10dB. Compressed dry air is stored in a high pressure tank that has a capacity of $5m^3$, and is supplied to the plenum chamber, in which a honeycomb system reduces flow turbulence. A convergent-divergent nozzle with a design Mach number of 2.0 is installed in the end wall of plenum chamber. The nozzle has a throat height of 9.6mm, an exit height (D) 16.2mm, and a width 30mm. A Schlieren optical system is employed to visualize the qualitative structures of supersonic jet. Acoustic measurements are made using a condenser microphone that has a diameter of 6mm. The microphone is located at a 96° from the jet direction, and the radial distance of 34D (550mm) from the exit of the nozzle. The acoustic signals are analyzed by using a FFT analyzer. A FFT analysis provides the noise spectra, and providing the spectral data in the range from 0 to 40 kHz, with a frequency band width of 25 Hz. The temperature in the plenum chamber is measured by using a thermocouple (approximately 288K), and it maintains constant at room temperature during test. The pressure is measured by a pressure transducer flush mounted on the top wall of the plenum chamber and nozzle wall. The results obtained show that generation of transonic resonance is closely related to the pressure oscillations in the nozzle, and the large area of Mach stem increases the amplitude of transonic tone.

W-1E-2. COMPUTATIONAL ANALYSIS OF JET IN SUPERSONIC REGIME WITH VARIABLE AMBIENT CONDITIONS

Ajmal BAIG, S. BILAL and S. ZAHIR, *National Engineering & Scientific Commission, Islamabad. Pakistan,* Computational study of the behaviour of the supersonic jet in supersonic regime has been done for fully-expanded and under-expanded jets and compared with the still ambience. The supersonic jet is produced with a convergent-divergent nozzle. Initially the centre-line pressure distribution with an ambience of still air is calculated for fully and under-expanded jets and then the pressure distributions for fully and under-expanded jets are calculated when ambient flow is supersonic. The centerline pressure distribution in still air shows that the oscillations in fully expanded jet are very fast as compared to the under-expanded jet. These pressure oscillations are reduced in the supersonic regimes as a result of supersonic pressure relief effect. The length of shock cells for underexpanded jet is greater than the full-expanded jet both in still air and supersonic freestream. The computational analysis showed that the jet pressure adjust to the ambient pressure very quickly in the supersonic regime as compared to the still ambience. The problem is solved using CFD software based on the finite control volume technique. Air is taken as working fluid and solved as ideal gas. Viscosity is calculated using Sutherland law. For 2D axisymmetric geometry, the continuity and momentum conservation equations in axial and radial direction are solved. The energy equation is also solved. Density based solver with implicit formulation and 2nd order upwind flow discritization is used. Two equations k epsilon turbulence model with standard wall functions is used. Symmetry boundary condition is applied along the axis of symmetry for nozzle flow simulation. At the inlet of nozzle, reservoir stagnation conditions are employed. Pressure farfield condition is used for the outer boundaries. At a very high Reynolds number, the boundary layer developing at the nozzle wall is very thin, and its influence on the mean core of the jet is very weak.

W-1E-3. DETAILED ANALYSIS OF THRUST PLUME AND SATELLITE BASE REGION INTERACTION

J. G. KIM, *KAIST, Korea*, O. J. KWON, *KAIST, Korea*, M. J. YU, *KARI, Korea*, K. H. LEE, *KARI, Korea* and S. K. KIM, *KARI, Korea,* The interaction between thrust plume and satellite base region for the Korea multipurpose satellite-Ⅲ configuration was investigated by using direct simulate Monte Carlo calculations. For the accurate simulation of H2 collisions and rotation-translation transition, a variable soft-sphere model and a recent rotational relaxation model of N2 and H2 were used. For the investigation of the interaction between thrust plume and base region, the number density distribution for each species, translational and rotational temperature distributions, heat flux, and pressure were examined by DSMC calculations. It was found that most of the surface properties are affected by H2 collisions and a strong non-equilibrium state is observed on the S-band antenna and at the base region. It was demonstrated that an accurate model is needed to simulate H2 collisions and the rotation-translation transition. The results by the present calculation are more accurate than previous DSMC calculations because more accurate models were used in simulating elastic and inelastic collisions in the present study.

W-1E-4. EXPERIMENTAL INVESTIGATION ON HYSTERESIS PHENOMENA OF MACH DISK IN UNDER-EXPANDED AXISYMMETRIC JET

S. MATSUO, *Saga University, Japan*, T. HIGASHI, *Saga University, Japan*, T. SETOGUCHI, *Saga University, Japan*, H. D. KIM, *Andong National University, Korea,* When the high-pressure gas is exhausted to atmosphere from the nozzle exit, the under-expanded supersonic jet with the Mach disk is formed at a specific condition. The jet structure has been known as a fundamental phenomenon of the supersonic fluid mechanics. The jet is very important for some industrial devices and there exists many papers. These papers are on the steady jet as the ratio of reservoir stagnation pressure to back pressure is fixed. In two-dimensional under-expanded supersonic jet, it is reported that the hysteresis phenomenon for the reflection type of shock wave in the jet is occurred under the quasi-steady flow in the recent studies and the transitional pressure ratio between regular reflection and Mach reflection in the jet is affected by this phenomenon. The purpose of this study is to clarify the hysteresis phenomena for the reflection type of shock wave at the under-expanded axi-symmetric jet experimentally and to discuss the relationship between hysteresis phenomenon and rate of the change of pressure ratio with time. Furthermore, the effect of Mach number at the nozzle exit on hysteresis loop was investigated for two kinds of nozzle. The design Mach numbers of Nozzles A and B are M_e= 1.0 and 1.5, respectively. The Mach disk diameter and the distance from nozzle exit to Mach disk were obtained from shadowgraph pictures. As a result, in the under-expanded axi-symmetric jet, hysteresis phenomena for the configuration of shock wave were investigated experimentally. The phenomena were confirmed in the supersonic axi-symmetric jet at the present experimental condition. Furthermore, the range of hysteresis loop extended with an increase of Mach number at the nozzle exit and this phenomenon had the same characteristics as that in the transition between regular and Mach reflection of shock waves in two-dimensional flow field.

09:00 ~ 10:20 (Room106)

General Fluid Dynamics

Session Chair : Prof. M. Alam JNCASR/India

W-1F-1. THERMOMAGNETIC CONVECTION IN A MAGNETIC NANOFLUID LAYER

I. S. SHIVAKUMARA, *UGC-Centre for Advanced Studies in Fluid Mechanics, Department of Mathematics, Bangalore University, India,* Magnetic nanofluids are commercially manufactured stable colloidal liquids formed by suspending fine magnetic monodomain nanoparticles in non-conducting carrier liquids like water, heptane, kerosene, etc. Thermal convection in magnetic nanofluids has become a topic of current technical importance because magnetic forces can be used to create circulation of coolant in small passages where natural convection is either absent or ineffective. In the present paper, the linear stability of an initially quiescent magnetic nanofluid layer under the influence of an external magnetic field is investigated. The lower rigid-ferromagnetic boundary is heated by a constant heat flux, while at the upper rigid-ferromagnetic boundary a general thermal condition which encompasses fixed temperature and constant heat flux as particular cases is invoked. The resulting eigenvalue problem is solved numerically using the Galerkin technique and it is observed that the instability is always onsets into steady convection. Realizing this fact, closed form analytical solutions are also obtained using regular perturbation technique for constant heat flux thermal boundary conditions with wave number a as a perturbation parameter. It is found that the results obtained from these two techniques are in excellent agreement suggesting the analytical solution obtained for the constant heat flux thermal conditions is exact. It is also found that an increase in the magnetic number M_1, and the nonlinearity of fluid magnetization M_3, as well as decrease in the Biot number Bi, is to hasten the onset of thermomagnetic convection. To the contrary, the nonlinearity of fluid magnetization is found to have no effect on the threshold values for the onset of thermomagnetic convective instability in the case of constant heat flux thermal boundary conditions. Besides, comparison of results with earlier work is also made under the limiting case and good agreement is found.

W-1F-2. FRICTION FACTOR IN A V-SHAPED OPEN CHANNEL

Mirali MOHAMMADI, *Department of Civil Engineering,Urmia University, Urmia,* Alireza MOGHADDAMNIA, *Faculty of Natural Resources, University of Zabol, Iran,* The experimental study on the distribution of friction factor, f, of a V-shaped channel is examined as it occurs in sewers and culverts. Several series of experiments were conducted for measuring velocity and boundary shear stress. It may be seen that the Darcy-Weisbach friction factor, f, is more sensitive than the other resistance coefficients such as the Manning n. The contour plots of 2D isovels shows that the isovels are parallel to the channel boundary in a region close to the bed, and almost