Development of hoop grain structures in flow-formed ODS-FeCrAl

In a pressurised tube the principal stresses lie parallel to the hoop direction, and for optimum creep resistance it is advantageous for the tube's grains to be elongated and aligned in the hoop direction. Such hoop grain structures have been achieved in ODS-FeCrAl tubes and this has obvious potential for use in heat-exchanger tubing in modern power plant.

Following initial trials involving flow-forming at room temperature, further trials have been undertaken where the flow-forming was performed at temperatures of 600-700ºC in an attempt to increase the levels of deformation possible in each operation and to increase the extent of the plastic zone into the tube wall.

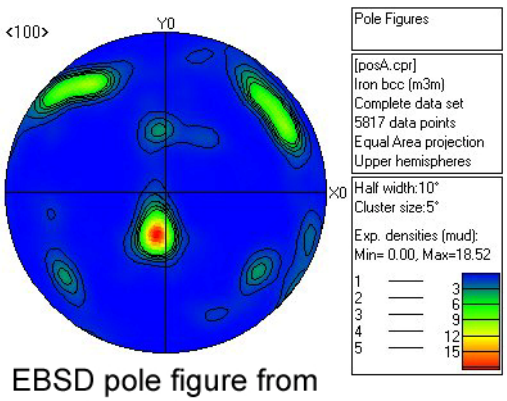
During secondary recrystallisation after flow-forming, certain regions of the tube outer surface have been found to recrystallise less readily than others. During recrystallisation, residual unrecrystallised material acted as a barrier to recrystallised grain growth and thus defined the shape of the secondary recrystallised grains. This 'reluctant' material described a helical path around the tube outer surface, following the edges of tracks left by the flow-forming rollers.

Electron Back-Scattered Diffraction (EBSD) investigations into the possible reasons behind this behaviour have shown that significant differences exist in grain texture and morphology prior to secondary recrystallisation at different points on the tube surface. Along the centres of tracks left by the flow-forming rollers, there was a clearly defined and strong texture with the <100> direction normal to the tube surface and some fibrous rotation about this <100> axis. At the edge of the tracks left by the rollers, where secondary recrystallisation was slowest, the texture was much weaker and more convoluted. The pole figures illustrating these textural differences are shown below. It was also noted that the differences faded with depth into the tube wall.

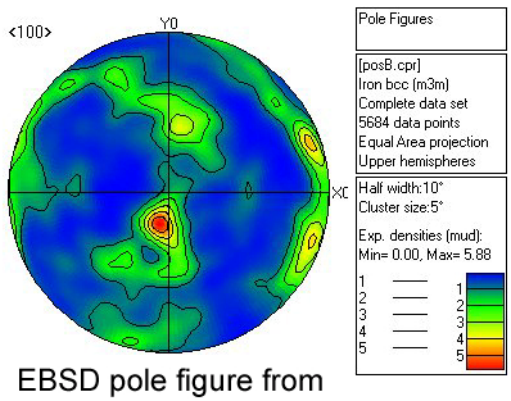
The periodic nature of the textural differences and their confinement to the outer surface of the tube coincide exactly with the morphology of the hoop grains formed, which also follow the roller tracks and exist only to a shallow depth at the outer surface of the tube wall.

Further work is underway to clarify and refine this effect in order to exploit the flow-forming process to produce optimised grain structures and enhanced creep strength.

Read more about this work.



EBSD pole figure from roller track centre



EBSD pole figure from roller track edge