ESRF	**Experiment title: “In situ” study of the lattice parameter mismatch of the MC-NG new generation superalloy during a creep test at high temperature**	**Experiment number**: ME 20
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Report:

Due to their good mechanical properties at high temperature, Ni based superalloys are used to manufacture aircraft engine turbine blades. The improvement of the turbine performances goes through an increase of the gas temperature at the turbine entrance. For this aim, a superalloy of a new generation named MC-NG is currently under development at the ONERA. As the previous superalloys, it is a diphasic compound with ordered γ’ precipitates inside a FCC γ matrix. The creep characterisation of this new material shows a significant increase of the life duration before rupture compared to the superalloys of the previous generation (AM1, MC2). Furthermore the shape of the creep curves differs significantly from that of the previous generation. Preliminary studies by scanning electron microscopy (SEM) allow to correlate the creep characteristic to the microstructural evolution of the γ’ precipitates. Among the parameters which control this evolution, the lattice parameter mismatch between the γ and the γ’ phases is one of the most important. The aim of this study is to determine the evolution of the lattice parameter mismatch of this new superalloy, first as a function of the temperature and then as a function of time during a creep test in order to understand the microscopic mechanisms at the origin of the differences between the two generations of superalloys.

Using the Triple Crystal Diffractometer (TCD) installed on the high energy beamline ID15A which allows “in situ” bulk measurements, we measured during this experiment the evolution of the lattice parameter mismatch of four MC-NG samples. All of them have received the standard heat treatements which lead to a cuboïdal precipitate morphology with a cube edge of 0.45 μm. One was kept in this state and is considered as the reference sample. The others were submitted to creep test at 1050°C under 150 MPa during 20, 120 and 310 hours respectively. These durations correspond approximatively to the end of the first stage of the creep deformation curve, to the end of the second stage and the middle of the third stage. For the crept samples, the measurement was performed in parallel and perpendicularly to the rafts.

The aim of these measurements were first a comparison with similar measurements performed on the AM1 superalloy (1) in order to check the differences between these two alloys which could explain the better performance of the new superalloy. Then to find the best experimental conditions for the next “in situ” creep experiment. Indeed, as shown for the AM1 superalloy (2), it is mainly this type of measurements which allows to understand and to modelize the creep behaviour of the material.

The obtained results are not fully analysed. However, some conclusions can be reported now. First the behaviour of the reference sample exhibits similarities with that of the AM1 superalloy. In particular the misfit is slightly negative at room temperature and its absolute value increases with T. But the solutionizing of the γ’ phase occurs at higher temperature by about 50°C and its volume fraction remains larger at high temperature. The hardening phase presents a better structural stability in this temperature range. It is certainly one of the origin of the improved mechanical properties. On crept samples, as for AM1, different temperature evolutions of the misfit are found along the directions parallel and perpendicular to the rafts. There are some similarities with the measurements on AM1, but in the case of MC-NG, the misfit is always negative for both directions. As expected, in parallel to the rafts, its value depends on the deformation but it also evolves with temperature showing that the coupling induced by the dislocation network at the γ - γ’ interfaces is weaker. Now we have to perform the “in situ” creep experiment in order to follow the time evolution of the misfit under stress. This will allow to check the validity of the model previously proposed (3) and to apprehend the origin of the difference of the mechanical properties.

references

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