euspen's 17th International Conference &
Exhibition, Hannover, DE, May 2017
www.euspen.eu

The surface properties of a roll mould according to the fluid jet polishing conditions

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Abstract
Many moulds for mass production are fabricated by mechanical machining using a cutting tool. Machining marks, however, are easily generated by the tool in the cutting process. These marks deteriorate the quality of the mould surface and affect the performance of the optical components. Fluid Jet Polishing (FJP) is a process that improves the quality of a mould surface by use of a jetting abrasive liquid. In this study, the spot was machined by applying the FJP process to the surface of a roll mould machined by turning. Variations of the spot shape and the surface profile were studied according to the discharge pressure of the liquid, the standoff distance of the nozzle, and the polishing time. Finally, the possibility of polishing the surface of the roll mould was confirmed.

Fluid Jet Polishing, Feed Marks, Polishing Condition, Abrasive, Surface Property, Roll Mould

1. Introduction

Various finishing processes have been studied to address the problem of deteriorated performance of optical components by feed marks. Fluid Jet Polishing (FJP) improves surface quality by jetting a liquid mixed with an abrasive onto the surface of a mould [1-2]. Li, et al. showed that the FJP was effective in removing feed marks on the flat surface [3]. In this study, the shape of a spot and surface properties were analysed according to varying conditions such as the discharge pressure of the liquid, the standoff distance of the nozzle, and the polishing time. In addition, the possibility of efficient polishing of the roll surface was confirmed by polishing a rotating roll mould.

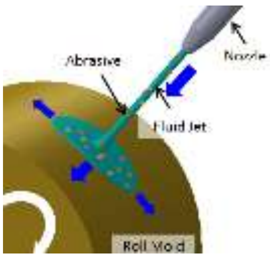


Figure 1. Schematic illustration of the fluid jet polishing

2. Experiment system and method

Fig. 2 shows the FJP system used in this experiment. Abrasive and liquid are mixed by the agitator in the tank. The mixed liquid is transported to the nozzle through the pump and jetting. The discharge pressure was controlled by the flow rate in the pump and by adjusting the relief valve. The nozzle was mounted on the tool post of the FJP system. The tool post can move in the direction of the roll surface and the length. The workpiece used in the experiment is a 64 brass roll mould machined by a turning process. Fig. 3 shows a photomicrograph

Figure 2. Configuration of the fluid jet polishing system

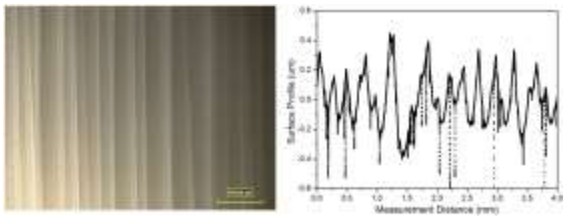


Figure 3. Photomicrograph and roughness profile of the a mould surface machined by turning process

Table 1 Conditions of the fluid jet polishing

Workpiece	64Brass, Roll, Surface base roguhness Ra 0.13 um, Rz 1.2 um
Nozzle diameter	1 mm
Abrasive Liquid	ISOPAR-H(96.5wt%)+Green Silicon Carbide #6000(3.5 wt%)
Discharge Pressure	10, 20 bar
Standoff Distance	10, 15, 20 mm
Polishing Time	30, 60, 90 sec
Rotation Speed	60, 350, 580 rpm

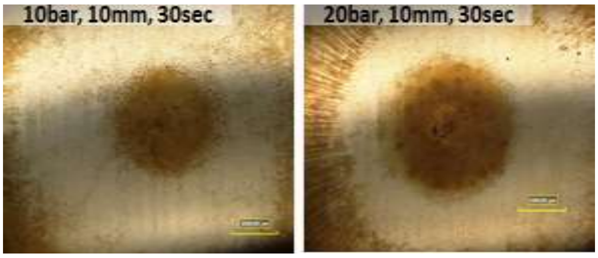
and roughness profile of the surface. The surface roughness is Ra 0.13 µm, Rz 1.2 µm.

Table 1 shows the polishing conditions employed in this experiment. The inner diameter of the nozzle was 1 mm, and the standoff distances from the workpiece were 10, 15, and 20 mm. The abrasive liquid was fabricated by mixing ISOPAR-H solution (96.5 wt%) and green silicon carbide #6000 (3.5 wt%, average particle size is about 3 µm).

3. Results and discussion

3.1. Comparison of surface properties according to discharge pressure

In order to compare the shape according to the variation of the discharge pressure, the spot generated during 30 sec at a standoff distance of 10 mm was analysed. Fig. 4(a) and Fig. 4(b) show the spot generated at 10 bar and 20 bar. Each average diameter was about 1.9 mm and 2.6 mm.



(a) (b)

Figure 4. Spots generated by FJP at 10bar (a) and 20 bar (b)

Fig. 5 shows profiles of the cross-section of the spots generated at each pressure. At the discharge pressure of 10 bar, the polishing area and shape were unclear. However, the profile of the spot at 20 bar shows a typical 'W' shape obtained in FJP. Also, the maximum depth of about 1.6 um was shown at 1 mm from the center of polishing area. This phenomenon is attributed to the abrasive having high kinetic energy for removing material at higher pressure because the jetting velocity is higher at high pressure.

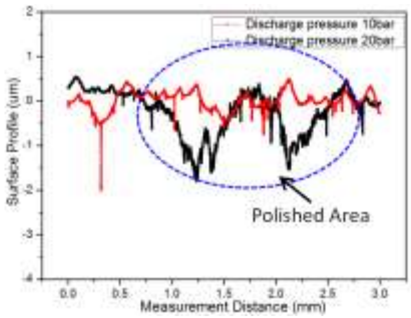


Figure 5. Cross-section profiles of the spots generated during 30 sec at standoff distance of 10mm, discharge pressure of 10bar and 20bar

3.2. Surface properties according to standoff distance

Fig. 6 shows profiles of the spots generated during 30 sec at discharge pressure of 20 bar and standoff distance of 10 mm and 20 mm. When the standoff distance was 10 mm, the surface was polished roughly 0.8 µm deeper. This is believed to be due to the difference in the fluid velocity when it reaches the mould surface. Hence, an appropriate standoff distance is advantageous.

3.3. Surface properties according to polishing time

Fig. 7 shows profiles of the cross-sections of the spots generated during 30 s and 90 s at discharge pressure of 20 bar, and standoff distance of 10 mm. The depth did not show a large difference according to increasing polishing time, but the central shape collapsed. Because the fluid jet applies force to the surface when it makes contact, this phenomenon shows that the surface can be damaged with excessive polishing time.

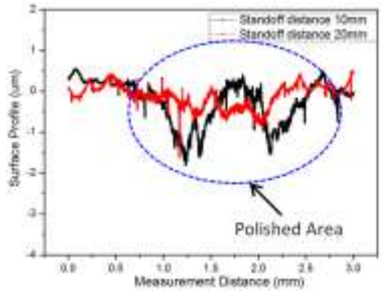


Figure 6. Cross-section profiles of the spots generated during 30 sec at standoff distance of 10mm and 20mm, discharge pressure of 20bar

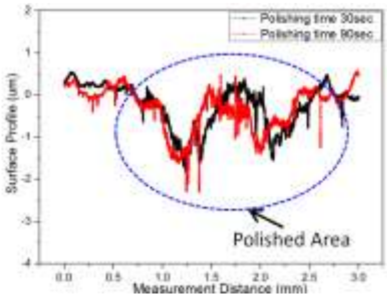


Figure 7. Cross-section profiles of the spots generated during 30 and 90 sec at standoff distance of 10mm, discharge pressure of 20bar

3.4. Experiment of rotary polishing of the roll surface

Based on the above study, rotary polishing experiments were conducted to generate a polishing line along the roll surface. Polishing conditions were 20 bar, 10 mm, and 60 s. The roll mould was rotated at 60, 350, and 580 rpm. Fig. 8 shows polishing lines generated on the roll surface. These results show the possibility of polishing the entire area of the roll using the method of transporting the nozzle to the direction of the length of the mould.

Figure 8. Polishing lines were generated by FJP along the roll surface

4. Conclusion

In this study, roll mould was polished by FJP method. Machining spots and varying surface were analysed according to the polishing conditions. Also, it was confirmed that polishing effect of the roll surface was increased as the number of machining increases. Based on these studies, the possibility of ultra-precision continuous polishing on large area mould was confirmed.

References

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