**Grain boundary analysis of HT9 steel under accelerated creep test**

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**Introduction**

HT9 steel is a typical ferritic/martensitic stainless steel which has been chosen by the Department of Energy Alloy Department Program for structural applications in fusion reactors because of its good creep strength and excellent swelling resistance. During its service life, one of the major types of damage is from thermal creep, thus the grain boundary character plays a very important role in this inter-granular damage. Various papers show that, grain boundaries with certain crystallographic relationships are more resistant to creep damage while others are not.

The main objective of this study is to characterize the damaged grain boundaries after accelerated creep tests, the creep damage is observed using the EBSD method.

**Chemical composition**

<table>
<thead>
<tr>
<th>Alloy</th>
<th>C</th>
<th>S</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
<th>W</th>
<th>V</th>
<th>other</th>
</tr>
</thead>
<tbody>
<tr>
<td>HT9</td>
<td>0.2</td>
<td>0.4</td>
<td>0.6</td>
<td>12.0</td>
<td>1.0</td>
<td>0.5</td>
<td>0.25</td>
<td>0.50</td>
</tr>
</tbody>
</table>

**Methodology**

Creep tests were conducted under constant loading at 600°C and initial stress of 250 MPa. The sample broke after 87 hours, the fractured sample was polished up to 0.3 um manually, followed by a vibratory polish with colloidal silica. The Field Emission Scanning Electron Microscope (FESEM) equipped with Electron Backscatter Diffraction (EBSD) capability was used. Orientation Imaging Microscopy (OIM) Analysis, was used to analyze the data.

**Data analysis and result**

The image above is the SEM image of the fracture surface and a crack as seen on the polished surface of HT9 steel. There is a high density of voids in the fracture surface, and the dimpled microstructure indicates the plastic deformation of HT9 steel at high temperature.

The misorientation distribution map for HT9 steel a) before creep test, b) after creep test.

The misorientation distribution map of low angle boundaries (misorientation<10 degrees) decreased greatly after the creep test. The fraction of low angle boundaries is 0.63 and 0.47 respectively.

The creep tested material has a higher fraction of high angle misorientation, and most of the high angle KAM (kernel average misorientation) is located at the cracks or at the grain boundaries, which indicate the highly deformed region there.

**Conclusion**

Low angle boundaries are more resistant to the crack formation and propagation. For B.C.C structure, the low energy coincidence site lattice boundaries were susceptible to creep damage, with cracks occurring preferentially a misorientation of 60 degrees about the <111> axis. At 600°C, the HT9 steel will go through a plastic deformation before failure, and the area near the grain boundaries or cracks will deform most.

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