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Acid Dew Corrosion Behavior of Cu-Sb bearing Low Alloy Steel

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Corrosion behavior of low alloyed steels in acid dew corrosion environments were studied by filed exposure tests and laboratory corrosion or electrochemical measurements. Tested steels were mild steel (JIS SS400), weathering steel (0.3%Cu-0.6%Cr-0.3%Ni bearing high tensile steel, COR-TEN[1], Nippon Steel), and sulfuric acid dew corrosion resistant low alloy steel[2,3] (0.3%Cu-0.1%Sb bearing high tensile steel, S-TEN1, Nippon Steel). In some experiments, Type304 and Type316L stainless steel were also tested for comparison. Field tests were conducted at various exhaust gas facilities at fossil fuel fired power stations or commercial plants.

In sulfuric acid dew corrosion, concentration of condensed acid is determined only with the metal surface temperature[4]. By using this relationship, immersion tests in various sets of acid concentration and temperature were conducted in order to compare corrosion rates of steels. Fig.1 shows effect of acid concentration / temperature on corrosion rates of steels. This result suggests that comparing to carbon steel, S-TEN1 would show lower corrosion rate in acid dew corrosion condition, where metal temperature and acid concentration are relatively lower as reported before[2]. A typical result of long term exposure tests in sulfuric acid dew corrosion conditions is shown in Fig.2. Test coupons were placed on the inlet duct surface to the steel stack in a high sulfur heavy oil fired power station. S-TEN1 showed clearly lower corrosion rate than COR-TEN or mild steel. As S-TEN1 does not contain chromium (<0.02%), this result demonstrates chromium is not an essential chemical element for acid resistant low alloyed steel.

It is often encountered in the exhaust gas treatment facilities that fly ash contains high amounts of chlorides or flue gas contains several hundred ppms of hydrochloric acid. In these cases, sulfuric acid dew corrosion behavior of steels may be affected with chlorides and hydrochloric acid atmosphere can develop at the steel/ rust interface[5].

Fig.3 shows corrosion rates of steels in hydrochloric acid solutions (10.5mass% and 1.0mass%) at 80 deg.C. In 10.5mass% HCl solution, corrosion rate of S-TEN1 is substantially lower than even that of type 316L. In more dilute 1%HCl solution, S-TEN1 still showed comparable low corrosion rate to type 316L steel, otherwise COR-TEN showed higher corrosion rate in both concentrations. This results suggest that S-TEN1 would show lower corrosion rate in applications in which hydrochloric acid atmosphere could develop.

Fig.4 showed a result of field test in which several mass percent of chloride containing ash involved in sulfuric acid dew corrosion. Steels were actually applied as duct panels without external heat insulator. As predicted from Fig.3, S-TEN1 showed substantially lower corrosion rate compared to mild steel.

This study clarified and confirmed that a low alloyed steel containing Cu-Sb without Cr shows better corrosion resistance than Cu-Cr-Ni bearing steel in (1) relatively lower metal temperature/ lower acid concentration environments, and (2) sulfuric acid dew corrosion environments involving chlorides.

Effect of micro alloying elements such as Cu, Sb, Cr were also investigated electrochemically and discussed in terms of anodic dissolution and hydrogen evolution reactions.

1) J.F Barkley et.al.: Bureau of Mines Rept. of Investigation, No.4996 (1953)
2) A.Teramae et.al.: Fuji Steel Tech. Rept.,**17**,103(1968)
3) A.Usami et.al.: Nippon Steel Tech. Rep, in press(2004)
4) H.D. Taylor, Trans. Faraday Soc., **47**, 1114(1951)
5) A.Usami et.al.:13th APCCC,Osaka, JSCE, G-13 (2003)

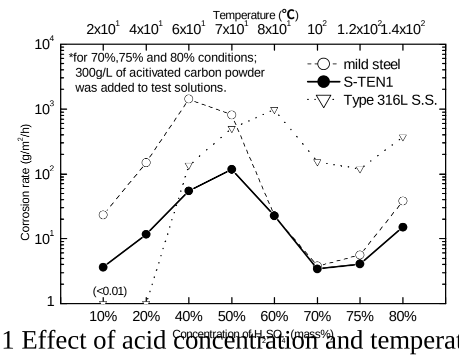

Fig.1 Effect of acid concentration and temperature on corrosion rate of steels in sulfuric acid solution.

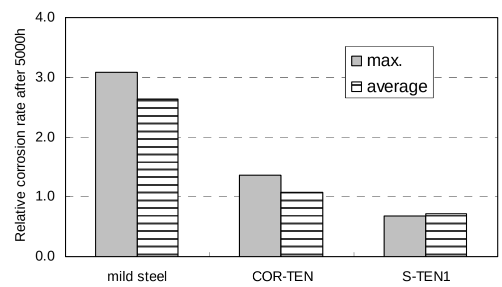

Fig.2 Corrosion rates at a inlet flue to stacks in a high sulfur heavy oil fired power station.

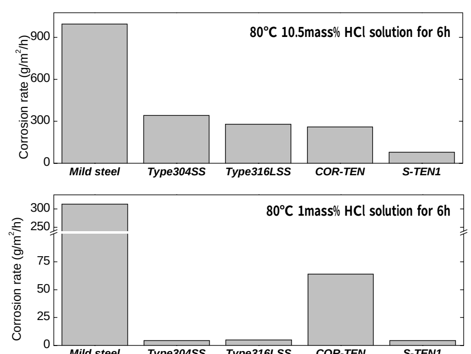

Fig.3 Corrosion rates in dilute hydrochloric acid solutions (upper; 10.5%, lower; 1%HCl)

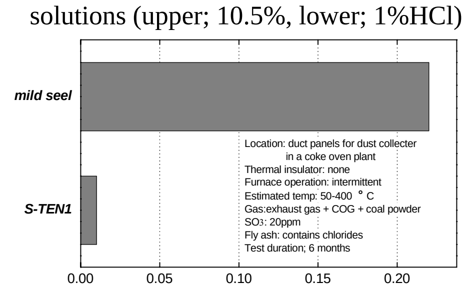

Fig.4 Corrosion rates from a field test