Micro-WEDM 을 이용한 티타늄 합금의 가공 특성 연구
Study on Machining Characteristics of Titanium Alloy in μ-WEDM

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Key words : Micro-WEDM, Titanium alloy, Material removal rate, Surface roughness, Feedrate

1. Introduction

Titanium alloys have found very wide application in aerospace industry, automotive, medicine and dentistry which require great reliability due to their excellent corrosion resistance, high strength to weight ratio, high temperature stability and mechanical properties. However due to high melting temperature, low thermal conductivity, chemical reactivity and high electrical resistivity these alloys have poor machinability and are difficult to machine with traditional machining methods.[1]

EDM is a non-conventional machining process which removes material based on thermoelectric energy created between work piece and an electrode submerged in a dielectric fluid. EDM can machine any conductive material regardless of its hardness. However the limitations of EDM process are low cutting speed and formation of recast layer while machining titanium alloy which affects the surface integrity of the machined part. The important machining characteristics of EDM are material removal rate (MRR) and surface roughness (SR) which are greatly influenced by various process parameters namely gap voltage, Pulse ON/OFF time, discharge gap, capacitance and etc.[2,3]

Many researches on machining characteristics of titanium alloys using EDM have been done during the last decade. However researches about the machining characteristics of these alloys using micro-WEDM are very few.

In this paper, we present the investigation of machining characteristics of the most widely used titanium alloy Ti-6Al-4V by μ-WEDM based on gap voltage, capacitance and feedrate.

Table 1 Experimental design

Symbol	Control Parameters	Level		
		1	2	3
P1	Gap voltage (V)	80	100	120
P2	Capacitance (nF)	1	10	100
P3	Feedrate (μm/s)	1	2	3

2. Experiment setup

The experiments were conducted on a multi-process micro machine tool Mikrotools DT110 as shown in Fig. 1. The EDM module of the machine is controlled using a RC type pulse generator. Micro slots of 1.5mm length were machined on a 1.5mm thick Ti-6Al-4V plate by μ-WEDM using zinc-coated brass wire of diameter 70μm. EDM-3 synthetic oil was used as the dielectric fluid. Different levels of gap voltage (V), capacitance (nF), feedrate (μm/s) used in the experiments are given as in Table 1. High precision weight balance (HR-200) and surface roughness measurement equipment (SJ-400) were used to measure the MRR and SR of the EDM processes respectively.

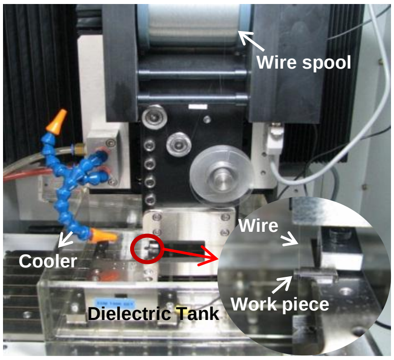

Fig. 1 μ-WEDM experimental setup

Table 2 Design matrix and results of experiments

Trial	P1	P2	P3	MRR (mm^3/min)	Ra (μm)
1	3	3	**1**	0.0075	1.37
2	3	3	**2**	0.0063	1.88
3	3	3	**3**	0.0127	1.80
4	3	**1**	1	0.0040	0.22
5	3	**2**	1	0.0050	0.79
6	3	**3**	1	0.0075	1.75
7	**1**	3	3	0.0049	1.75
8	**2**	3	3	0.0172	1.98
9	**3**	3	3	0.0127	1.80

3. Results and discussion

The experiments were carried out by selecting parameters as shown in Table 2. Fig. 2 shows the effects of gap voltage, capacitance and feedrate on MRR and SR. As reported in many researches, gap voltage is an important operating parameter. High voltage results in high discharge energy, hence high MRR. However, the increase of discharge energy also increases the density of the debris which in turn obstructs the discharge. This can be seen as a reason for the decrease of MRR at 120V.

In RC type pulse generator, capacitor controls the charge and discharge process as well as the duty cycle. Thus the performance is greatly affected by the capacitance. Larger capacitance results in higher discharge energy, hence deeper and larger craters which increase the MRR and decrease the SR.

In many researches, feedrate is usually considered as trivial parameter. However, choosing the proper feedrate can provide more efficient machining. When the feedrate is increased, the non-discharge time is shortened which in turn increases the MRR.

4. Conclusion

To summarize, capacitance is found to be the most significant factor. Gap voltage highly affects MRR but slightly influence SR. Moreover, feedrate showed a considerable effect on MRR as increased feedrate causes more contribution of energy in material erosion.

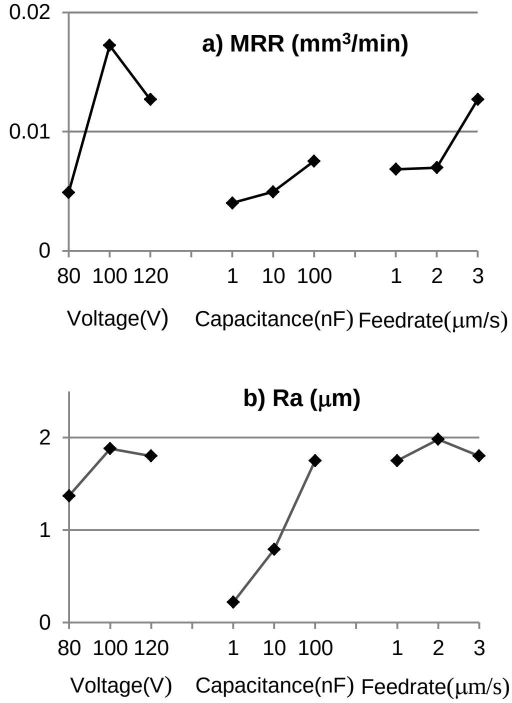

Fig. 2 Effect of process parameters on a) MRR b) SR

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