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Influence of crack tip plasticity on fatigue propagation

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The propagation of fatigue cracks in engineering materials is strongly connected to the mechanisms taking place at the crack tip. A number of both linear and non-linear fracture mechanics parameters have been proposed over the last few decades to model such damage and they are all related to the plasticity generated at the tip of the crack (e.g. plasticity induced crack closure [1], contact forces along the crack wake and elastic–plastic boundary forces in CJP model [2], plastic intensity factor [3], plastic stress intensity factor [4], or plastic component of the crack tip opening displacement [5] to mention a few). Accordingly, a key method for assessing the fatigue damage is to characterise the plasticity developed at the crack tip.

It is our pleasure to provide a guest editorial on such an important topic. The initial seed for this special issue was planted at the 35th Encuentro del Grupo Español de Fractura (Spanish Group of Fracture Conference)1 held in Malaga, Spain, from 14th to 16th March 2018. During the conference, it became clear to the conference organisers that a number of high quality works were presented that aimed at quantifying the crack tip plasticity from very different perspectives. After discussion with the Editor in Chief of Theoretical and Applied Fracture Mechanics, we decided to produce this Virtual Special Issue based on recent works presented in the conference in Malaga and complemented with works from international renowned scientists and engineers also working on this fundamental topic.

The work by Jie Tong and co-authors evaluated the crack tip plasticity beyond the small-scale yielding regime in 316L stainless steel with the help of Digital Image Correlation and the Finite Element Method.

Neil James and co-authors developed a powerful method capable of separating the elastic and the plastic components of the crack tip opening displacement from Digital Image Correlation information to understand the propagation behaviour of a titanium specimen.

Stefano Beretta and his group in Milan presented a very comprehensive analysis, based on Digital Image Correlation technique and incorporating closure concepts to approximate the fatigue propagation from the effective J-integral range.

Giovanni Meneghetti and his co-author presented a fascinating contribution on assessing the plasticity at the crack tip using temperature measurements taken from the vicinity of the crack tip with an infrared camera.

James Newman and his colleague characterised the crack tip plasticity on different aluminium alloys with the help of the strip yield model under both constant amplitude and spectrum loads simulating an aircraft wing.

Luis Borrego and co-authors analysed the combined effect of heat treatments and overload events on an additive manufactured steel. The changes in fatigue crack growth were instigated by microstructural variations and their impact on the crack path.

Valery Shlyannikov and his colleague proposed a model based on a non-linear stress intensity factor but enhanced by the plastic zone size to predict the fatigue crack growth on gas turbine engine compressor disks used in aviation.

Alfredo Navarro and co-workers presented a constitutive model to quantify the plastic zone both at notches and during fatigue crack growth. It is based on employing the metric tensor as a material property to predict the multiaxial behaviour under non proportional tension and torsion loads.

Andrei Kotousov and his co-workers described an elegant analytical procedure for evaluating the fatigue growth of surface cracks. The formulation allows incorporation of crack closure mechanisms to predict the fatigue life and also the crack shape.

Filippo Berto and co-authors devised a numerical scheme to determine the level of plasticity induced crack closure and its impact on the fatigue propagation behaviour, with a reduced computational cost.

Finally David Nowell and his co-author presented an in depth summary of different key methodologies that have been recently used for estimating the plasticity at the crack tip and how this can be taken into account in different fatigue models.

With representation from universities and research centres from Spain, UK, USA, Italy, Czech Republic, Norway, Portugal, South Africa, Australia and Russia, this Special Issue presents a truly international view on this subject.

The above fully peer reviewed papers address a variety of new approaches to estimate the crack tip plasticity experimentally, numerically or analytically; to incorporate the crack tip plasticity into predicting tools; to develop consistent methods for reliable quantification of crack tip plasticity; and, in general, to use some form of plasticity developed at the crack tip as a driving force to predict the fatigue propagation on engineering materials.

As guest editors of this Virtual Special Issue, we would like to warmly thank all authors for their valuable contributions and the Editor in Chief and the Board of Theoretical and Applied Fracture Mechanics for deciding on this subject for this special issue. We would also like to extend our gratitude to the different reviewers who assisted us in the reviewing process for their efforts to maintain the excellence of the publication. We are delighted with the quality and depth of the selected papers. We are confident that the methods and techniques described in this volume represent a significant progress in this field and will make a stimulating read for the engineering and scientific community.

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