In situ and post mortem TEM characterization of creep deformation micromechanisms in the AD730 superalloy: influence of the stress level and grain size.

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In the current aeronautic competitive context, there is a crucial issue to design new alloys for civil aeroengine application with reduced specific fuel consumption, better efficiency, with a reasonable cost. The nickel based superalloy AD 730^{TM} was also developed by Aubert & Duval for new turbine disks application. The disk superalloys are expected to experience severe using conditions combining tensile test, creep and fatigue tests at different temperatures. It is thus of major interest to identify the physical parameters, which control the mechanical properties at the microscopic scale, in order to contribute to the improvement of this class of alloys.

During the last decades, the mechanical behavior of nickel based polycrystalline superalloys has been extensively studied over a wide range of temperatures and mechanical tests, particularly in the case of Udimet, N18 or NR3. The results available on AD730^{TM} are still rare, especially at the microscopic scale, because of its recent development. However, regarding the previous results obtained in other similar polycrystalline superalloys, the creep mechanical properties in the case of AD730^{TM} is expected to depend on microstructural parameters such as the size and spatial distribution of grains, and the characteristics of hardening precipitates γ ' (size, distribution, chemistry). The aim of this paper is thus to present the TEM results obtained after creep tests at 700°C in the AD730^{TM} for different creep tests and different microstructural states. The effect of the grain size and the effect of the stress level will be focused.

In order to analyze the influence of the microstructural features on the creep behavior different heat treatments (which induce different microstructures: fine grains and coarse grains) were carried out. Conventional TEM experiments on crept samples as well as *in situ* TEM straining tests have been realized. The microstructure and the deformation mechanisms have been also characterized for the different microstructures. Theses observations have evidenced mechanisms involving perfect a/2 <110> type dislocations. Orowan bypassing was highlighted with the presence of loops around the precipitates whereas shearing process was evidenced by the presence of straight dislocations. Mechanisms involving partial dislocations as well as shearing with strong pair-coupling or weak pair-coupling have been observed. A quantitative analysis has been used to compare the experimental observations and the stress associated with each mechanisms. There is a good agreement between the expected dislocation mechanisms and the observed ones.

Else, in order to also analyze the effects of the stress on the creep behavior, creep tests at different stress levels were performed for the same microstructural state. The TEM observations associated with a quantitative analysis of the local stress, taking into account the Schmid factor, reveal that different slip systems are activated at the grain boundaries at high stress, whereas only one slip system is activated at low stress level.

A summary of all the TEM results associated with a quantitative approach will be presented. An interpretation of the differences in the macroscopic creep behavior based on the TEM analysis of the dislocations mechanisms will be proposed.