Electrode Feeding Device for Micro-hole Electrical Discharge Machining by Using AZARASHI Mechanism

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Abstract

An electrode feeding device for micro-hole electrical discharge machining by using AZARASHI mechanism is described in this paper. This device consists of a controlled friction device, a friction device applying a constant friction and an extension device to change the distance between the friction devices. For easy friction adjustment, the displacement of a stacked piezoelectric actuator was magnified in the controlled friction device, and the constant friction was applied with a coil spring. The relationship between the feeding velocity of an electrode with a diameter of 0.2 mm and driving frequency was measured. Then performance of electrical discharge machining with a capacitance discharge circuit was measured. Because this device responds quickly, a high cut-off frequency of a low pass filter was usable.

1 Introduction

Multiple microholes are often machined in small parts such as nozzles for diesel engines. Because reaction force on a tool electrode is very small in electrical discharge machining (EDM), fine tool electrodes can be made of inexpensive materials. Hence, EDM is often applied to micromachining of small parts. Various electrode feeding devices have been proposed for microhole-EDM [1]. In particular, piezoelectric actuators allow stable EDM by a quick retraction of the electrode [2]. Because a thin electrode wears heavily in microhole-EDM, it is preferable to feed it directly through a sleeve guide instead of holding with a chuck [3]. The authors have applied AZARASHI (Seal) Mechanism [4] to an electrode feeding mechanism for parallel multiple electrodes [5]. This paper describes performance of microhole machining of a prototype for compact manufacturing systems.

2 Principle of electrode feeding

Fig. 1 shows a principle of electrode feeding. The electrode feeding device consists of a controlled friction device (Friction device A), a friction device applying a constant friction (Friction device B) and Extension device to change the distance between the friction devices. Friction device A is connected with an end of Extension device and its another end connected with Friction device B by a housing is fixed to a stand. An electrode is fed downward by the following sequence: (1) Release Friction device A; (2) Deform Extension device to feed the electrode with fine steps; (3) Grasp with Friction device A; (4) Contract Extension device to retract the electrode. By alternating motions of Friction device A, the electrode is fed bidirectionally.

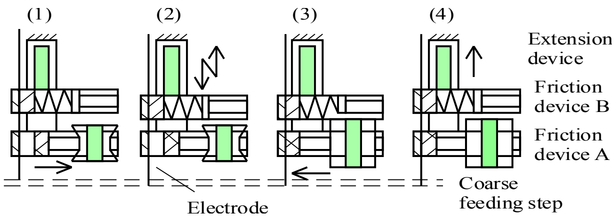


Figure 1: Principle of electrode feeding

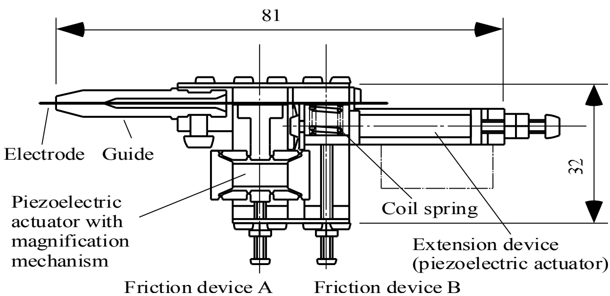


Figure 2: Sectional view of electrode feeding device

3 Structure of electrode feeding device

Fig. 2 shows a cross-section of a prototype. The whole device measures 81 mm×16 mm×32 mm. For adjusting friction easily, the displacement of a stacked piezoelectric actuator was magnified 8.5 times in Friction device A, and the constant friction was applied with a coil spring with a spring constant of 9.5×10^3 N/m in Friction device B. A stacked piezoelectric actuator was used for Extension device.

Table 1: Machining conditions

Open-gap voltage		100 V
Discharge circuit		Capacitance circuit Capacitance: 0.033 μF, Resistor: 260 Ω
Electrode		Tungsten ϕ0.2 mm, (-)
Workpiece		SUS304 t0.3 mm
Coarse feeding frequency		400, 1200 Hz
Coarse feeding step		7 μm
Fine feeding frequency		10 kHz
Fine feeding step	Forward	0.35 μm
	Backward	0.7 μm
Cut-off frequency of low pass filter		500, 1000, 2000 Hz

4 Machining performance

At first, the coarse electrode displacement a step was adjusted to 7 μm at a driving frequency of 10 Hz. Then the relationship between the feeding velocity of the electrode and driving frequency was measured. The electrode can be stably fed below 500 Hz, and 1000 to 1250 Hz. Consequently, the electrode was driven at 400 or 1200 Hz in the following machining experiments. The fine steps were set to 0.35 and 0.7 μm for forward and backward motions, respectively. Performance of EDM by using a capacitance discharge circuit. Table 1 shows machining conditions. The electrode feeding was controlled by feedback of the gap-voltage through a low pass filter (LPF). When the cutoff frequency of the LPF was high, the electrode frequently oscillated back and forth. It helped to flush debris from the machined hole. The ellipticity of machined holes at 1200 Hz was larger than that at 400 Hz due to a resonance frequency of the device. Fig. 3 shows examples of electrode feeding during EDM. The electrode feeding was fluctuated at high cut-off frequency of the LPF because of high frequency response of the device. High driving

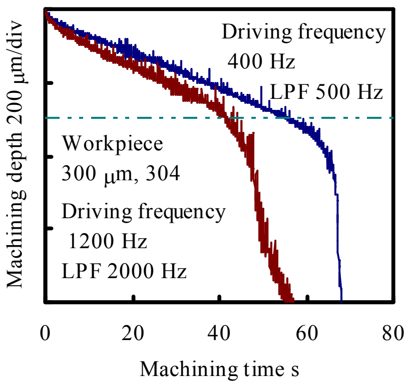
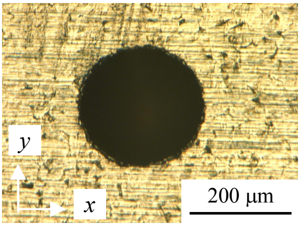
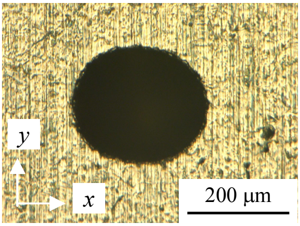


Figure 3: Examples of progress of machining



(a) Driving frequency:
400 Hz, LPF: 500 Hz



(b) Driving frequency:
1200 Hz, LPF: 500 Hz

Figure 4: Examples of machined holes

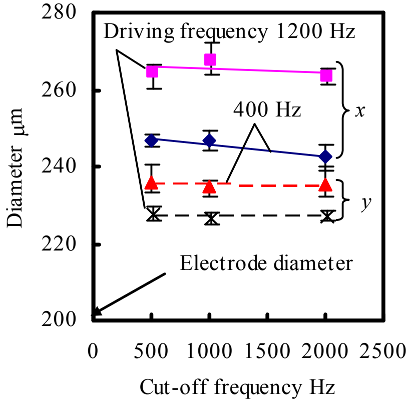


Figure 5: Diameter of machined holes

and cut-off frequencies redude the machining time. The fluctuation helped flushing debris in the gap during EDM. Fig. 4 shows machined holes. The diameter in the *x*-direction, in which Friction device A was moved, was larger than its orthogonal direction. Fig. 5 shows diameters of machine holes. The driving frequency affected the ellipcity of machined holes.

5 Conclusions

In this paper, the electrode feeding device for micro-hole EDM by using AZARASHI mechanism for compact manufacturing systems is described. Quick electrode motoin improved the machining performance. The machining accuracy will be improved after analyzing vibration modes.

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