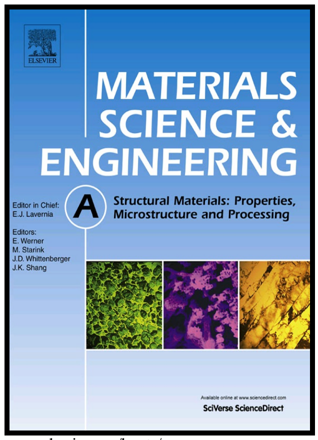

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Experimental study and multiscale modelling of the high temperature deformation of tempered martensite under multiaxial loading

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ABSTRACT

The microstructural deformation of ex-service 9Cr-1Mo steel, with a tempered martensitic microstructure, has been examined in this study, through the combined use of electron backscatter diffraction (EBSD) and multiscale modelling techniques. Both the experimental and predicted deformation of the material at a notch root on a range of scales from the specimen level down to the microstructural block level are compared. A tension loaded notch specimen of the material which was extracted from an ex-service power plant pipe was used for this analysis. The deformation at the specimen level was quantified by analysis of the load displacement curves and notch opening displacement, which showed excellent agreement with the predicted results from the experimentally calibrated elastic-plastic finite-element model of the specimen geometry. The microstructural deformation was experimentally measured through the use of EBSD carried out at the notch root before and after high temperature mechanical testing. The initial orientation of the microstructure as well as the displacement around the boundary of the area of interest in the macroscale model were applied to a representative volume element (RVE) and a slip based crystal plasticity modelling framework was implemented to model the in-elastic deformation of the material under high temperature loading.

***KEYWORDS**: Ex-service material, 9Cr-1Mo steel (P91), Elevated temperature, EBSD, multiscale modelling, Plastic strain, Mean orientation difference (MOD)*

1 INTRODUCTION

1.1 Background

In recent years there has been an increased emphasis on the thermal efficiency of conventional (fossil fuel) power plant operating under flexible loading conditions (Bugge et al., 2006). A key route to improving efficiency is by increasing the steam temperature and pressure entering the turbine. The development of materials capable of withstanding these conditions under flexible (cyclic) loading is therefore needed, coupled with an understanding of how the material microstructure changes when subjected to conditions