Short-time corrosion behavior of steel surfaces cleaned by abrasive blast and abrasive water-jet treatments

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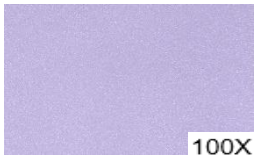
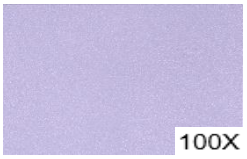
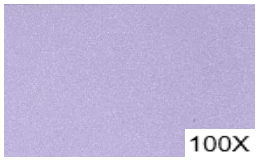
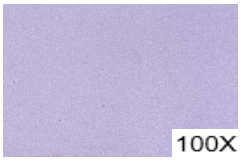
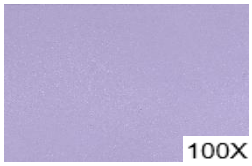
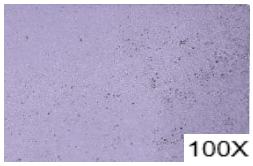
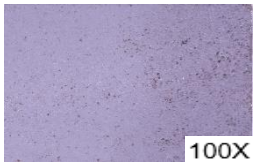
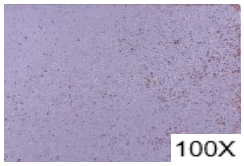
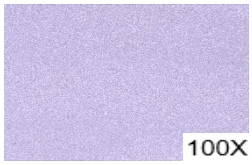
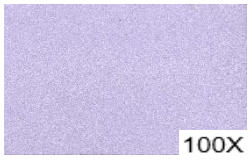
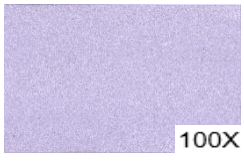
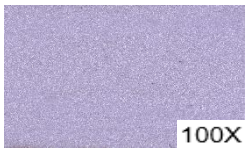
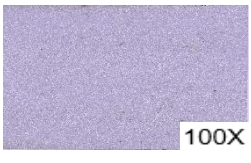
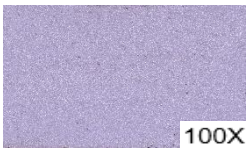
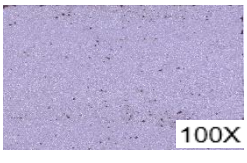
1. Introduction Different surface treatment methods can foster different surface conditions of carbon steel and residual salts which lead to rapid and uneven growth of corrosion products. Localized corrosion studies of carbon steel surfaces undergoing residues are characterized. Significantly, the corrosion products are found to grow rapidly and in homogeneously. They evolve to higher oxidation state oxides quickly within short corrosion time. This work investigates the corrosion of steel surfaces over particularly short timescales after milling and corroded parts are treated by Abrasive Blasting Treatment (ABT) and Abrasive Water-jet Treatment (AWT). It focuses on the short-term effects between surface preparation and coating application (turning time, typically several hours).

2. Test method In this experiment, carbon steel plates (JIS G3106 SM490A) with dimensions of 150×70×6 mm, were used to prepare the test specimens. Test specimens were divided into two groups. One is denoted as milling group, the initial state of steel plate was milling by an NC machine (Cutting diameter: 50 mm, cutting speed 215 m/min, Revolutions per minute:1,369 (rev./min), Blade material: Cermet). Another is denoted as the corroded group. One side of the surface of all the blasted steel plates was exposed for 120 cycles of Cycle-D, as specified in JIS K 5600-7-9. Each cycle takes 6 h and consists of 1) atomization of saltwater for 0.5 h (30°C, RH98), 2) a wetting step for 1.5 h (30°C, RH98), 3) a drying step with hot air for 2.0 h (50°C, RH20) and 4) a drying step with warm air for 2.0 h (30°C, RH20). During the cyclic corrosion test (CCT), the samples were set up at an angle of 15° with respect to the vertical direction according to JIS Z2371.Two groups of steel panels surfaces which were cleaned by ABT and AWT were evaluated. Parameters of ABT and AWT are written as following: 1) ABT: Garnet grit size #30-60 coarse, pressure 70MPa,treating angle 90°,treating distance 300mm. 2) AWT: Garnet grit size #30-60 coarse, pressure 230MPa,treating angle 90°,Treating distance 300mm. To stimulate the atmosphere condition of a short period of timescale between finishing surface treatment and applying coating, the treated surfaces are exposed to constant temperature and relevant humidity (T and RH respectively) chamber with 28℃,RH87 (gauging T and RH data of average summer's daytime in Okinawa) in different timescales: 0, 2, 4 and 24h. In the study, this timescale is named turning time. Corrosion products during this period was called flash rust. Corrosion identification of surfaces undergoing turning time use spatial statistics numerical simulation to quantify corrosion. The surface area of the steel plate is defined as A0, and the corrosion area is defined as As. Residual salt and residual grit of corroded panels after ABT and AWT were observed by the Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDX).

3. Results and discussion As shown in Fig.1, neither the AWT nor the ABT steel plate has clear flash rust within 24 h. For the corroded steel plate, the area of flash rust produced by the AWT steel plate is smaller than that of the ABT steel plate.

Table.1 Digital photos undergoing turning time at constant 28℃,RH87

Turning time (h)	0	2	4	24
Milling ABT				
Corroded ABT				
Milling AWT				
Corroded AWT				

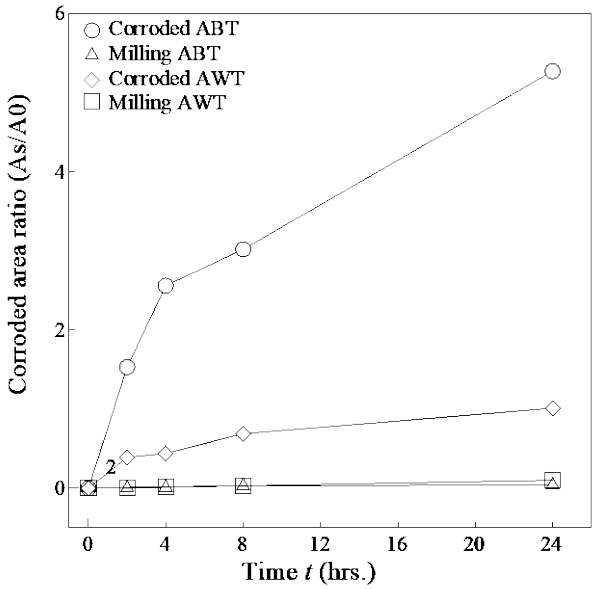


Fig.1 Percentage of corroded area along turing time

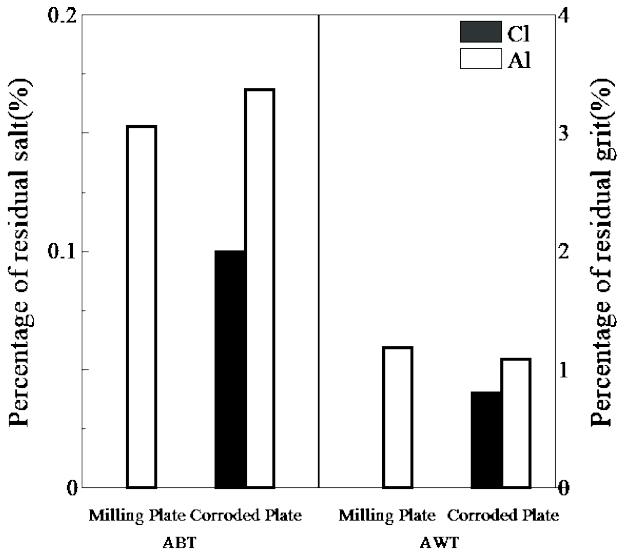


Fig.2 Percentage of residual Salt and Grit

Table.2. Digital photos of SEM micrograph and EDX analysis of surfaces after ABT and AWT

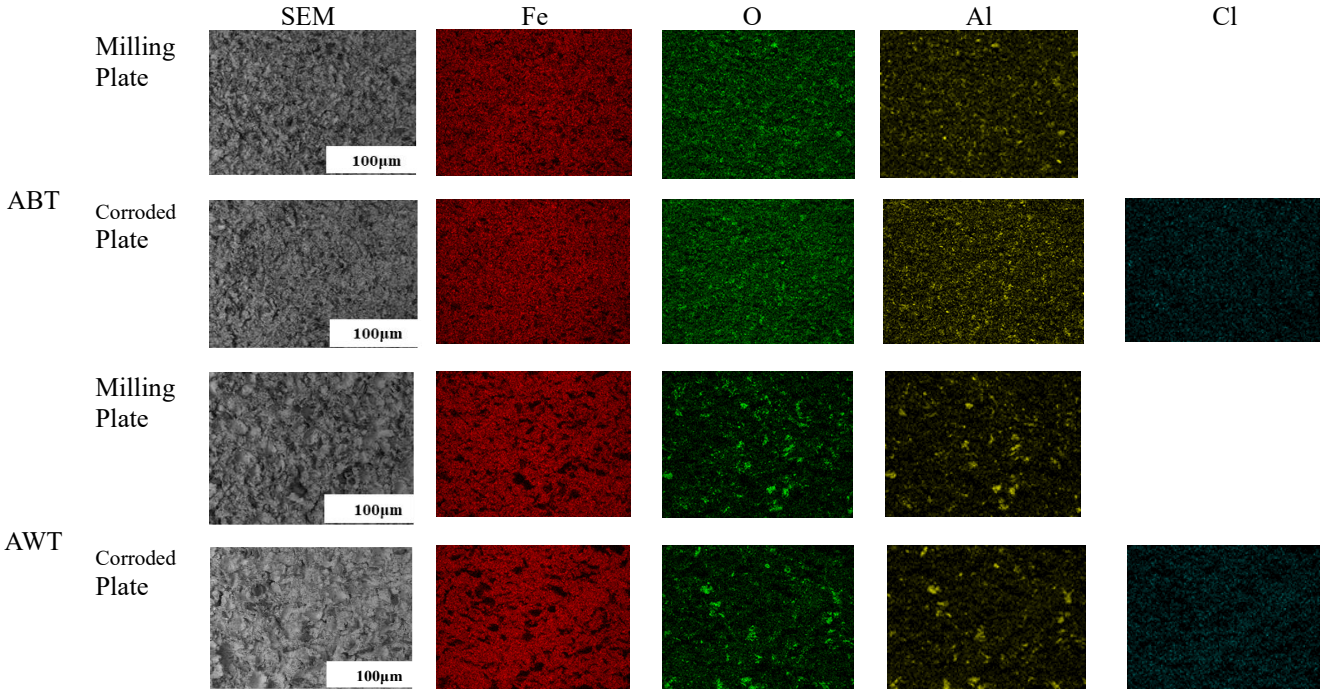


Figure 2 shows that AWT treated surface remains less residual salt and residual abrasive grit than ABT, but the residual grinding material is relatively concentrated on the surface. The milling method has greatly improved the desalination effect of ABT, while left less grinding material on the surface of the steel plate. The EDX mappings shows in Table 2 propose that both ABT and AWT can clean most corrosion production, however, remain traceable iron(III) oxides and residual grit. At the same time, ABT is limited in cleaning soluble salt. The SEM pictures and the cluster of residual grit indicate that AWT made a greater change on the steel surface shape.

4. Summary & Findings 1) Both AWT and ABT have good rust removal effect, however AWT has less residual salt and grinding material but has a greater change in surface shape. 2) The AWT steel plate exhibits a smaller tendency to develop flash rust, perhaps due to its modification of the surface shape of the steel plate. In the further study, authors will investigate the effect of surface treatment methods on surface adhesion and surface roughness, which may exert an influence on the mechanism and composition of flash rust.

Reference 1) Yang, M., Kainuma, S., Xie, J., Liu, W. and Liu, Y.. Bond Behavior between CFRP and Corroded Steel Plate Associations with Surface Treatments. Composites Part B: Engineering, 246, 110280, 2022. .2) Bard, A.J., Parsons, R. and Jordan, J.: Standard Potentials in Aqueous Solution, Marcel Dekker, New York, 1985. 3) Luo, J., Li, G., Rao, M., Peng, Zh., Zhang Y. and Jiang ,T.: Atmospheric Leaching Characteristics of Nickel and Iron in Limonitic Laterite with Sulfuric Acid in the Presence of Sodium Sulfite, Minerals Engineering, Vol.78, pp.38-44, 2015.