

WATERJET IN-PROCESS DRESSING (1ST REPORT)

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1. INTRODUCTION

Super abrasive grain wheels using diamond or CBN abrasive grains are increasingly applied to the state-of-the-art technology in various fields such as the vehicle, aerospace, electronics and communication industries. Super abrasive grain wheels are suitable for grinding of materials which are difficult to grind. However, they do not have self-sharpening characteristics and tend to cause loading.

Recently waterjets have been utilized in various types of processing, such as civil engineering and the mechanical, medical and food industries. It can eliminate weak parts of material by adjustment of the injection air pressure without causing damage to other parts.

This report offers a proposal of in-process dressing using a water jet. As shown in Figure 1, a water jet is injected to the surface of the grinding stone for machining material which is difficult to grind and chips are removed from the stone without damaging the stone.

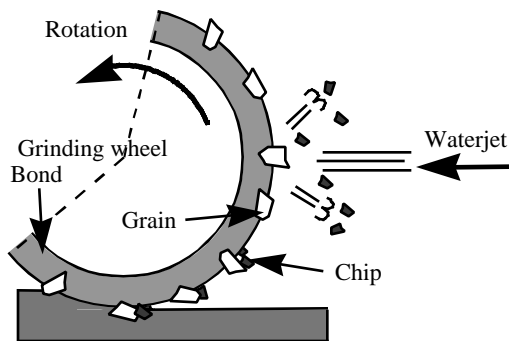


Fig.1 Principle of waterjet in-process dressing

2. MEASURING DEVICES

The configuration of the devices used in this study is shown in figure 2. A water jet device was installed on the grinder to inject water on the surface of the CBN wheel. The high pressure water was injected as water jet through the nozzle. Figure 3 shows the outline of our proposed system, an in-process dresser. A nozzle is the nozzle head, which revolves by compressed air. Since both the dresser nozzle head and the CBN wheel revolve, water jet is spread over the CBN wheel surface

evenly.

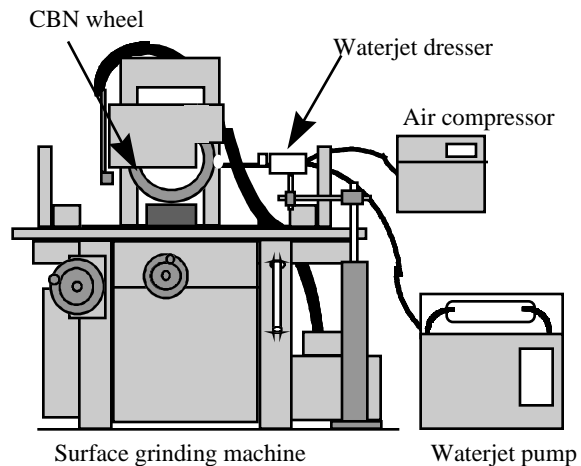


Fig.2 Constitution of experimental apparatus

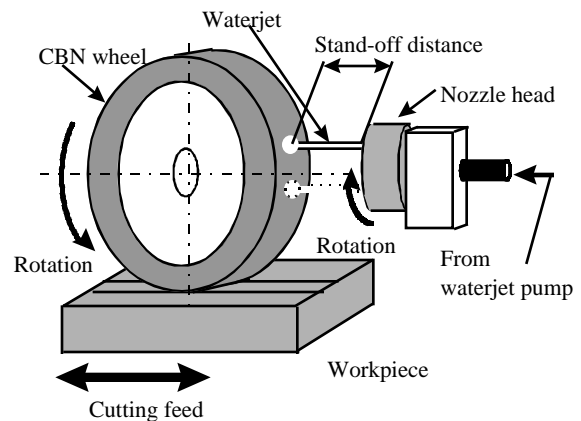


Fig.3 Outline of waterjet in-process dressing

3. METHOD

3.1 IN-PROCESS EROSION

Since water jet was used for in-process dressing in this study, it was suspected that if water jet pressure is too high, erosion may occur on the CBN wheel although chips attached to the abrasive grains can be removed. We examined the surface change and erosion of the CBN wheel along with dressing as the water jet pressure was changed when the CBN wheel was revolving with no grinding. Table 1 shows the conditions of the test.

Table1 Conditions of in-process erosion test

Grinding wheel	$\phi 180 \times 10$ mm, str Metal bond, CBN #325
Wheel speed	33 m/s
Injection pressure of waterjet	77.2-124.5 MPa
Stand-off distance	20 mm
Nozzle diameter	0.2 mm
Nozzle revolution diameter	40 mm
Nozzle revolution number	1120 rpm

3.2 IN-PROCESS DRESSING

We examined the effectiveness of water jet in-process dressing. We used a metal bond CBN wheel on the surface grinder and Ti6Al4V as a material and performed rectilinear motion grinding with water-miscible grinding fluid. At the same time, in-process dressing by water jet was conducted and the dressing effect under the different level of water jet pressure was examined. As grinding proceeded, we measured the surface roughness of CBN wheel and the surface roughness of the material. Table 2 shows the conditions of this test.

4. RESULTS AND DISCUSSION

4.1 IN-PROCESS EROSION

Figure 4 shows magnified photographs of the CBN wheel surface when the injection time is approximately 300s. When the injection pressure was high, at levels such as 107.1 MPa and 124.5 MPa, there were releasing traces of CBN abrasive grains on the surface of the wheel. We suspected this was because the metal bond adjacent to the abrasive grains was eroded due to water jet impact.

Figure 5 shows the change of the CBN wheel surface roughness along with water jet injection.

when the injection pressure was 107.1 MPa and 124.5 MPa, the surface roughness increased as the injection proceeded. It was suspected that the metal bond on the CBN wheel was eroded due to water jet impact, the abrasive grains protruded and eventually came off the wheel, resulting in an increased R_z value.

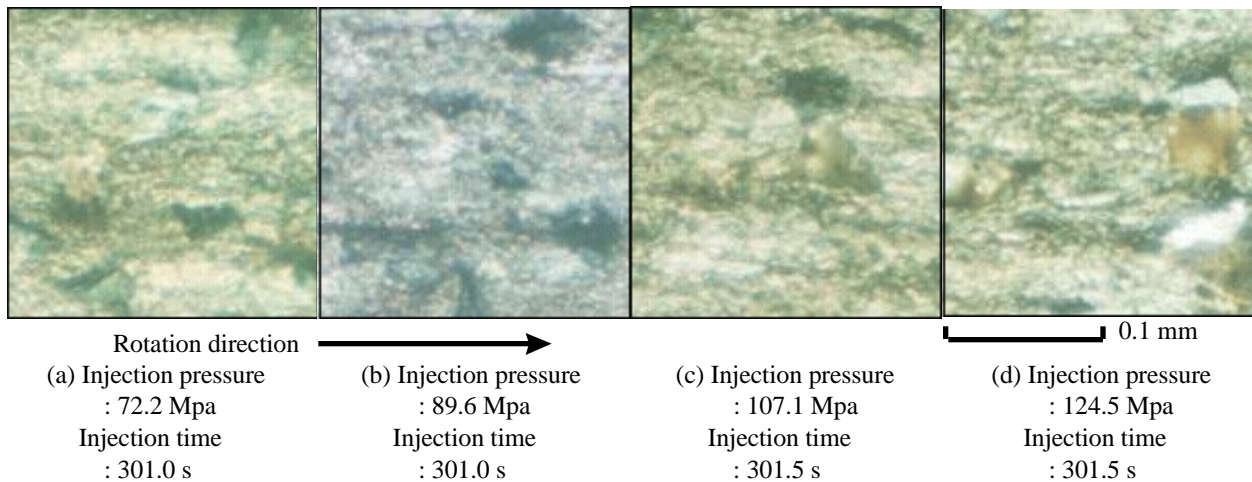


Fig.4 Photograph of wheel surface on in-process erosion test

Table2 Conditions of in-process dressing test

Grinding wheel	$\phi 180 \times 10$ mm, str Metal bond, CBN #325
Wheel speed	33 m/s
Feed speed	10 m/min.
Depth of cut	5 μ m
Workpiece	Ti6Al4V
Injection pressure of waterjet	54.7-124.5 MPa
Stand-off distance	20 mm
Nozzle diameter	0.2 mm
Nozzle revolution diameter	40 mm
Nozzle revolution number	1120 rpm

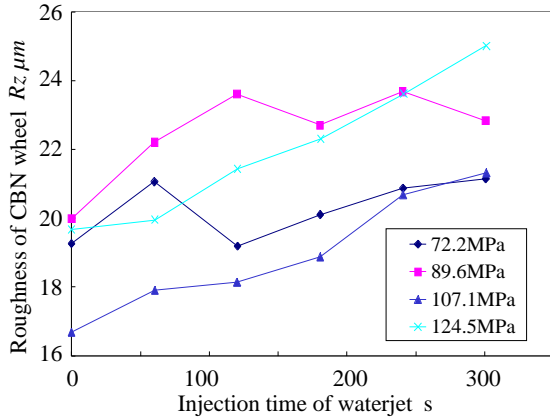


Fig5. Relationships between injection pressure of waterjet and roughness of CBN wheel

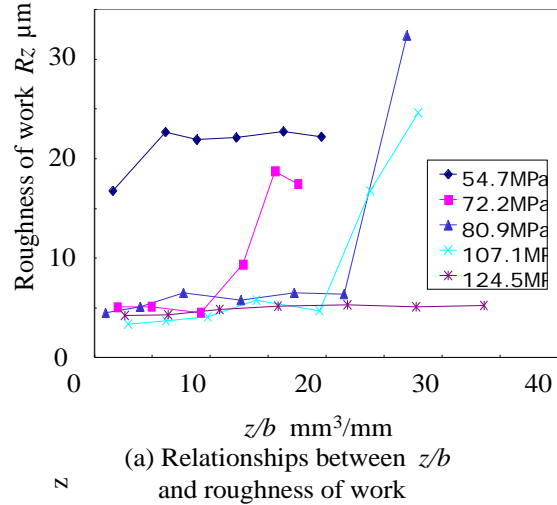
4.2 IN-PROCESS DRESSING

Figure 6 shows how the surface roughness of the material and the CBN wheel changes as grinding proceeds. The value (z/b) given by the volume z (mm^3) divided by CBN wheel width b (mm) is used as a parameter to indicate the degree of grinding.

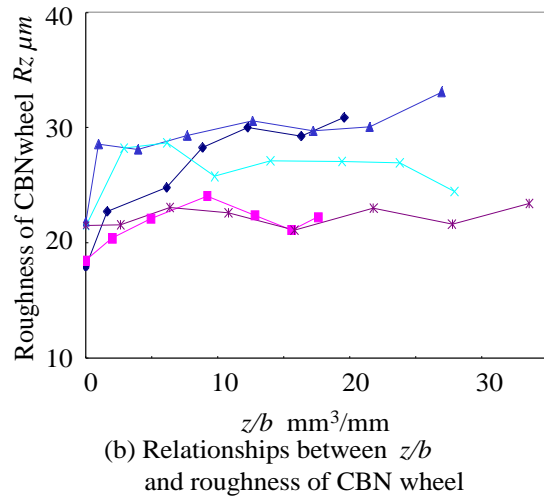
When the injection pressure was 72.2 MPa, R_z showed low value as long as z/b was around $9 \text{ mm}^3/\text{mm}$. However, subsequently, the R_z value rose sharply. In light of these results, it is speculated that waterjet dressing allowed chips on the CBN wheel to be removed to some extent, but not completely and chips accumulated on the wheel and loading happened as grinding proceeded. Consequently, it was revealed that an injection pressure of 72.2 MPa was not sufficient to prevent loading in in-process dressing.

When the injection pressure was 80.9 MPa and 107.1 MPa, the surface condition was good from the beginning as long as z/b was $20 \text{ mm}^3/\text{mm}$. Subsequently, however the surface condition worsened. In the test of 80.9 MPa and 107.1 MPa, the point of z/b where the surface roughness drastically worsened was quite similar. After that point, the cutting performance of the CBN abrasive grains also got worse sequentially in both cases, causing dulling and worse surface roughness. Accordingly, we predict that until z/b reaches $20 \text{ mm}^3/\text{mm}$, waterjet in-process dressing is effective and proper cutting performance was maintained without being affected by chips for the duration of the CBN wheel's lifetime.

When the injection pressure was 124.5 MPa, no loading or dulling happened at any time during the grinding process. The value R_z was low and a good surface condition was maintained. However, the results of the erosion test indicate that the



(a) Relationships between z/b and roughness of work



(b) Relationships between z/b and roughness of CBN wheel

Fig.6 Result of in-process dressing test

water jet pressure for dressing was too high so that the bond on the CBN wheel was eroded and grains came off the wheel before dulling, and that new abrasive grains protruded as cutting blades. The grinder did not lower its performance and maintained a constant surface condition without any effects caused by grinding. As such self-sharpening becomes active, grinding ratio as well as surface accuracy may decrease. Judging from the final surface condition after this test, 107.1 MPa is the most suitable value for water jet pressure.

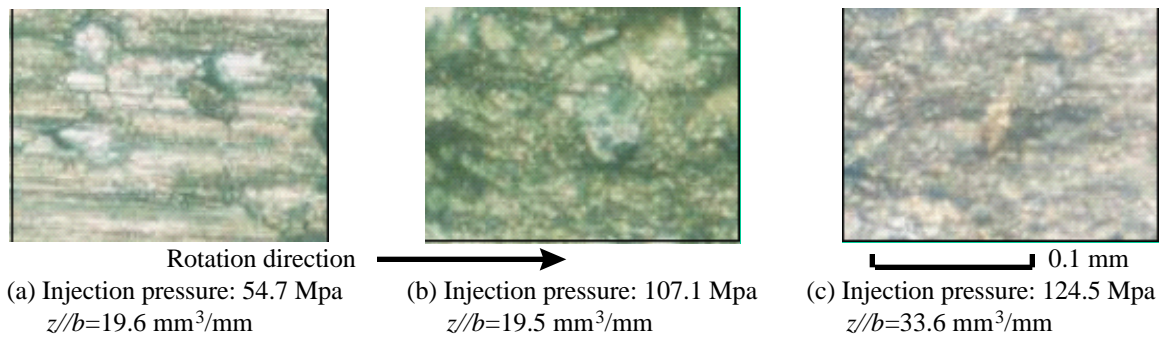


Fig.7 Photograph of CBN wheel surface on in-process dressing test

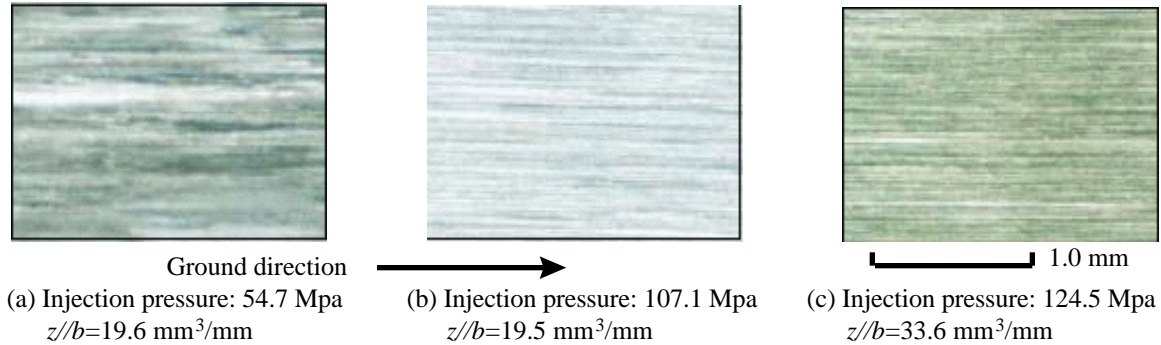


Fig.8 Photograph of work surface on in-process dressing test

Figure 7 shows the photographs of the CBN wheel surface in this test. In the case of (a), the abrasive grains were embedded with melted chips. (b) shows that chips were removed from the wheel due to in-process dressing, while in (c), it is characteristic that the metal bond holding the CBN abrasive grains was eroded. Figure 8 shows the finished surface ground by the CBN wheel shown in figure 7. In (a), the surface was not flat because water jet in-process dressing was not effective, while in (b) and (c), a good surface condition was obtained.

5. CONCLUSION

We tested the effect of in-process dressing by means of water jet using this system. The following are the results obtained from the test.

- (1) In-process dressing by means of water jet on a surface grinder with a CBN wheel in Ti6Al4V linear motion grinding was effective.
- (2) Water jet removed only chips on the CBN wheel and the wheel lasted its full lifetime. A water jet pressure of 107.1 MPa was the most suitable to obtain good results.
- (3) It was confirmed that if the water jet pressure is too low, in-process dressing is not effective and if it is too high, the CBN wheel becomes eroded.

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