

A UNIFIED VIEW OF DEPOSIT-INDUCED CORROSION

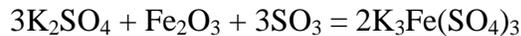
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Extended Abstract:

Deposit-induced corrosion has been studied for many years in a variety of applications. These include *Fireside Corrosion* of ferritic steels in coal-fired boilers and *Hot Corrosion* of gas turbine blades and vanes. Fireside corrosion is an accelerated form of corrosion induced by deposits, which form from impurities in coal, with maximum rates at temperatures near 700°C. The deposits are complex and contain a variety of oxides and sulfates. It has been presumed that alkali iron trisulfates are the main contributor to fireside corrosion [1]. Alkali iron trisulfates form from reactions of alkali sulfates and iron oxides with SO₃ from the gas, e.g.



These compounds have low melting points and are often detected in post exposure analysis of deposits and have, thus been presumed to result in the degradation of otherwise protective oxides. However, a clear mechanism has never been developed.

Hot corrosion is caused primarily by alkali sulfates and tends to be catalogued as *Type I* and *Type II* hot corrosion. Type I Hot Corrosion is presumed to occur at temperatures near 900°C and occurs by the well-understood mechanisms of “basic fluxing” and “sulfidation”, as well as “alloy-induced acidic fluxing” if the alloy contains refractory metals [2]. Type II Hot Corrosion occurs near 700°C and has been postulated to occur by rapid removal of the base metal elements (Co and/or Ni) through a liquid sulfate mixture, which is stabilized by SO₃ from the gas phase [3]. As the operating temperatures of gas turbines have been increased, turbine disk temperatures have also risen into the 700°C range and accelerated corrosion of disks has been reported. The deposits in gas turbines are not always simple sulfates but may contain oxides in addition

to or in place of the sulfates. The oxides can have substantial influence on the corrosion processes.

The various forms of corrosion are generally assumed to occur by substantially different mechanisms. However, recent work at the University of Pittsburgh suggests there is significant commonality among the various forms of deposit-induced corrosion processes.

This presentation will begin with a review of the basic principles of deposit-induced corrosion, which have largely been derived from results on Type I Hot Corrosion [2]. Then a comparison of five forms of corrosion (*Type I Hot Corrosion, Type II Hot Corrosion, Disk Corrosion, Oxide-induced Corrosion and Fireside Corrosion*) of a group of model- and commercial-alloys, both chromia- and alumina-formers will be presented. The effects of alloy composition, deposit composition, gas composition and temperature on the kinetics and mechanisms of corrosion will be described. An attempt will be made to describe the features, which are common to the various modes of degradation and those, which are different. Finally, mechanisms for Type II Hot Corrosion and Fireside Corrosion, which are significantly different from those, which are generally presumed to operate, will be proposed.

References

1. REID, W.T., *External Corrosion and Deposits: Boilers and Gas Turbines*. 1971, New York: American Elsevier Publishing Company, Inc.
2. PETTIT, F.S., *Oxidation of Metals*, **76**, 1 (2011).
3. LUTHRA, K. L., *Metallurgical Transactions A*, **13A**, 1982 (1853)

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