Monitoring the Progressive Degradation of Steel in Energy Facilities as a Result of Fatigue

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The safe service life for most power units used in domestic power plants has already been significantly exceeded, and therefore ongoing actions are being taken to monitor the condition of structural elements still in operation. Heat-resistant steels used in heating devices and steam transport during the commissioning period of the mentioned energy facilities were characterized by significantly lower strength than materials used today. During repairs and the construction of new structures, increasingly modern heat-resistant materials are being used, such as steels with increased chromium or nickel content. Despite the use of advanced materials, there is still a lack of sufficient research aimed at predicting their behaviour in the period preceding failure. Therefore, the presented work proposes a new methodology that allows assessing the effectiveness of non-destructive testing in the form of optical measurement systems in monitoring the development of damage in power engineering steel subjected to cyclic loading. The tests were carried out on power engineering steel 10CrMo9-10 (10H2M) used in pipelines and steam distribution systems in the supercritical state. Experiments were conducted on the material in the as-received state and after its long-term service for 280 000 hours at an elevated temperature of 540°C and an internal pressure of 2.9 MPa. A series of strength and microstructural studies were conducted, including tensile tests as well as high- and low-cycle fatigue tests within a stress amplitude range from 250 MPa to 450 MPa, in order to characterize the damage mechanisms depending on the degree of material exploitation. A development of damage during fatigue tests was monitored using Digital Image Correlation. In addition, to characterize the dynamics of material damage development, laboratory-measurable indicators of material damage were used in the form of: (a) fatigue damage strain indicator φ, reflecting the mechanisms of the degradation process, Fig.1; (b) defined fatigue damage parameter D; [1].

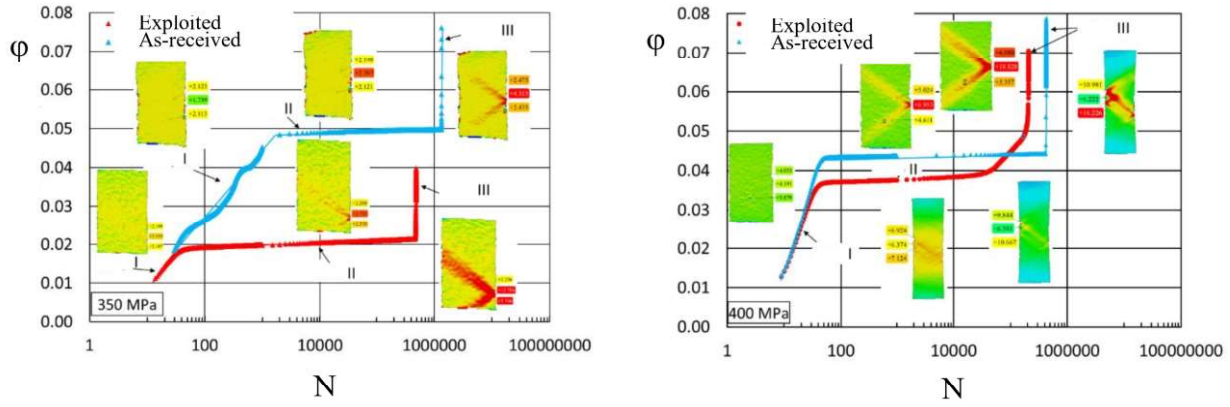

Figure 1. Variation of the fatigue damage strain indicator φ as a function of the number of cycles for the as-received and exploited steel; tests were carried out for stress range 350 MPa and 400 MPa.

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