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## 1. Introduction and Scope

Devices, working structures and their elements are subjected to the influence of various loads. These can be static, cyclic or dynamic loads. The accumulation of damage and the development of fatigue cracks under the influence of loads is a common phenomenon that occurs in metals. To slow down crack growth and ensure an adequate level of safety and the optimal durability of structural elements, experimental tests and simulations are required to determine the influence of various factors. Such factors include, among others, the impact of microstructures, voids, notches, the environment, etc. Research carried out in this field and the results obtained are necessary to guide development toward the receipt of new and advanced materials that meet the requirements of the designers. This Special Issue aims to provide the data, models and tools necessary to provide structural integrity and perform lifetime prediction based on the stress (strain) state and, finally, the increase in fatigue cracks in the material, which would result in the application of advanced mathematical, numerical and experimental techniques.

## 2. Contributions

Fracture mechanics are present in most structures that work cyclically, e.g., in the automotive or aviation industry. To extend the life of structures, they must be properly fatigue-proofed and made of appropriate materials. This Special Issue shows the fatigue behavior of various alloys and the conditions under which these alloys work. A paper by Sharma et al. [1] reviews the research and development in the field of fatigue damage, focusing on the very high cycle fatigue (VHCF) of metals, alloys and steels. In addition, they showed the influence of various defects, crack initiation sites, fatigue models and simulation studies to understand the crack development in VHCF regimes. A paper by Wang et al. [2] investigates the influence of the crack behavior propagation process in welded joints and sheds light on the mechanism of their branching, and a paper by Wei Xu et al. [3] proposes an ultra-high-frequency (UHF) fatigue test of a titanium alloy TA11 based on an electrodynamic shaker to develop a feasible testing method in the VHCF regime. The results from UHF tests data show good consistency with those from the axial-loading fatigue and rotating bending fatigue tests. Moreover, the fatigue life obtained from an ultrasonic fatigue test with the loading frequency of 20 kHz is significantly higher than all the other fatigue test results.

Artola et al. [4] investigated the impact of quench and tempering and hot-dip galvanizing on the hydrogen embrittlement behavior of a high-strength steel. Slow-strain-rate tensile testing was employed to assess this influence. Two sets of specimens were tested, both in-air and immersed in synthetic seawater. It was found that the risk of rupture only arises due to hydrogen re-embrittlement in wet service.

The closure of the crack was discussed in three articles [5–7]. Zakavi et al. [5] presents new tools to evaluate the crack front shape of through-the-thickness cracks propagating in plates under quasi-steady-state conditions. A numerical approach incorporating simplified phenomenological models of plasticity-induced crack closure was developed and validated against experimental results.



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Lesiuk et al. [6] showed a comparison of the results of the fatigue crack growth rate for raw rail steel, steel reinforced with composite material—CFRP—and the case of counteracting crack growth using the stop-hole technique, as well as with an "anti-crack growth fluid". It has been shown that the fatigue crack grows fastest in the case of the raw material and slowest in the case of the "anti-crack growth fluid" application. As a result of fluid activity, the fatigue crack closure occurred, which reduced the growth of this crack.

Ahmed et al. [7] investigated the fatigue crack propagation mechanism of CP Ti at various stress amplitudes. One crack at 175 MPa and three main cracks via sub-crack coalescence at 227 MPa were found to be responsible for the fatigue failure. The crack deflection and crack branching that cause roughness-induced crack closure (RICC) appeared at all studied stress amplitudes; hence, RICC at various stages of crack propagation (100, 300 and 500  $\mu$ m) could be quantitatively calculated. Noticeably, a lower RICC was found at higher stress amplitudes (227 MPa) for fatigue cracks longer than 100  $\mu$ m than for those at 175 MPa. This caused the variation in crack growth rates under the studied conditions.

Lee et al. [8] conducted fatigue tests at room temperature and 1000 K for 0.135-mmthick alloy 625 tubes (outer diameter of 1.5 mm), which were brazed to the grip of the fatigue specimen. The variability in fatigue life was investigated by analyzing the locations of the fatigue failure, fracture surfaces and microstructures of the brazed joint and tube. At room temperature, the specimens failed near the brazed joint. Rusnak et al. [9] fatigue tested nine poles with 18 openings using four-point bending at various stress ranges. Among the 18 hand-holes tested, 17 failed in one way or another as a result of fatigue cracking. Typically, fatigue cracking would occur at either the three or nine o'clock positions around the hand-hole and then proceed to transversely propagate into the pole before failure. Finite element analysis was used to complement the experimental study.

Ishihara et al. [10] analyzed the structural integrity of ferritic steel structures subjected to large temperature variations, which required the collection of the fracture toughness ( $K_{Jc}$ ) of ferritic steels in the ductile-to-brittle transition region. In this study, a Windows-ready  $K_{Jc}$  predictor based on tensile properties (specifically, yield stress and tensile strength at room temperature and yield stress at  $K_{Jc}$  prediction temperature) was developed by applying an artificial neural network to 531  $K_{Ic}$  datapoints.

Liu et al. [11] subjected the 2524-T3 aluminum alloy to fatigue tests under the conditions of R = 0, a 3.5% NaCl corrosion solution and loading cycles of 10<sup>6</sup>, and the S-N curve was obtained. The horizontal fatigue limit was 169 MPa, which is slightly higher than the longitudinal fatigue limit of 163 MPa. The influence mechanism of corrosion on the fatigue crack propagation of the 2524-T3 aluminum alloy was discussed. The fatigue source characterized by cleavage and fracture mainly comes from corrosion pits, whose expansion direction is perpendicular to the principal stress direction.

## 3. Conclusions and Outlook

In this Special Issue, there are various topics relating to the latest approach to fatigue crack growth. They relate to the influence of load, microstructure, friction, corrosion or to welded joints. However, many issues in this area of research have not yet been explored and the dissemination of these results should be continued. As a Guest Editor, I hope that the research results presented in this Special Issue will contribute to the further progression of research on the growth of fatigue cracks.

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