OPTICAL MEASUREMENT TECHNIQUES FOR FATIGUE DAMAGE DEVELOPMENT MONITORING

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Key words: fatigue, damage, P91 steel, digital image correlation

1. ABSTRACT

In this work, an effectiveness of two 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 was compared. The specimens were subjected to fatigue loadings and monitored using DIC and ESPI techniques. DIC allows to monitor the fatigue behaviour of steel specimens and accurately indicates the area of potential failure, even within an initial stage of the fatigue damage development. The application of ESPI method during fatigue monitoring was not so successful due to a high frequency vibrations generated by the testing machine. As a consequence, a work of the very sensitive ESPI cameras was disturbed significantly.

2. RESULTS

The fatigue tests were force controlled with zero mean level and a constant stress amplitude with a frequency of 20 Hz in the range of stress amplitude from ±400 MPa to ±640 MPa. The range of fatigue loads was established on the basis of the yield strength $R_{0.2}$ determined from the uniaxial tensile test. The fatigue damage development was monitored by DIC Aramis 12M equipped with lenses of total focal length of 75mm and calibration settings appropriate to the measuring area equal to 170x156mm. The calibration was performed prior to testing using a certified GOM calibration plate. DIC technique captured a strain localization area after even the first cycle (Fig.1a). A subsequent evolution of the fatigue damage up to 100 000 cycles enabled to clearly indicate the area of potential crack initiation (Fig.1b) and its development (Fig.1c-d) up to specimen fracture.

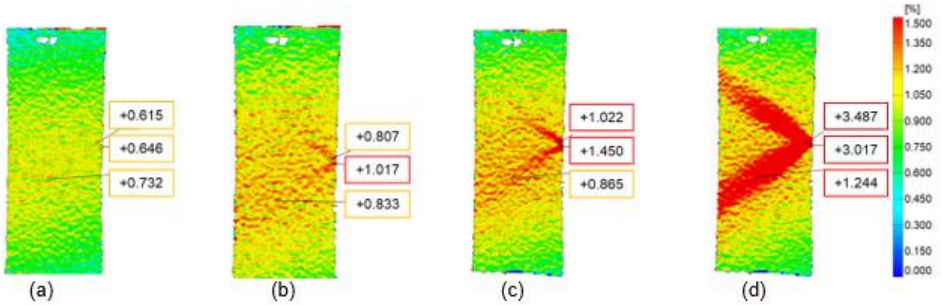

Fig. 1. DIC measurements carried out for the stress amplitude equal to 500 MPa with the unified scale after : 1 cycle (a); 100 000 cycles (b); 250 000 cycles (c); 301 251 cycles (d).