Investigations on the Influence of Powder Suspended Dielectrics in μ-Wire-EDM

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Abstract

In Wire-EDM the machining time is relatively high compared to conventional cutting technologies. In addition the workpiece surface often needs to be polished in order to achieve a better surface roughness and to reduce the rim zone. In order to reach optimum results in Sinking-EDM one approach is the use of powder additivated dielectrics. Here the application of powder suspended dielectrics in Wire-EDM is investigated. Hence, the influences of different powder concentrations and machining parameters are analysed regarding average gap width, material removal rate and surface roughness in different workpiece materials.

1 Introduction

To increase the competitiveness of Wire-EDM technology it is important to enhance the cost efficiency of the process. Therefore the increase of material removal rate and the improvement of surface quality directly in the process are of high importance. In Sinking-EDM this is partially achieved by the use of powder additivated dielectrics.

Investigations can be found in the Sinking-EDM literature about the use of powder suspended dielectrics where a higher material removal rate could be achieved [1], the highest with the use of graphite powder [2]. Also it was reported that the surface roughness is improved by adding graphite powder to the dielectric [3]. But due to the technology and material dependency not all these advantages appear in all tests simultaneously.

Wire- and Sinking-EDM differ mostly in the different process geometries and in the use of different generator techniques. In this paper the possibilities to improve the process in Wire-EDM are presented.

2 Experimental set-up and results

The investigations on the influence of powder suspended dielectric in Wire-EDM were done on a Sodick AP200L Wire-EDM machine. Here an external dielectric circulation loop with a separate working tank with tilted walls was needed to avoid a mixture of the powder suspended dielectric with the pure dielectric and to ensure that no deposition of powder could take place. Also a new workpiece clamping system and new wire guidance and evacuation system are applied. The wire feeding system and the control of the machine can still be used. A schematic drawing of the new device is shown in Figure 1.

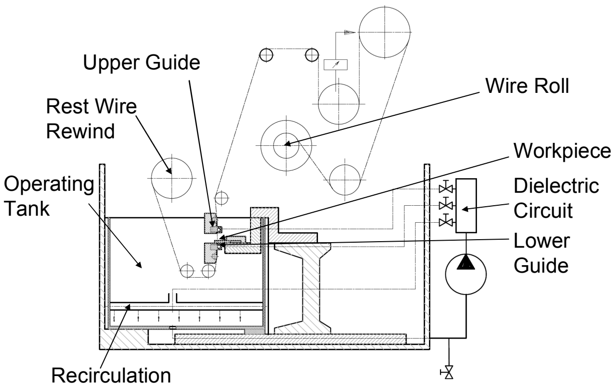


Figure 1: Schematic drawing of the device for powder suspension in Wire-EDM.

As workpiece materials the middle-sized grain cemented carbide CF-H40S and a powder-metallurgical produced high-speed steel S 6-5-3 PM were used. The tests were accomplished with 50 µm Micro-Cut and tungsten wire. The used working media was the CH-based dielectric Ionoplus IME-ET and the additive was a graphite powder with a middle grain size of $d_{50} = 4$ µm. Four different concentrations which are 0 g/l, 2 g/l, 4 g/l and 8 g/l were used.

The utilized technologies are shown in Table 1. They vary in current, pulse duration and duty cycle. With these exact technologies µ-Sinking-EDM tests were already accomplished. The electrode is poled negative, the workpiece positive, like in standard Wire-EDM. Here just rough cuts are analysed. Further trimcuts would improve the surface roughness more, but the geometry of the gap is different.

Table 1: Test parameters.

	T 1	T 2	T 3	T 4	T 5	T 6
Open circuit voltage $\hat{u}_i$ / V	150	150	150	150	150	150
Servo voltage / V	120	120	120	120	120	120
Current I / A	0.6	0.6	1.8	1.8	5.4	5.4
Pulse duration t_i / µs	1.5	4	1.5	4	1.5	4
Pulse interval t_0 / µs	1	2	1	2	1	2

For all combinations the added graphite powder in the dielectric increase the working gap width with increasing powder concentration due to a decreased dielectric strength. For the cutting of S 6-5-3 PM the enlarged gap width at 2 g/l graphite concentration makes the flushing of the debris easier which results in a more stable process and an improved material removal rate and surface roughness.
With the used technologies for the cutting of CF-H40S the enlarged gap width does not led to a more stable process. Here it resulted in a smaller material removal rate with high dispersions and only in an improvement of the surface roughness.

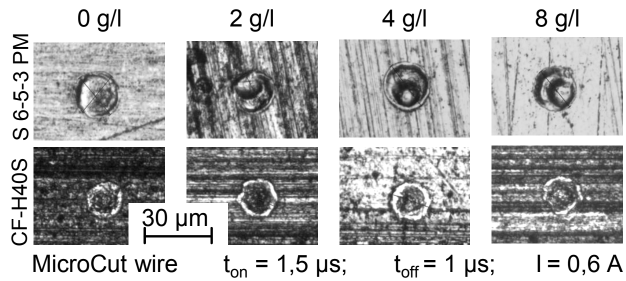
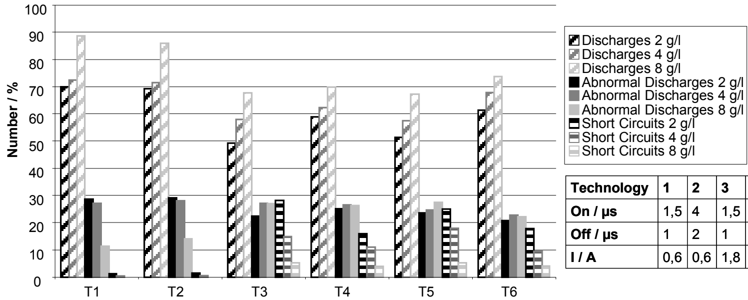


Figure 2: Pictures of single discharge craters in S 6-5-3 PM with MicroCut wire.

In general the achieved surface roughness was better in CF-H40S than in S 6-5-3. Fundamental tests with single discharges have shown that this is caused by smaller crater diameters in CF-H40S than in S 6-5-3 PM (Figure 2) and also due to the higher melting temperature of the cemented carbide. The decrease of surface roughness with increasing powder concentration in the dielectric can be led back to smaller single crater diameters. The larger gap width in powder suspended dielectric leads to a higher transfer of energy to the dielectric. Thus a smaller amount of energy is available which can melt the material and produce the crater. Therefore the smaller crater diameters appear.

An analysis of sequence discharges in S 6-5-3 shows a large increase of normal discharges and a decrease of short circuits for the use of powder suspended dielectric (Figure 3). This proves the stabilisation of the process due to the additives in the dielectric.



Technology	1	2	3	4	5	6
On / µs	1,5	4	1,5	4	1,5	4
Off / µs	1	2	1	2	1	2
I / A	0,6	0,6	1,8	1,8	5,4	5,4

Figure 3: Number of resulting discharges, abnormal discharges and short circuits in S 6-5-3

3 Conclusion

In this paper the influence of powder suspended dielectric on the material removal rate and the surface roughness is analysed. It was found that the surface roughness is improved, which can be explained by the crater diameters. The effect on the material removal rate is depending on the workpiece material and can not only be explained by the crater shape but also by the effective discharges.

References:

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