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Title:

A note on opening load effects on the driving forces for fatigue crack growth

Authors & affiliations:

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Abstract: (Your abstract must use **Normal style** and must fit in this box. Your abstract should be no longer than 300 words. The box will 'expand' over 2 pages as you add text/diagrams into it.)

Preparation of Your Abstract

1. The title should be as brief as possible but long enough to indicate clearly the nature of the study. Capitalise the first letter of the first word ONLY (place names excluded). No full stop at the end.
2. Abstracts should state briefly and clearly the purpose, methods, results and conclusions of the work.
Introduction: Clearly state the purpose of the abstract
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Discussion: Emphasize new and important aspects of the study and conclusions that are drawn from them

In 1971 Elber proposed [1] a very reasonable concept assuming that only a portion of the cyclic load imposed on a cracked component would be responsible to control its fatigue crack growth (FCG) behavior. This assumption was based on his identification of plasticity-induced crack closure under tension through compliance measurements, a mechanism that can rationalize transient effects on FCG ratios observed under service loading, such as acceleration, delays and arrests. Due to this fact, this interesting idea was readily accepted by a research community avid for explaining such sequence effects, and based on it several models were developed in order to predict residual lives, which are still used in many important practical applications [2-3]. However, even after more than 45 years of its development many uncertainties related to the validity of its assumptions (in particular its central hypothesis that the actual fatigue crack driving force is the effective stress intensity range ΔK_{eff}) remain unsolved. Indeed, crack retardation or arrest after overloads when the applied minimum load is higher than the opening load [4], cracks that grow with constant rates under fixed {ΔK, K_{max}} but highly variable ΔK_{eff} conditions (Fig. 1) [5], or a crack arrested at a given R-ratio that can restart to grow at a lower R without changing its ΔK_{eff} [6], are examples that cannot be explained by Elber's hypothesis. Due to the major importance of this topic for practical applications, this work revisits the main arguments that seriously support or question plasticity-induced crack closure as the primary cause for sequence effects, through a critical analysis of soundness of the experimental evidences published by their supporters and critics. This interesting exercise has produced surprising results, which should be properly discussed by all interested in practical structural integrity evaluations that depend on residual life predictions.

[1] Elber,W. The significance of fatigue crack closure. ASTM STP 486:230-242, 1971.
[2] Newman Jr,JC. An evaluation of the plasticity-induced crack-closure concept and measurement methods. NASA/TN-1998-208430, Langley Research Center, 1998.
[3] Newman Jr,JC; Anagnostou,EL; Rusk,D. Fatigue and crack-growth analyses on 7075-T651 aluminum alloy coupons under constant- and variable-amplitude loading. Int J Fatigue 62:133-143, 2014.
[4] Castro,JTP; Meggiolaro,MA; Miranda,ACO. Singular and non-singular approaches for predicting fatigue crack growth behavior. Int J Fatigue 27:1366-1388, 2005.
[5] Castro,JTP; Meggiolaro,MA; González,JAO. Can ΔK_{eff} be assumed as the driving force for fatigue crack growth? Frattura ed Integrità Strutturale 33:97-104, 2015.
[6] Chen D. L., Weiss B., Stickler R. The effective fatigue threshold: significance of the loading cycle below the crack opening load, Internation Journal of Fatigue, volume 16, issue 7, 485-491, 1994.

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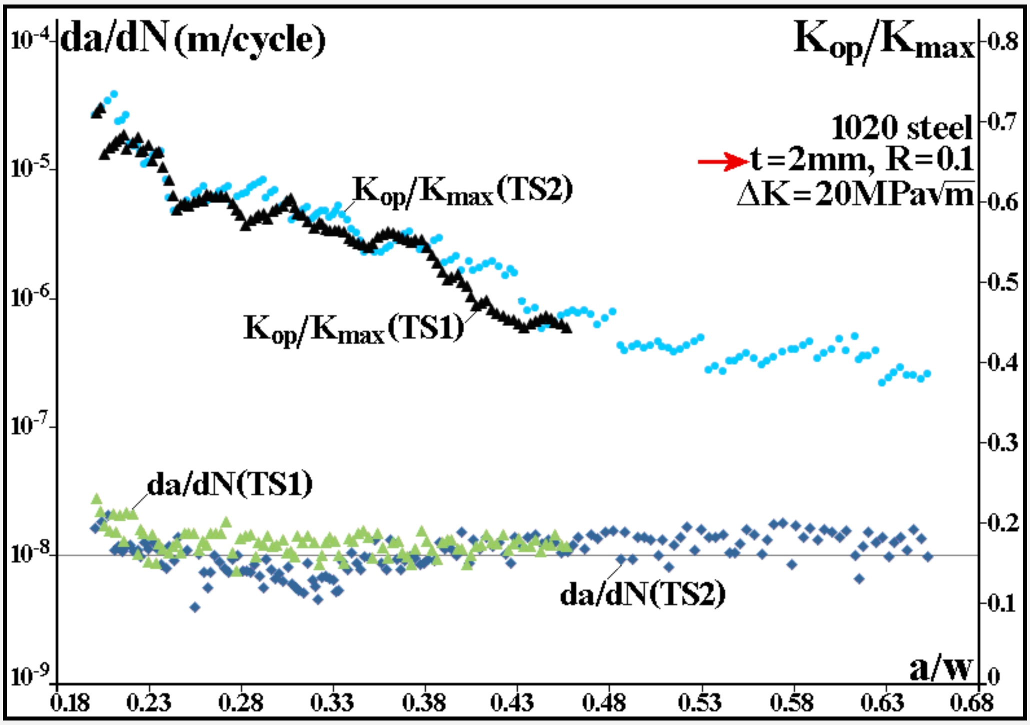

Fig. 1: FCG rates da/dN and crack opening ratios K_{op}/K_{max} measured along the crack path under fixed {ΔK, K_{max}} conditions in a thin (2mm) DC(T) specimen [5].