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B. Pyttel, A. Fernandez Canteli, A. Argente Ripol

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Comparison of different statistical models for description of fatigue including very high cycle fatigue

B. Pyttel[1], A. Fernandez Canteli[2], A. Argente Ripol[1]

[1] University of Applied Sciences, Faculty of Mechanical and Plastics Engineering,
Schöfferstr. 3, 64295 Darmstadt, Germany

[2] Universidad de Oviedo, 33203 Gijon, Spain

Corresponding author: tel. +49 6151 16 7956; fax: +49 6151 16 8957

E-mail address: brita.pyttel@h-da.de

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Abstract

In this paper the fatigue behaviour of welded joints and helical compression springs are analysed using two different statistical models. The data consist of results from low cycle, high cycle and very high cycle fatigue and different number of investigated specimens. In particular, the software program ProFatigue is used for derivation of the probabilistic *S-N* field from experimental fatigue data. The program, based on a former regression Weibull model, allows the estimation of the parameters involved in the *S-N* field model, providing an advantageous application of the stress based approaches in the fatigue design of mechanical components. The results obtained are compared with the customary Wöhler-curve, represented as a straight line in a double-logarithmic scale. Application to probabilistic assessment of cumulative damage and further program enhancement can be now envisaged.

1. Introduction

Many, almost all, components in the field of mechanical engineering are subjected to cyclic loading leading to fatigue problems, sometimes till failure. Already 1999 Bathias [1] stated that there is no infinite life in metallic materials under cyclic loading. Depending on the number of cycles the regions Low Cycle Fatigue (LCF, $N_f < 10^4 \ldots 10^5$ cycles), High Cycle Fatigue (HCF, $10^5 < N_f < 10^7$ cycles) and Very High Cycle Fatigue (VHCF, $N_f > 10^7$ cycles) has been introduced. Depending on the material and component state failure can occur in every region. Under a scientific point of view the definition of a fatigue limit, where an unlimited number of cycles can be sustained by a specimen or component, is not necessary. Fatigue strength can be just defined as a special material value at any number of cycles. Many experimental investigations have been done and are necessary for their determination.

For the analysis related to lifetime prediction, three approaches are generally envisaged: the stress, the strain and the fracture mechanics based approach. Any of them implies advantages and disadvantages depending on the particular application pursued. The first approach, represented as Wöhler- or *S-N* curves, characterizes the most common description for practical application and, as such suitable one for the data assessment, is handled in this paper.

Often, the Wöhler-curve is represented as a straight line in a double logarithmic plot with

$$N = N_k \cdot (\sigma_a / \sigma_k)^{-k}, \qquad (1)$$