Comparison of Outputs for Dry EDM and EDM with Oil: A Review

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ABSTRACT

Electric discharge machining (EDM) is one of the important production technologies in now days. It is very useful in the machining of the material which are very hard for conventional machining and are conductor of electricity. These materials are vastly used in various sectors such as manufacturing, aerospace and medical instruments etc. Dry EDM is one of the types of the EDM in which gas is used as dielectric medium; this results in low electrode wear ratio. This review paper presents the comparison between EDM with oil and dry EDM for different output parameters like MRR, TWR, cost etc.

Keywords- Dry EDM, EDM, MRR, TWR, Dry-WEDM

1. INTRODUCTION

EDM is generally carried out in a dielectric liquid such as kerosene-based oil. The use of liquid has been regarded as indispensable for the stability and efficiency of the process, because it is known that the liquid serves as a cooling medium in the discharge gap and also plays one of the most important roles in the material removal mechanism. EDM with oils is called conventional EDM also [1], [2], [3], [4].

Using inert gas to drill small holes (NASA, 1985) is the first dry EDM attempt. Dry-electrical discharge machining (dry-EDM) is EDM process, which is conducted in a gas atmosphere without using dielectric liquid. Die-sinking EDM in dry condition was first attempted by to discontinue the use of EDM working oil in consideration of environmental preservation, human health and prevention of fire hazards. They found other advantages of dry-die-sinking EDM such as: 1) significantly low tool wear ratio, 2) thinner white layer and lower residual stress, and 3) narrower discharge gap length [5]. Kunieda et al. found that when the EDM gap is filled with dielectric liquid, a considerably large process reaction force is applied to the tool electrode at the moment dielectric breakdown occurs. This is because a bubble is generated due to the evaporation and dissociation of the dielectric liquid, and because rapid expansion of the bubble is prevented by the influence of the inertia and viscosity of the dielectric liquid, resulting in extremely high pressure inside the bubble. In contrast, the process reaction force was found to be negligibly small when a discharge occurs in a gap filled with air instead of liquid [6].

2. PRINCIPLE

Figure 1 shows the principle of dry EDM. Figure also shows the different input and output Variables. In dry EDM, tool electrode is formed to be thin walled pipe. A high velocity gas jet from a pipe tool electrode reacts with the work piece material under high temperature caused by arc discharge and enhances the evaporation and melting of the work piece at the discharge spot. The gas used is normally oxygen gas when the
work piece is made of steel. The gas jet also flushes the removed material away from the discharge gap and prevents them from adhering onto the surfaces of the tool electrode and work piece. Furthermore, during pulse interval, the gas jet blow of the plasma formed by the previous discharge, thus guaranteeing the recovery of the dielectric strength of the gap. The greatest advantage of dry EDM is that the tool electrode wear ratio is very low compared with that of conventional EDM in liquid. The material removal rate improves as the concentration of oxygen gas in the gas jet is increased and even higher material removal rate than the conventional EDM can be obtained when pure oxygen gas is used [7].

Tool may be rotated during the machining. Tool rotation during machining not only facilitates flushing but also improves the process stability by reducing arcing between the electrodes. The technique was developed to decrease the pollution caused by the use of liquid dielectric which leads to production of vapour during machining and the cost to manage the waste. Dry EDM method with the shortest machining time compare to oil die sinking EDM, & lowest electrode wear ratio. Work removal rate also get enhanced by dry EDM [8].

3. COMPARISON BETWEEN DRY EDM AND EDM WITH OIL

We can compare these two processes on the basis of parameters of the process. There are so many input and output parameters of EDM. Here in this review paper we have focused mainly on output parameters.

3.1 Experimental Set Up

In dry-EDM we use gas as the dielectric fluid while in conventional EDM liquid mostly oil is used. An air drier is connected between the compressor and the regulator to eliminate the influence of water vapour contained in the compressed air on the machining characteristics. The work piece electrode is also a cylindrical pipe whose cross section is the same as that of the tool electrode. [5]

3.2 Effect of Polarity

M. Kunieda et al. found that in the case of EDM in air, the tool electrode wear ratio is much lower and the material removal rate is much higher when the polarity of the tool electrode is negative compared with the case in which the polarity of the tool electrode is positive. In contrast, in the case of EDM in a liquid, there is less tool electrode wear and higher material removal rate when the polarity of the tool electrode is positive. Therefore, machining characteristics were compared between EDM in air with a negative tool electrode and EDM in oil with a positive tool electrode. [5]

3.3 Tool Wear Ratio

M. Kunieda et al. shows the influence of the pulse duration on the ratio of volumetric wear of the tool electrode to volumetric removal of work piece when a pipe electrode whose wall thickness is 0.3mm is used. It is noteworthy that, in air, the tool wear ratio is always nearly zero, independent of the pulse duration. On the other hand, in oil the tool wear ratio increases drastically with decreasing pulse duration. [5]
It is well known that carbon is deposited on the tool electrode surface and that the deposited carbon protects the tool electrode from wear when a pulse duration longer than 20 $\mu$s is used in hydrocarbon dielectric liquids. However, air contains no carbon. Therefore, it is considered that the molten workpiece material is attached to the tool electrode surface in place of carbon and protects the surface from wear independent of the pulse duration. [11], [12]

### 3.4 Straightness

Starting from a flat surface pre-processed by grinding, finish-cutting with a depth of cut of 5$\mu$m was repeated until the straightness measured became invariable. Figure 3 shows the difference in straightness between conventional and dry-Wire EDM. It is clear that the straightness is better in dry-WEDM than in conventional WEDM. Under the conditions used in this experiment, all the surfaces finished were concave. [13]

![Fig-3: Comparison of straightness.](image)

### 3.5 Surface roughness

Figure 4 shows a comparison of surface roughness obtained from the experiments. It was found that the surface roughness is better in dry-WEDM than in conventional WEDM. This is because since there is no dielectric liquid in the working gap in dry-WEDM, the discharge column expands easily, increasing its diameter more quickly. Thus the lower current density than conventional WEDM results in a shallower discharge craters, leading to better surface roughness. [13]

![Fig-4: Comparison of surface roughness](image)

### 3.6 Material Removal Rate

Figure 5 shows a comparison of the material removal rate between conventional and dry WEDM obtained under the same condition. The material removal rate of dry-WEDM is considerably lower than that of conventional WEDM. This is because the frequent occurrence of short circuiting due to the narrower gap length in dry-WEDM causes unfavourable repetition of turning back and forth of the wire electrode in the feed direction. Consequently, dry-WEDM requires better frequency response in wire feed control to obtain the same removal efficiency as conventional WEDM. Yoshida et al. demonstrated that the material removal rate of dry-die sinking EDM can be improved to almost equal to that of conventional die-sinking EDM by utilizing a piezoelectric actuator for supplementary gap control [14]. Z.B. Yu et al. shows that MRR of dry EDM milling is about six times larger than that of oil EDM milling [15].

![Fig-5: Comparison of MRR](image)

### 3.7 Waviness
Figure 6 shows profiles of the finished surfaces. From the profiles measured parallel to the wire ($\theta = 0^\circ$), the straightness of dry-WEDM was found to be better than that of conventional WEDM. From the profiles measured in the direction ($\theta = 1^\circ$), more streaks were however seen generated over the dry-WEDMed surface than the conventionally WEDMed surface. This is because the wire feed turns back and forth frequently due to short circuiting in dry-WEDM.

**3.8 Machining Time and Cost**

As die sinking EDM requires the use and subsequently production of tool electrodes, machining time is longer and costs higher than cutting methods such as milling by machining centre. Cost of EDM with oil is more because of cost of oil and greater electrode wear.

**4. CONCLUSIONS**

As the result of above discussion we can see that there are so many things different in dry-EDM as compared to conventional EDM. Now we can see that dry-EDM have several advantages such as low tool electrode wear ratio, better surface roughness. One of the prominent advantage is that no need to worry about fire or the generation of harmful gases and waste from the dielectric liquid as in case of EDM with oil. Cost of machining is high due to more tool electrode wear and cost of oil in EDM with oil. Major disadvantage of dry-WEDM is that material removal rate is lower as comparison with conventional EDM, but in case of dry EDM milling material removal rate is higher in conventional method.

**REFERENCES**


