Effect of Temperature on Corrosion Behavior of AISI 304 Stainless Steel with Magnesium Carbonate Deposit

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Abstract: *The effect of temperature on corrosion behavior of AISI 304 stainless steel was investigated in the presence of magnesium carbonate ($MgCO_3$) salt at 900°C, 950°C and 1000°C for 24–120 h. The results indicated that the initial carbonate coating caused acceleration in oxidation, resulting in the formation of scales, followed by the decreased in oxidation rate due to evaluation of CO/CO_2 gas. The mass change of metal increased as the temperature and time exposure increased. The morphological structures of deposits were analyzed by using a scanning electron microscopy (SEM).*

Keywords: corrosion, austenitic stainless steel, deposit

1. INTRODUCTION

Austenitic stainless steel type AISI 304 is extensively and widely used in petrochemical, thermal power plants, boiler part, pressure vessel, etc. because of their improved corrosion resistance at ordinary temperatures and conditions. However, at high temperature and in oxidizing or hazardous atmosphere, the surface of the alloy is seriously attacked resulting in the formation of Cr_2O_3, NiO or Fe_2O_3 scales.[1–2] The molten carbonate are diffused to the electrolytic matrix, resulting the formation of porous NiO.[3]

The formation of alkaline scales strongly depends on temperature, pH, the rate of CO_2 release as well as the concentrations of carbonates ions.[4] Several works have been reported[5–6] on the studies of deposits on the AISI 304 alloy. However, the study on the carbonate deposit at high temperature is not yet reported. In this work, the corrosion behavior of commercial AISI 304 stainless steel with the presence of $MgCO_3$ deposit at temperature 900°C –1000°C for the period of 120 h was investigated.

2. EXPERIMENTAL

Specimens of 20 x 10 x 2 mm thickness were cut from sheets of AISI 304 (10.5% Ni, 20% Cr, 0.08% C, 2% Mn, 0.05% P, balance Fe) steel. The specimens were ground sequentially with 180, 320 and 600 grades of SiC

abrasive paper and cleaned with acetone. Each specimen was weighed and measured for the length, width and thickness.

The specimens were heated to about 100°C on a hot plate. An air gun was used to spray the saturated $MgCO_3$ aqueous solution in the air mist until a nearly uniform coating of the salt was obtained. The salt coupons were transferred into crucibles and dried in oven at 70°C for about 30 min, then cooled to room temperature and weighed. Oxidation kinetic studies were carried out in high temperature furnace at 900°C, 950°C and 1000°C for the duration of 24–120 h. Mass change was recorded at 24 h intervals throughout experiments. After the completion of oxidation, the specimens were taken out, cooled in a desiccators and weighed. Oxidized specimens were mounted, abraded and polished using SiC abrasive paper and diamond pastes of various grades, and then etched for SEM examination.

3. RESULTS AND DISCUSSION

The oxidation kinetics (mass change versus time) of AISI 304 coated with $MgCO_3$ for 120 h, oxidized at different temperatures of 900°C, 950°C and 1000°C are showed in Figure 1. The coated alloy oxidized at 900°C showed the mass gain up to 24 h followed by loss up to 48 h and there was an increased in mass gain up to 120 h. At 950°C, the alloy coated with $MgCO_3$ showed a gradual mass gain throughout the experiment period. At 1000°C, the coated alloy showed initial increased, followed by a decrease in mass loss up to 72 h. Then further increase in time has resulting an increased in mass.

The effect of temperature on the corrosion behavior of AISI 304 stainless steel with $MgCO_3$ deposit has been studied. The oxidation rates were found to be influenced by both of time of exposure and temperature. Deposit caused the

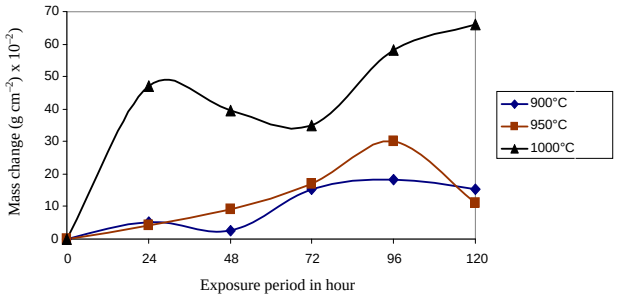
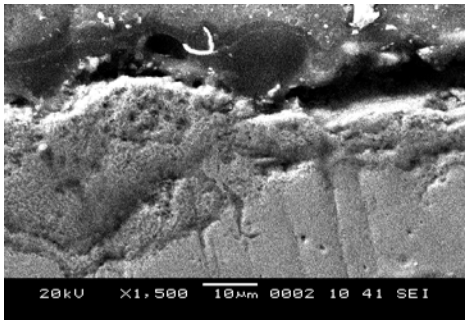


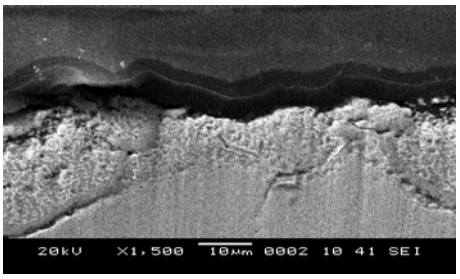
Figure 1: The change in mass with time (oxidation kinetic) curves of stainless steel AISI 304 coated with $MgCO_3$, oxidized at 900°C, 950°C and 1000°C.

formation of oxide layer on the metal surface, and mass of steel are changed with the increasing temperature.[4–6]

Figures 2(a), (b) and (c) show the SEM of $MgCO_3$ coated alloy. The layer of scales are thick, compact and adhered. At 900°C and 950°C, the spotted area indicated pitting corrosion and at 1000°C, stress cracking corrosion and badly deterioration were observed.



(a)



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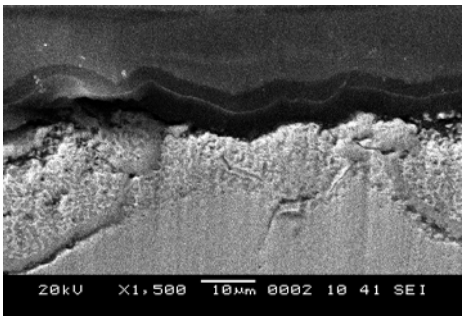

(c)

Figure 2: Scale morphologies of AISI 304 coated with $MgCO_3$, oxidized at (a) 900°C, (b) 950°C and (c) 1000°C for 72 h.

From the SEM micrographs analyses, the alloy coated with $MgCO_3$ that exposed at 1000 ^oC underwent a serious corrosion and exhibiting a crack on the alloy than that exposed at 900^oC and 950^oC. It is determined that temperature affect the corrosion rate other than time exposure and ionic salts. The carbonate salt have a deleterious effect on the scales and rapid decomposition of the alloy is noted.[7]

4. CONCLUSION

$MgCO_3$ coated stainless steel AISI 304 alloy appeared to have suffered mass loss; losses initially due to evolution of CO/CO_2 gases further increase of time and/or at higher temperature have enhanced mass gain due to deposits of metallic oxides as well as formation of fluxing products. At 1000^oC, the formation of oxide layer scale on the surface of alloys exhibiting the formation of Cr_2O_3, NiO and SiO_2.

5. ACKNOWLEDGMENT

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