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Effect of repeated cyclic using of blast abrasive material on the steel surface characteristics

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ABSTRACT

Nonmetallic abrasive materials have been widely used for the blasting treatment. It has been found that the grinding ability of abrasive would decrease due to the changes in grain size distribution caused by repeat using of non-metallic blasting abrasives. However, for the effect of grain size distributions on the surface texture of the blasted steel substrate still has not been clarified clearly. This research focused on a conventional blasting abrasive material of fused alumina, and investigated the relationship between its cyclic using numbers and grain size distribution. Test results showed that the repeated cyclic using of abrasive would lead to the decreasing in the grain size. Moreover, the surface roughness of the blasted steel substrate also decreased according to the increase of repeated cyclic using of abrasive.

1. INTRODUCTION

Generally, for the purpose of securing the durability of the coating film at the time of painting repainting of steel structures such as steel bridges, steel substrate adjustment using blasting has been performed. Non-metallic abrasives are often used for blasting. Non-metallic blasting abrasives are inexpensive and easy to handle, but repeated use changes the grain size distribution of the abrasives and reduces the grinding ability[1)]. However, there are many unclear points on the effect of repeated use of blast abrasives on the grain size distribution and the effect of the distribution on the surface properties of steel substrates.

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In repainting procedure of steel bridges, inexpensive ferronickel slag is generally used as an open blasting abrasive. Also, in vacuum blasting, in order repeatedly to use abrasives, fused alumina is used, which is more expensive than ferronickel slag, but has high grinding performance.

Regardless of the cost of the abrasive, the significant corrosion damage of the steel bridge is effective in delaying and preventing corrosion under the coating by selectively using abrasives. Therefore, in this fundamental research, the relationship between the number of cycles of abrasives used and the grain size distribution in the case of applying fused alumina with high grinding ability to open blasting was examined experimentally. In addition, the effect of the number of cycles used on the surface roughness of the steel substrate and the residual degree of the surface of the steel substrate of the abrasive was also examined.

2. TEST METHOD

2.1 Test specimen and blasting conditions

The dimensions of specimens are 150×70×6mm, which are fabricated by the uncoated carbon steel according to the Japanese Industrial Standard (JIS) G3106 SM490A. The steel surface was polished with a motorized sander (roughness of abrasive paper: #600) before the blast treatment. The specimen had a line roughness after polishing, Rzjis was 30 μm or less and Ra was 3 μm or less.

The parameters of blasting condition were considered as abrasive material, blasting pressure, distance, and angle. The abrasive used was fused alumina (Mohs hardness: 12 (Vickers hardness: 1810), JIS particle size index: 57.8, specific gravity: 4.0), which has a relatively high Vickers hardness. Fused alumina is generally used for vacuum blasting on existing bridges. The blasting weight was set to 10,000 g in consideration and powderization of the abrasive after projection. Before blasting, the grain size distribution of the abrasive was adjusted as shown in Table 1.

The blasting treatment used in existing bridges, generally the conditions were controlled with the pressure, distance and angle 0.7MPa, 300mm and 60°. The number of cycles used for the abrasive was 30 cycles. The blasting method is shown in Figure 1. Blasting was performed using 10,000 g of unused abrasives. After blasting, 120 g of the abrasive was collected for each cycle and sieved. Abrasive materials were classified into each grain size and mass measurement was performed to evaluate changes in grain size distribution (JIS R6001-1998). The grain size distribution was measured for abrasives collected when the number of cycles of abrasive use N was 0, 1, 5, 10, 15, 20, 25 and 30.

Table.1 Grain size distribution of abrasives before blasting

Abrasive	Opening of sieve (μm)								PAN
	600	425	300	212	150	106	75	53	
Fused alumina	0.2	52.2	43.5	3.8	0.4	0.1	0	0	0

2.2 Measurement of surface roughness and abrasive residue

The surface roughness of the blast-treated specimen was measured by a three-dimensional laser microscope (Spot diameter: 0.4μm, Movement resolution: 0.01μm), measuring area is 25 mm^2 (2.5×10 mm) at the center of each blasted specimen, using pitch of 2.5 μm. The line roughness was calculated from the measurement result of an mean value of 10 mm × 11 lines. To examine the surface roughness depending on blasting conditions, it was evaluated by the mean height of roughness profile at ten points (Rzjis), arithmetic mean of the roughness profile (Ra), and mean width of the roughness profile elements (RSm).

In addition, the cross-section after the blast base adjustment was observed using SEM (Resolution: 3.5nm (30kV), Acceleration voltage: 20kV) under low vacuum condition, and element analysis was performed by EDX (Fe, O, Al). The constituent ingredient Al oxide which is the main component of the abrasive mapped about Al oxide.

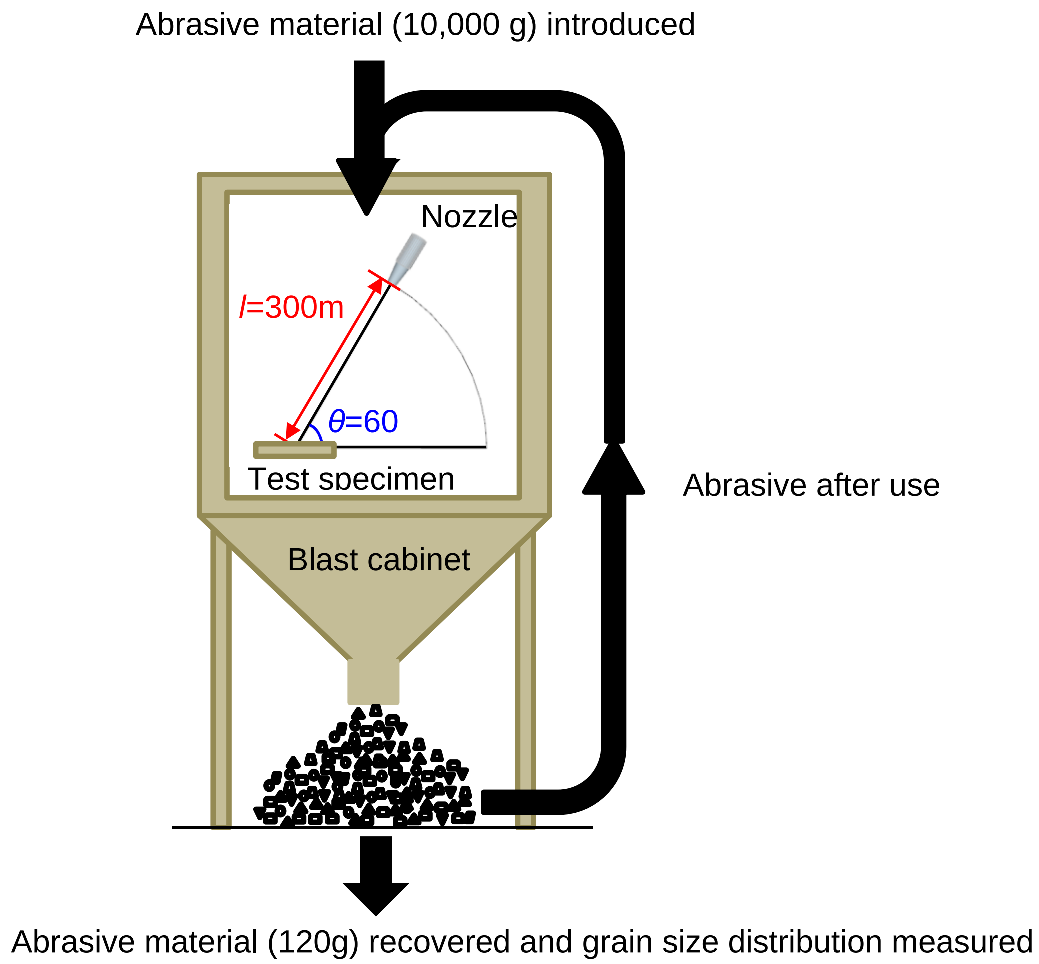


Figure.1 Blasting method

3. RESULT

3.1 Surface roughness and line roughness

Figure 1 shows the change in grain size distribution with the number of cycles of abrasive. The horizontal axis of the figure is the opening d of the sieving wire mesh, and the vertical axis shows the weight of the abrasive remaining on the sieve with respect to the number N of cycles of the abrasive used. The grain size decreases as the number of cycles of use of the projected abrasive increases. Also, as N increases, the weight of grains with diameter of 425 μm and 300 μm decreases significantly. On the other hand, the weight of grain is increasing when diameter smaller than 212 μm. After 15 cycles of use, the grain weights of less than 150 μm accounts for about half of the total.

Figure 3 shows the measurement results of a laser microscope on the surface of the blasted polished steel sheet. The figure shows the surface roughness of the steel according to the number of cycles of the abrasive used. Figure 3 (a) shows that the N is 5 cycles, related surface roughness is higher than that of other cycles. On the other hand, Figure 3 (c) shows that the N is 15 cycles, the surface roughness of the steel decreases. Figure 3 (d), Figure 3 (e) and Figure 3 (f) show that after 15 cycles, there is no difference in the surface roughness of the steel even if cycles increase.

Figure 4 shows the relationship of line roughness Rzjis, Ra and RSm of the steel substrate surface to working cycle number N of abrasives. The line roughness Rzjis, Ra and RSm in Figure 4 show the same tendency that, as N increases, Rzjis, Ra, and RSm tend to decrease. It is considered that as the cyclic using number of grinding material increases, the grinding force is reduced and the corners of the outer shape of material is reduced. Also, when N is 10 cycles or more, the difference among Rzjis, Ra, and RSm is small.

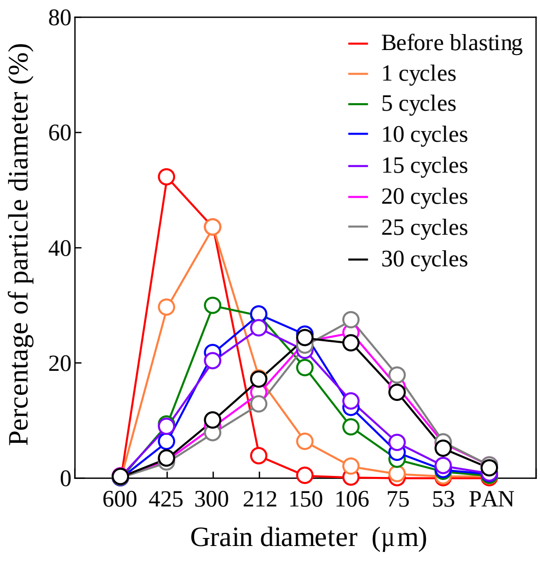
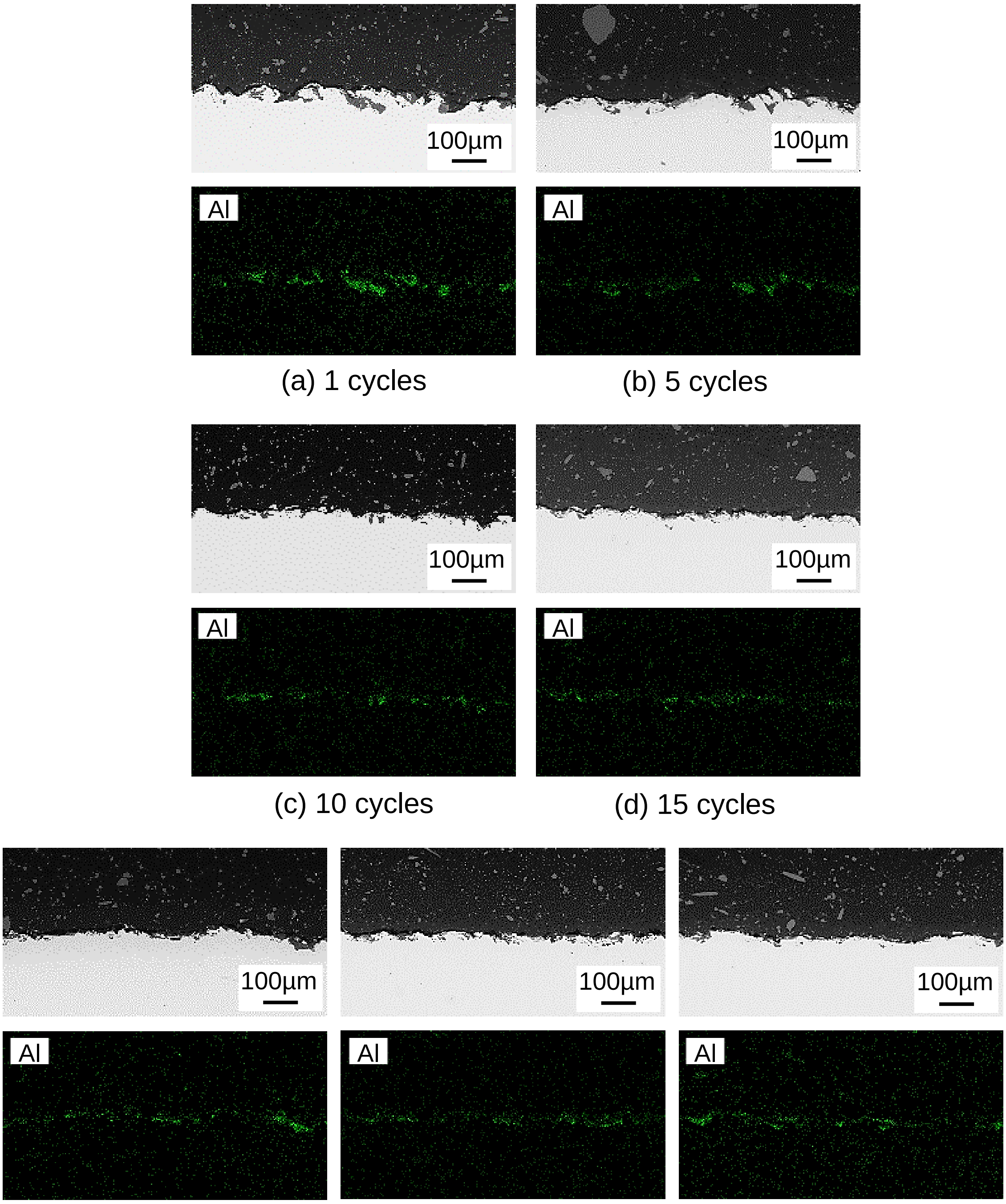


Figure.2 Grain size distribution for the number of cycles of abrasives used

3.2 Abrasive residue

Figure 5 shows that the SEM image of the cross-section in steel substrate after blasting and the Al element mapping by SEM-EDX. Al element owns a green color. It shows that the surface roughness of the steel base itself tends to decrease as N increases, and the residual amount of abrasive also decreases. Especially, when cycles



(a) 1 cycles (b) 5 cycles

(c) 10 cycles (d) 15 cycles

(e) 20 cycles (f) 25 cycles (g) 30 cycles

Figure.5 Influence of the number of cycles of abrasive used on residual abrasive shown in Figure 5 (a) is once, the roughness of the cross-section of the steel base is extremely rough, and a large amount of abrasive remains on the surface base. On the other hand, when N is 10 cycles as shown in Figure 5 (c), the roughness of the cross section of the steel base decreases. In addition, in Figure 5 (g) when N is 30 cycles, the roughness of the cross section of the steel base is small. It can be said that as the repeat cyclic using of abrasive increased, the grinding force was reduced because the grain of the abrasive were crushed.

From this, it is thought that abrasive material can be used to secure the line Roughness of the surface of the steel substrate by the initial abrasive with less than 5 cycles. However, with regard to the residue of abrasives, it is possible that the adhesion of the coating decreases because a large amount of abrasives remains on the surface of the steel substrate after 5 cycles or fewer cycles.

4. CONCLUSIONS

This study investigated the effect of repeated cyclic using of fused alumina which is the blast abrasive material, on surface characteristics of steel material and residual degree of abrasive material on the steel. The main conclusions obtained in this study are shown as follow:

(1) The grain size of the abrasive decreases as the number of cycles of the abrasive increases.

(2) The surface roughness of the steel substrate and the residual amount of abrasive decrease as the number of cycles of abrasive used increases.

(3) Abrasive material can be used to secure the line Roughness of the surface of the steel substrate by the initial abrasive with less than 5 cycles. However, it is apprehended that the adhesion of the coating decline due to the abrasive remaining on the surface of the steel substrate.

In the future, it is planned to study the residual number of corrosion products and salts on the surface of the steel substrate by using the number of cycles of grinding material, by using a corroded steel sheet.

REFERENCES

T.Kubohori, K.Kuramoto, Y.Inui, J.Morimoto. (2009), “Study on the Durability of Blast Materials”, *Journal of High Temperature Society,* **35**(6), 308-313.