Surface Characteristics of a Micro-channel by Hybrid Micro-EDM

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Abstract

Ultra precision machining requires high accuracy in modern manufacturing industries. Even though dimensional accuracy is important in precision machining, surface characteristics of machined parts are also an important factor to predict the surface quality of machined parts. The micro machined parts such as micro holes and channels have been manufactured for the optical and medical instruments. Recently, micro electrical discharge machining (micro-EDM) is effective in machining of 'difficult-to-machine' materials. In addition, it shows usability for fabricating micro diaphragms or channels due to its machining characteristics.

In this study, machinability of hybrid micro-EDM was studied during machining of various materials such as aluminum, brass and steel. The effects of various machining factors such as spindle speed, federate, current, voltage, and polarity, etc. on surface characteristics of the micro-machined channels were investigated during micro-EDM. Finally, we compared the advantages and drawbacks of micro-EDM with micro-mechanical machining process in machining of micro-channels.

1 Introduction

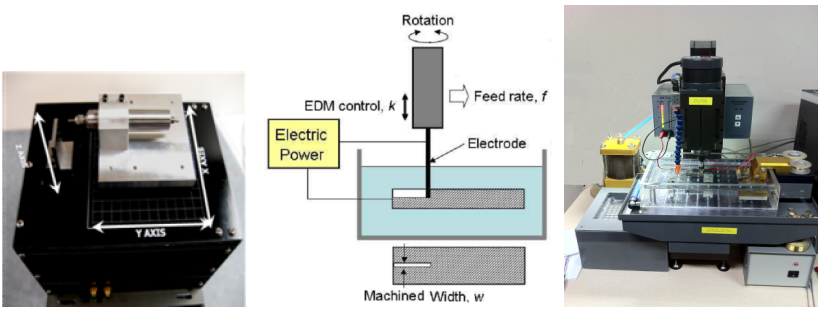
The field of ultra precision machining is developing in a fast pace. The technology is used in aerospace, electronic engineering and medical fields. Rather than the initial semiconductor based micro electro mechanical systems (MEMS) that required a complex production process, expensive machinery, and were limited by material, machining systems such as micro-mechanical machining or micro-EDM that are less expensive and less limited by material, are researched and developed. Micro-

mechanical machining is one of the many machining methods involved in creating micro devices and parts, and is capable of creating dozens of μ m to a few mm, and can machine several different materials. Micro-EDM using electric discharge requires the material to have electrical conductivity, but does not limit the material by strength or hardness of the material. In addition, hybrid micro-EDM, the hybridization of micro-EDM and milling processing, has been proven to be effective in creating micro components and 3D structures. This paper discusses the different surface properties and pros and cons of hybrid micro-EDM and micro mechanical machining which are processes used to produce micro-channels.

2 Theoretical background

Conventional cutting methods using direct contact micro mechanical cutting provided high precision and speed but required specified static and dynamic conditions which were difficult to fulfill.[1,2] Micro-EDM utilizes heat energy from sparks to melt and cut the material, thus even materials with high hardness can be processed as long as it is conductive.

Fig. 1(a) shows the machine used in the experiment, which is created to micro cut with air bearing spindle as the principal axis. This allows micro drilling as well as micro milling. The flat type micro endmill with 500±0.25 ㎛ was used to create the micro-channel and brass alloy 260, a widely used non-ferrous metal, was used as the specimen. [3]



(a)Micro-mechanical machine (b) Hybrid micro-EDM machine

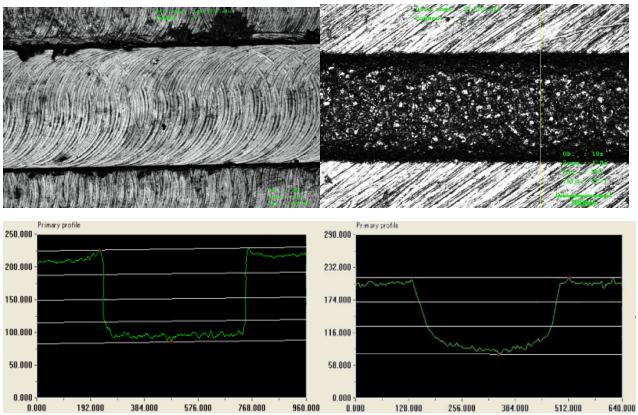
Figure 1 : Machine systems

Fig. 1(b) shows the exprimental system used to analyze characteristics of channels created using micro-EDM. The X-Y-Z axis of hybrid micro-EDM with WC electode is controlled by a PC based NC and the movement of the Z-axis to create continuous sparks. Table 1 shows the parameters used in the experiment.

Table 1: EDM parameters

Volt. (V)	Res. (kΩ)	Spindle(rpm)	Control(μm/s)	Electrode	Polarity
200	1	1000	1	WC	SP, RP

3 Experimetal result



(a) Micro mechanical machining (b) Hybrid micro-EDM

Figure 2: Machined surfaces at F = 300mm/min and DOC =200μm

Figure 2 shows the images of brass alloy 260 processed with micro mechanical machining and hybrid micro-EDM, respectively. In Fig. 2(a), the particular feed rate and depth of cut (DOC) influenced the brass's surface negatively. Also, as the cutting depth increased, burr phenomena increased at the side which renders the products unsuitable to use as channels. In Fig. 2(b), the consistent results show that hybrid micro-EDM products were not influenced by feed rate or DOC. Also, there were no obvious burr phenomena, but the sides were slanted, which is a characteristic of hybrid micro-EDM. In the micro-mechanical machining process creates a floor with visible tool marks, but in the hybrid micro-EDM case, a bumpy floor is created due to the electrodes.

4 Conclusion

In this paper, hybrid micro-EDM processing and micro mechanical machining used in micro channel production were analyzed for the surface characteristics of the results and weighted for their pros and cons.

In the case of micro mechanical machining, the product surface was influenced by the material and DOC. Materials with lower hardness such as brass alloy 260 had successful channel processing for DOC at 100μm but at 250μm, burr phenomenon occurred and the surface roughness negatively influenced channel production.

On the contrary, cutting depths did not influence products cut by hybrid micro-EDM but the processing time was very long compared to micro mechanical machining. Also, the side wall had a gentler slope compared to micro mechanical machining.

The experiment showed that the rough cut should be done using micro mechanical machining, and the fine cut should be done using hybrid micro-EDM. The development of an integrated process will greatly decrease production time and increase precision.

Aknowlegment

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