

Characterization of high temperature corrosion scales on austenitic stainless steel

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Abstract— The high temperature corrosion scales were characterized and analyzed by SEM and XRD techniques. The AISI 310S austenitic stainless steel was tested in wet chloride containing environment at 900 degree Celsius within horizontal tube ceramic furnace. The scales were built up on stainless steel surface. The corrosion layers were partially separated from specimen surface. SEM/EDS is an efficient tool in order to microscopically investigate scale's microstructures and analyze chemical compositions. Then, types of corrosion scales were qualitatively identified by XRD. The results showed that the layers principally consisted of Fe and O because protective chromium oxide was destroyed by high temperature, wet condition and chloride environment. However, the split scale mainly composed of Haematite and $Fe_{21}O_{32}$ which are the oxygen rich ferrous oxides.

Index Terms—High temperature corrosion, Austenitic stainless steel, XRD.

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 extensively occurred in several industries for example power generation, heat treating industry, automotive, aerospace, defense etc.

The oxidation behavior of austenitic stainless steel has been extensively observed more than a decades. [2] 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, Wüstite on the surface, and chromite. [3] 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. [4] comparative investigation between 304 austenitic grade and 430 ferritic grade were analyzed at temperature more than $1,000^\circ C$ and concluded that the main crystalline phases found in the oxidized materials were hematite and magnetite for 430 steel, and hematite and a spinel-like phase for 304 steel. Hematite was found to be the dominant oxide at lower temperatures, whereas magnetite preferentially forms at higher temperatures. 304 steel is less sensitive to oxidize at high temperatures because the activation energy for oxidation is smaller for 430 steel. In case of chloride induced corrosion, researcher also devotes to investigate such problems. [5] reviewed and summarized the effect of chloride corrosion that chloride under some

conditions may cause accelerated corrosion resulting in increased oxidation, metal wastage, internal attack, void formations, and loose non-adherent scales. The corrosion can be severe in air, but can be further enhanced by SO_2 , which may cause intra-deposit sulfation of alkali chlorides releasing $HCl(g)$ or $Cl_2(g)$ close to the metal surface. Furthermore, alkali chlorides may react with the metal scale or with chromium carbide to form gaseous HCl or Cl_2 close to the metal. In case the metal temperature becomes high enough for the deposit to form molten phases, the corrosion may be further enhanced. Small concentrations of alkali chlorides may increase the corrosion rate caused by molten sulfates in the case of co-combustion of straw and coal.

In this study, the corrosion products after exposed to wet chloride environment were characterized by SEM/EDS and XED techniques.

II. MATERIAL AND CORROSION TESTING

A. Material

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

TABLE I: CHEMICAL COMPOSITION OF AISI 310S

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

B. High temperature corrosion testing

The specimen was heated inside ceramic tube furnace as shown on Fig.1. The temperature was gradually increased from ambient temperature to 900 degree Celsius with heating rate $6^\circ C/min$ and, then, held 13 hours before shutting off furnace heater to decrease temperature to ambient again. The heating cycle was seen on Fig.2.

The environment 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.