Cutting Capabilities for Macro-Micro Cylindrical Shapes Component by Wire Electrical Discharge Turning (WEDT)

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ABSTRACT – This paper presents the evaluation for cutting capabilities of wire electrical discharge turning (WEDT) for combinatorial macro and micro size dimension features. The experimental result demonstrates by WEDT has shown capability to formed the blending of micro dimension straight shafts and fins (~200 µm) to the macro dimension of ellipse, cone and hour glass features that was made by Ti6Al4V as materials.

1. INTRODUCTION

Wire electro discharge turning (WEDT) is the process that integrated the perpendicular travelling electrode wire to a revolving cylindrical work piece by linear motion of feed in the electrical discharge basis technology [1]. Most studies in the field of WEDT are limited to the macro of dimensional features such as injector plunger for diesel engine [2], tool steel punches in application of mold and die [3], not to mention predominantly typical geometrical design specific to straight shaft [4,5]. Despite the micro-scale diameter of electrode wire in WEDT, it has clearly shows the capability of this process in cutting the blends of macro and micro free-form geometries. However, little is known about the capability of WEDT in contouring of blending macro and micro dimension cylindrical shape as well as the achievable thickness dimension by slitting operations. In this study, the cutting capabilities of WEDT were conducted in fabricating free-form of the combinatorial macro-micro dimension.

2. EXPERIMENTAL SETUP

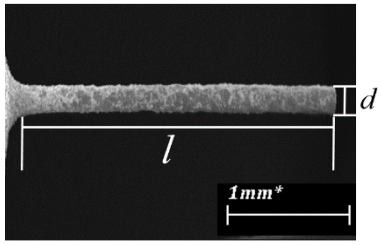
In this experiment, a 9.49 mm diameter Ti6Al4V was used as the work pieces material which is known to has difficulty to cut material with low machinability rating by conventional machining [6]–[8]. Brass wire with 250 µm diameter and single pass machining were employed for the all the cutting condition. The cutter path code is develop by EdgeCAM and loaded into Mitsubishi Ra-90 machine system for NC path programming. To obtain the effectiveness of the develop rotary axis mechanism [9], the part are designed that consists of several geometry features and blended with macro-micro dimension i.e. contouring and slitting of micro straight shaft and fins unified with macro dimension of ellipse, cone and hour glass. Meiji Techno EMZ-13TR stereo microscope assisted by VIS pro software was used to measure the actual dimension the machined part. Scanning electron microscope (SEM) was used to further examine the parts structures.

3. RESULTS AND DISCUSSION

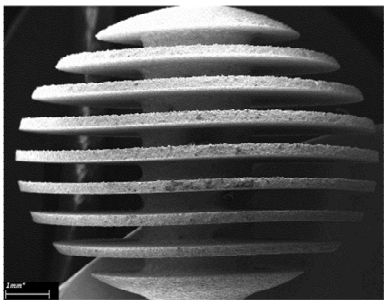
In this study, a complex combination of macro-micro parts that features on geometrical design was successfully machined. Figure 1 and Table 1 show the particulars fabricated parts that comprises of fine details of features respectively. By the high stability of bearing, the fine structure of micro fins as much as 200 µm, it can be successfully fabricated (Figure 2). The combinatorial of macro and micro dimension was easily achieved with one single pass approach including contouring and slitting without changing the cutting path. The machined down to become straight shaft diameter as much as 200 µm with 2.5 mm of the machining length approximately 12.5 of aspect ratio (length to diameter) and averages of 400 µm slitting kerf width can be attained which indicate the effectiveness of the developed rotary axis mechanism unit.

Figure 1 Complex macro and micro dimension of Ti6Al4V parts with tiny details of features

Table 1 Tested profile geometries by WEDT

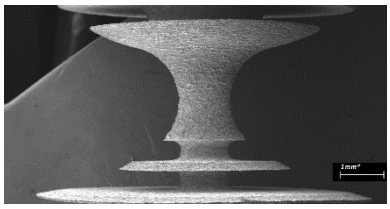
Picture	Features
Profile 1: Straight shaft 	**Length, *l*:** 2.5 mm **Diameter, *d*:** 200 µm **Aspect Ratio, *l/d*:** 12.5

Profile 2: Ellipse with Fins



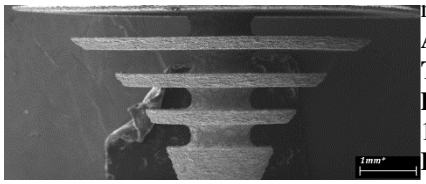
Shape: Ellipse
Height: 6 mm
Fins Size: 200 µm

Profile 3: Hour Glass with Fins



Shape: Hour Glass
Height: 2.8 mm
Throat Diameter: 1.125 mm
Fins Size: 200 µm

Profile 4: Cone with Fins



Shape: Cone
Height: 3.2 mm
Angle: 70°
Throat Diameter: 1.125 mm
Fins Size: 200 µm

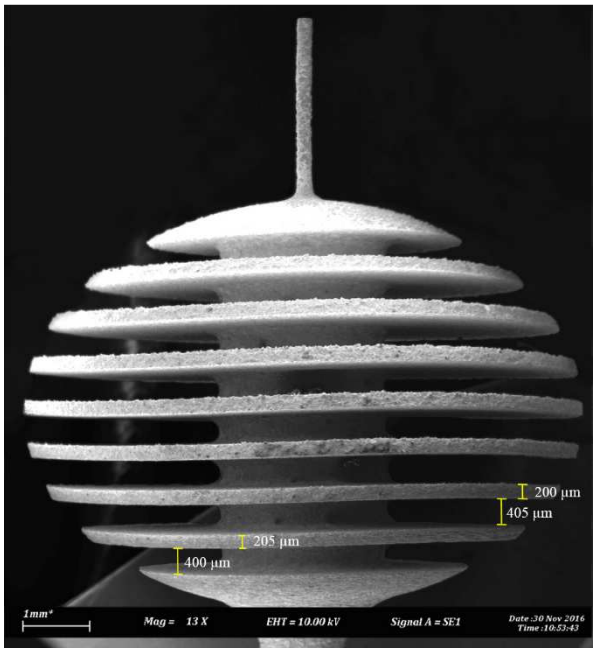


Figure 2 SEM of fabricated micro fins features by slitting operation on ellipse shapes

4. CONCLUSION

This study has explored cutting capabilities of WEDT in the fabrication of combinatorial macro and micro dimension for free-form cylindrical components. The reasonable tense of electrode wire and synchronous of feed motion by linear and rotation allows the parts being machined by single pass cutting certainly accelerates the processing time compared to the existing micro-turning process with several passes cutting. The remarkable benefit of this study is discovering the potential of WEDT process in opening new possibilities for extraordinary features for components production.

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