STRUCTURAL INSTABILITIES OF HIGH TEMPERATURE ALLOYS AND THEIR USE IN ADVANCED HIGH TEMPERATURE GAS COOLED REACTORS

(Abstract)

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High temperature, iron-nickel and nickel based alloys are the candidate heat exchanger materials for advanced high temperature gas-cooled reactors supplying process heat for coal gasification, where operation temperatures can reach 850 - 950 °C and service lives of more than 100 000 h are necessary.

The high operating temperatures and long service lives coupled with the required fabricability to produce thin-walled tubes favour the application of wrought alloys which rely on solid solution hardening for their mechanical strength. However, even in these alloys, structural changes occur during exposure under service conditions, which may have a significant effect on the high temperature deformation behaviour of the alloys.

In the present paper, typical examples of structural changes which occur in two representative alloys (Alloy 800 H, Fe-32Ni-20Cr and Alloy 617, Ni-22Cr-12Co-9Mo-1Al) during high temperature exposure will be given and the effects on the creep rupture properties discussed.

At service temperatures, precipitation of carbides occurs which has a significant effect on the creep behaviour, especially in the early stages of creep when the precipitate particles are very fine. During coarsening of the carbides, carbides at grain boundaries restrict grain boundary sliding which retards the development of creep damage. In the service environments, enhanced carbide precipitation may occur due to the ingress of carbon from the environment (carburization). Although the creep rate is not adversely affected, the ductility of the carburized material at low and intermediate temperatures is very low.

During simulated service exposures, the formation of surface corrosion scales, the precipitation of carbides and the formation of internal oxides below the surface leads to depletion of the matrix in the alloying elements involved in the corrosion processes. In thin-walled tubes the depletion of Cr due to Cr_2O_3 formation on the surface can lead to a loss of creep strength. An additional depletion effect resulting from environment-metal reactions is the loss of carbon (decarburization) which may occur in specific environments. The compositions of the cooling gases which decarburize the material have been determined; they are to be avoided during reactor operation.