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Characteristics of scalloped appearance and oxide layer and their relation to FAC rate of carbon steel piping elbow used in fossil power plant

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ABSTRACT

Scallop patterns and horseshoe-shaped pits are widely recognized as a typical morphology on the corroded surface by high flow-accelerated corrosion (FAC) rate in single-phase flow [1,2]. Although turbulence flow condition could be closely related to scalloped appearance, the detailed process of scallop development is not fully known. The oxide layer present on the corroded surface under FAC condition is normally very thin (less than 1 μm), and the oxide layer thickness varies inversely with FAC rate [2,3]. However, a role of oxide layer on FAC process is not fully understood. In this study, systematic and quantitative characterization of scalloped appearance (scallop size, depth, and density) and oxide layer (nano-void structure, thickness, and compositional profile) on the corroded surface of the carbon steel piping elbow used in fossil power plant have been carried out. The relationship between above characteristics and FAC rate has been also discussed. The dorsal side of the piping elbow with very fine scallops showed maximum FAC rate. On the other hand, the ventral side of that with smooth surface showed no FAC. The FAC rate lineally decreased from the center of dorsal (0-degree) to ventral side (180-degree), while the scallop patterns disappeared completely at the 70-degree part which showed approximately half of the maximum FAC rate. It has been notable that there was no significant increase of the FAC rate by scallops formation although the local turbulence was increased by hydrodynamic effect due to scallop surface. The relationship among scallop size, depth, and density obtained in this study indicated that the occurrence of overlapping horse-shoe shaped pits that give a scalloped appearance [2]. The surface morphologies under FAC condition is considered to be essentially depend on the nucleation density of pits. Nanometer-scaled thin porous oxide layer was formed on both dorsal and ventral sides, and there was no significant difference in nano-void structure, thickness, and crystalline structure obtained by transmission electron microscope characterizations despite a big difference in the FAC rate. Since no Cr enrichment was observed in the oxide layers formed on both dorsal and ventral sides, FAC suppression by Cr content of carbon steels could be negligible in this condition.

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