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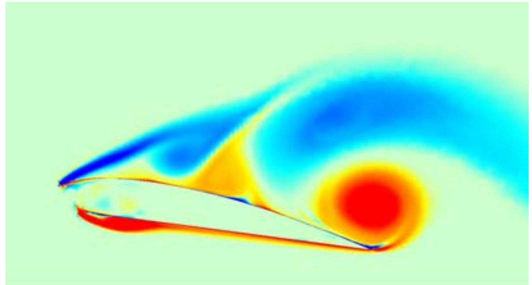

VORTEX INDUCED VIBRATIONS OF A CIRCULAR CYLINDER AT LOW REYNOLDS NUMBER

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Friday, June 17, 2005, 1pm
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Results are presented for the numerical simulation of vortex-induced vibrations (VIV) of a cylinder at low Reynolds numbers. A stabilized space-time finite element formulation is utilized to solve the incompressible flow equations in primitive variables. The cylinder, of low non-dimensional mass (m*=10), is free to vibrate in both the transverse and in-line directions. To investigate the effect of Re and reduced natural frequency, Fn, two sets of computations are carried out. In the first set of computations the Reynolds number is fixed (=100) and the reduced velocity (U*=1/Fn) is varied. Hysteresis, in the response of the cylinder, is observed at the low- as well as high-end of the range of reduced velocity for synchronization/lock-in. In the second set of computations, the effect of Reynolds number (50 <Re<500) is investigated for a fixed reduced velocity (U*=4.92). The effect of the Reynolds number is found to be very significant for vortex induced vibrations. While the vortex shedding mode at low Re is 2S (two single vortices shed per cycle), at Re~300 and larger, the P+S mode of vortex shedding (a single vortex and one pair of counter-rotating vortices are released in each cycle of shedding) is observed. This is the first time that the P+S mode has been observed for a cylinder undergoing free vibrations. This change of vortex shedding mode is hysteretic in nature and results in a very large increase in the amplitude of in-line oscillations.

Next, the VIV is investigated at sub-critical Re. It is well known that the flow past a stationary cylinder becomes unstable at Re~47. It is found that, for certain natural frequencies of the spring-mass system, vortex shedding and self-excited vibrations of the cylinder are possible for Re as low as 20. Lock-in is observed in all cases. However, the mass of the oscillator plays a major role in determining the proximity of the vortex-shedding frequency to the natural frequency of the oscillator. A global linear stability analysis (LSA) for the combined, flow and oscillator, is carried out. The results from the LSA are in good agreement with the 2D direct numerical simulations.

Dr. Sanjay Mittal is currently an Associate Professor in the Department of Aerospace Engineering at the Indian Institute of Technology at Kanpur where he has been since 1994. Prof. Mittal received his PhD in Aerospace Engineering from University of Minnesota in 1992 and his MS in 1990. His areas of interest include Unsteady Aerodynamics, Computational Fluid Dynamics, Finite Element Methods, Bluff Body Flows, Vortex Induced Vibrations, Parachute Aerodynamics, Fluid Structure Interactions, High Speed Flows, Air-Intakes, Shock-Boundary Layer Interactions, Stability analysis, High Performance Computing, Parallel Computing, Scientific Graphics & Visualization. He has published over 50 papers in international peer reviewed journals in these areas.
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