Influence of High Temperatures and Off-Design Operating Conditions on the Degradation of Grate Blocks in a Refuse-Derived Fuel (RDF) Boiler

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Grate blocks in a Refuse-Derived Fuel (RDF) boiler, designed for a five-year service life, experienced catastrophic failure after just one year of operation. The components, made of a heat-resistant cast steel, were intended to operate within a temperature range of 215°C to 280°C. However, post-mortem analysis revealed that localized temperatures significantly exceeded these design limits, accelerating material degradation. This study investigates the failure mechanisms of these critical components within Thailand's waste-to-energy infrastructure.

A comprehensive suite of analytical techniques was employed to identify the root causes of the premature failure. These included macroscopic visual inspection, chemical composition analysis, scanning electron microscopy (SEM) with energy-dispersive spectroscopy (EDS), X-ray diffraction (XRD) for phase identification of the oxide scale, and micro-hardness profiling.

The primary failure mechanism was identified as severe high-temperature oxidation exacerbated by chlorine-induced corrosion. Prolonged exposure to temperatures well above the design range led to the formation of a thick, brittle oxide scale. This scale repeatedly spalled, causing a continuous loss of material. The presence of chlorine from the RDF further intensified this degradation by disrupting the protective oxide layer and promoting highly aggressive corrosion. This synergistic effect between thermal stress and a corrosive environment resulted in the premature and catastrophic failure of the components.

The findings demonstrate the critical effect of off-design operating conditions on the long-term durability of heat-resistant alloys in waste-to-energy applications. The results provide valuable insights for improving material selection, design, and operational control to enhance the reliability and service life of RDF boiler systems.

Micrograph of a degraded grate block surface, showing the effects of high-temperature exposure and chlorine-induced corrosion. This dual-mechanism attack disrupts the protective oxide layer, leading to its repeated spalling and a continuous reduction in component thickness.