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The influence of trace elements on the creep and stress-rupture properties of Nimonic 105*

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The influence of certain trace elements, namely Pb, Sn, Te, Se and Tl, on the creep and stress-rupture properties of Nimonic 105 was investigated at 815 °C. The work was supported by the Ministry of Defence, and was planned in close collaboration with Rolls-Royce, who advised, in particular, on the trace elements to be studied and the levels at which harmful effects on creep performance might be expected. The results obtained have confirmed that, with the exception of Sn, all the elements reduce the life to rupture and the ductility at failure when present in sufficient amount. The most deleterious impurities were Te and Pb.

Stress-rupture testing with notched specimens gave a generally more sensitive indication of the presence of harmful amounts of impurity than did tests with plain specimens.

Metallographic studies, with the optical microscope, of creep specimens that had fractured or been taken from tests interrupted before fracture showed that when deleterious amounts of impurity were present, intergranular cavitation began early in the creep life of the material but cavities were only found during tertiary creep in specimens substantially free of these impurities. In addition, the rate of accumulation of cavitation damage with creep strain was much greater when harmful levels of impurity were present. Consequently, the density of cavitation in fractured specimens was considerably increased by the presence of impurity and the elongation at rupture was correspondingly lower.

Auger electron spectroscopy was used to examine the fracture surfaces of a specimen prepared from a test-piece fractured in creep after 1200 h at 815 °C and 232 MPa and which contained 34 μg/g of lead. Augergraphs showed that about one monolayer of lead was present on areas of the fracture shown by scanning electron microscopy to be cavitated.

It is known that the segregation of an impurity to an interface can reduce the surface energy, γ_s, and this effect would be expected to increase the amount of cavitation during creep since the radius, r, of a stable cavity is related to γ_s by $r = 2\gamma_s/\sigma$, where σ is the applied stress. Consequently, smaller cavities will be stable when the alloy contains an impurity that reduces the surface energy and the evidence obtained is consistent with a mechanism of this type in that the amount of cavitation increased significantly when Pb or Te were present. In particular, Pb can be shown to be a highly surface active impurity in this alloy, comparable with bismuth in copper.

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