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Investigations on high temperature corrosion of wire enameling oven

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ABSTRACT

The oven belonging to a wire enameling plant was heavily oxidized resulting in the contamination of the final product. The heating chamber of the oven therefore had to be removed prematurely from service and was replaced by a new one. Investigation carried out showed high phosphorous contents in the oxide scale of service exposed AISI 321. Service exposed AISI 321 subjected to the oxidation test in laboratory did not show phosphorous in the oxide scales. The phosphorous presence obstructed the chromia layer from protecting the underlying surface. Formation of coarse chromium carbide and sigma phase in the stainless steel was observed within a short exposure time. This reduced the chromium content below the critical limit required for protective chromia formation. These were the possible reasons of early service failure of the oven.

1. Introduction

Austenitic stainless steels having chromium more than 18% are generally considered for use in high temperature service [1]. The resistance to high temperature of stainless steels primarily arises from the formation of protective chromia (Cr_2O_3) which protects the underlying metal from further oxidation. The Cr_2O_3 is thermodynamically more stable than the iron oxide; also chromium gets preferentially oxidized. The integrity such as adherence and protective nature of chromia, however, depends on several process variables such as chloride (Cl^-), sulfur (S), temperature, and pressure [2]. Additionally, the frequent thermal cycling, start–shutdown during operation significantly affects the stability of the Cr_2O_3. At temperatures beyond 950 °C, chromia scale is not protective due to its dissociation into chromium trioxide (CrO_3) which provide diffusion path for other constituent elements [3]. Excursion in operating temperature beyond 950 °C may therefore cause the damage of Cr_2O_3 layer and result in accelerated oxidation.

Wire enameling plant uses stainless steel for fabrication of oven where polymerization of enamel coating occurs at temperatures up to 750 °C. An oven belonging to a wire enameling plant had reportedly suffered from heavy oxide spalling and resulted into contamination of the final product. The process was used to coat enamel on copper wires for insulation and therefore the quality of insulation and aesthetics were important parameters. Extent of oxide formation and spalling was exceedingly high and a section of oven had to replace with a new one only after 2 months of operation. The present paper reports investigation carried out on such unexpected heavy oxidation of the oven and the root cause of degradation.

2. Technical background

The enameling plant consists of different sections namely, wire drawing, annealing, enamel coating, pre-heater, and enameling oven. The latter contained an evaporation/polymerization chamber and a heater chamber. The schematic of

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