HIGH TEMPERATURE CORROSION OF 310S AUSTENITIC STAINLESS STEEL IN CO_2/HCL ENVIRONMENT

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Abstract ─ High temperature corrosion of SUS 310S austenitic stainless steel was investigated comparatively in CO_2 and HCl/H2O environment at 900°C. The thickness of corrosion layer in case of CO_2 surrounding was thinner than HCl/H_2O environment because of protective chromium oxide layer formation. The corrosion layer of HCl/H_2O environment was porous and weak caused by water vapor leading to intergranular corrosion and intermetallic compounds (oxide, chloride, carbide)

Index Terms ─ High temperature corrosion, austenitic stainless steel.

I. INTRODUCTION

[1]High temperature corrosion is a form of corrosion that does not require any liquid-formed electrolyte reacts with corrosive material. There are many researches devotes to investigation high temperature corrosion because it is widespread in various application for example power generation, heat treating industry, automotive, aerospace, defense etc. [2]Goutier et al studied oxidation behavior of 304 austenitic stainless steel between 1193 K and 1293 K in CO_2 environment and found that the corrosion products were chromia at grain boundary, wustite on the surface, and chromite. [3]Shariff et al comparatively studied between dry and wet high temperature corrosion of 304 stainless steel in CO_2 and found that oxidation occurred instead of carburization due to decomposition of CO_2. Wet condition was more deteriorate than dry condition because of porous oxide scale.

In this study, the corrosion products after exposed to CO_2 and HCl/H_2O environment were comparatively characterized and approximately identified thickness of corrosion products as well.

II. EXPERIMENTAL SET UP

A. Materials

The selected austenitic stainless steel was SUS 310S grade containing high chromium and nickel contents. The material had been chemically analyzed by XRF technique and result was shown on table 1. The size of specimen was 15x15 millimeters and the thickness was 4 millimeters.

Table 1 Chemical composition of material

Element	C	Cr	Ni	Si	Mn	Fe
Quantity (%)	0.08	24.58	19.13	0.59	1.85	53.93

B. High temperature corrosive environment

The specimen was heated inside ceramic tube furnace. The temperature was gradually increased from ambient temperature to 900 degree Celsius with heating rate 6ºC/min and, then, held 13 hours before shut off furnace heater to decrease temperature to ambient again. The heating cycle was seen on Fig.1.

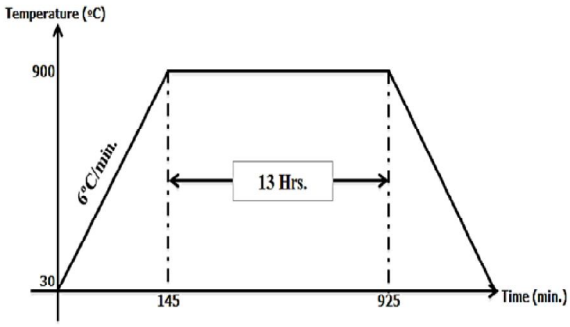


Fig.1 heating cycle

The atmosphere was prepared thermally into 2 cases. For the first case, CO_2 gas directly fed into heated furnace with 5 lite per minute feeding rate. The feeding time was 1 minute. The second case, HCl acid solution was prepared by mixing 12 moles concentrated HCl 200 mL with 800 mL of distilled water, boiled such solution, and fed the stream into furnace. The schematic of test apparatus was shown on Fig.2.

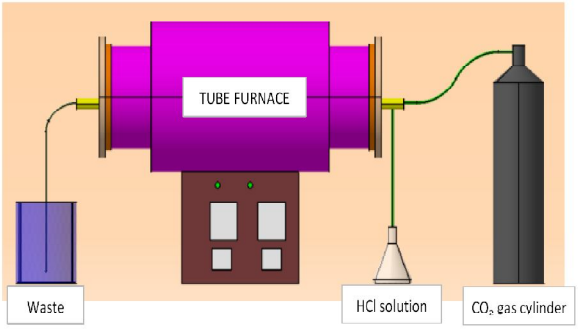


Fig.2 Schematic diagram of test apparatus

C. Characterization technique

The layer of corrosion product was analyzed by optical microscope to measure approximately corrosion layer thickness and survey appropriate area for corrosion product classification.

III. RESULT AND DISCUSSION

A. Surface investigation

The comparison of surface among three kinds of specimen was shown on Fig.3. The corroded specimens were covered with corrosion product and the colors of corrosion surface were differed depending on type of corrosion product. Fig.3b was covered with chromium oxide which was dense and not found any surface splitting aspect. In contrast with HCl/H2O condition, Fig.3c, the surface would envelop with 2 stacking film; base metal/rust/corrosion product. The outer surface separated out from rust layer because of differentiation in their thermal expansion coefficients.

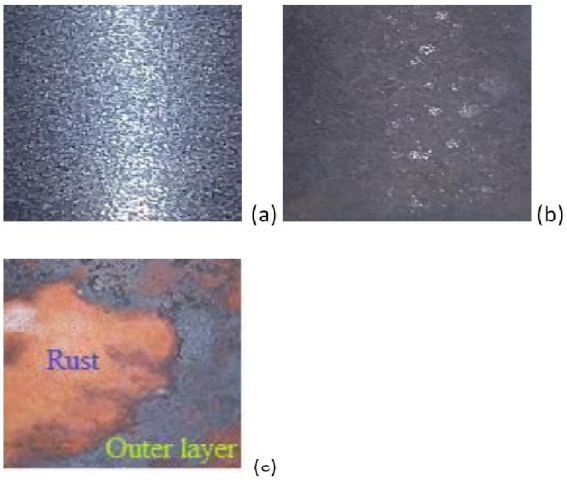


Fig.3 Surface comparison between (a) normal condition, (b) CO2 environment, and (c) HCl/H2O environment

B. Corrosion film microstructure

The microstructure of corrosion layers were investigated by optical microscope with 200 magnifications as shown on Fig.4. It was obviously that the layers of CO2 corrosion were laid on only surface of specimen in contrast with the layer of HCl/H2O corrosion. In CO2 corrosion case, at high temperature, the layer of Cr2O3 forms on specimen surface. This type of film is very dense and stable at high temperature especially SUS 310S which containing high chromium contents (~25%). Additionally, oxidizing agent cannot conveniently pass through Cr2O3 film to increase oxidation layer thickness. So that, the film of CO2 corrosion is thinner than HCl/H2O corrosion and they could be measured thickness approximately as shown on table 2.

For HCl/H2O case (Fig.4b) it developed stacks of corrosion film composing of chromium oxide, ferrous oxide, and chlorine compound. The stream effect which was mixed into corrosive environment deteriorates to stability of Cr_2O_3 film so that chloride ions and H_3O^+can react with base metal forming chloride and oxide compound on the surface respectively. Moreover, the chromium-depleted zone also was widely investigated because of chromium compound formation causing intergranular corrosion as shown on Fig.5.

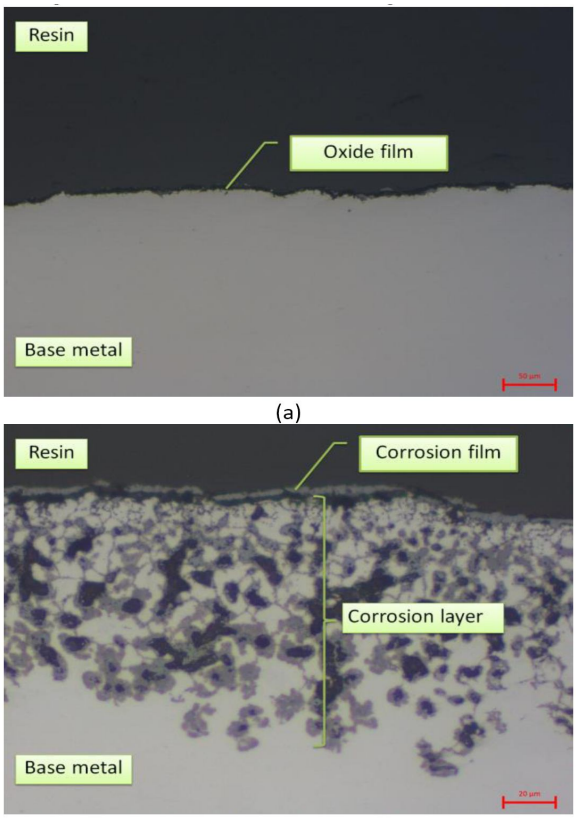


Fig.4 200x Microstructural investigation of corrosive film (a) CO_2 corrosion (b) HCl/H_2O corrosion

Table 2 Corrosion layer thickness

Corrosive Environment	CO_2	HCl/H_2O
Thickness (μm)	9.5	125

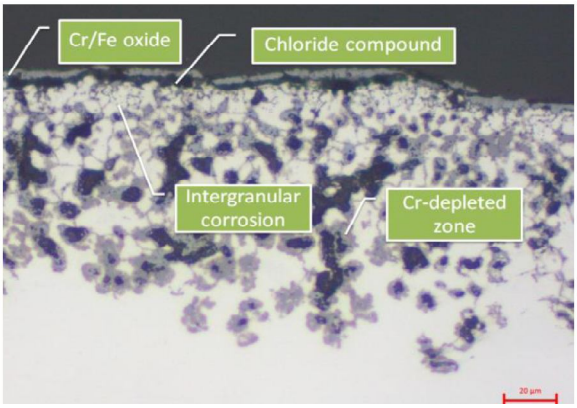


Fig.5 500x Microstructural investigation of HCl/H_2O specimen

CONCLUSION

SUS 310S austenitic stainless steel was controlled experimented with CO_2 and HCl/H_2O environment respectively in order to investigated corrosion behaviors. The result was concluded as following;

1. The surface of CO_2 corrosion was dramatically differed from HCl/H_2O corrosion because of corrosion product of CO_2 corrosion contained only chromium oxide but HCl/H_2O corrosion product existed more than chromium oxide.
2. The corrosion layer in case of CO_2 corrosion was thinner than HCl/H_2O corrosion because chromium oxide still protected specimen surface.
3. HCl/H_2O environment could deteriorate chromium oxide film leading to Cr-depleted zone and intergranular corrosion on austenitic stainless steel.

ACKNOWLEDGEMENT

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