# Behavior Characteristics of Magnetic Medium for Improving Surface Integrity in Rotating Magnetic Field

Y. S. Seo[1], S. Y. Lee[1], Y. K. Jung[1], J. H. Lee[1] and J. S. Kwak[1*]

[1]Department of Mechanical Engineering, Pukyong National University, Busan, Korea

[*]Corresponding author: jskwak5@pknu.ac.kr

## 1. Introduction

Since surface finishing is necessary for high quality, various methods have been studied to increase the surface integrity. In particular, the studies in terms of magnetic energy have been conducted because of numerous advantages [1]. Magnetic energy can drive the magnetic media without any mechanical transmission. It allows the workpiece to be machined widely by using media located in the magnetic field. However, it is difficult to predict the status of the surface after machining because there are many parameters contributing on polishing. Hence, it is needed to identify the principle of a magnetic pin polishing(MPP) process. Therefore, this study aims to explain characteristics of the magnetic pins' behavior in the MPP process.

## 2. Theoretical background

Schematic diagram of the MPP process is shown in Fig. 1.Four permanent magnets are located on a disc at the same radial distance. When AC motor operates, the disc is rotated so that the magnetic field moves around the rotational direction. Above the disc, there is a container having compound liquid, workpiece and magnetic medium. Magnetic medium are the magnetizable stainless steel pins (SUS 304SS).After magnetization, magnetic pins have the two opposite poles, $+\mathrm{m}$ and $-\mathrm{m}$ and then behavior of pins is affected by generated force and torque under the magnetic field. Force and torque by the magnetic field, $\bar{H}(\bar{r})$, are shown in Fig. 2. The scalar quantity of distance vector between the two poles, $\bar{d}$, is extremely small compared with distance vector between pin and permanent magnet, $\bar{r}$, so force, $F_p$, and torque, $T_p$, acting on a pin are represented as follows [2].

$$\bar{F}_p = m\bar{d} \cdot \nabla\bar{H} = \chi V\bar{H} \cdot \nabla\bar{H} \qquad (1)$$

$$\bar{T}_p = m\bar{d} \times \nabla\bar{H} = \chi V\bar{H} \times \nabla\bar{H} \qquad (2)$$

where $\chi$ is the susceptibility of the pin and $V$ is the pin volume.

These magnetic force and torque provide the magnetized pins in the container to move along the circumferential direction and rotate to align with longest axis of pin parallel to magnetic field vector.

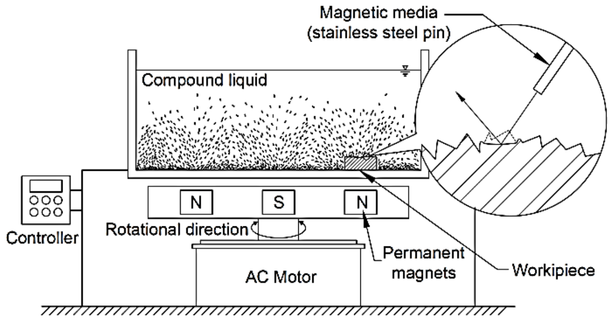
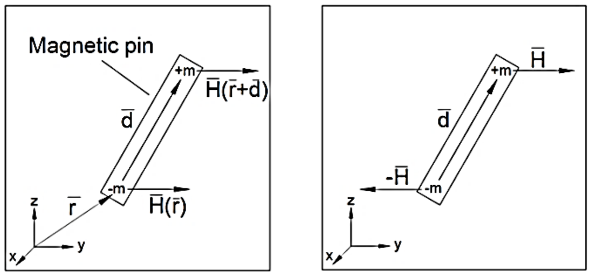



Fig.1 Schematic apparatus of the MPP process




(a) Magnetic force (b) Magnetic torque

Fig. 2 Behavior of a pin in magnetic field

When the disc is rotated with permanent magnets, magnetic flux density and direction of magnetic field vector change continuously. As a result, pins exhibit violent motion and hit all the workpieces in the container. When the pins collide with the surface of workpiece, plastic deformation occurs and then accumulates during operation. It can be increase the surface integrity because of the planarization of microscopic concave and convex at the surface.

## 3. Experimental details for MPP

Table 1 lists the fixed experimental conditions. In order to figure out the pin behavior with respect to only the pin size, rotational speed was1,800rpm and location of workpiece was the same radial distance during the process. Maximum magnetic flux density was measured at center of each magnet based on the bottom of the container. Total pin weight is about 2kg enough to impact the surface finish. The experiments were carried out under variance in pin size and working time. Since magnetic force and torque were proportional to volume, pins with 3mm of length and various

Table 1 Experimental conditions

| Items | Conditions |
|---|---|
| Workpiece | Al6061, 40x50x0.5t |
| Maximum magnetic flux density(mT) | 60 |
| Radial distance of magnet from center(mm) | 150 |
| Rotational speed(rpm) | 1,800 |
| Pin weight(kg) | 2 |

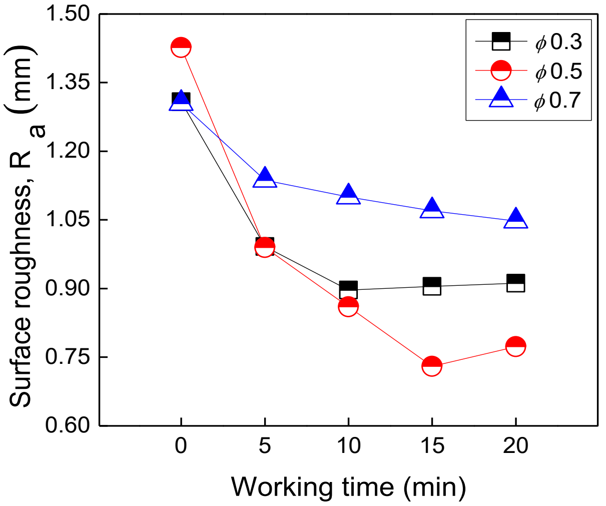
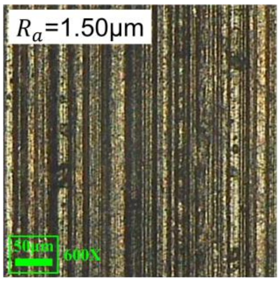
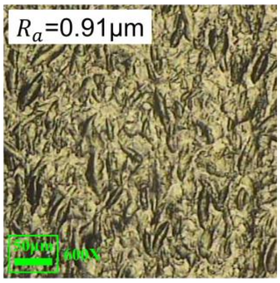


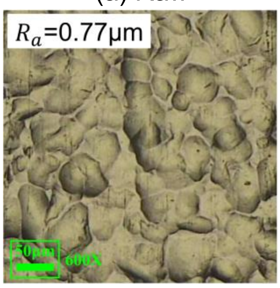

Fig. 3 Surface roughness versus to working time



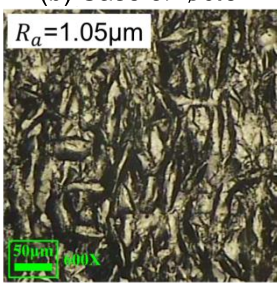

(a) Raw




(b) Case of Ø0.3




(c) Case of Ø0.5




(d) Case of Ø0.7

Fig. 4 Surface status at each condition

diameters which were Ø0.3, Ø0.5 and Ø0.7 were used in experiments.

Surface roughness was measured every 5minutesafterthe MPP process by using surface profile tester (SJ-301, Mitutoyo).

## 4. Results and discussion

Fig. 3 shows the change in surface roughness during working time. As can be seen that surface roughness decreased in contrast with increase in working time. After 20 min, Ø0.5 of pins achieved the fine surface, followed by Ø0.3 and Ø0.7. This was because plastic deformation and magnetic force were closely associated. The bigger size of the pin was exerted the larger magnetic force and torque so it caused deep indentation on the surface, not planarization, compared to other case. On the other hand, the small force with Ø0.3 of pinsled to small amount of deformation hence planarization did not progressed easily. Fig. 4 represents the microscopy of the surface status in each case and exhibits well the above explanation. As a result, appropriate magnetic force was needed to enhance the surface integrity.

## 5. Conclusions

Obtained results were summarized as follows:

1. Magnetic force and torque were proportional to the volume of the magnetic pin.
2. The MPP process helped to enhance the surface cleanness by accumulating plastic deformation but proper size of the pin was needed to get better surface integrity.

## Acknowledgment

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## References

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