15th North American Waste to Energy Conference
May May 21-23, 2007, Miami, Florida USA
NAWTEC15-3220

High Temperature Corrosion Resistance of Different Commercial Alloys Under Various Corrosive Environments

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ABSTRACT

High temperature corrosion is a major operating problem because it results in unscheduled shutdowns in Waste-to-Energy (WTE) plants and accounts for a significant fraction of the total operating cost of WTE plants. Due to the heterogeneous nature of municipal solid waste (MSW) fuel and the presence of aggressive elements such as sulfur and chlorine, WTE plants have higher corrosion rates than coal-fired power plants which operate at higher temperature. To reduce corrosion rates while maximizing the heat recovery efficiency has long been a critical task for WTE operators.

Past researchers focused on high temperature corrosion mechanisms and have identified important factors which affect the corrosion rate [1-4]. Also, there have been many laboratory tests seeking to classify the effects of these corrosion factors. However, many tests were performed under isothermal conditions where temperatures of flue gas and metal surface were the same and did not incorporate the synergistic effect of the thermal gradient between environment (flue gas) and metal surface. This paper presents a corrosion resistance test using an apparatus that can maintain a well controlled thermal gradient between the environment and the surface of the metals tested for corrosion resistance. Two commercial substrates (steels SA213-T11 and NSSER-4) were tested under different corrosive environments. The post-test investigation consisted of mass loss measurement of tested coupons, observation of cross-sectional morphology by scanning electron microscopy (SEM), and elemental analysis of corrosion products by energy dispersive spectrometry (EDS).

The stainless steel NSSER-4 showed good corrosion resistance within the metal temperature range of 500 ^{0}C to 630 ^{0}C. The alloy steel SA213-T11 had an acceptable corrosion resistance at metal temperatures up to 540 ^{0}C, and the performance decreased dramatically at higher temperatures.

INTRODUCTION

High temperature corrosion mechanisms on waterwall and superheater in Waste-to-Energy (WTE) plants have been investigated extensively in laboratory and field tests. Many factors such as flue gas composition, operating gas and metal temperature, fluctuations of flue gas temperature, thermal gradient between flue gas and metal surface, and characteristics of molten salts deposits are all considered to be crucial factor for high temperature corrosion.

Work done previously has been done mostly to compare and evaluate the corrosion tendencies of materials by controlling one of the corrosion factors mentioned above [5-7]. However, these tests may not be adequate for forecasting long term and synergistic effects of these corrosion factors on the tube life. Especially, some dynamic factors, such as fluctuations in the flue gas temperature and thermal gradient between the gas and metal surface, which are difficult to be reproduced and controlled in laboratory tests have been found to be accountable for the breakdown of the protective oxide scales on metal surface and attendant increased corrosion [8]. Also, the thermal gradient between the gas and metal surface has been observed to strongly influence the deposition behaviors and rates of molten salts that contain corrosive compounds from WTE combustion [1].

In order to elucidate the synergistic effects of these corrosion factors, the authors developed an apparatus which can maintain a thermal gradient between a representative WTE combustion gas and tested samples that are maintained at representative waterwall and superheater temperatures. In this