Damage analysis of power engineering steels supported by DIC/ESPI techniques

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Damage development in power engineering steel structures requires instant monitoring to maintain their properties, ensure the safety of working components and estimate their service life. One should highlight, that the operational loads and simultaneous microstructural changes occurring due to high-temperature exposure accelerate the development of damage dynamics significantly. Thus, it is of the highest importance to maintain the safe state of power engineering steel pipes subjected to continuous operations under high pressure and temperature to further minimize the operating costs of industrial structures. Therefore, the first main goal of this research is to assess and describe the effect of 280 000 h operating conditions on the microstructure, strength properties and dynamics of fatigue damage development of 10CrMo9-10 power engineering steel (10H2M). The quantitative assessment of the degradation state in 10H2M steel was described as a function of the fatigue damage measure, φ, and the fatigue damage parameter D.

The second goal of this research was to compare an effectiveness of two different optical measurement techniques (Digital Image Correlation – DIC and Electronic Speckle Pattern Interferometry - ESPI) during fatigue damage development monitoring in X10CrMoVNb9-1 (P91) power engineering steel for pipes. The specimens machined from the as-received pipe were subjected to fatigue loadings and monitored simultaneously using DIC and ESPI techniques. It was found, that DIC enables to monitor the fatigue behaviour and accurately indicate the area of potential failure within early stage of fatigue damage development. Contrary to this, the application of ESPI method was not so successful. It also enabled to indicate a location of potential damage area, however, significantly later than DIC. The main limitation of ESPI technique usage results from its high sensitivity which procures many difficulties during working with the servo-controled hydraulic testing machines. Such machines generate a high frequency vibrations during experiments due to oil flow supplying the machine loading systems. The vibrations disturb significantly a work of ESPI cameras and narrows greatly its measuring capabilities.