Effect of spheroidization of cementite and micro-alloying on improving the corrosion resistance of ferrite-pearlite steel

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Abstract

Carbon steels are the earliest, the largest amount and the most widely used basic material in modern industry. The proportion of carbon steel in the total steel output is about 80%. It is widely used in construction, bridge, railway, vehicle, ship, petroleum chemical industry, marine development and various mechanical manufacturing industries. While increasing the production of low alloy high strength steel and alloy steel, the industrial countries in the world pay great attention to improving the quality of carbon steel, expanding the variety and application range. Among them, improving the corrosion resistance of carbon steel is one of the important research contents in improving the quality of carbon steel.

Ferrite + pearlite phases is the most common microstructure of carbon steel, in which pearlite with a typical lamellar structure consisting of alternating layers of ferrite and cementite (Fe_3C) plays an important role in the mechanical properties of steel. However, the electrical contact between Fe_3C phase as the cathode and ferrite phase as the anode in electrolyte solution can cause the galvanic corrosion, which will promote the deterioration of the corrosion resistance of ferrite-pearlite steel. It is believed that the corrosion resistance of ferrite-pearlite steel can be effectively improved by adjusting its microstructure and micro-alloying.

The current study focused on improving the corrosion resistance of ferrite-pearlite steels in an acid solution simulating the COT bottom plate environmental by means of cementite spheroidization and alloying with Cu, Sn and Mo to reduce the galvanic effect between cementite and ferrite phases. Two processes of cyclic spheroidizing annealing and quench + high temperature tempering were adopted to realize cementite spheroidization. Immersion test, X-ray diffraction, micro morphology observation, potentio-dynamic polarization, open circuit potential monitoring and electrochemical impedance spectroscopy was utilized. The results show that: 1, with extending the immersion time, the preferential dissolution of the exposed ferrite resulted in a lot of lamellar cementite accumulation on the unspheroidized carbon steel surface, which enhanced the galvanic effect and hence accelerated the corrosion. The promoted anodic dissolution of ferrite phases was controlled by charge transfer process, while the hydrogen evolution reduction occurred on cementite was controlled by the diffusion process. 2, spheroidization and dispersion of cementite can effectively reduce the corrosion acceleration caused by the galvanic effect between ferrite and cementite phases. This can be attributed to the looseness and separation of the spheroidized cementite with the dissolution of the surrounding ferrite, which prevents the increase of the area fraction of cathode to anode. 3, alloying with Cu, Sn and Sn-Mo in the ferrite-pearlite steel can also effectively reduce the corrosion acceleration caused by the galvanic effect between ferrite and cementite phases. Cu precipitates as the nano-sized particles on the steel surface after immersion test, which reduces the galvanic effect between the ferrite and cementite phases. Besides, Sn and Mo should exist as the elementary substance and were uniformly distributed on the steel surface, which can also retard the galvanic corrosion between the ferrite and cementite phases. 4, the spherical dispersion treatment of cementite combining with Cu alloying can further reduce the corrosion acceleration caused by the galvanic effect between ferrite and cementite.