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Fatigue Design of high stressed aluminium structures under cyclic loading

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Abstract

DIN EN 1999 provides static material datas and rules to design lightweight-structures with static and variable quasi-static loading until ultimate strength. Tensile and fatigue test with the aluminium alloy EN AW-6063 T66 are evaluated and discussed in relation to DIN EN 1999 and conducted numerical stress investigations.

Keywords: EN AW-6063 T66, Ramberg-Osgood, DIN EN 1999, Low-Cycle-Fatigue

1 Introduction

The use of aluminium alloys for lightweight structures is not common, but it has also advantages for structural engineering. In [1] a summary of constructions made of aluminium alloys is given and an overview to the design criteria with different benefits for aluminium alloys and steels like deformation, strength and buckling was discussed. Regarding to the elastic limit $f_{p,0.2\%} = [80\ MPa\,; 290\ MPa]$ [2] of aluminium alloys in DIN EN 1999-1-1 [2] it is just compared to structural steel S335 / ASTM A572 ($f_y = 355\ MPa$) [3]. Taking also into account the low density of aluminium ($\rho_{AL} = 2700 \frac{kg}{m^3}$ [2]) to structural steel ($\rho_{St} = 7850 \frac{kg}{m^3}$ [3]) it is evident, that for strength optimized structures the aluminium alloys can take care of higher variable loads due to the lower death weight.

In the design codes the linear damage rule of palmgren-miner [4] has been established for fatigue design in high cycle fatigue $10^5 \leq N \leq 5 \cdot 10^6$, which is so far for a linear elastic material behaviour (Hooke's Law). Also in [4] it is mentioned, that work-hardening in the case of aluminium alloys is neglected. This point will be discussed in chapter 2.2

In DIN EN 1999-1-3 [5] rules for fatigue design by local plasticity, in reference to the main principal stress, is available. This rule take in consideration low cycle numbers $10^3 \leq N \leq 10^5$ (LCF) with high variable stresses. This is also in context of DIN EN 1999 [2] a stress related assumption.

In this paper the results of fatigue test with aluminium alloy EN AW-6063 T66, which is also introduced in DIN EN 1999-1-1, are presented and discussed according to the Low-Cycle-Fatigue design approach in DIN EN 1999-1-3.

2 "Quasi" Static Design

DIN EN 1999-1-1 [2] already supply for the static design material data with linear, bi-linear and multi-linear stress-strain material resistance curves and also the hardening exponent n for the Ramberg-Osgood-Model (1).

$$\epsilon(\sigma) = \frac{\sigma}{E} + 0{,}002 \cdot \left(\frac{\sigma}{f_{p;0,2\%}}\right)^n \qquad (1)$$

Each characteristic material property for the static loading situation is evaluated by tensile tests and the curve should represent the characteristic value

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