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Fracture Fatigue and Wear

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Investigation on Fretting Fatigue Failure Mechanism of Steam Generator Tubes Coupled with Fretting Wear Morphological Evolution

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Introduction

As a critical pressure boundary between the primary and secondary loops of nuclear power plants, steam generator (SG) tubes are subjected to high-temperature, high-pressure, and complex flow-induced vibration environments. With the worldwide extension of nuclear power plant service life, the coupled damage of fretting wear and fatigue between the tubes and support structures has become a major bottleneck for structural integrity.
This study establishes a numerical framework to evaluate the coupled damage of surface wear and fatigue initiation. The investigation focuses on the nonlinear evolution of wear pit morphology during long-term operation and the resulting local stress concentration effects. By integrating wear models with multiaxial fatigue criteria, the reduction of fatigue initiation life due to wear depth is assessed, and the competitive failure mechanisms between wear and fatigue under various vibration parameters are discussed.

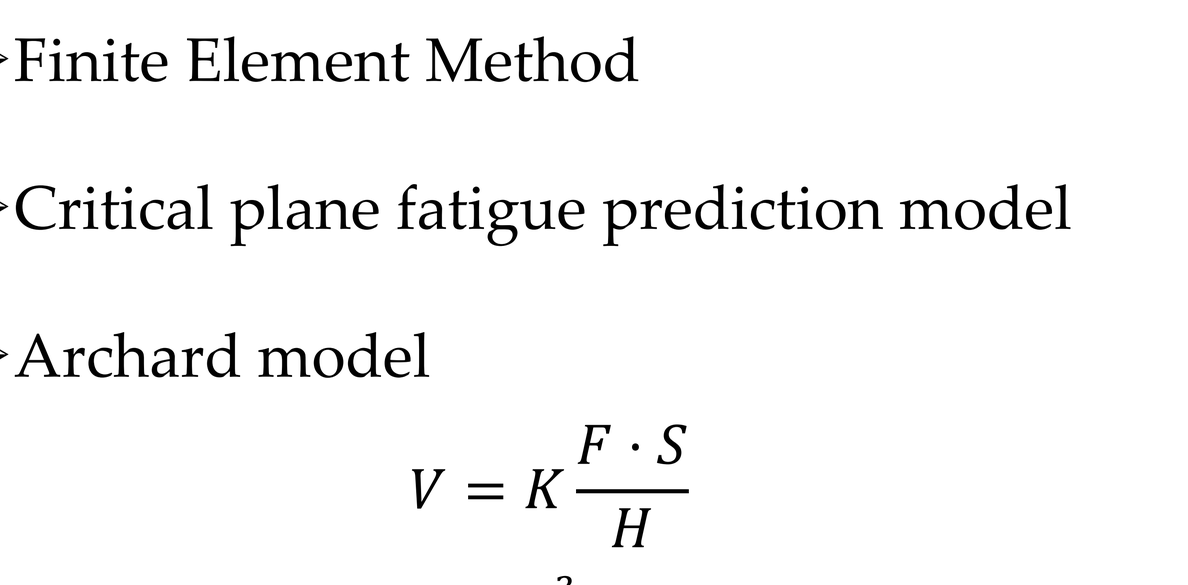
Methods

- Finite Element Method
- Critical plane fatigue prediction model
- Archard model

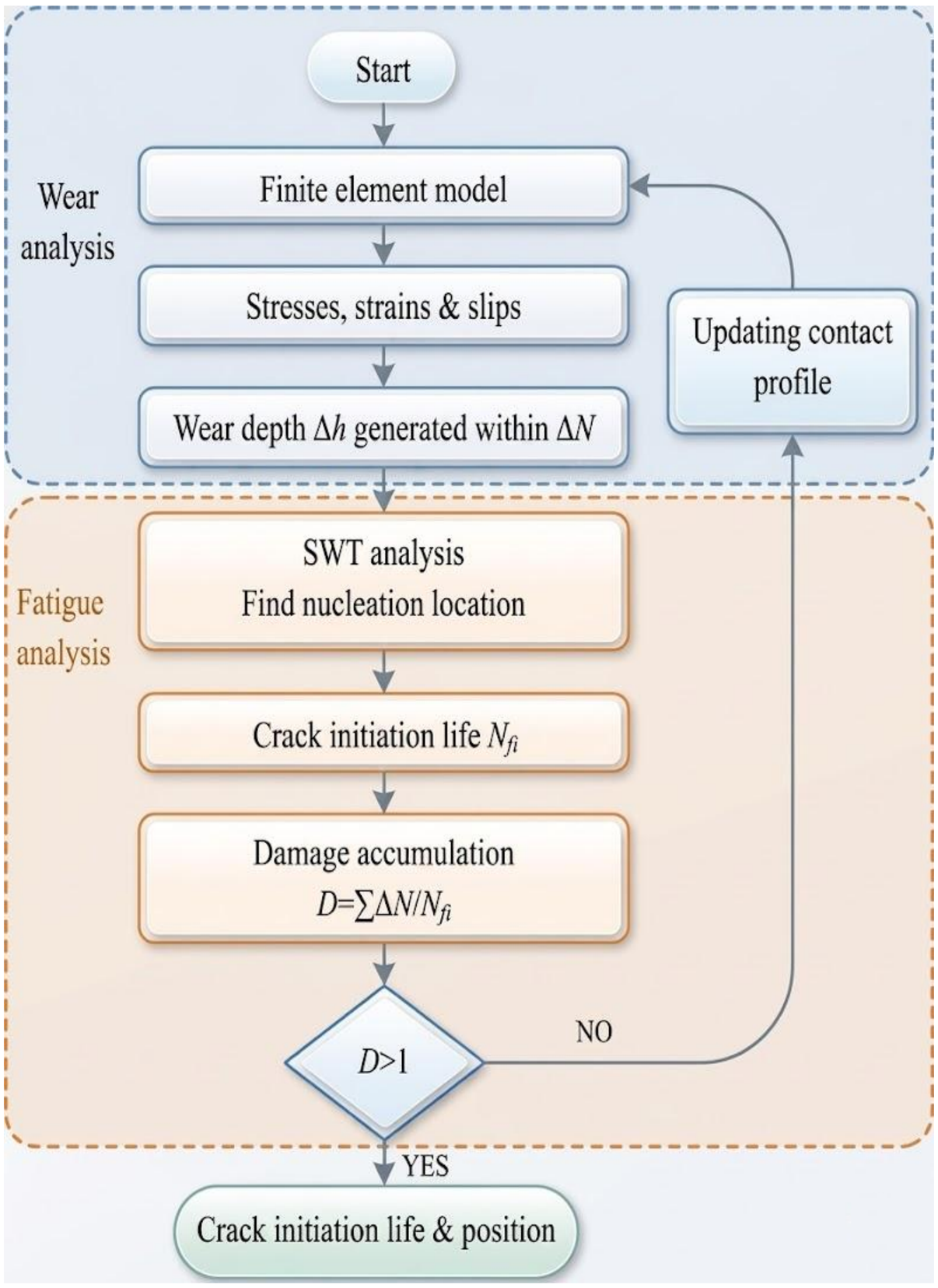
$$V = K\frac{F \cdot S}{H}$$

$$SWT = \sigma_{max}\frac{\Delta\varepsilon}{2} = \frac{\sigma_f'^2}{E}(2N_i)^b + \sigma_f'\varepsilon_f'(2N_i)^{b+c}$$

Graphics / Images



3D numerical model



Flowchart of the Fretting Fatigue Life Prediction Framework Considering Wear Evolution Effects

Preliminary Work

- ✓ Contact Model Development
- ✓ Validation of Wear Algorithm
- ✓ Convergence Study

Expected Outcomes

- ✓ Coupled Evolution Patterns
- ✓ Fatigue Life Prediction under Morphological Changes