Key role of gradient-nanostructure and extremely thin amorphous passive film on tribocorrosion behavior of a novel Cr+N alloyed high-Mn austenitic steel

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Abstract High manganese steel is influenced by the combined effects of corrosion and wear during service under specific conditions, resulting in components with shortened service life. As a new type of railway steel, newly developed Cr+N alloyed austenitic high manganese steel (Mn18Cr7C0.6N0.2 steel) has shown promising results under harsh service environments. Herein, the tribocorrosion behaviors of Mn18Cr7C0.6N0.2 and Mn13C1.1 steel (the traditional high manganese steel) in artificial acid rain were studied using electrochemical methods, field emission scanning electron microscope (FE-SEM), focused ion beam scanning electron microscopy (FIB-SEM), scanning transmission electron microscopy-energy dispersive X-ray spectroscopy (STEM-EDS), and high resolution transmission electron microscopy (HR-TEM). The results showed the formation of passive film and gradient-nanostructure on surfaces of both test steels during tribocorrosion. A dense and tightly adhering amorphous passive film was formed on Mn18Cr7C0.6N0.2 steel surface with a superior blocking effect toward invasive ions. The high strain resistance and plasticity of the Mn18Cr7C0.6N0.2 steel resulted in an intact gradient-nanostructure, suitable for obtaining good surface hardness and maintaining the toughness of the matrix, contribute to providing high wear resistance. By contrast, the oxide film on the Mn13C1.1 steel surface comprised crystal α-FeOOH. Vortex cracks formed in its gradient structure due to strain localization. Meanwhile, the relatively poor corrosion protection ability and vortex cracks of its gradient-nanostructure prevented it from maintaining interface integrity of the gradient nanostructure, resulting in inferior tribocorrosion resistance. In artificial acid rain, the new type of Cr+N alloyed Mn18Cr7C0.6N0.2 steel exhibited higher tribocorrosion resistance than traditional high manganese steel, promising for use as an excellent wear-resistant material under corrosive environments.