Future Directions for High-Temperature Oxidation and Corrosion Research

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Abstract

The first paper on high temperature oxidation is generally regarded as that published by Tammann, in 1920. However, papers written by Pilling and Bedworth in 1922 and 1923 make it clear that studies had already been in progress for a few years; the motivation for this had been the increase in the need for materials capable of performing structural functions at elevated temperatures in aggressive environments. This has continued to be the driver for the interest ever since. In several branches of engineering the need for ever higher temperatures has been a thread which has been evident long before the beginning of the 20th century: ceramics, glass-making, metal extraction, metal forming, heat-treating, and so forth have been materials processes pacing the development of civilization for at least three thousand years. However, in early processes, the high-temperature environment was contained within a thermally insulated vessel, and the only components which had to perform any mechanical function were crucibles and supports.

The industrial revolution resulted in the development of machines to do work of various kinds; and the motive power began to require what are now called heat engines. These involved components which had to perform more advanced and dynamic mechanical functions – shafts, pistons, exhaust valves, and so forth. The appearance of steam turbines, internal combustion engines, gas turbines and so forth at the end of the nineteenth century demanded a different class of structural materials; and the appearance of the airplane also required light weight and improved thermal efficiency. The 20th century has seen a continuous progress in the development in the temperatures that can be attained in working machines; it has also seen a progressive demand in the severity of the environment to which the high-temperature mechanical components are exposed. Oxidation, and what is often called high-temperature corrosion (to describe the reactions in the more complicated environments) has been one of the factors determining the progress; others include creep resistance, aging processes in the materials, embrittlement, and so forth.

The problem to be addressed is therefore defined by the application, and thus research in this area is in a real sense applied research. However, although much of the earlier research was empirical in nature, basic research to understand the underlying mechanisms of the degradation processes of complex materials in complex environments over very long times has also been in progress since the earliest days of our subject.

Future developments of research in high-temperature oxidation and corrosion will therefore continue to look at the issues in ever-more demanding engineering requirements, and it is clear that empiricism will not be able to match the rate of progress required. At the same time, the experimental techniques capable of studying the underlying processes, and the theoretical and quantitative techniques needed to model the multidimensional issues have been developing rapidly. Currently, there is a significant lag between the research directions presently being followed, and those that are required for the new requirements.

This paper will describe techniques that will identify the longer-range goals that must be reached, and the research directions – both fundamental and developmental – that will be required, and the planning tools that will be needed to ensure an optimum plan.