Al-hot Dipping Followed by High-Temperature Corrosion of Carbon Steels in Air and Ar-0.2%SO_2 Gas

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초 록: Al-rich coatings were prepared on hot rolled low carbon steel by hot dipping method in molten Al-bath to investigate the corrosion resistance with the possible outcomes and defects of aluminized coatings in air and Ar-0.2%SO_2 mixed gases. Coating microstructure was composed of an inner Al-Fe intermetallic layer and outer Al-rich layer. Aluminum oxidized preferentially to the thin, outer, protective α-Al_2O_3 layer, without forming the nonprotective iron/sulfur-oxide layer after heating at 800°C for 20h, in both the gases and provided the resistance against corrosion.

1. 서론

Hot rolled mild-steel is the most common and quite good steel for industrial applications due to lower cost than high alloy steels, but destructive at elevated temperature corrosion environments containing oxygen and/or sulfur. Steel sheets are exposed to high temperature oxidative environments during the process of hot-rolling, and also during operation industrially these steels are heavily oxidized by oxygen in open air and/or are sulfur corroded in the power plants, refineries and in the combustion gases. Generally, sulfidation rates are 10-100 times faster than oxidation rates because sulfides have much larger defect concentrations, and have lower melting points than the corresponding oxides. Al hot-dipping is the greatest of various coating techniques to better the corrosion resistance of low-carbon-steels, where enriched Al surface is formed on the surface of the treated steel from an aluminum molten bath. Dense, continuous and protective Al_2O_3 layer covers the steel surface after exposure at elevated temperatures. The interface between the matrix and the intermetallic layer appeared tongue-like morphology in most cases, and the intermetallic-layer mainly consisted of Fe_2Al_5. Due to high-aluminum content(49-59wt%), the surface layer of the Fe-Al intermetallics hasextremely good-resistance to wear and thermal erosion at temperatures between 450°C and 980°C. In this study, low carbon steel was aluminized by Al-hot dipping method, oxidized in air and sulfurized in Ar-0.2%SO_2 mixed gases at 800°C for 20h. The effect of Al-hot dipping was discussed and results of the oxidation and Ar-0.2%SO_2 mixed gases were compared.

2. 본론

For Al-hot dipping samples were machined ($80\times30\times3mm^3$) from the plates, cleaned and were immersed in 10vol%HCl solution to remove surface oxide sandwashed with 20vol.%KCl+AlF_3(in4:1weightratio) solutionin water. After drying, they were put in pure Al-molten bath salt 800°C for 10min, on to pof which a solid-flux(KCl+NaCl+AlF3in2:2:1weight ratio)was spread to protect the molten baths from oxidation, cooled to ambient temperature in air and were further cleaned using 5vol% HNO_3 solution to remove any flux adhered on the aluminized surface. Hot-dipped substrates were further cut into small rectangular shaped coupons with the dimensions of 5mm×10mm×5mm, followed by heat treatment for the microstructural analysis. The specimens were corroded in mixed Ar(99.9999%pure) and SO_2 gas(99.99%pure) in side a closed quartzre action tube. Sulfur has major effect to corrode the specimens; oxygen also played a role for oxidizing the specimen has a result of O_2 from SO_2 gases. Morphology of the hot dipped and subsequently heat treated specimens was studied using SEM equipped with an energy-dispersive spectroscope(EDS).

3. 결론

Fig. 1 shows the SEM/EDS results of low carbon steel after dipping in molten Al-bath. Cross-sectional microstructure (Fig. 1(a)) shows a uniform crack free surface with three well defined layers, the first one at outer side a thin Al top coat (around 38 μm thick), the second one in the mid thick hot-dipped intermetallic layer (around 240 μm thick) and Al free steel substrate in the bottom. Absence of any void and crack shows the good adhesion property of aluminum over base alloy. However, the intersection between the matrix and the alloy layer was highly variable showing tongue like peaks orientated towards the matrix. This tongue-like morphology originated from the preferential growth of Fe_2Al_5 along the diffusion direction. Due to it sorthorhombic crystal structure with 30% of voids along the c-axis, diffusion occurs rapidly in Fe_2Al_5. Reason for this tongue-like morphology for mation was attributed towards the inward diffusion of Althrough Fe_2Al_5 to the Fe_2Al_5/steel reaction fron t or the outward diffusion of Fe from the substrate through the Fe_2Al_5/steel reaction front in to the Fe_2Al_5 phase, or the combination of these two reasons. Another possible reason maybe the atomic size mis match between Al(a to micradius;0.143nm) and Fe(atomic radius;0.126nm). The element all composition(Fig.1(b)) at spot ① suggests that top coat consist of similar composition like that of molten aluminum bath with minor iron dissolved in it, at spot ② it was suggested that Al_5Fe_2[5] phase was formed and the spot ③was pure