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Dressing of grinding wheel utilizing laser cleaning

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Abstract
The purpose of this study is the realization of high precision grinding by in-process removing the adhered swarf from the grinding wheel surface. For the achievement of the purpose, a laser cleaning device with a long focus distance was used. The removal performance of adhered swarf from wheel surface was investigated in the case of a conventional abrasive grinding wheel and a fine diamond grinding wheel. Results showed that it was possible to remove the adhered swarf of titanium alloy, copper, graphite easily when laser cleaning assisted dressing was applied to conventional abrasive (WA400) grinding wheel. The surface roughness was improved when laser cleaning assisted dressing was applied to grinding of titanium alloy. Furthermore, it was possible to remove the adhered swarf and improve the surface roughness when hardened steel (AISI M2) was ground with a fine diamond (SD600) grinding wheel.

Grinding, Dressing, Laser cleaning, Grinding wheel, Surface roughness

1. Introducion

In precise grinding of high hardness steel and heat resistant alloys, a number of problems related to the dressing of the grinding wheel still remain. In particular, there are many problems in conventional dressing method of fine abrasive grits wheels and formed wheels. Although several dressing methods of diamond and cBN grinding wheel by using laser has been proposed [1-3], these dressing methods could not be employed because it is not possible to integrate them into the grinding machine. The purpose of this study is the realization of high precision grinding by removing the adhered swarf and embedded swarf on grinding wheel surface, either by in-processing or off-processing on the machine. To achieve this purpose, a laser cleaning device with a long laser focus distance [4,5] was applied.

In this study, the removal performance of adhered swarf from wheel surface and its grinding performance were investigated when the laser cleaning assisted dressing method was applied to conventional abrasive grinding wheel. Further the dressing method was also applied to fine diamond wheel.

2. Features of laser cleaning assisted dressing method

Figure 1 shows the removal mechanism of adhered material on the workpiece by laser cleaning. When a Nd:Yag short pulse laser is irradiated onto the workpiece surface, the rust, painting, dirt adhesion and so on are removed by the laser ablation effect. In the process, the heat damage on workpiece surface is extremely low because the laser energy absorption is very small. The advantage of laser cleaning assisted dressing is that the fine adhered swarf to the wheel surface can be removed. In addition, it is possible to apply to materials with easy adhesion such as for example aluminium alloys, copper alloys, glass, silicon, graphite, plastics. As shown in Figure 2, the laser cleaning assisted dressing can be also applied to the formed wheel (arc-shaped wheel and formed wheel for ball screw) because the laser working distance is sufficiently long. It is expected that the laser cleaning assisted dressing can be applied to wet grinding with coolant as well. [6]

3. Experimental device and condition

The experiments were carried out on a vertical machining centre. The laser cleaning device (MTR-02, P-Laser) was set on the machining table. Conventional grinding wheel (WA400, WA220) and fine diamond wheel (SD600 resinoid bonded wheel) were used. Figure 3 shows the experimental setup and the situation of laser cleaning assisted dressing of grinding wheel. The working distance between laser irradiate port and wheel surface was set to 300 mm. The range of laser irradiation was set to 25 mm. The conditions are listed in Table 1.

4. Experimental result

4.1. Application to conventional grinding wheel

The laser cleaning assisted dressing method was applied to a WA400 vitrified bonded wheel. The removal performance of swarf and the improvement of surface roughness were

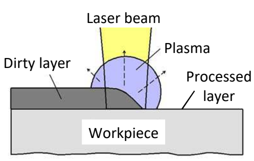

Figure 1. Removal mechanism by laser cleaning

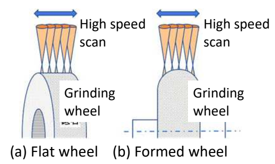

Figure 2. Schematic of laser cleaning assisted dressing

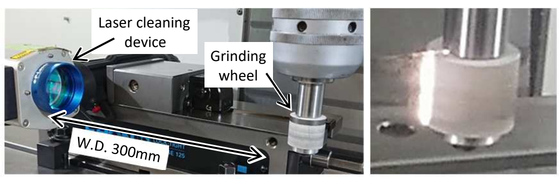

Figure 3. Experimental setup and laser cleaning of grinding wheel

Table.1 Experimental devices and conditions

Machine	Vertical MC (VSC430A, Mazak)
Laser device	Laser cleaning equipment (MTR-02, P-Laser) Nd:Yag, P_{max} = 100W
Grinding wheel	WA400/WA220 H7 V 75R (ϕ30 mm × *t* 24 mm, Noritake) SDC600 T75 BW6 (ϕ30 mm × *t* 20 mm, Noritake)
Work piece	Ti alloy (w 4.5 × L 68 mm) Hardened steel (AISI M2, w 4.5 × L 41 mm)
Coolant	Soluble (Finecut R-5000H, Neos)

investigated when Ti alloy was ground for 100 passes. Grinding conditions were: wheel speed V_S = 380 m/min, feed speed V_W = 200 mm/min, depth of cut a = 5 µm. Laser cleaning assisted dressing was carried out under the following conditions: wheel speed V_S = 380 m/min, power P = 70 W, frequency f = 100 kHz in dry conditions.

Figure 4 shows the wheel surface after laser cleaning assisted dressing. As the number of grinding passes increases, the amount of adhesion of Ti alloy swarf was increased. After grinding for 20 or 60 passes, the adhesion of swarf was removed completely when the laser cleaning assisted dressing was carried out for 20 seconds. The huge adhesion of swarf obtained after 100 passes grinding was also possible to be removed when laser cleaning assisted dressing was carried out for 20 seconds. After laser cleaning assisted dressing, WA grains and vitrified bond were not removed. Figure 5 shows the wheel surface profile curve after laser cleaning assisted dressing for 80 seconds. It was found that there is no wheel wear by laser cleaning assisted dressing even for 80 seconds. A change of wheel surface profile curve was not observed after grinding of 100 passes comparing that of before grinding.

Figure 6 shows the change of surface roughness of workpiece by laser cleaning assisted dressing for 60 seconds. Although the surface roughness was characterized by Rz = 7.4 µm, Rz = 8.7 µm and Rz = 11.8 µm after 20, 60 and 100 passes grinding respectively, the surface roughness after applying laser cleaning assisted dressing was improved to Rz = 6.7 µm, Rz = 7.4 µm and Rz = 8.0 µm. The adhesion of swarf on grinding wheel that wet with coolant was also removed by laser cleaning assisted dressing.

4.2. Application to formed conventional wheel

Figure 7 shows the change of wheel shape when laser cleaning assisted dressing was applied to WA220 wheel formed with V shape (90°). The shape wear did not occur after laser cleaning assisted dressing for 80 seconds. Furthermore, when laser cleaning assisted dressing was applied to formed wheel after grinding of Ti alloy, the swarf on inclined wheel surface (difference in height: 1mm) was removed.

4.3. Application to fine diamond wheel

Figure 8 shows the result of laser cleaning assisted dressing of SD600 resin bonded diamond wheel (ϕ 30 mm × t 20 mm). Hardened steel (AISI M2) was ground under conditions of V_S = 570 m/min, V_W = 200 mm/min, a = 2µm. Laser cleaning was carried out with a power P = 35 W. Figure 9 shows the wheel surface after laser cleaning assisted dressing. The thermal expansion of resin bond material was not occurred on the wheel surface. Although the adhesion of steel swarf was observed on wheel surface after grinding of 60 passes, the adhesion was completely removed.

Figure 10 shows the change of surface roughness after laser cleaning assisted dressing. Although the surface roughness was characterized by Rz = 0.99 µm, Rz = 1.14 µm, Rz = 1.07 µm after 20, 60 and 100 passes grinding, the surface roughness after applying laser cleaning assisted dressing was improved to Rz = 0.90 µm, Rz = 0.94 µm, Rz = 0.98µm.

5. Conclusion

In order to remove the adhered swarf on conventional WA400 wheel and fine diamond SD600 resin bond wheel, a laser cleaning assisted dressing method was applied. As shown by the results, it was possible to remove the adhered swarf. Surface roughness was improved. When the laser cleaning assisted dressing was applied to formed V-shape wheel, shape wear was not occurred. In the future, the removal property of adhered swarf for various materials will be investigated. The laser cleaning assisted dressing will apply to the conditioning of lapping tool and polishing pad.

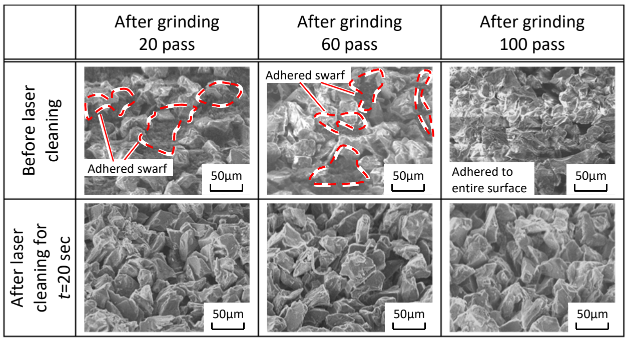

Figure 4. Removal of adhered swarf on conventional WA400 wheel after grinding of Ti alloy by laser cleaning assisted dressing

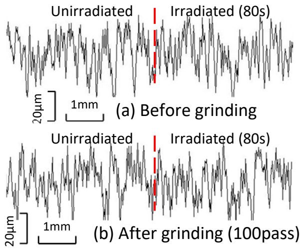

Figure 5. Change of surface profile on conventional WA400wheel

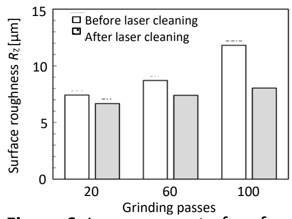

Figure 6. Improvement of surface roughness by laser cleaning in conventional WA400 wheel

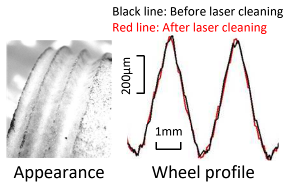

Figure 7. Effect of laser cleaning on wheel wear of V-shape formed WA220 wheel

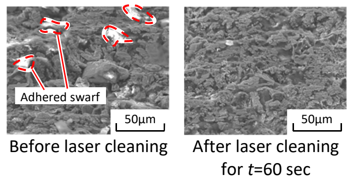

Figure 8. Removal of adhered swarf on SD600 diamond wheel after grinding of hardened steel by laser cleaning

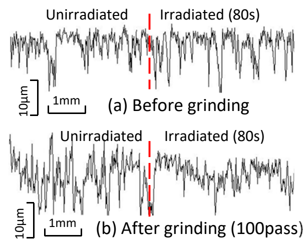

Figure 9. Change of surface profile on fine diamond SD600 wheel

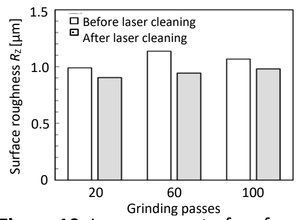

Figure 10. Improvement of surface roughness by laser cleaning in fine diamond SD600 wheel

Aknowledgements

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