Flutter analysis of missile configurations at transonic speeds by the not-so-slender wing/body theory

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Aeroelastic stability of missile configurations in the transonic speed range represents a particularly challenging problem. The combination of complex geometrical configurations and the strong nonlinearities inherent to this flow regime generally require the use of CFD methods in order to accurately capture the physical phenomena of the problem. However, during the design process more elementary approaches can be highly valuable, as they allow for a large number of analyses to be performed at a reduced computational cost, while nonlinear effects can be neglected. Within the approaches that fulfill this condition, the slender wing/body theory extended to unsteady flows and including elastic and rigid-body missile motions has been widely used, representative examples in the literature can be found at Refs [1-4].

Unsteady slender wing/body theory has the limitation of being independent of the Mach number, which restricts its range of applicability to flow conditions in the vicinity of Mach number 1. To overcome this limitation and to upgrade this theory, the not-so-slender wing and body theories (Refs [5-7]) were developed in the past to investigate the static and dynamic stability of rigid bodies and wings. To our knowledge, these theories have not yet been extended to account for flexible wings and bodies nor applied to the flutter computation of these configurations.

This work extends the not-so-slender body/wing theories to configurations with elastic deformations, applying them to flutter computations of complete missile configurations. In a first step, flutter analyses of isolated bodies and wings are performed in the transonic Mach number range, and the results linked up with the classical linear methods for subsonic and supersonic unsteady flows. This approach provides a unified methodology applicable across a wide Mach number range while circumventing the nonlinearities associated with transonic flow. In a second step, the proposed method is applied to a complete missile configuration of wing/body over the full Mach number range, comparing the results with available theories or experimental data.

References

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