

Calculation and Analysis of Dynamic Response Characteristics of Acoustic Liner Structures under Thermoacoustic Loads

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Vibration and noise during aero-engine operation may cause fatigue fracture and structural damage, threatening component strength and reliability. Acoustic liners, composed of a perforated face sheet, honeycomb core, and back plate, are widely used to suppress broadband noise inside aero-engines, especially in the fan or propulsor[n1].

This study investigates acoustic-fatigue-induced damage in aero-engine acoustic liner structures. Thermo-acoustic loading tests were conducted on alloy plates, and the numerical results were compared with experimental data to validate the simulation method.

A finite element model of the acoustic liner was established based on thin-walled large-deflection theory, thermo-random vibration theory, and acoustic-structure coupling[n2]. Static and modal analyses show that natural frequencies decrease with increasing temperature, with the first-order frequency being the most sensitive. In contrast, mode shapes of the same order vary only slightly, indicating good modal stability. This behavior is mainly related to temperature-dependent material properties and nonlinear effects induced by thermal expansion.

Steady-state temperature loads and finite-bandwidth Gaussian white noise were then applied through a diffuse-field approach to analyze the dynamic response under combined thermo-acoustic loading. The maximum von Mises stress, velocity response, and strain at critical locations were evaluated. The maximum von Mises stress first increased and then decreased with temperature, but increased with sound pressure level, reaching its peak at SPL=170 dB and T=25°C. The velocity response increased with temperature and sound pressure level and reached its maximum at SPL=170 dB and T=600°C. The X- and Y-direction strains showed similar trends and reached their maxima at SPL=170 dB and T=25°C. At 25°C, the X-direction strain was slightly lower than the Y-direction strain, whereas at 200°C, 400°C, and 600°C, it was slightly higher.

Finally, weak regions were identified from the thermo-acoustic response results. Perforated composite liners and star-shaped liner configurations were proposed to improve noise attenuation and structural durability. By optimizing honeycomb components, inlet-outlet layouts, and multistage aperture design, low- and mid-frequency noise absorption can be enhanced while maintaining structural strength and durability. This study provides theoretical support and engineering guidance for aero-engine acoustic liner design.

Источники и литература

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Иллюстрации

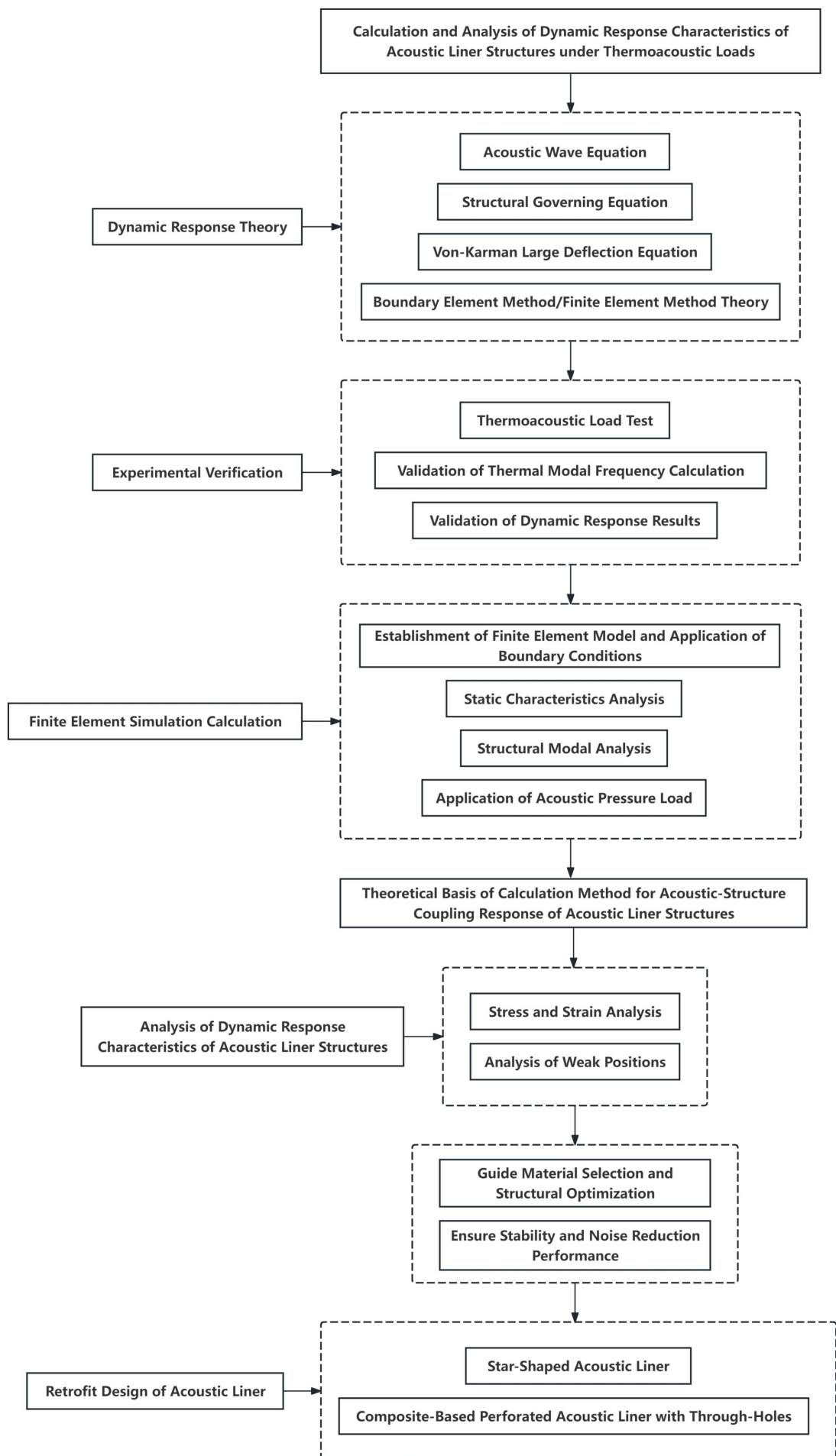


Рис. : Research Flow Diagram