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Investigation of the creep-fatigue behavior of 310-NB steel - relation between loading frequency and time until fracture

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The utilization of high-temperature materials like the novel 310-Nb steel presents a critical challenge in predicting their lifespan, particularly in creep-fatigue conditions. This study explores the relationship between loading frequency (f) and time until fracture (tf) for 310-Nb steel, crucial for understanding the complex interplay between time-dependent and cycle-dependent mechanisms. The methodology involves establishing a correlation between f and tf, in an experimental creep-fatigue at 1 Hz frequency and holding times (th) of: 0, 5, 60 and 600s. Enabling estimation of time-dependent and cycle-dependent mechanisms. Results indicate a transition zone where both mechanisms interact, influencing crack growth. For high wait times (60 and 600 s), corresponding to frequencies of 1.7E-2 and 1.7E-3 Hz, the relationship tends to start parallel to the log f axis, indicating dominance of the time-dependent mechanism. In contrast, for shorter wait times (5 and 0 s), corresponding to frequencies of 1.7E-1 and 1 Hz, the relationship exhibits some gradient, suggesting influence from the cycle-dependent mechanism. Yokobori et al.'s (2004) theoretical framework provides insights into this phenomenon, proposing equations to model crack growth under interactive creep-fatigue conditions. The proposed method demonstrates good agreement between calculated and experimental results (for th=5, experimental tf=21:22, while calculated tf=18:04). Thus, the Yokobori method offers a valuable tool for predicting the lifespan of high-temperature materials under creep-fatigue conditions, aiding in the design and maintenance of industrial components subjected to such environments.