Sulphidation

Technical White Paper

SureScreen Scientifics

Description

Sometimes referred to as Hot Corrosion, sulphidation is the rapid oxidation of a material due to the deposition of molten salts, often in the form of sodium sulphate that can occur in components in the hot gas path of gas turbine engines.

Mechanism and Appearance

Sulphidation is generated by the combination of sulphur from fuel, and sodium chloride in the ingested air. During combustion, sulphur and water vapour chemically react with the oxides on the metal surface at high temperatures which then produces deterioration of that surface by the production of sulphuric acid and then sodium sulphate. There are two types of sulphidation;

Type 1 characterised by thick and porous layers of oxide with the underlying matrix depleted of chromium, and typically occurs in the metal temperature range of 850-950°C

Type 2 characterised by pitting with no underlying depletion of the matrix, and occurs at lower temperatures of 650-700°C

There are four main stages of Type 1 sulphidation. The first stage is where the surface has undergone light attack resulting in a minor increase in the surface roughness, but the mechanical integrity of the component remains unaffected. The second stage is manifest by increasing surface degradation that is more visible to the unaided eye. Stage three is where there is a build-up of scale and the mechanical integrity of the component is compromised. Stage four would be considered to be the failure of the component with severe material loss such as the penetration of thin-walled sections. Ideally, inspection regimes should be carried out at a periodicity to ensure degrading components are identified and replaced at or before stage three.

Avoidance

The operating environment that leads to sulphidation may be unavoidable, due to the composition of fuels and the air used for combustion processes, so to avoid this degradation mechanism, the material may require protection by the application of coatings e.g. diffused platinum aluminide, and silica.

Alternatively, changes to the material may be considered although there are limitations on what grades can be used. An alloy with a high chromium content is generally required for resistance to Type 1 corrosion but there has been a trend for higher strength alloys that inherently have a lower chromium level, but this then renders such alloys more prone to sulphidation e.g. materials with chromium levels less than 15% are considered to be very susceptible. There is then a balance to be struck between high temperature strength and hot corrosion resistance. Materials such as Alloys 738 and 939 are an example of such materials.

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