AEROELASTIC STABILITY AND RESPONSE ANALYSIS IN THE TRANSONIC RANGE

Question:
Can LINFLOW be utilized for Aeroelastic Stability Analysis in the range Mach 0.9 - Mach 1.1?

Answer:

We are not aware of any software that can solve this problem reliably, including LINFLOW. Performing aeroelastic stability and response analysis close to Mach 1 is not a trivial task.

The difficulty is extreme at a range form Mach 0.9-1.1

To be honest there is no really good numerical approach for these analyses. The aeronautical industry today relies on aeroelastic wind tunnel experiments to validate the system behavior in this Mach number range.

So, even if you try an approach utilizing ANSYS/CFX™, FLUENT™ or other state of the art Navier-Stokes solvers, you will not do very well.

Physically the difficulty is due to the strong unsteady “shock wave – boundary layer” interaction that appear in this Mach number range. If you then combine this with the interaction with the elastic structure then the problem becomes very difficult. Some academic research has been done globally during the past 10-15 years on this problem, trying to come up with a good feasible approach,. This engineering area of research is still in its early stages.

The problem with most Navier-Stokes approaches available are the limitations in the turbulence models, were most of them time average the unsteady behavior and this is not good for these problems. In the case with the unsteady characteristics in the “shock wave – boundary layer” interaction, the key to the solution is the ability to describe the unsteady behavior. If it would be possible to combine ALE based CFD with LES turbulence modeling this would at least have the basic mathematic formulation to deal with the problem. There have so far only been a few academic attempts in this direction (globally). So, even for very simple academic examples these types of problems are very difficult.

What is then done in industry? The LINFLOW type approach is used for the sub-sonic Mach number range and so called mach-box type method is user in the supersonic Mach number range. Based on experience and empirical approaches “guesstimates” are made for the transonic part. These analyses are then complemented with wind tunnel work.

Presently, LINFLOW is missing the supersonic part, it is on our “to do next” list and we hope to get it into LINFLOW sometime in the future.