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COMPARATIVE ANALYSIS OF APPROACHES TO LOW-CYCLE FATIGUE

Determining the service life of a component subjected to cyclic mechanical loads under significant temperature fluctuations, and therefore exposed to thermal, thermomechanical, and mechanical fatigue combined with creep, is a complex engineering task. In attempts to address this non-trivial problem, over a hundred theories of thermomechanical fatigue have been developed. These theories can be

classified into the following categories: Damage Summation (DS) (linear or nonlinear accumulation of damage from individual load cycles); Frequency Separation (FS) (considers differences in the time scales of thermal and mechanical loading); Ductility Exhaustion (DE) (analyzes the accumulation of plastic strain until a critical threshold is reached); Strain Range Partitioning (SRP) (divides total strain into elastic and plastic components to assess fatigue damage); Total Strain-Based SRP (TS-SRP) (takes into account the full strain range, including temperature effects, to predict failure); Strain Energy Partitioning (SEP) (evaluates fatigue damage based on the dissipated strain energy within the material) [1].

The SEP approach, among other, may be applied for estimating the service life of a component made of heat-resistant austenitic steel and subjected to cyclic creep and thermomechanical fatigue loading. This method provides a comprehensive assessment of all energy-related components of the deformation process, including the contribution of plastic deformation and creep. It also enables an accurate description of the behavior of austenitic steels under high-temperature conditions, where damage mechanisms become energetically interrelated. The SEP approach further allows for consideration of the nonlinear nature of damage accumulation, which is typical of thermomechanical fatigue in heat-resistant steels operating under cyclic thermal and mechanical loading.

REFERENCES

1. Zhuang W. (1998). Thermo-Mechanical Fatigue Life Prediction: A Critical Review. Aeronautical and Maritime Research Laboratory.