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Fabrication of micro rod electrode by electrical discharge grinding using two block electrodes

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ABSTRACT

With the development of micro-electro-mechanical system (MEMS), micromachining techniques have become a hot issue in modern industry. As the tools of micromachining, the requirement of micro rod electrodes has also greatly increasing. Wire electrode discharge grinding (WEDG) and Block electrode discharge grinding (BEDG) are effective approaches to produce micro rod electrodes. However, in order to get micro rod electrode with desired diameter, both methods need the help of an on-machine measuring device in the processing of machining, which increases the complexity of the equipment. In this study, electrical discharge machining grinding using two block electrodes (EDG-TBE) was created in an effort to overcome the problem of measurement and reduce the complexity of the equipment. In this method, rod electrode with initial diameter was driven through a narrow slit between two block electrodes. The desired diameter is determined by the width of narrow slit and the discharge gap. Because the discharge gap is determined by power supply parameters, desired diameter can be obtained as long as the width of slit is set correctly when power supply parameters is fixed. In the experiment, the machining efficiency and accuracy of micro rod electrode were investigated. Experimental results show that machining efficiency of micro rod electrode is higher in EDG-TBE than that in BEDG. In addition, the error between machined diameter and target diameter is less than 2 μm and the cylindrical error of micro electrode is also less than 2 μm in EDG-TBE.

1. Introduction

Nowadays, micro electrodes have been widely used in various industrial fields, such as micromachining, electrochemistry, and hyper microscope. With the development of micro-electro-mechanical system (MEMS), micromachining techniques have become a hot issue in modern industry. As the tools of micromachining, the requirement of micro electrodes has been also greatly increasing. Many researches show that the micro rod electrodes can be widely used for different purposes in micro machining and measuring fields. For example, Fan and Hourng (2009) fabricated a 100 μm micro-pin used in scanning tunneling microscope by electrochemical polishing. Huang et al. (2006) presented a fine sharp needle probe with diameter of 50 μm and length of 1.5 mm after etching for 5 min from a preformed probe of 200 μm diameter. Ghoshal and Bhattacharyya (2012) machined blind micro channel of 1000 μm length, 135 μm width and 50 μm depth on a SS-304 plate of 60 μm thickness using micro electrode with diameter 60 μm.

Variations of the EDM process aiming at the production of micro rod electrode can be found in the literature. Masuzawa et al. (1985) invented WEDG for precision machining of micro tools. This method successfully solved the problem of fabricating micro rods with high precision on-line. Various kinds of micro mechanical parts have been produced using the WEDG method. On the basis of WEDG method, a tangential feed WEDG method was proposed by Zhang et al. (2015) for improving on-line machining accuracy of micro electrodes. Experimental results show that the repeated machining accuracy of micro electrodes was less than 2 μm. The above two methods require a WEDG setup, thus involving more expensive and complex facilities. Comparing with WEDG, block electrode discharge grinding (BEDG) is alternative to fabricate micro electrode due to its low cost, simple structure, quick setting and high machining speed. However, it is difficult to manufacture micro electrode into desired miniature and precision due to the occurrence of wear on the block electrode, reported by Zhao et al. (2006). Besides, there are several other existing micro rod electrode formations methods in use today. Minoru et al. (2004) proposed self-drilled holes to form micro-rods. The method makes the tool

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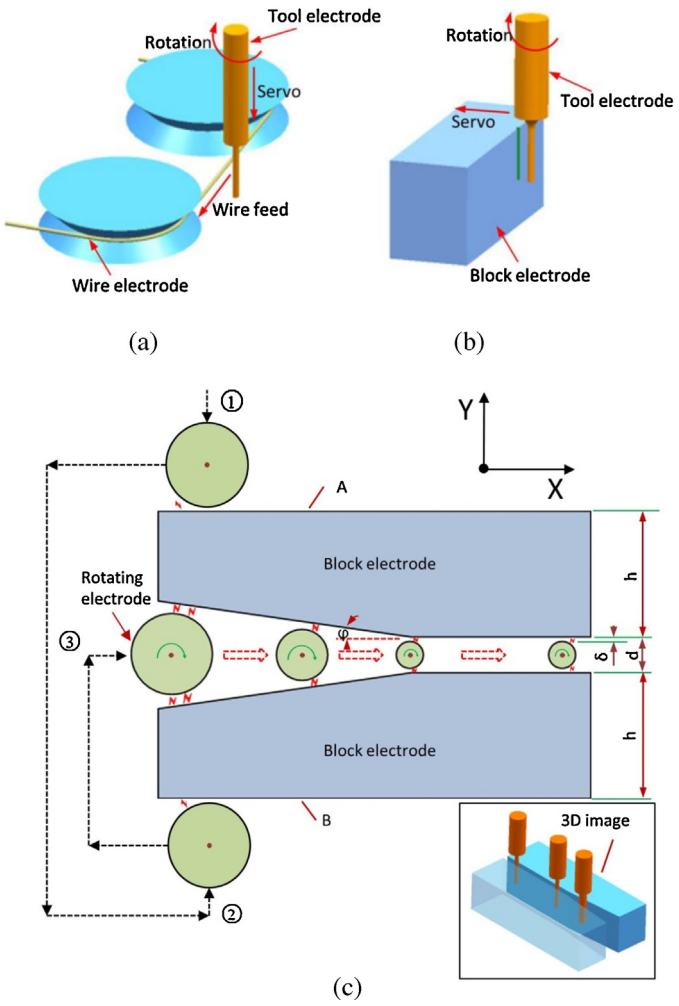

Fig. 1. Schematic diagrams of different machining types. (a) WEDG. (b) BEDG. (c) EDG-TBE.

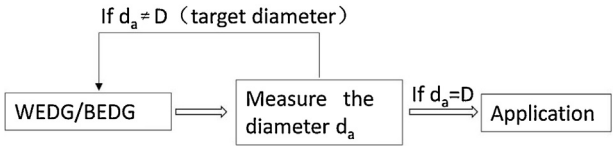

Fig. 2. Machining procedures of WEDG and BEDG.

electrode off-centered at a certain distance from the center of the holes drilled on a plate in advance to carry out reverse copying. Experimental results showed that the machined micro electrodes still have taper errors in the direction of the electrode axis even after reverse copying several times. Naotake and Takayuki (2006) proposed a micro-electrode formation by micro-scanning electrical discharge machining Process. This method can manufacture micro rod electrode with high efficiency, but involve to a complex control system. Gil et al. (2012) and Gil et al. (2013) presented a low-cost method, named inverse slab electrical discharge milling (ISEDM). This method is proposed for the manufacturing of high-aspect ratio micro-pins with diameter ranging between 0.2 and 0.5 mm, but not suitable for the fabrication of micro electrode less than 100 μm yet.

In terms of manufacturing efficiency and precision, the above methods had its unique characteristics and application scope, but can't obtain high efficiency, high precision and low cost at the same time. In order to realize micro rod electrode with high efficiency and accuracy in conventional machine tool with low cost, electrical discharge grinding using two block electrodes is proposed in this paper, which does not require measuring device on-line. This method not only have the advantage of high efficiency, But also avoiding the influence of electrode wear on machining precision. The micro rod electrode can be fabricated by this method with high efficiency and high machining accuracy. More importantly, the Characteristic of this method which can obtain accurate electrode diameter without online measurement device reduces the complexity of the process, at the same time saves manufacturing cost.

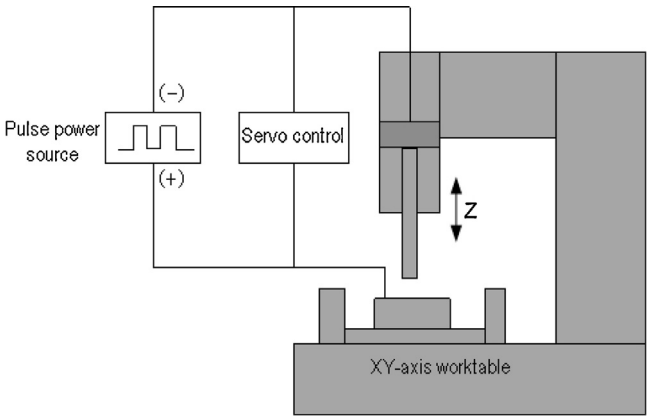

Fig. 3. Schematic diagrams of experiment setup.

2. Electrical discharge grinding using two block electrodes (EDG-TBE)

2.1. Principle of EDG-TBE

The schematic diagram of EDG-TBE compared with WEDG and BEDG is shown in Fig. 1. WEDG employs electro-discharge grinding on micro electrode by using a wire electrode feed on a wire guide, as shown in Fig. 1(a). WEDG provides an effective approach for machining micro electrodes with high accuracy, because the continuous feeding of wire electrode compensates its wear. BEDG employs electro-discharge grinding on micro electrode by using a block electrode, as shown in Fig. 1(b). Compared with WEDG, BEDG can get more efficiency of machining micro electrode, because a larger area of block electrode participates in grinding micro electrode. But due to dimensional change in the block electrode, the

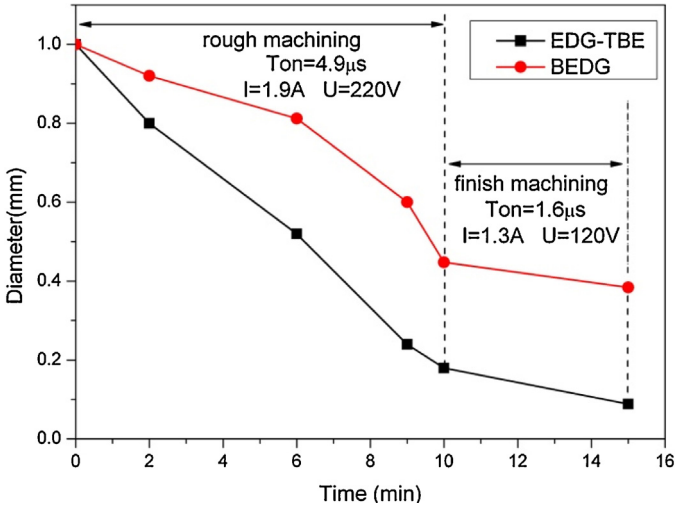

Fig. 4. Comparision of the machining efficiency of BEDG and EDG-TBE.