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Numerical Assessment of the Fatigue Strength of Press-Hardened Chassis Members

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Abstract

The fatigue strength of thick press-hardened components is predicted in this paper with a particular focus on the Heavy-Duty Vehicle industry. Transferring fatigue data from fatigue testing to components faces two major challenges: differences both in stress state and in the loaded volume. Both effects are discussed in this paper with a focus on the latter effect. To handle these issues to obtain accurate fatigue life predictions, a model for predicting the fatigue life of press hardened components is outlined and validated with experiments.

The modelling consists of two parts. Firstly, the local risk of fatigue is calculated using a local effective stress criterion based on the stresses obtained from FE simulations. In a second step, the component probability of failure is calculated using so-called weakest-link theory which makes the model to account for stress concentrations and loaded volume. The framework provides probabilistic load life curves, i. e. the probability that a component will survive a given number of load cycles at a given load. The weakest-link model shows excellent agreement with component testing data and compares favorably to used comparing the stresses directly in fatigue specimen testing to the stresses in the component.

1 Introduction

There is an increasing interest in using Press Hardened Steel (PHS) for chassis members in the Heavy-Duty Vehicle (HDV) industry due to their excellent strength. However, one of the dimensioning load cases for HDV chassis components is fatigue and thus must be considered during the design phase. It is expected that local stress concentrations such as bent radii and holes have a significant effect to the high material hardness which complicates the usage of fatigue specimen test results. Thus, the scope of this work is to present a fatigue strength prediction framework for press-hardened components made of thick steel sheets for the HDV industry.

Fatigue of PHS is not a widely studied topic in the literature, probably as in the typical use of PHS is for components where fatigue is not the dimensioning failure mode. However, when applying PHD to the HDV industry, the fatigue behavior becomes important. The mechanism behind fatigue crack initiation has been well understood by Parareda et. al [1] where it was shown, and for utmost relevance of this work, that surface irregularities and defects control the fatigue behavior. Later, the cutting sensitivity of the fatigue strength of PHS was studied by Lara et. al [2] were it was further confirmed the strong defect sensitivity of PHS.

For defect sensitive materials, the size of the loaded volume is important for the strength. For such cases, the Weibull weakest-link model [3] can successfully be applied to predict the probability of failure for different loaded volumes. This approach has been extended to finite fatigue life by Olsson et. al [4] and this model will be applied here. The modelling will be applied to predicting the fatigue strength in bending of a cross member, shown in Figure 1 subjected to fatigue loading in bending.