

Application of Instrumented Indentation to Obtain Mechanical Properties of In-service Components using a Scoop Sampling Procedure

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Methodologies have recently been developed in the Gordon Laboratory, in collaboration with AWE, for extraction of various thermo-mechanical properties from instrumented (nano)indentation data, in conjunction with (iterative) FEM modelling. These include yield stress and work-hardening rate data [1], residual stress levels [2] and creep parameters [3]. Experimental outputs include load-displacement-time data and shapes of residual indents. This project will be focussed on the extraction of property data for metallic components in ongoing service, such as pressure vessels exposed to radiation of various types. The methodology will involve the removal of small samples from such vessels or other components, using a scoop technique, and subjecting them to laboratory indentation tests. The Gordon Laboratory have housed an indenter in a vacuum chamber, which can be employed over a wide range of temperatures allowing the kinetics on accelerated ageing to be assessed in-situ. The volume of material required for such testing is very small ($< \sim 1 \text{ mm}^3$), so this sampling can be carried out without impairing the continued usage of the component in any way. The work will focus initially on yielding and work hardening rates but will also extend to creep, with the modelling results validated against conventional testing techniques. Attention will be paid to any changes in these characteristics, compared with the original spec of the material concerned to enable lifetime predictions. Related ongoing work is described at:

<http://www.ccg.msm.cam.ac.uk/directory/research-themes/Fine%20Scale%20Mechanical%20Interrogation>

- [1] J Dean, JM Wheeler & TW Clyne, *Use of Quasi-static Nanoindentation Data to obtain Stress-strain Characteristics for Metallic Materials*, *Acta Mater.*, **58** (2010) 3613-3623. ([doi:10.1016/j.actamat.2010.02.031](https://doi.org/10.1016/j.actamat.2010.02.031))
- [2] J Dean, G Aldrich-Smith & TW Clyne, *Use of Nanoindentation to Measure Residual Stresses in Surface Layers*, *Acta Mater.*, **59** (2011) 2749-2761. ([doi:10.1016/j.actamat.2011.01.014](https://doi.org/10.1016/j.actamat.2011.01.014))
- [3] J Dean, A Bradbury, G Aldrich-Smith & TW Clyne, *A Procedure for Extracting Primary and Secondary Creep Parameters from Nanoindentation Data*, *Mechanics of Materials*, **65** (2013) 124-134. (<http://dx.doi.org/10.1016/j.mechmat.2013.05.014>)