STRAIN-AGEING IN ZIRCONIUM

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Summary

A quantitative study of the factors affecting deformation of zirconium and some of its alloys has been undertaken. Special attention was paid to the temperature range 200-350^{o}C, in which strain-ageing can occur.

Strain-ageing and work-hardening were studied as functions of grain size, solute content, ageing time, and testing temperature. The observed variations in the deformation parameters suggested that the important process during ageing is the introduction of obstacles which greatly increase the friction opposing movement of dislocations during subsequent straining. Strain-ageing tests could not be used to identify the nature of these obstacles, so the necessary information was obtained from stress-relaxation experiments. Analysis of the results of these experiments indicated that, during strain-ageing, a significant rise occurs in that component of the flow stress attributable to long-range internal stresses.

To explain the strain-ageing and stress relaxation results, a mechanism was proposed in which, during ageing, a significant drop occurs in mobile dislocation density, as dislocations become immobilised in a cellular substructure which forms during stress relaxation.

Direct evidence for the existence of this mechanism has been produced by thin foil electron microscopy. A dislocation structure consisting of free dislocations with only a few loosely-defined tangles was produced by straining at 300°C, whilst strain-ageing at that temperature caused the dislocations to form into cellular arrays. Further straining and ageing treatments did not cause any change in the size of the cells, but produced a further reduction in the number of mobile dislocations, as a result of migration to already existing cell walls.

Specimens which had been strained and aged at 300°C exhibited serrated yielding when tested after cooling to room temperature. This behaviour has been shown to be caused by twinning.