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Lifetime prediction of fatigue loaded welded joints with help of micromagnetic parameters

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ABSTRACT

In the presented project different measurement techniques were examined in order to use the related parameters in a simply applicable life prediction model. The change of different micromagnetic parameters like the Barkhausen noise and the coercivity were controlled with an easy to handle magnetic multi parameter device with the aim to correlate the magnetic parameters with different stages of fatigue damage. A laser triangulation sensor was used to examine the notch geometry in order to identify possible crack initiation sites. Additionally X-ray diffraction was used to analyze the residual stresses due to the welding processes and their alteration during fatigue loading. The results of the experiments with different types of specimens show a rather good agreement between the predicted and the real life time.

INTRODUCTION

When existing buildings achieve their dimensioned life time, an economical decision about maintenance and repair or a new structure is necessary. The basic problem is the identification of the actual fatigue condition of a structure and consequently the approximation of the remaining life time for a defined and prognosticated load condition. The monitoring based on measured data which depend on indicators for the fatigue damage is an expedient alternative solution to classic life time prediction methods. The fatigue degradation of ferrous materials is a complex field due to the great number of influencing factors and the difficulties to project these factors. In this case welded joints are of special interest. This is due to the circumstance that weld details in fatigue loaded structures are frequently initiation sizes of failures. On the other side weldments include many characteristic material features which are important for the fatigiue behaviour of the entire structure. The geometry of the weld, the cyclic material properties of the different weld zones and residual stresses can affect the fatigue strength negatively, so that welded joints can often turn out as failure-relevant weak points. The interaction of these influencing factors on the one side and the effort to get information about the fatigue condition by measured data on a complex structure on the other side enforces the approach presented in Figure 1. The complex structure can be simplified by building substitutes in order to make fatigue test up to different failure condition. The generated prediction model created on bench-scale specimen can be adapted to these substitutes in order to verify and validate the model for a better accuracy. The measurement and evaluation of parameters which could be used as indicators of the fatigue status should be performed with nondestructive testing methods and have to be reliable and economical.

In this investigation a micromagnetic method has been applied for the development of a life prediction model of cyclically loaded welds. The life prediction model used in this investigation should be applied on a steel girder with some typical details like a butt weld in the bottom zone with the largest stresses due to the applied loads. Because the different magnetic parameters depend on the microstructure and its

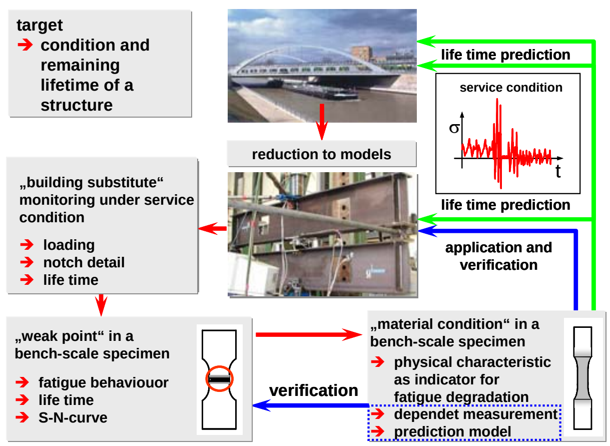

Figure 1: Monitoring approach.

changes, the method could not be applied directly [Altpeter et.al.]. In the first step the parameters had to be calibrated under use of specimens with a homogenuous microstructure. Therefore the temperature profiles and especially the cooling curves after welding of Double-V-Weld were measured. In the next step the temperature profiles were used to create representative specimens with a microstructure, which was the same as in the heat affected zones (HAZ) of the welds. The results of this investigation, to examine the correlation between the magnetic parameters and the state of the specimens during different time points of cyclic load, are presented in [Bruns et al.2]. In the next step the model developed as described shall be applied for the life time prediction of welded specimens and welded components like the building substitute in (Fig.1).

EXPERIMENTAL SETUP AND EVALUATION PROCEDURE

Specimens with a double V-weld were produced by using structural steel S355J2G3. The weld seam in the IPE 500 type steel girder was produced manually as gas metal arc (GMA) V-welding with four layers, in each case after cutting the flange of the beam and making a preparation of the weld. The residual stresses in the weld were deter-