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New fabrication method of metal tiny-3d-structure using capacitor electro-discharge-deposition-device

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Abstract
This study deals with new metal tiny-3d-printing method by using capacitor electro-discharge-deposition-device . Various studies of metal 3d-printing system are proposed so far. They are categorized into laser aided system or electric welding aided system. These systems are employing high-power electro supply, the purpose of those system is to fabricate object in practical size. In case of fabrication of tiny-structure, however, the scale of power supply of those system is too much. Therefore, capacitor electro-deposition device which energy is smaller than that of conventional system is selected, basic experiment of tiny-3d-printing by means of electro discharge deposition induced by capacitor is executed. The obtained result demonstrates metal 3d-printing by utilizing capacitor electro-discharge-deposition-device is feasible.

Electro discharge, Deposition, Micro structure fabrication, Capacitor, 3d-printing

1. Introduction

In order to realize metal 3d-printing, the method that deposits atomised powder-metal with spotted Laser irradiation [1], or that deposits melted composition of pole of die sinking electro discharge machining [2], or that deposits composition of pole of arc welding is proposed recently [3,5]. These methods, however, basically employs too large scale of power supply to fabricate tiny 3d-structure.

Therefore, in order to fabricate relatively small size 3d-structure that is from µm to a few mm, new 3d-printing method employing capacitor electro-discharge-deposition-device is reported in this paper.

2. Experimental system

Micro depo made by Techno Coat ltd., which employs capacitor to induce electro discharge, is a product for coating work-surface. Figure 1 shows the illustration of the discharging zone. The metal-composite-electrode which is mainly made of tungsten carbide is melted by electro discharge and deposited on the surface. The Electro discharge phenomenon by using capacitor is observed as an impulsive spark. In this system, the electrode is rotated to generate continuous spark. User can select conditions of dischage about materials of electrode and parameters of controller. As for electrode, composite, diameter, revolution of materials of electrode is available. As for parameters of controller, input voltage capacitor is available.

The system is installed to the numerical controlled (NC) milling machine as shown in Figure 2.

Figure 3 shows installation of applicator unit of the Micro depo system. The Applicator unit is held to the spindle axis of the NC milling machine with some inclination through Jig, since It is clarified from the experimental result that the applicator should be inclined to the work-surface.

The angle between the work-surface of horizontal direction and the applicator-unit is defined as Approach angle in this paper, also as shown in figure 2.

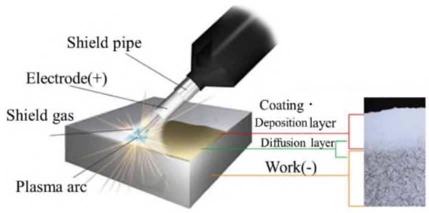


Figure 1. illustration of electro discharge coating [4]

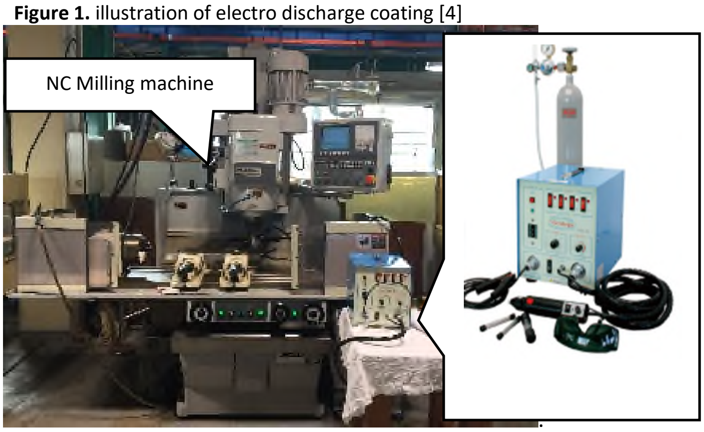


Figure 2. capacitor electro discharge deposition system (Micro depo) and how to set on milling machine [4]

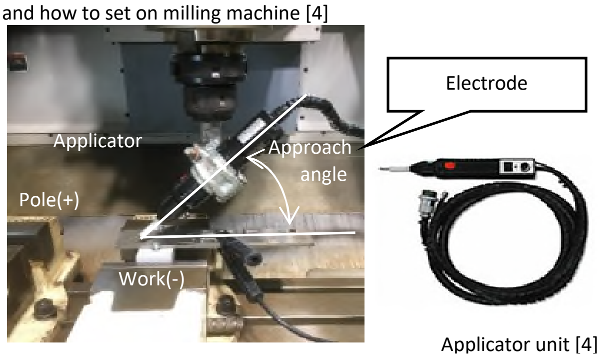


Figure 3. applicator set-ups to spin electrode

SS 400 plate is selected for material of workpiece. It is bound with insulator to a vice.

3.Investigation of deposition conditions

Table 1 effect of control parameters on deposition in one process

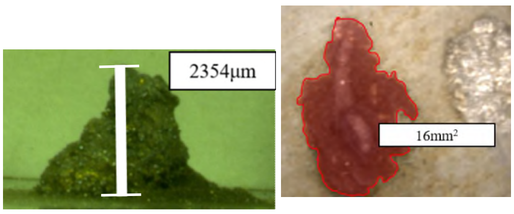
Approach angle[°]	60							
Electrode diameter [mm]	ϕ1.6				ϕ2.4			
Input Voltage [V]	50		150		50		150	
Capacitor [μF]	10	100	10	100	10	100	10	100
Result	NG	NG	NG	Good	NG	NG	ENBL	ENBL
Approach angle[°]	30							
Electrode diameter [mm]	ϕ1.6				ϕ2.4			
Input Voltage [V]	50		150		50		150	
Capacitor [μF]	10	100	10	100	10	100	10	100
Result	NG	NG	NG	Good	NG	NG	No	ENBL

In order to understand how each controllable parameter can effect on one deposition process, basic deposition experiment in various conditions as shown in table 1 is carried out.
In this experiment, 'one deposition process' means the phenomenon that one spark between applicator-spindle and work surface can be observed. In the line of 'Result', NG means failure of deposition, 'ENBL' means success of deposition but the deposited material is easy to remove, 'Good' means the deposited material has sufficient strength to fix on the surface, respectively.

In this table, despite of two different approach-angles is applied, the condition: electrode dia. 1.6 [mm], input voltage 150 [V], capasitor 100 [μf], 8000 min^{-1} rotation of applicator spindle, 1400 Hz of voltage frequency, demonstrates stable deposition. Therefore, these parameters are applied in the following section.

5. Cylindrical pin fabrication

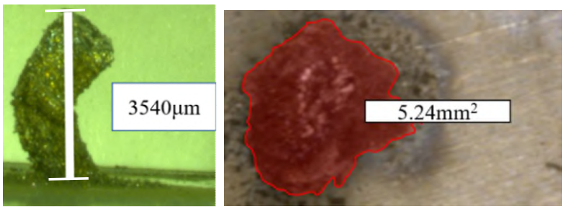
5.1 Influence of radial runout of applicator spindle



(a) side view (b) top view

Figure 4. observation of deposited cylindrical-pin

In order to investigate performance of 3D depositing in vertical direction, cylindrical-pin-fabrication experiment is carried out. Figure 4 is the magnified photos of the deposited pin after 600 times of the deposition process which is taken with Keyence VW-6000. The height of the deposited pin 2354 μm, the area from top view is 16 mm^2. The fabricated pin seems to be not only the shape like a hill in vertical direction, but also broad in horizontal plane. It is conjectured that one of the reasons is radial runout of the electrode. Therefore, experiment is executed after radial runout of electrode is trued with abrasive-stone dresser.



(a) side view (b) top view

Figure 5. pin fabrication experimented after truing electrode

Figure 5 shows the obtained shape after truing electrode. Although Higher pin shape with narrower area is accomplished, the fabricated pin describes curve at the middle of the body. In this fabrication, compensation of electrode-wear caused by electro discharge was not considered. Therefore, that could be the major reason.

5.2 Compensation of electrode wear

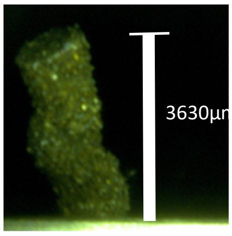


Figure 6. pin fabrication compensating electrode-wear

Figure 6 shows the fablicated pin with compensating elecrode-wear in NC programing during one electro discharge process. 3630 μm of straight pin is obtained.

6. Miniature Bowling Field

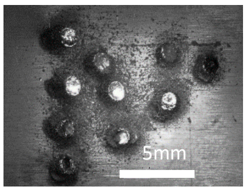


Figure 7. miniature bowling field

Finally, the sample of the proposed process is fabricated as shown in figure 7. This work is named as Miniature bowling field.

7. Conclusions

In order to fabricate relatively small size 3d-structure that is from μm to a few mm, 3d-printing method employing capacitor electro-discharge-deposition-device is proposed, It is proved that capacitor electro-deposition-device with NC feeding is feasible to fabricate tiny structure.

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