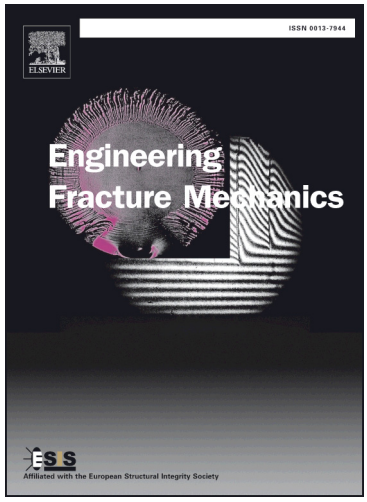

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Kinetics of fatigue crack growth and crack closure effect in long term operating steel manufactured at the turn of the 19th and 20th centuries

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Abstract

In this paper the fatigue crack growth behavior in structural components from the old 19th century structures (e.g. bridges) has been investigated. The delivered material for investigation was extracted from a beam made of puddled iron, commonly used in the 19th century. The obtained results from several ancient railway metallic bridges (located in Lower Silesia, Poland) have shown the presence of microstructural degradation processes in puddled iron. The kinetic fatigue fracture diagrams (KFFD) have been obtained for post-operated steel. The problem of crack closure has been involved in fatigue crack growth process during the experiments and its understanding is fundamental for the analysis of stress ratio effects on KFFD. An experimental and numerical approach has been involved for the evaluation of the crack closure/opening forces based on the hysteresis loop deformation. The implemented algorithm in the numerical environment gives promising results in the description of the kinetics of fatigue crack growth of the old metallic materials with consideration of crack closure effect. The problem of fatigue crack growth rate description from the energy point of view has been presented and discussed. The Universal Graph method (based on Dimensional Analysis approach) was used for phenomenological formulation of the kinetic equation.

Keywords: puddle iron, mild steel, crack closure, hysteresis loop.

Nomenclature	
χ_{ij}	hyperplane for ij- dimensional basis
a	crack length
B	specimen thickness
ΔH	energy parameter
ΔK_{eff}	effective stress intensity factor range
ΔK_{th}	threshold stress intensity range
F	applied force
F_{cl}	closure force load value
K	stress intensity factor
K_{fc}	critical value of stress intensity factor
Q	dissipated energy per cycle