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Effect of chemistry on the small punch creep properties of low carbon steels

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Small punch creep testing (SPCT) is a small-scale short-term (<1000h) test that can be used to determine the remaining life of power plant materials. The mechanical property data generated by this new technique needs to be correlated to more established testing techniques such as uni-axial creep testing and ultimately to predictions regarding the remaining service life of the plant component. In this study, we investigated the microstructure-to-property relationships of service exposed low carbon steels with the view to understand the deformation mechanisms operating during this accelerated test. SPCT were performed on 80 samples taken from an industrial steam-line that operated at 425 ℃. The chemical composition of the extracted samples was measured using wet-chemical analysis to quantify the minor elements of carbon and manganese, as well as trace elements (P, Si, Cr, Mo, Ni, Cu, Al). In addition, graphite formation in the samples was quantified using 3D X-Ray Tomography. The quantitative data consisting of the creep-life, chemical composition and graphite content were analysed using Pearson's correlation, exploratory factor analysis and Bayesian neural networks to determine the relationships between the different variables. The results of the statistical analysis show that carbon and manganese are strongly positively correlated (>0.50) with creep-life, while graphite content showed no relationship with the creep-life measured using SPCT. The graphite content (>0.50) was strongly positively correlated with both aluminium and silicon content. Future work will include quantitative microstructural characterisation of the samples, in order to confirm the proposed deformation mechanisms.

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PhD

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