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Title:

A novel incremental fatigue method based on traditional stress and strain-based damage models

Authors & affiliations:

M.A. Meggiolaro[1], J.T.P. Castro[1], H. Wu[2]*

[1]Pontifical Catholic University of Rio de Janeiro, Brazil; [2]Tongji University, P.R. China

meggi@puc-rio.br, jtcastro@puc-rio.br, wuhao@tongji.edu.cn

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
Methods: Describe your selection of observations or experimental subjects clearly
Results: Present your results in a logical sequence in text, tables and illustrations
Discussion: Emphasize new and important aspects of the study and conclusions that are drawn from them

Most fatigue crack initiation models need to identify load cycles to compute the damage induced by them. These methods are discrete in nature, since they can accumulate fatigue damage only after a full cycle or half-cycle is identified. Thus they require cycle identification and counting, a challenging task under non-proportional (NP) multiaxial loadings, not to mention the somewhat arbitrary definition of path-equivalent stress or strain ranges for damage calculation.

A completely different fatigue calculation approach assumes damage as a continuous variable, with increments computed as the loading proceeds. Fatigue damage is continuously calculated after each infinitesimal stress or strain increment, thus not requiring the identification of load cycles. Most works based on this idea use Continuum Damage Mechanics (CDM) concepts. Other approaches are based on the continuous integration of strain energy density, damage parameters, or fatigue damage itself. In the Incremental Fatigue (IF) approach, damage itself (instead of a damage parameter) is integrated until reaching a critical value, usually 1.0 according to Miner's rule. Wetzel and Topper proposed in 1971 the first uniaxial IF method, based on rheological models, revisited in 2000 by Chu.

In this work, a novel IF approach is introduced. Instead of using rheological models, a direct analogy between incremental fatigue and non-linear incremental plasticity is used to store damage memory through internal material variables and nested "damage surfaces." The proposed method is relatively simple to implement, since such a continuous damage calculation approach does not require rainflow counting or path-equivalent range computations, while adopting traditional damage equations such as Fatemi-Socie or Smith-Watson-Topper. This method is not a CDM approach, since it does not rely on macroscopic properties such as the progressive loss of elastic stiffness. The IF predictions are validated from several tension-torsion experiments on tubular 316L stainless steel specimens following several non-proportional strain paths.

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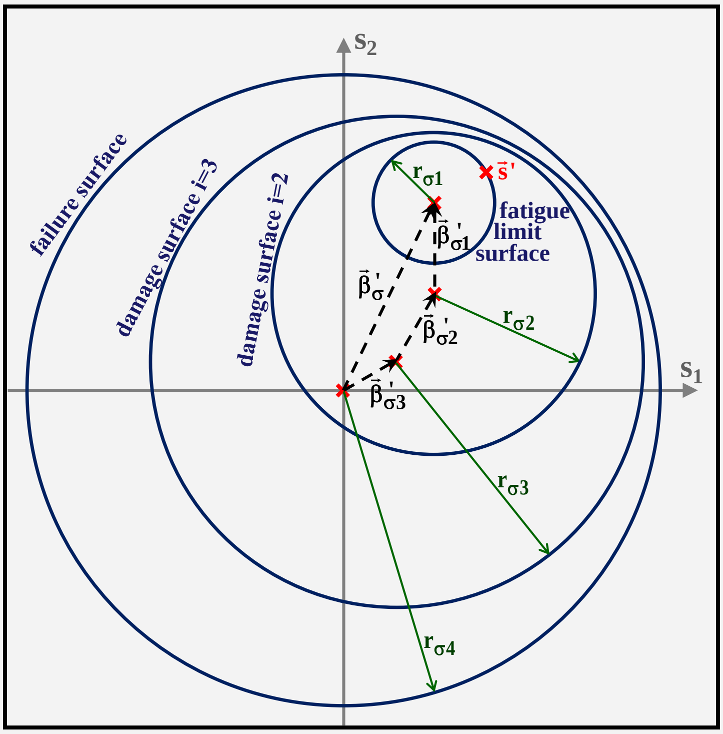

Fig. 1: Fatigue limit, damage, and failure surfaces in a deviatoric stress space, showing the *damage backstress* vector $\vec{\beta}'_{\sigma}$ that defines the location of the *fatigue limit surface* center, and its components $\vec{\beta}'_{\sigma 1}$, $\vec{\beta}'_{\sigma 2}$, and $\vec{\beta}'_{\sigma 3}$ that describe the relative positions between the centers of consecutive *damage surfaces*.

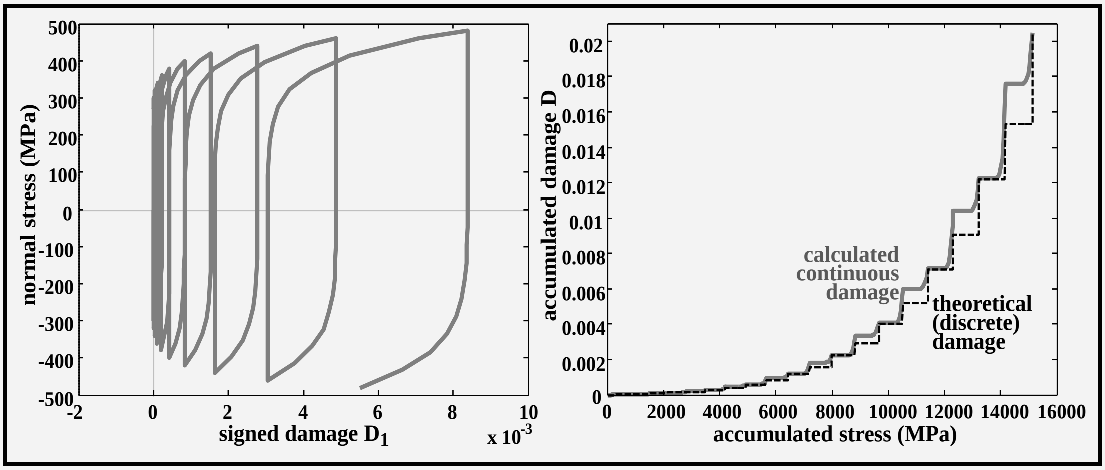

Fig. 2: Stress × damage hysteresis loops (left) and resulting accumulated damage (right) for a uniaxial variable amplitude loading history with zero mean stress.