H. G. KIM, *KIER (Korea Institute of Energy Research), Korea*, S. W. WOO, *KIER, Korea,* This paper presents the improvement effect of wind shear by a structure installed upstream of a horizontal axis wind turbine. The atmospheric boundary layer has low wind speed near the ground surface due to friction but wind speed increases according to height above ground which leads a vertical wind speed profile having wind gradient, i.e. wind shear. Although such vertical wind speed profile gets strong wind loads while the wind turbine blades passes through the upper semicircle of the hub, there is a danger of decreasing the durability of wind turbine due to periodic aerodynamic fatigue loads as it gets relatively weak wind loads at the lower semicircle of the hub. Also, it can be the cause of vibration and noise due to eccentricity. Therefore, this study has performed a research on the method of uniformly distributing the wind speed delivered to the wind turbine blades by improving the wind shear. As an analysis method, the two-dimensional computational flow analysis has been carried out by assuming the structure installed upstream of a wind turbine as sold fence or windbreak forest. As a result, both the structure assumed as solid fence and the one assumed as windbreak forest showed near-uniform wind speed profile than in case of not installing the structure and the mean wind speed was shown as the one that can be increased. Assuming a 1.5MW wind turbine for reference, the difference between the wind speed at the top of blades and the wind speed of at the bottom of blades was shown as 9.5% in case of using solid fence and 12.5% in case of using wind break forest so that the wind speed was considerably reduced from 18.9% when nothing has been installed. That is because such a ground structure introduces a recirculation zone at the back of structure and this recirculation zone acts as a virtual streamline shaped hill to increase wind speed just like the hill effect with simple structure. Also in case of windbreak forest showing porous nature, it has the similar effect of increasing the wind speed by creating recirculation zone. But in case of the windbreak forest having porosity, it could be confirmed that the length of recirculation zone becomes shorter and this has verified the fact that a uniform wind speed can be delivered and also can expect the wind speed increasing effect if the structure is installed by adjusting porosity according to the surrounding environment and layout. Finally, the designing conditions on the installation position between a wind turbine and the structure is being presented by non-dimensional wind speed profiles.

W-3E-4. SOME INVESTIGATIONS INTO NEAR SURFACE WIND AND SALTATION INTENSITY IN MINQIN AREA

F. SHI, N. HUANG, X. J. ZHENG, *Key Laboratory of Mechanics on Western Disaster and Environment, Lanzhou University, China,* In recent decades, the research on the windblown sand movement has been intensified in order to meet the need of preventing from the increasing endangerment of wind erosion, desertification and dust storm. Current research on sand saltation concentrates on wind tunnel experiment, theoretical analysis and numerical simulation of sand saltation at ideal and controllable conditions and most field observation results are hour or day length averaged sand flux and wind velocity. Whereas the results on turbulent characteristics of near surface wind in real atmospheric boundary layer and the effects of fluctuations in wind velocity on sand saltation appear to be much fewer although these topics have obtained increasing recognition of importance in recent decades. Based on some instruments imported from abroad, we jointly developed a system with colleagues from The Wind Erosion and Water conservation Research Unit of US Agriculture Department, which consists of four lightweight fast-responding cup anemometers, four SENSITs, eight BSNE collectors, the HMP50 Temperature and Relative Humidity Probe and can simultaneously measure pulsed wind velocity at near surface, sand transport intensity, sand mass flux, temperature and humidity are measured with 1Hz frequency on sand dune in Minqin area, which locates between edges of the Badain Jaran Desert and the Tengger Desert. The analysis on the measured data shows that wind fluctuation with high frequency and sand saltation is with high level of intermittency accordingly. The moving sands can fully respond to the fluctuation of wind whose frequency is lower than 1/30 Hz. And, only when the mean time step is more than 30s, can the average wind velocity distribution obey logarithmic distribution.

13:20 ~14:40 (Room106)

Convection and Buoyancy – Driven Flows (I)

Session Chair : Prof. K. Mansour, Amirkabir Univ of Tech/Iran

W-3F-1. EFFECT OF EVAPORATOR SURFACE ROUGHNESS ON THE PERFORMANCE OF A TWO-PHASE CLOSED LOOP THERMOSYPHON

M. A. R. AKHANDA, *IUT, Bangladesh,* S. L. MAHMOOD, *IUT, Bangladesh,* A. B. M. N. BAGHA, IUT, *Bangladesh,* A two-phase closed loop thermosyphon has been designed, fabricated and tested. This thermosyphon consists of four components in its loop: an evaporator with boiling enhancement structure, vapor rising tube, condenser and condensate return tube. Tests are conducted at atmospheric pressure to assess the effects of evaporator surface geometry using three working fluids (acetone, ethanol and methanol). Evaporator surface is heated by using an electric capsule heater which is connected to the A.C power supply. Heat supply is varied using a voltage regulator which is measured by a precision ammeter and a voltmeter. Condenser section is cooled by natural circulation of air. Temperatures at different locations of the evaporator surface are measured using calibrated K type thermocouples. Four different evaporator surfaces namely smooth surface (SS), semicircular ribbed surface (SCRS), triangular ribbed surface (TRS) and saw tooth ribbed surface (STRS) have been tested in this study. It is found that, for ethanol, at 20°C wall superheat, heat flux dissipated from saw tooth ribbed surface (STRS) is around 35% higher, from semicircular ribbed surface (SCRS) is around 25% higher and from triangular ribbed surface (TRS) is around 16% higher than that of smooth surface (SS) respectively. Among the working fluids used, heat flux dissipation from evaporator surface using ethanol is about 1.3 times higher than that of methanol and about 2 times higher than of that of acetone respectively. Thus saw tooth ribbed surface (STRS) shows the best performance among all the evaporator surfaces tested in this study and among all working fluids used ethanol's performance is the best.

W-3F-2. INCOMPRESSIBLE MULTI-RELAXATION-TIME LBM WITH NON-UNIFORM MESH FOR LES OF RAYLEIGH-BÉNARD CONVECTION FLOW

A. R. RAHMATI, *Isfahan University of Technology, Iran*, M. ASHRAFIZAADEH, *Isfahan University of Technology, Iran*, E. SHIRANI, *Isfahan University of Technology, Iran,* Rayleigh–Bénard convection flow is an original phenomenon which occurs in a wide variety of atmospheric and industrial applications. Various numerical schemes have been implemented to study this problem, including the lattice Boltzmann method (LBM) which has appeared as one of the strongest CFD methods for simulating fluid flows and modeling physics in fluids in recent years. In the present work, the application of incompressible MRT-LB model for large-eddy simulation (LES) of turbulent thermally driven flows is considered. A Taylor series expansion and least square based Lattice Boltzamnn method (TLLBM) has been implemented in order to use a non-uniform mesh. It permits to reduce the required mesh size and consequently the computational cost to simulate the turbulent buoyant flow fields. The implementation is discussed in the context of a D2Q9-MRT-LB model in conjunction with the Smagorinsky subgrid closure model. The MRT-LB-LES is applied to a two-dimensional turbulent Rayleigh-Bénard convection flow at different Rayleigh numbers for Prantdl number of 0.71. Results show that the calculated Nusselt number is over predicted in comparison with the Nusselt number computed by the empirical formula at higher Rayleigh numbers. The over-prediction of the Nusselt number may be due to the SGS model through the evaluation of the SGS heat flux or due to insufficient spatial resolution.

W-3F-3. EFFECT OF WALL-NORMAL FLOW ON HIGH Sc NATURAL CONVECTION BOUNDARY LAYERS

G. Vijaya Rama REDDY and Baburaj A. PUTHENVEETTIL, *Department of Applied Mechanics, IIT Madras, India,* We investigate the effects of wall-normal velocity (V_b) on high Schmidt number (Sc>600) natural convection boundary layers formed on permeable horizontal surfaces. Using integral boundary layer equations, we define a blowing parameter, $S = (Re_L^5/Gr_L)^{1/8}$ to characterize the strength of blowing relative to the buoyancy and the viscous effects. The analysis is performed for $0.1 \le S \le 0.26$. The upper limit being given by $Re_\delta = V_b\delta_v/\nu < 1$ so that inertial effects in the boundary layer are small. The lower limit of S ensures that there is negligible diffusive mass transfer in the species boundary layer. As expected, blowing increases the velocity boundary layer thickness and the species boundary layer thickness; the effect is felt more on the species boundary layer thickness. Blowing also increases the horizontal velocity in the boundary layers. We show that the species boundary layer thickness scales as $x(Re_x/Gr_x)^{1/4}$ while the horizontal velocity scales as $V_b\,(Gr_x/Re_x)^{1/4}$.

W-3F-4. EFFECT OF INCLINATION ANGLE ON MIXED CONVECTION IN A LID-DRIVEN ENCLOSURE WITH INTERNAL HEAT GENERATION

A. K. M. SADRUL ISLAM, *IUT, Bangladesh*, G. SAHA, *AUST, Bangladesh*, S. SAHA, *BUET, Bangladesh,* M. Q. ISLAM, *BUET,*