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Testing methodologies for thermo-mechanical fatigue evaluation in advanced aerospace materials

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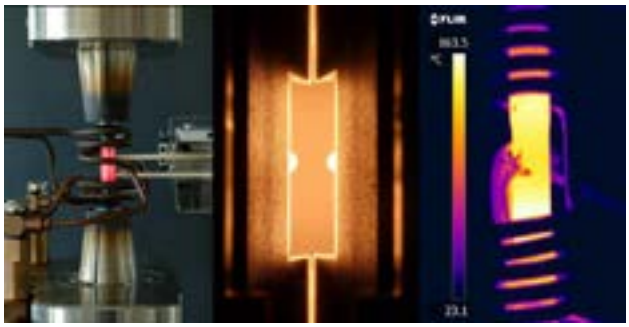
Fatigue failures are common within structural components used throughout a range of industrial sectors, and are often a critical design criterion during the specification and development stage of a new product. However, most mechanical testing is performed under isothermal conditions which may not be truly representative of in service conditions. Thermo-mechanical fatigue (TMF) testing offers the opportunity for the evaluation of a range of advanced material under more appropriate thermal cycles, hence providing more appropriate lifing approaches to ensure component integrity. TMF tests however, are complicated and difficult to perform, with much consideration necessary to understand the complex interactions of issues such as the heating/cooling method, the phase angle between thermal and mechanical strains/stresses, temperature measurement techniques and cycle frequencies. Over the past 15 years, the Institute of Structural Materials at Swansea University has devoted significant effort in a number of developmental programmes which have led to internationally recognised expertise in experimental setup and lifing approaches. Consideration in this paper is given to the experimental difficulties associated with using traditional techniques for temperature and crack length measurements (thermocouples and direct current potential difference techniques) and the possibility of utilising more innovative approaches such as thermography is discussed. Research has shown that it is difficult to design a single solution for TMF testing due to the numerous testing requirements that include peak cycle temperature, heating/cooling rate, and the impact of electromagnetic fields associated with induction coils. As such, TMF experiments are often by their very nature, bespoke. Future developments such as the generation of a validated code of practice for crack growth measurements under TMF loading are also discussed.



Biography

Dr Whittaker joined Swansea University in 2003 and has produced over 60 publications including an invited book chapter and 40 papers in leading international journals on topics including High Temperature Lifing, Thermo-Mechanical Fatigue and Modern Creep Lifing Approaches. He is also a Board Member of the IOM3 Structure and Properties of Materials Committee. Current research programmes involve sponsorship from EU Clean Skies, Rolls-Royce, EPSRC and ATI. Dr Whittaker has over 15 years of experience in a wide range of alloys and is leading the development of a code of practice for thermo-mechanical fatigue crack propagation testing. He is also heavily involved in creep lifing of alloys for the power generation/aerospace sectors, with particular expertise in property extrapolation using the recently developed 'Wilshire equations'.

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