14:30 ~ 15:50 (Room 104)

Aerodynamics (I)

Session Chair : Dr. D. S. Lee, KARI/Korea

T-2D-1. USE OF CONFORMAL MAPPING TECHNIQUE TO THEORETICALLY VISUALIZE THE FLOW AROUND AN AIRFOIL GENERATED FROM A LIFTING CYLINDER IN A UNIFORM AERODYNAMIC FLOW FOR FLUSH PORT AIR DATA SYSTEM

U. N. MUGHAL, *NED Univ. of Eng. and Tech., Pakistan,* J. MASUD, *Air Univ., Pakistan,* Many methods have already been devised and are in use to calculate pressure co-efficient at various Mach Numbers and AOAs; a basic part of Aerodynamics. Conformal Mapping is also one of the various techniques by virtue of which we can develop such flows from simple aerodynamic bodies like cylinder. Potential flows start with an ideal flow over cylinders since the mathematics is more tractable. However, to use potential flow theory on usable airfoils the author have used conformal mapping to show a relation between realistic airfoil shapes and the knowledge gained from flow about cylinders. This method can further be used in the designing of an airfoil section. In this paper, author has used Joukowski Tranform to generate the flow around airfoils of various geometries. During the transformation the stagnation points on the cylinder map to stagnation points on the airfoil that were not realistic. Kutta condition was then used to force the stagnation point at the trailing edge. This was done by adjusting the value of vorticity strength Γ. Using different offset values different airfoil geometries were obtained. Once the profile of airfoil at different AOAs is generated in w plane then it is used to calculate the velocity profile over the entire contour which is further used to calculate the C_P variation over the complete geometry. These C_p values were then corrected using Karman-Tsien compressibility correction equations. Calculated C_p values were then compared with standard NACA Airfoil and were found very close to them. Corresponding pressure differential, ΔP values were then evaluated at different AOAs for different airfoil geometries.

T-2D-2. A CELL VERTEX BASED FINITE VOLUME TIME DOMAIN TECHNIQUE FOR MAXWELL'S EQUATIONS

Narendra DEORE and Avijit CHATTERJEE, *Department of Aerospace Engineering, IIT Bombay, India,* A three-dimensional cell-vertex finite volume time domain (FVTD) technique is developed to predict an electromagnetic scattering from aerospace configurations. The dynamics of the electromagnetic scattering is governed by the Maxwell equations. The time-dependent Euler equations of gas dynamics are normally solved using characteristic based numerical techniques in the FVTD framework. A similar approach is adopted to solve the time-domain Maxwell's equations posed as a set of hyperbolic conservation laws written in a total field form. This similarity accounts for the popularity of the FVTD technique for aerospace applications where characteristics based method is increasingly being applied to solve for electromagnetic scattering from aerospace configurations. Initial value problems based on "fluctuation-signal" framework was first proposed by Roe for time dependent Euler equations of gas dynamics. This approach leads to a cell vertex based finite volume techniques for hyperbolic conservation laws in multidimensions. The fluctuation-signal concept for one-dimensional time dependent Euler equations leads to the distribution of the nodal information based on the characteristics property of the hyperbolic conservation laws. Literature does not report a generalized natural multidimensional concept as an routine extension of one-dimension. The traditional way of extension to multidimensions is done by dimensional splitting equivalent to solving Riemann problems normal to cell faces. A basic feature of the scheme is, the values of the dependent variables are specified at cell vertices instead of cell centre and they form the basis for approximation of the flux balance for a computational cell. Special "distribution formulas" based on the fluctuation-signal approach, are used to distribute the second order change from the cell centre to the cell vertices. A three-dimensional cell vertex based finite volume time domain technique to solve the Maxwell's equations on structured grids has not been previously reported in literature. The benchmark test cases are validated and simulation results are compared successfully with the analytical results.

T-2D-3. ON THE EFFECTS OF ADVANCED AND DELAYED PITCHING ON A 2-D HOVEING WING

K. B. LUA, T. T. LIM and K. S. YEO, *National University of Singapore, Singapore,* This paper reports the results of an experimental investigation on the effects of advanced and delayed pitching on a two-dimensional (2-D) hovering wing. The hovering motion consists of simple harmonic translation/flapping and pitching motions. In the case of advanced pitching, the pitching motion is +30° phase angle (ϕ) in advance of the translation/flapping motion, and in the case of delayed pitching, the pitching motion is -30° phase angle behind the translation/flapping motion. Digital particle image velocimetry (DPIV) and strain gage force measurement techniques have been employed to measure the flow field and the associated aerodynamic forces. The DPIV setup consists of a 2-D flapping mechanism which is capable to execute coupled translation/flapping and pitching motions, a synchronized Nd-YAG pulsed laser as the illumination source and one megapixel digital CCD camera to capture the image data. Force measurement was conducted using a separate force measurement flapping mechanism installed on a 1m x 1m x 0.38m square tank. A 2-D force sensor was installed at the base of the wing above fluid surface. For a simple harmonic flapping with a symmetric pitching, both the lift and drag distributions show a "dual-peak" pattern over a single stroke of flapping. The first peak is mainly due to the induced velocity of the attached leading edge vortex formed in previous stroke and the second peak is due to the new leading edge vortex formed in the current stroke and also the wing pitching up motion. As for the advanced pitching, although it significantly increases the second peak in lift due to the early pitching up motion, it also causes negative lift at the beginning of a stroke due to the low angle of attack. Overall, the advanced pitching increases the average lift, accompanying by a significant increase in drag. On the other hand, the delayed pitching increases the first peak in drag and decreases the second peak significantly. This behavior can be attributed to the increasing angle of attack during the early part of a stroke and the decreasing angle of attack during the second half of the stroke. Overall the delayed pitching reduces the average lift and increases the average drag significantly.

T-2D-4. ALLEVIATION OF UNSTART OF A SUPERSONIC INTAKE ADOPTING COWL DEFLECTION AND BLEED

S. DAS, *Department of Space Engineering & Rocketry, B.I.T Mesra - Ranchi, India*, J. K. PRASAD, *Department of Space Engineering & Rocketry, B.I.T Mesra - Ranchi, India,* Ramjet powered aerospace vehicle needs compressed air, for a stable combustion, which could be obtained through air-intakes for improved performance of engines. At supersonic speeds, the shock wave system generated inside the intake influences the overall efficiency. One of the critical issues is the unstart phenomena of intake which could be induced by variations in the operating conditions or non-sustainable back pressure from the combustor. In general, this phenomena is unsteady in nature and may be detrimental for the vehicle. Mixed compression intakes are highly susceptible to the unstart phenomena compared to other forms of configuration. The intake unstart can be identified by the presence of subsonic flow near the throat which will have a complex internal flow. Suppression of these unstarts are done usually by boundary layer bleed, fluid injection, spillage through wall perforations etc. The present study deals with suppression of unstart by means of cowl deflection as well as by bleed and its effect on overall performance. A numerical simulation to study the starting phenomena of a supersonic air-intake has been made for a mixed compression rectangular intake designed using inviscid solutions. Computations have been made with RANS solver using k-ω turbulence model. Intake unstart was observed during viscous simulations which could be due to a large scale separation at the intake throat, expelling shock system out of the duct. Experiments were also made at a Mach number of 2.2. Schlieren photographs were taken and the flow field details inside the intake duct were investigated. It is observed through the computations made and as well through the experiments, that a deflected cowl could start the intake. Separately, simulations through adoption of boundary layer bleed, could also avoid the unstart. Studies were made for different cowl deflection angles and bleeding rates. Results indicate that deflected cowl has better performance in comparison to boundary layer bleed. This suggests that cowl deflection to control the separation could be thought of as an alternative to boundary layer bleed, to alleviate the starting problems of mixed compression intakes.

14:30 ~ 15:50 (Room 105)

Compressible Flows (I)

Session Chair : Prof. Y. Miyazato, Kitakyushu Univ/Japan

T-2E-1. INFLUENCE OF TRAILING WALL ANGLE ON THE UNSTEADINESS OF CAVITY FLOWS

VIKRAMADITYA, N. S. *IIT MADRAS, India*, Job KURIAN, *IIT MADRAS, India,* An experimental study of supersonic flow over two-dimensional cavities is presented in this paper. All the experiments were carried out at