Session Chair : Prof. T. Yasunobu, Kitakyushu Univ/Japan

W-4D-1. A STUDY ON STRAIGHT-BLADED VERTICAL AXIS WIND TURBINE WITH A DIRECTED GUIDE VANE

M. TAKAO, *Matsue National College of Technology*, *Japan*, H. KUMA, *Matsue National College of Technology*, *Japan*, S. OKUHARA, *Matsue National College of Technology*, *Japan*, T. MAEDA, *Mie University*, *Japan*, K. KAMEMOTO, *Yokohama National University*, *Japan,* A straight-bladed vertical axis wind turbine (this is named "S-VAWT" in the study) has been developed and investigated so far. According to previous studies, it was clarified that the performance of this wind turbine can be improved by means of the directed guide vane. In this case, the guide vane rotates around the rotor and is directed to the wind by aerodynamic force generated by a tail vane, so as to put the guide vane upstream of the rotor. However, mechanism of the performance improvement of the proposed S-VAWT has not been clarified to date. The objective of the study is to clarify its mechanism. First, the performance of S-VAWT with a directed guide vane was investigated by a wind tunnel and was compared with that of the original S-VAWT which has no guide vane. And then, in order to clarify mechanism of the performance improvement, flows around the wind turbine have been estimated by use of the vortex method which provides a Lagrangian simulation of unsteady and vortical flows. The results in the study are summarized as follows: (1) The performance of proposed S-VAWT was improved by means of the directed guide vane and its power coefficient was approximately 1.2 times higher than that of the original wind turbine. (2) Since the guide vane generates wake in its downstream and increases the whirl velocity of inlet flow to the rotor, the performance of S-VAWT is enhanced.

W-4D-2. OPTIMIZATION CONFIGURATION OF MULTI-ELEMENT AIRFOIL GAP WITH THE MODIFIED GENETICAL ALGORITHM

G. SUN, X. YAN, Y. C. CHEN, *Mechanics and Engineering Science Dep., Fudan Univ., China,* Compare with some traditional optimal methods, genetic algorithm(GA)is more and more widely applied in the field of engineer optimization for its robustness, randomicity as well as global optimal performance. Meanwhile, aerodynamic performance of multi-element airfoil is becoming very important for aircraft design. The configuration of gap is very important for high-lift device design. This paper presents chimera technique with Bi-directional holes for main wing and flap. To increase the flexibility in the selection of sub-domains, this implementation removes region of a mesh containing an embedded grid from that mesh. That is, an embedded mesh introduces a "hole" into the mesh in which it is embedded. Because these regions do not enter into the solution process, inter-grid communication is simplified as communication among the grids is established through the grid boundaries. It can provide enough wide overlap to make the information transfer easy and it can also improve the mesh quality of both main wing and flap wing. The modified genetic algorithm (GA) remarkably improves the efficiency. The resulting optimized multi-element has higher aerodynamic performance than the initial shapes.

W-4D-3. FORWARD FACING ARRAY OF MICROJETS FOR IMPROVING THE FILM COOLING PERFORMANCE AT HYPERSONIC MACH NUMBERS

R. SRIRAM, *Indian Institute of Science, Bangalore, India*, G. JAGADEESH, *Indian Institute of Science, Bangalore, India,* Injection of a forward facing jet (opposite to the freestream direction) from the stagnation point of a blunt body can be used for mitigating both the aerodynamic drag and heat transfer rates at hypersonic Mach numbers. If the jet has enough momentum it can push the bow shock forward, resulting in reduced drag. This will also reduce heat transfer rate over most part of the body except around the jet re-attachment region. A reattachment shock impinging on the blunt body invariably increases the local heat flux. At lower momentum flow rates the forward facing jet cannot push the bow shock ahead of the blunt body and spreads easily over the boundary layer, resulting in reduced heat transfer rates. This technique is usually referred as film cooling. While the effectiveness of the film cooling improves with mass flow rate of the jet, higher momentum flow rates can lead to a stronger reattachment leading to higher heat transfer rate at the reattachment zone. If we are able to reduce the momentum flow rate of the coolant for the same mass flow rate, the coolant coming out can easily spread over the boundary layer and it is possible to improve the effectiveness of the film cooling. Experimental investigations have been carried out in the IISc hypersonic shock tunnel to study the improvement in the effectiveness of film cooling using an array of micro-jets. A 58 deg. Apex angle blunt cone has been selected for the experimental study. Time resolved schlieren flow visualization using high speed camera, aerodynamic drag measurement using a single component free-floating accelerometer balance and measurement of surface convective heat transfer using platinum thin film sensors deposited on Macor substrate are the diagnostics used to understand the effect of an array of micro-jets on the blunt body flow features. Studies have been carried out using a single jet (2mm diameter) and an array of 46 micro-jets (300 micron jet diameter) confined to an area of 25 sq. mm in the stagnation zone of the blunt cone. All the experiments have been carried out at a nominal Mach number of 5.9 with a corresponding stagnation enthalpy of 1.82 MJ/kg. The stagnation pressure of the freesteam is measured in the shock tunnel using a pitot probe. The reservoir pressure for the micro-jet array is measured using a PCB pressure sensor located in the internal chamber inside the blunt cone model. Nitrogen is the coolant gas injected. The jet is injected with a total pressure of 54 KPa. Up to 33% reduction in heat transfer was observed with the array of micro jets near the stagnation zone when compared with the corresponding single jet. No change in drag was observed with injection of coolant and the visualizations show no changes in the flow field external to the boundary layer.

W-4D-4. AERODYNAMIC STUDY ABOUT FORWARD FLIGHT OF A NEW BIONICS FLAPPING STYLE

BAI Peng, CUI Er-jie, ZHAN Hui-Ling, *China Academy of Aerospace Aerodynamics, China,* Firstly, a new kind of bionic flapping style, based on the research about the high unsteady lift mechanisms of the general fruit fly hovering flight, was introduced in this paper. The high aerodynamic lift mechanisms of this new flapping style were explained, and from the viewpoint of the aerodynamic lift and drag, the advantages of this new style comparing to the fruit fly flapping were also introduced. Secondly, The effects of the flapping parameters, the time of accelerating flapping: $\Delta\tau_t$, the time of accelerating rotating: $\Delta\tau_r$ and the angle of attack at constant flapping velocity: α, to the aerodynamic characteristics were studied. And the benefit of the wing flex to the new flapping style aerodynamic characteristics was also studied. It is obvious that wing flex is unuseful for the fruit fly flapping style. Finally, assuming the weight, flapping frequency, drag, wing area and wing average chord are all same with the fruit fly, the numerical simulation method was used to study the forward flight aerodynamic characteristics of this new bionic flapping style. And the mechanisms of the aerodynamic lift and thrust were analyzed carefully. The conclusion could be drawn that this new bionic flapping style can obtain enough aerodynamic lift and thrust to realize forward fly. And the stabilization of this flapping method need to be studied further.

15:00 ~ 16:20 (Room105)

Geophysical Fluid Dynamics (III)

Session Chair : Prof. Van Groesen, Twente Univ/Netherlands

W-4E-1. A NEW METHOD FOR QUASI-THREE DIMENSIONAL VISUALIZATION OF CLOUDS FROM SATELLITE IMAGES

T. N. VENKATESH, *National Aerospace Laboratories, India,* In the field of atmospheric science, visualization is crucial for understanding the underlying processes. While the use of dyes and imaging techniques have advanced to a high degree in laboratory experiments, direct experiments are difficult in the atmosphere. Fortunately, clouds form natural markers and indicate large-scale flows. The main objective of the present work is to construct animated three-dimensional views of large cloud systems from available satellite imagery to understand their dynamics better. The key idea is that since the infra-red (IR) radiation is a measure of the cloud top temperature which in turn is a function of the altitude, it should be possible to infer the three-dimensional nature of the surface of the cloud top. A novel technique for construction of quasi-three dimensional images of clouds from available two dimensional IR satellite images has been developed. Software has been developed using the OpenGL library to render this inferred three-dimensional surface over the globe. To the best of our knowledge, no work of this kind has been reported before. This technique has been applied for a number of cases using IR images from METEOSAT and GOES series of satellites. These cases include tropical cyclones (1999 Bay of Bengal super-cyclone and hurricane Katrina, 2005 etc.) as well as other cloud systems. Animations of the Indian summer monsoon cloud systems for the complete season (June to September) for many years have also been done and have been very useful in gaining an understanding of the monsoon.

W-4E-2. EFFECTS OF NUTRIENTS ON ALGAL BLOOMING IN