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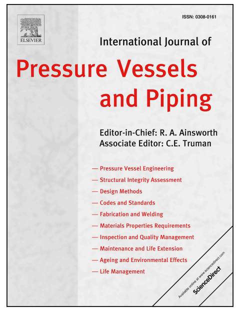

Optimised modelling of AISI 316L(N) material behaviour in the NeT TG4 international weld simulation and measurement benchmark

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Optimised modelling of AISI 316L(N) material behaviour in the NeT TG4 international weld simulation and measurement benchmark

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ABSTRACT

The NeT TG4 benchmark specimen consists of a three-pass type 316L Tungsten inert gas slot weld in a AISI type 316L(N) plate. Phase one of the finite element simulation round robin performed on TG4 by the NeT network made the assumption that weld metal exhibits the same mechanical behaviour as parent material. A comprehensive series of material characterisation tests on weld metal was performed by NeT participants, and these allowed the derivation of several sets of mixed isotropic-kinematic material model parameters specifically for weld metal. The derived models have been used to improve the predicted stresses in the TG4 benchmark specimen. This paper first reviews the weld metal materials testing programme, and then discusses the optimum material hardening model fitting strategy to use for austenitic weld metal. The derived material models are tested by using them to predict residual stresses in the TG4 benchmark, and validating the predictions against the extensive database of measured residual stresses.

KEYWORDS

Welding, Weld modelling, Finite element modelling, Materials characterisation, Material hardening models

1 INTRODUCTION

The mission of the European Network on Neutron Techniques Standardization for Structural Integrity (NeT) is to develop experimental and numerical techniques and standards for the reliable characterisation of residual stresses in structural welds. NeT was first established in 2002, and involves over 35 organisations from Europe and beyond. It operates on a "contribution in kind" basis from industrial, academic, and research facility partners. Each problem examined by the network is tackled by creating a dedicated Task Group (TG), which undertakes measurement and modelling studies and the interpretation of the results.

NeT Task Group 4 (TG4) was launched in 2008, as a follow-on project to the highly successful Task Group 1 (TG1) [1-18]. NeT TG1 examined a single weld bead laid onto the surface of an austenitic steel plate. This weld geometry produces a strongly three-dimensional residual stress distribution, with similar characteristics to a weld repair, and proved to be challenging to simulate accurately.

NeT TG4 was designed as a natural follow-on to NeT TG1, with the single weld bead of TG1 replaced by three superimposed weld beads laid into a slot. Hence it introduces both a multi-pass weld and a significant volume of weld metal, while retaining the portability of TG1. The primary simulation challenges for NeT TG4 were to make accurate predictions of both the development of material properties and the final residual stress field in weld metal, and in the adjacent heat/strain affected zone in parent material. These undergo multiple thermo-mechanical cycles, with repeated high temperature excursions into regions where creep, recovery, or re-crystallisation may occur. In addition, weld metal is introduced as a molten weld pool and its mechanical properties such as yield strength develop progressively as the weldment is manufactured. This considerably complicates the task of generating weld material properties data suitable for use in a finite element weld simulation, since there is no obvious initial state for the material from which to extract test specimens.

Companion papers in this special issue describe the conduct of NeT TG4 in more detail. In particular [19] gives an overview of the project, describing TG4 specimen design and manufacture, the organisation and conduct of the parallel