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学位（博士）論文要旨

(Doctoral thesis abstract)

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論 文 題 目 (Title)	Study on Depth-dependent Characteristics in Micro EDM Drilling Based on Observation of Bubble and Debris Behavior

論文要旨（2000 字程度）
(Abstract(400 words))
※欧文・和文どちらでもよい。但し、和文の場合は英訳を付すこと。
(in English or in Japanese)

In this research, the depth-dependent characteristics in Micro EDM drilling has been investigated Based on observation of bubble and debris behavior

Firstly, the feasibility of observing the inter-electrode is explored based on the original compressed sandwich workpiece. The detail of gap area is clarified based on the observation of bubble and debris in SiC and stainless steel SUS304 workpiece. The phenomenon of decreasing machining speed with increase of hole depth is analyzed. Then an improved glued sandwich workpiece is put forward to make use the gap area is totally blocked. The results shown that with increase of hole depth, both bubbles and debris accumulate in the gap area. Bubble will grow up or merge with other bubble to become a big bubble. Debris is not freely distributed in the gap area. They will stick on the wall of micro hole and surface of micro tool, which decreases the insulated strength of gap area seriously. Thus, the abnormal discharges and short circuit occur frequently, resulting in the frequent retreat of micro tool. Moreover, the discharge can even occur in debris, leads to the material in workpiece can't be removed and the machining limitation.

Secondly, the bubble and debris in actual micro EDM drilling is quantitatively

estimated based on the observation of bubbles escaping from the entrance of micro hole. A method is put forward to make the distribution of bubble escaping from entrance of orderly by creating a constraint flowing area in the entrance of micro hole. All the parameters are determined based on the simulation of velocity filed of dielectric liquid in COMSOL Multiphysics. The experiments are conducted in the specially debugged equipment to make sure the discharge signals and video can be synchronously recorded and matched. Then a series of solutions are put forward to realize the quantitative estimation on bubble behavior. An image segment method based on the digital image processing in MATLAB is used to extract the bubble precisely from the image of video.

In order to instigate the generation of bubble and debris in the single discharge process, the single discharge is observed by using a pair of needle electrode. It is found that in the breakdown stage only the discharge occurs. The bubble and debris are generated in 10μs after breakdown. The bubble firstly expends then contracts but the contracting time is much longer than the expending time. The melt material is scattered into the dielectric to become debris.

The depth-dependence characteristic of bubbles behavior is quantitatively estimated in micro hole drilling. In the normal discharge stage, with increase of hole depth, the size of bubble has the trend to become larger, the escaping frequency decrease seriously but the flowrate of bubble volume decreases firstly then increases. Two parameters, bubble escaping frequency and bubble flowrate frequency, are used to investigate the bubble behavior in the corresponding discharge frequency. In the consecutive short circuit, once the short circuit starts, the bubble will stop to escape from gap area immediately. Moreover, the debris cluster is observed, which proves that the debris is not freely distributed in the gap area. In the discharge in low open circuit voltage, mass littles bubbles escape from gap area, resulting in the increase of the bubble escaping frequency and flowrate frequency.

The amount of debris in different hole depth is quantitatively estimated by using an ultra-micro balance (the minimum measurement accuracy can reach 0.1mg). By measuring the quality of micro tool and workpiece before and after machining, the quality of debris in the gap area can be calculated. It is found that with increase of hole depth, the quality of debris in the gap area increase seriously especially when the hole depth is larger than 1mm.

Thirdly, a method to improve the machining speed by using the mist jet is put forward. Compared to the conventional water jet, the mist jet with high momentum can flush the gap area strongly and improve the exchange of dielectric liquid in gap area. The advantages of mist jet are analyzed from the mechanism and verified by the observation of gap area. An original mist device is designed, fabricated and used in the experiment of micro hole drilling to investigate its performance in micro EDM drilling. It is found that by using the mist jet, the machining speed can be improved significantly. It seems that the machining limitation disappears with mist jet. A deeper micro hole can be obtained in the faster machining speed with mist jet.