The Analysis on Surface Finishing Characteristics STD-11 Assisted by Magnetic Intensity

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1. Introduction

Recently numerous industries, such as automotive, aerospace, die and molds have faced challenges to manufacture micro or nano scale compartments with lightweight and minimum defects. In order to achieve precise surface in a short time, a magnetic abrasive cleanness(MAC) process assisted by magnetic force is applied. This advanced technique has a magnetized multi-cutting tool which looks a skirt and it is able to clean surface by removing small amounts of particles on the complex shape of the workpiece. Although it has been well known that the MAC process helps to efficiently bring excellent performance of fine surface, it has been focused on a plane or internal pipe surfaces of the workpieces [1-2]. To meet demanding requirements for precise accuracy and clean surface in advance technological areas, it is necessary to establish effects of the MAC process on complex surface of hardened ferromagnetic materials.

Therefore, the aim of this study influences four determined parameters on surface roughness and burr removal rate of slot area of hardened STD-11, machined by milling operation.

2. Material and measurement procedure

All the specimens used in this study were STD-11 having 55 HRC. Slot milling operation on the material was conducted using 2-flute flat end-mill with 6mm diameter in wet conditions at 7,200rpm of spindle speed and 80mm/min of feed rate. As shown in Fig. 1, length of slot was 25mm considering inductor size, Ø16mm, and width of the magnetic abrasive brush. In addition, total depth of slot was 0.5mm. After machining, burr height and surface roughness were measured at three different positions along the x-axis as presented in Fig. 1 by using a contour measurement (Mitutoyo CV-3200) and a surface roughness measurement (Mitutoyo SJ-301) respectively.

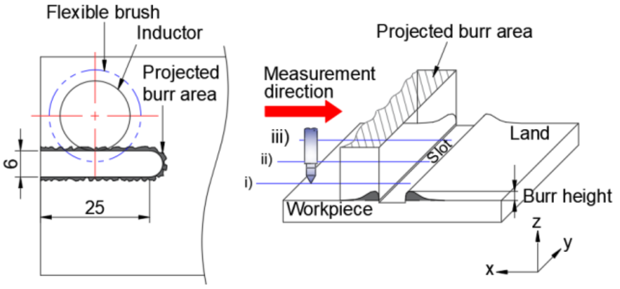

Fig.1 Schematic diagram of measuring method

3. Experimental setup and conditions

In order to verify the effects of MAC operation on slot edge of the top surface, the experiment was conducted based on Taguchi's $L_9(3^4)$ orthogonal array method with selected factors which were working gap, rotational speed, viscosity of silicone oil and mixing ratio between iron and abrasive particles by weight.

Fig. 2 shows experimental apparatus of the MAC process in detail used in this study. It mainly consists of coils for generating the magnetic field, a DC power supplier for adjusting magnitude of magnetic flux density and a flat-end inductor acting as a pole, and a rotational controller to decide speed and direction. The inductor turned into the magnetic tool by supplied current from the DC power supplier. It means that the inductor have ability to removed micro-sized particles on the surface by attaching magnetic abrasives.

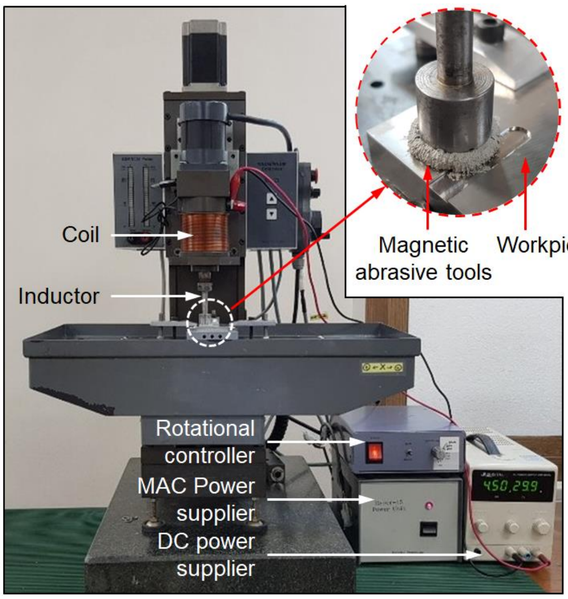

Fig.2 Experimental setup of MAC

Table 1 Experimental conditions

Items	Conditions
Workpiece	STD-11(HRC 55)
Current	4.5A
Magnetic abrasives	Fe(150 ㎛)+ GC(2 ㎛)) + Silicone gel
Abrasives amount	1.5 g
Working time	3.0 min

Experimental conditions are given in Table 1. Since the bigger size of ferromagnetic substance and the smaller particles of GC power is more effective based on previous research, magnetic abrasive particles for fine surface are made up of 150 micron of Fe powder, 2 micron of GC powder and silicone gel. Total amount of abrasives used in each experiment is about 1.0g taking working gap and falling rate of the tool into consideration. Total working time is 3 minutes which are 1.5 minute in the clockwise direction and half in the reverse direction. Applied current directly related to magnetic force is 4.5A to maximize the effect of magnetic force.

4. Experimental results

In accordance with experimental results of surface roughness as presented in Fig. 3, it was observed that the best combination was no. 6 corresponding to 1.0mm of working gap, 600rpm of rotational speed, 150,000cs of viscosity and 1:2 of mixing ratio of Fe and GC powder by weight. Based on all the experiment, S/N ratio analysis by the-larger-the-better performance was employed to determine optimal process parameters and primary contribution to better performance. Consequently, optimal combinations in this study were same parameters as the best configuration. It meant that working gap was the highest influence on change in surface roughness, about 50.7%, followed by mixing ratio, rotational speed, and viscosity which made up for 25.6%, 14.6%, and 9.1% respectively.

To verify behavior of deburring in presence of various process factors, the experiment was carried out using identical conditions mentioned above. As a result, simulation no. 6 had the highest removal rate, about 0.963. Since these results were not extracted in all possible combinations S/N ratio analysis were conducted to determine an ideal configuration. As can be seen from analysis, the optimal combination of burr free occurred at 1.0mm, 400rpm, 150,000cs, and 1:3 respectively. Fig. 4

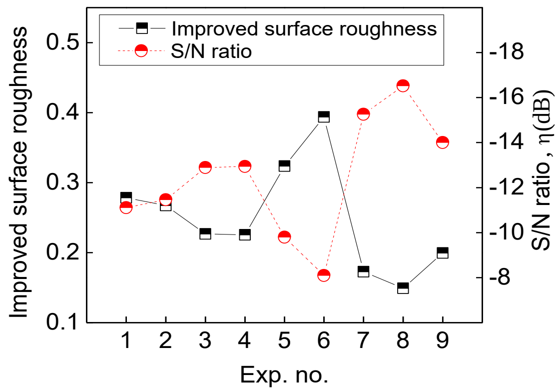

Fig.3 Improved surface roughness and S/N ratio

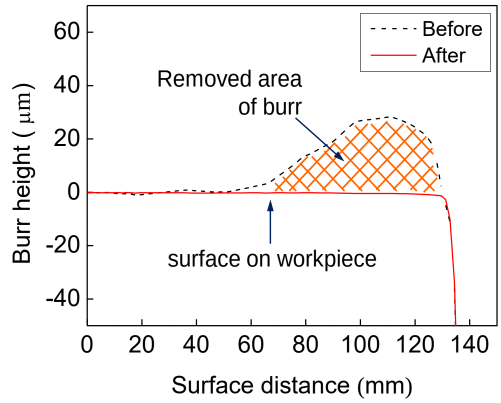

Fig.4 Averaged peaks of burr in optimal condition

showed the contour profile before and after measured burr height. As can be seen, the rate of burr reduction was enhanced by 3% from 0.963 to 0.992.

Acknowledgment

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