

## Effect of Noble Metal Coating on Carbon Steel Corrosion in High Temperature Water\*\*

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Erosion-corrosion is most frequently observed in regions of highly disturbed cooling water flow during the operation of boiling water reactor (BWR) under hydrogen water chemistry (HWC) condition. Carbon steels are extensively used in some parts of nuclear power plants and erosion-corrosion of carbon steel in water and wet steam is known to be a major failure problem.

Recently, noble metal technology has been developed as a new tool to mitigate the intergranular stress corrosion cracking (IGSCC) of BWR components. This approach involves improving the catalytic recombination of  $O_2$  and  $H_2O_2$  with  $H_2$  to form  $H_2O$  on metal surface and thereby achieve the thermodynamically lowest possible ECP (-550mV vs. standard hydrogen electrode, SHE) and lowest crack initiation/growth rates at much lower  $H_2$  addition rates and with minimal negative impact on BWR operation. This process thus requires only a stoichiometric amount of  $H_2$  in water (i.e. >2:1  $H_2:O_2$  molar ratio, >1:8  $H_2:O_2$  weight ratio).

The ECP behavior of carbon steel, Pt/Rh-doped carbon steel and pure Pt electrodes was also measured in 288°C water containing 150 ppb  $H_2$  with an incremental addition of  $O_2$ , as shown in Figure 1. The Pt/Rh-doped carbon steel possessed a potential similar to that of the platinum electrode. In contrast, the behavior of the undoped carbon steel did not parallel that of platinum; it exhibited a much lower ECP at low oxygen concentrations. This is attributed to a high overvoltage for hydrogen evolution and to the formation of a less protective oxide, permitting higher corrosion rates in the low oxygen regime.

By catalyzing the hydrogen/water reduction reaction, the presence of a catalytically active noble metal on the oxide surface can raise the potential to values closer to that of the reversible hydrogen/water couple (by lowering the overvoltage for hydrogen formation) where a protective passive film may form or, at the very least, minimize reductive dissolution. At high oxygen concentrations with excess hydrogen, the ECP is controlled by reducing oxygen and oxidizing hydrogen, and consequently shifts toward the hydrogen/water oxidation reaction.

Figure 2 shows the effect of Pt/Rh doping on the weight loss of carbon steel in 288°C water containing 150 ppb  $H_2$  and 30 ppb  $O_2$  as a function of immersion time. Both tests were conducted by using a rotating electrode system described previously. It is evident that the weight loss of carbon steel can be significantly reduced by the presence of noble metals on the surface. Catalyzing the hydrogen/water reduction reaction by noble metals on the surface would enhance the formation of a protective oxide, e.g.  $Fe_3O_4$ , and subsequently decreased the corrosion rate of carbon steel.

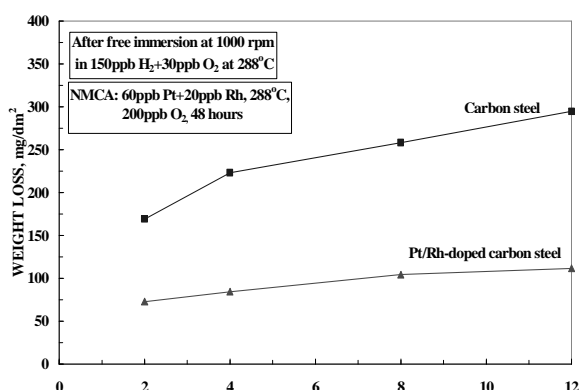
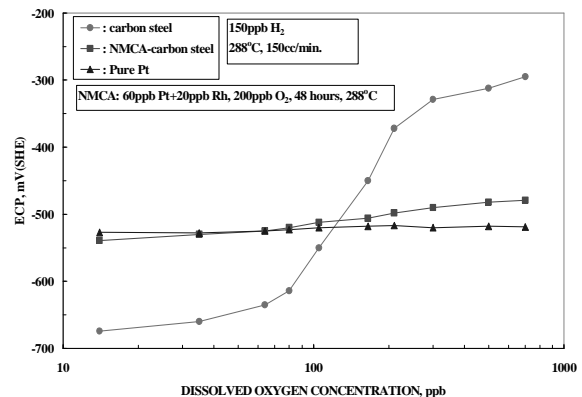


Figure 1: ECP of carbon steel, Pt/Rh-doped carbon steel and pure Pt in 288°C water containing 150 ppb  $H_2$  as a function of oxygen concentration

Figure 2: Effect of Pt/Rh addition on weight loss of carbon steel as a function of immersion time in 288°C water containing 150 ppb  $H_2$  and 30 ppb  $O_2$ .



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