

Abstract

Transonic flutter is an aeroelastic instability characterized by part-chord shocks over an airfoil and single mode oscillations leading to a drop in the flutter boundary. We present a numerical study that examines the influence of shocks, shock-boundary layer interactions, and three-dimensional flow features on the transonic flutter boundary. Using energy concepts we show that shocks and shock-boundary layer interactions have a profound influence on the stability of an aeroelastic system. Viscosity stabilizes the aeroelastic system through thickness effects up-to the bottom of the transonic dip. Beyond, shock induced separation not only stalls the aeroelastic system, but also makes it oscillate about a new equilibrium position. In this region, where viscous effects are dominant, the inviscid flutter boundary shows multiple flutter points. Modal contributions to the response of the aeroelastic systems —viscous and inviscid — indicate that viscosity restricts higher mode participation. Restriction of higher modes by viscosity is responsible for the elimination of multiple flutter points that are present in the inviscid case. Multiple forcing frequencies are observed in those regions of the flutter boundary where viscous effects are dominant. Further, the shock dynamics exhibit shock-reversal where-in the shock motion predicted by the viscous simulation is 180° out of phase relative to that of the inviscid case. At Mach numbers beyond the shock-stall region the shock moves close to the trailing edge of the airfoil, and inviscid and viscous simulations predict almost a similar flutter boundary. Three-dimensional transonic flow structures on a finite-span wing aeroelastic model de-stabilizes it relative to an equivalent two-dimensional model.