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Development of a rotary axis mechanism for wire EDM turning (WEDT)

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ABSTRACT - Wire electro discharge turning (WEDT) is a non- conventional machining process that takes advantage of electrical discharge machining (EDM) sparking phenomenon assisted by rotary axis. Incorporating the additional axis increase the wire electrical discharge machining (WEDM) capability for machining hardened and intricate cylindrical parts especially when conventional machining have failed to perform. This research emphasizes on the development of additional rotary axis mechanism in WEDT as well as evaluation for machining capabilities in blending of macro- micro feasible dimension and shapes.

1. INTRODUCTION

Wire EDM turning (WEDT) is a process that employs basis technology of the wire electrical discharge machining (WEDM) fundamentally based on the electrical machining (EDM) sparking phenomenon. A benefit of WEDT is it allows to produces free- form cylindrical geometries of symmetrical parts with minimal diameters and complex shapes without concerning electrode wear. Most of the current works on WEDT only focusing on macro size cylindrical parts and development of rotary axis mechanism. The rotary mechanism were basically formed by assembling of centring chuck or collet, carbon brush, bearing, pulley and belt, worm gear also driven by electrical motor either AC or DC [1-3].

2. METHODOLOGY

2.1 Design and working principle

As shown in Figure 1, the rotational motion that rotates the workpieces is simply transfer from electrical DC motor by tooth pulley and belt. The workpieces is clamped on straight shank collet holder which serves as spindle shaft and works with ER16M adapter as clamping devices. A pair of deep groove Si3N4 ball bearings with ABEC grade 5 was used to support and guide a rotating of spindle shaft. To prevent the excess melted material (debris) and dielectric fluid from enter to the bearing, radial oil seal is used. Carbon brush is used and held by using the carbon brush holder to transmit the electrical current from a static to a spindle shaft. In this WEDT, the rotating of the workpieces is interfered by continuous electrode wire that replenished during the machining for ensure the new electrode wire surface available for next sparks. By applying the rotational motion, the un- machined portion on the workpieces surface is replaced by machined portion, and vice versa. The rotary axis mechanism is mounted on the WEDM machine table (Figure 1). The pulse- width- modulation (PWM) method were used to controlled the rotational spindle speed generated by 24 volts DC brushed electric motor and pre- programmed with PIC16F887 memory with the maximum rotational spindle speed of 3000 rpm.

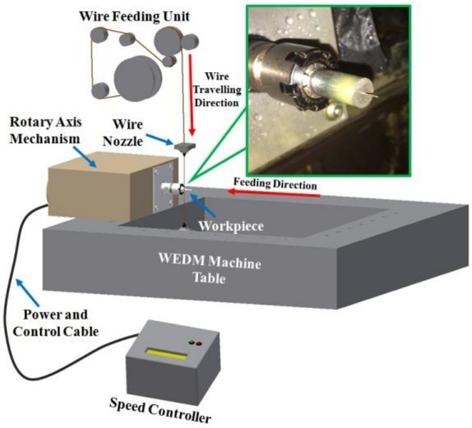

Figure 1 Location of rotary axis mechanism mounted on WEDM machine table.

2.2 Experimental setup

The developed rotary axis are tested in terms of the machining capabilities on Ti6Al4V material with diameter of 9.49 mm. Ti6Al4V was chosen as the workpieces due its low machinability rating by conventional machining [4,5]. The fabricated rotary axis mechanism is installed on Mitsubishi Ra-90 non-submergible WEDM machine. Brass wire with 0.25 mm diameter and single pass cutting condition were employed for all runs.

3. RESULTS AND DISCUSSION

The machining capabilities are tested based on geometries of turning operation and groove profile. As shown in Figure 2, there are four types of geometries feature that were tested and achieved by using this rotary axis mechanism with single pass cutting which are dovetail, cone, ellipse and groove shape. The micro size dovetail shape was successfully machined according to the designated dimension. The successful of machined down from diameter 9.49 mm of Ti6Al4V to dovetail shape with bottom (neck) diameter as much 163 µm and top diameter 372 µm. Figure 3 shows the comparison in size between machined part of free- form profile and a match.

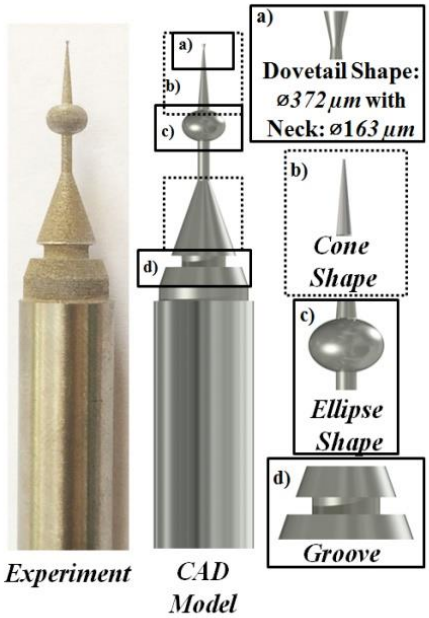

Figure 2 Different geometries in evaluation of machining capability.

Figure 3 WEDT free- form profile machined part.

Figure 4 shows the straight turning machined parts and Table 1 indicates the machined down achieved diameter and length to diameter (L/D) ratio by straight turning operation [6] and WEDT. It is noticable that by incorporating the rotary axis mechanism significantly improved the L/D ratio compared to micro- turning. Basically, the conventional process like micro- turning is well known with its limitation to fabricates parts with large L/D ratio as the workpieces easily deflects by the reacting force with a reduction in rigidity according to the decrease in the diameter.

Figure 4 Machined down diameter part to 230 µm by straight turning approach.

Table 1 Comparison of length to diameter ratio (L/D)

	Micro- Turning [6]		**WEDT**	
Material	**Brass**	**Stainless Steel 316L**	**Brass**	**Ti6Al4V**
Final Diameter (µm)	80	94	203	230
Final Length (mm)	2	1.46	15	15
Length to diameter ratio (L/D)	25	15.5	73.9	65.2

4. CONCLUSIONS

The developed rotary axis mechanism for WEDT proved to increase the capability in fabricating variation of complex macro and micro dimension geometries. In addition, the improvement on large L/D machining ratio with single pass cutting condition was also observed. This process also has high potential in open new possibilities for blending complex macro- micro geometries components production especially for medical instruments.

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