of powders influencing the EDM performance are particle size and concentration, electrical resistivity and the thermal conductivity. Since no stirrer placed in the operating tank, concentration of powder mixed with dielectric might not be uniform.

Wong et al. did a study on near-mirror-finish phenomenon in PMEDM and different types of powder were used [11]. High-pressure pump circulates the powder mixed dielectric from an extra tank and dispersed it in the operating by a low-pressure axial pump. Aluminum powder gives mirror surface finish compared to other powders. The results are promising whereas the concern is the contamination of whole dielectric since the powder is injected to whole dielectric tank. It might affect the next experiment result.

Ming et al. did research on powder suspended in dielectric fluid for EDM of high-carbon steel [12]. They designed an operating tank consisting of container, micro-pump, filter and stirrer. Conductive or inorganic-oxide powder mixed with dielectric is injected to the machining area. They found that conductive powders and lipophilic agent can lower the surface roughness and cracks size during EDM of high-carbon steel. The debris and powder settlement at the bottom of tank might be a concern.

Cogun and his colleagues explored the effect of powder on EDM performance [13]. Experiments were conducted in a designed operating tank. Graphite and H_3BO_3 powders were used and they found that the use of graphite powder mixed with kerosene dielectric improved surface finish. The concern may be a settlement of powders and debris at the bottom of tank.

Muhammad et al. did a study on graphite nano size powder added in sinking and milling micro-EDM of WC-Co [14]. Operating tank and powder mixed with dielectric circulation were designed. The results present a smooth surface in both sinking and milling micro-EDM. Deposit of powder at the bottom of tank particle is a concern.

3 Further study

After gone through many papers available in literature on powder mixed electrical discharge machining (PMEDM) with respect to powder dielectric circulation system, few points need to be addressed in order to improve this system.

Most of researches available on powder mixed dielectric employed macro size powders. There is a need for more investigations on the effect of nano powder since the smallest size of powder the better its suspension is.

Various operating tank volumes were employed, need to investigate the influence of different volumes on PMEDM performance and determine the optimal volume.

PMEDM operating tanks so far described in literatures are flat base and powder particles can easily settle down at the corner of tank. It will be good to investigate the influence of different tank bases.

There is a lack in literatures regarding evaluating the concentration of power mixed dielectric, mostly assumed. Need to find a way to evaluate the powder mixed dielectric concentration.

Application of EDM and PMEDM can be potential in biomedical implants machining but there is little documentations in literature. It will good to investigate more EDM and PMEDM application in biomedical implant manufacturing.

4 Conclusion

From the literature, the past research works showed an improvement of electrical discharges machining performance by suspending powder to dielectric. Different operating tank design systems namely closed and opened systems were described with different volume used. Some gaps were identified in terms of powder distribution, settlement of powder on the corner of tank and evaluation of concentration of powder mixed dielectric and deserve further investigations. Powder mixed dielectric can be explored more for biomedical application.

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