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Mechanical characterisation of a fibre reinforced oxide/oxide ceramic matrix composite

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ABSTRACT

Monotonic tension, fatigue and creep experiments were conducted on an oxide/oxide ceramic matrix composite over the range of temperature 20–1200 °C. The role of continuous fibre reinforcement, differential thermal expansion, stress redistribution interactions between fibres and matrix and the influence of inherent processing defects are all considered when describing the deformation and ultimate mechanical failure of these systems.

1. Introduction

High performance engineering designs for land based power generation systems and aero-engine applications continue to drive research into ceramic composites, mainly due to their high temperature capability which ultimately offers increased operating temperatures [1]. In the aerospace sector their low density provides attractive specific properties with the potential for reductions in component weight. Recent interest in oxide/oxide ceramic matrix composite systems (CMCs) originates from superior oxidation behaviour when compared to non-oxide based variants (e.g. SiC_f/SiC or SiC_f/Al_2O_3), which is particularly apparent at temperatures above 800 °C [2,3]. Additional benefits in the combined costs of raw materials, processing technologies and component manufacture should also be considered [4]. The successful implementation of oxide/oxide CMCs for structural applications will require a compromise in mechanical performance compared to the competing non-oxide systems, where SiC_f/SiC is currently viewed as the industry leader. However, this should not avert interest in the oxide/oxide systems.

Our recent research has assessed an oxide/oxide CMC under three important loading configurations, namely monotonic tension, low cycle fatigue and creep over a range of temperatures. This form of assessment constitutes a vital pre-requisite to component design and potential service lifing. Constitutive stress–strain behaviour, fatigue and creep strength were defined together with a detailed understanding of the micro-mechanisms controlling deformation and fracture in this CMC. All of these properties were considered in relation to the structural condition of the as-processed materials.

2. Experimental procedures

Continuous fibre reinforced oxide/oxide CMC material stocks were manufactured by a proprietary process at Cytec Ltd. Flat panels of nominal dimensions 120 mm × 120 mm and 3.5 mm thickness were produced utilizing Nextel™ 720 alumina-based fibres embedded in an alumina matrix. The twelve plies of single weave mats contained fibres in 0/90° orientations. Specimens with a parallel gauge section were machined from the panels utilizing diamond tooling, with their longitudinal axis parallel to the nominal 0° fibre orientation. The same specimen design was employed for all tensile, fatigue and creep testing (Fig. 1).

For all forms of testing, specimens were carefully aligned to avoid bend and torsional stresses during insertion into the load train and subsequent loading. For all high temperature tests a short, two zone MTS radiant furnace was employed, with specimen temperature monitored using calibrated R type thermocouples, to ensure uniform heating over the measured gauge length. Tensile

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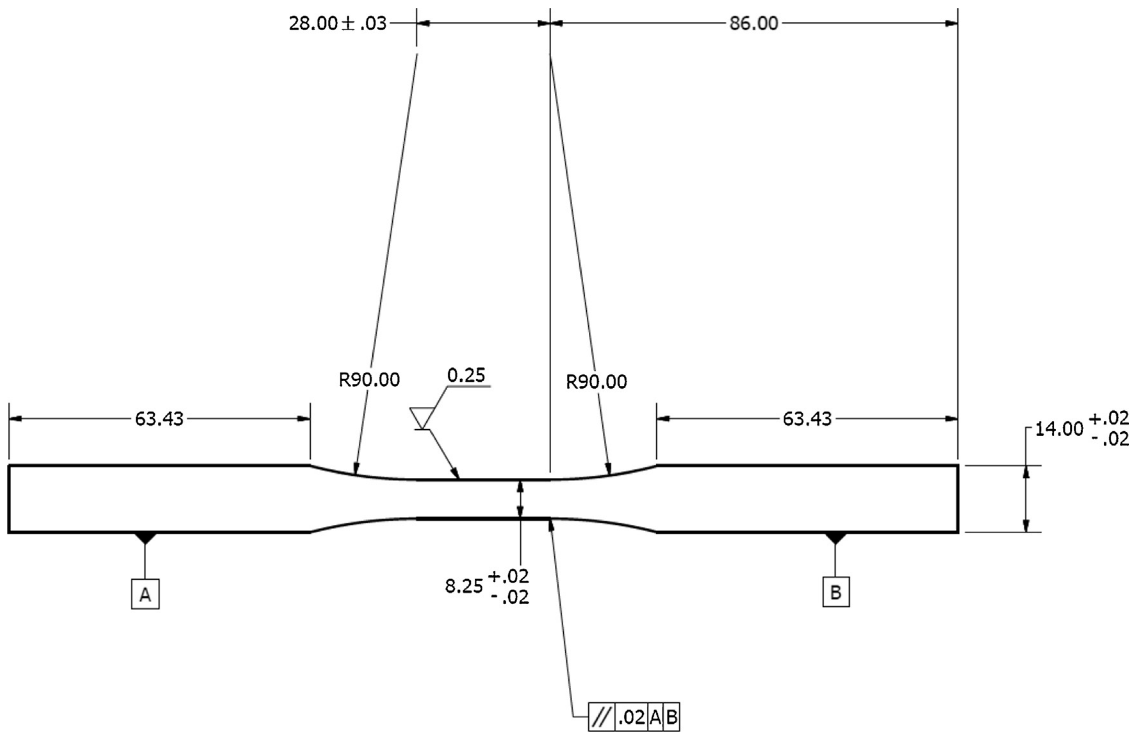

Fig. 1. Specimen design.

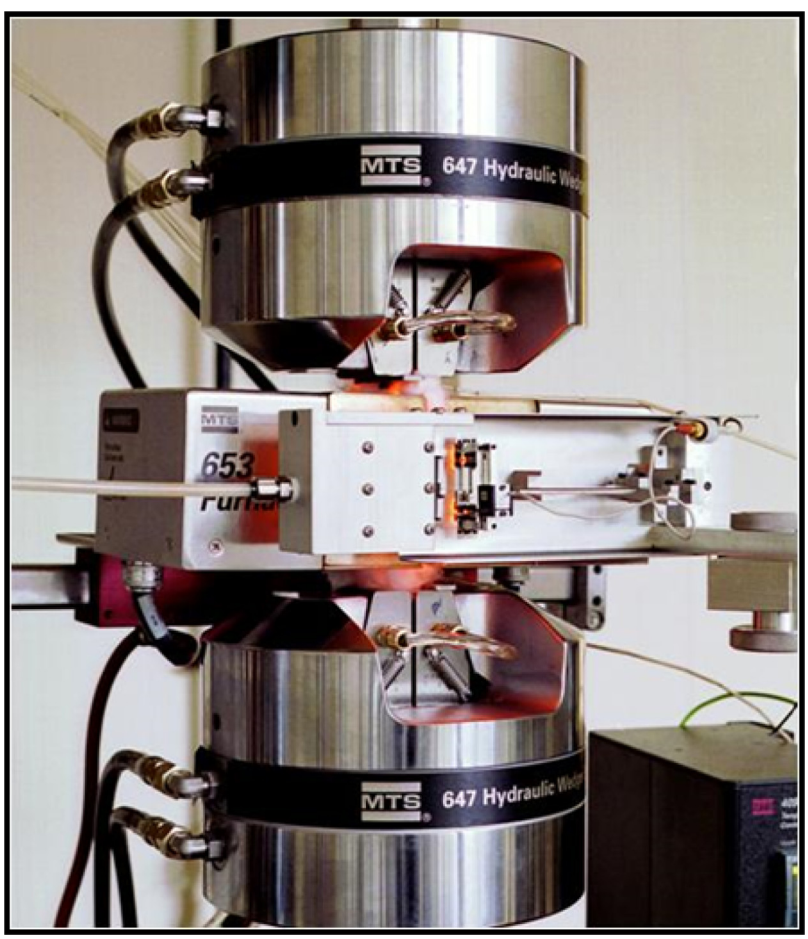

Fig. 2. Experimental facility for performing tensile and fatigue tests.

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