FORCED OSCILLATION TECHNIQUE: PRACTICAL ASPECTS

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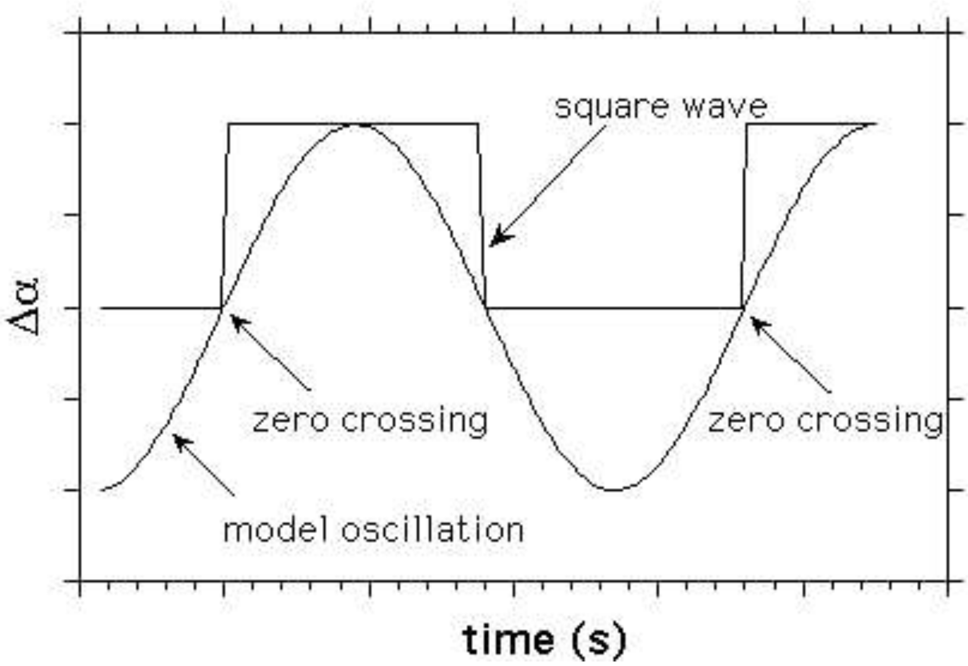
1. Post processing of experimental data

The processing of the experimental data is based on the determination of in-phase and out-of-phase load components (both in wind on and in wind off conditions). The floating components of the signal outputs from the force transducer are obtained (subtraction of averaged data) and voltages multiplied by the calibration matrix of the transducer. The forces and the moments are converted into spectral components (FFT). The signal is windowed over the oscillation period using a reference square wave generated by the oscillation system. The amplitude and the phase of the response at the forcing frequency are averaged over a large number of oscillatory cycles. Finally, the wind-off data are subtracted to the wind on measurements (vector superposition) and the result is normalized according to dynamic pressure, model geometry, oscillation amplitude and frequency. Several wind on data acquisitions are repeated over the same wind tunnel run.



The Reference Signals for Data Elaboration

2. Understanding the results

Blunt body aerodynamics

Most of the experimental activity concerning non lifting reentry configurations was performed by NASA during the early development of Mercury, Gemini and Apollo space missions. The characteristics of the ACM (Apollo Command Module) in reentry attitude were found to be dependent on angle of attack, Mach number and Reynolds number.

Appreciable nonlinear changes in the damping in pitch were measured at different oscillation center locations (extrapolation of pitch damping to different CG is difficult). It was shown that the effect of blunting the nose of the cone or changing from flat to a spherical segment base caused a decrease in the damping of pitching moment.

ACM static data showed an undesirable trim point (apex forward) at angles of attack between 10° and 50° and the experimental data indicated that the command module generally has stable damping for the entry flight attitudes except at low subsonic speeds.
ACM in reentry attitude was characterized by static and dynamic directional stability ($C_{n\beta} > 0$ and $C_{nr} < 0$).

Experiments also demonstrated that the length of the parachute towline, the type of bridle and the spacing of the attachment points could significantly affect the stability of the capsule.

New research programs concerning capsule aerodynamics and flight dynamics have been now carried out, due to the interest for applications such as planetary entry probes (Huygens or Viking) and capsules (ARD). The dynamic stability of blunt bodies like capsule shapes and planetary entry probes has been shown to be poor in subsonic flight[1].
The near wake recirculation and the rear flowfield pattern are responsible for the unstable dynamic behavior as a consequence of time lags in the wake[2] that provide a destabilizing driving force.

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[1] Baillion, M., "Blunt Bodies Dynamic Derivatives", AGARD-R-808, 1997

[2] Ericsson, L.E., Reding, J.P., "Re-Entry Capsule Dynamics", Journal of Spacecraft and Rockets, Vol. 8, No. 6, 1971, pp. 579-586