in the design of better combustors with proper alignment of the fuel injectors with respect to the flow for better evaporation and mixing of the fuel.

T-3A-4. THE EFFECT OF THERMAL MACH ON THE TEMPERATURE DISTRIBUTION AROUND A MOVING HEAT SOURCE

E. IZADPANAH, *Yazd University, Iran*, S. TALEBI, *Yazd University, Iran*, M. MIRZAEI, *K. N. Toosi University, Iran*, M. H. HEKMAT, *K. N. Toosi University, Iran,* In this paper the effect of thermal Mach number ($M=v/C$) on temperature distribution around a moving heat source (inside an infinite body) has been investigated. Due to rapid movement of heat source and small time scale in such problems, Fourier heat conduction model can not predict temperature distribution accurately because in Fourier conduction, speed of heat propagation has been considered infinity but in non-Fourier conduction, this speed is limited. In this work non Fourier heat transfer model is employed and the governing equation is solved using finite difference method. It can be considered that there are three manners for thermal Mach number. When $M>1$ the speed of the source is greater than the speed of the heat propagation, consequently the temperature at the region behind the heat source changes. When $M \leq 1$, the speed of heat propagation is greater than or equal to the speed of the source. This causes variation of temperature at the regions behind and in front of the source. And when $M=0(C=\infty)$ the non Fourier conduction model approaches to the Fourier model. From assessing the results, it is obvious that there is no critical mach number for heat source movement, and also for constant speed of heat propagation if Mach number become smaller the bounds of temperature variations is increased. For C=20m/s, the difference between Fourier and non Fourier models is small, but whatever we go more far from heat source , this difference increases. If speed of heat propagation is decreased, difference between Fourier and non Fourier conduction models will be increased.

16:00 ~ 17:20 (Room 102)

Experimental Techniques (III)

Session Chair : Prof. H. Ishikawa, Tokyo Univ of Sci/Japan

T-3B-1. THE MACRO & MICRO SCALE SIMULATION STUDY IN NICKEL ELECTRO-PLATING PROCESS

D. H. YOO, H. S. YOON and J. C. AN, *CAE Group*, *Corporate R&D Institute, Samsung Electro-Mechanics Co., Ltd, Korea,* Electro-plating has significant applications in present day industry ranging from microelectronics to metallurgy. But, although advanced numerical methods exist and have been applied with great success in engineering domains, the use of methods for electroplating applications remains very limited. One of the main reasons for this might be the complexity of the process that governs electroplating reactors. Mass transfer effects and reaction bath design play an important role in the plating process. To improve the performance of the electroplating process, a better understanding of the electrolyte flow, current density distribution and deposit thickness distribution in the plating bath is needed. In this study, we reported the mechanism of the non-uniformity of nickel deposit thickness increased by the fine pattern trend. To this purpose, we have developed a macro & micro scale multi-physics numerical method to calculate the deposit thickness of micro patterned PCB (printed circuit board). In our tool, all the mechanisms related to the electroplating process such as fluid dynamics, ion transport, and surface chemistry have been considered with the Butler-Volmer kinetics for calculating the current density on the electrodes. And, a micro scale method, we have redesigned the structural & driving conditions of nickel electroplating process that can improve the deposit thickness uniformity. The results of calculation well agree with the corresponding experimental data.

T-3B-2. AN EXPERIMENTAL STUDY ON SWIRLING FLOW IN A SUDDEN EXPANSION TUBE USING THE 3D PIV TECHNIQUE

Tae Hyun CHANG, *Senior Research Fellow of Korea Institute of Science and Technology Information 335 Gwahangno, Yuseog-gu, Daejeon, Korea,* During the past three or four decade, the characteristics of turbulent swirling flow have been studied extensively because of its great technological and scientific important. It well known that swirling flow improves heat transfer in tube flow. The reason for this is due to the effect of streamline curvature associated with the tangential velocity component. The swirling flow of water through a sudden 1:2 axisymmetric expansion has been studied experimentally in a horizontal round tube. Measurements of this flow were performed with a 3D PIV system. While swirling flow through an abrupt tube expansion is a relatively unknown problem. For a many years, this flow has been investigated in straight tube for heat exchangers or combustion chamber. In this research, the results are compared with swirl flow and non swirl at the sudden tube. The important objective of this research is to introduce velocity profiles at the expansion region with swirl and non-swirl flow. Other one is to design thermal fluid machinery in which swirling is playing a main source of heat and combustion.

T-3B-3. PIV STUDIES ON DRAINING FROM CYLINDRICAL TANK WITH ECCENTRIC DRAIN PORT

C. H. SOHN, M. G. JU , B. H. L. GOWDA, *Kyungpook National University, Korea,* When draining takes place through a axially located drain port in a cylindrical tank with initial rotating imparted, a vortex with an air core occurs. By providing the drain port eccentrically, the vortexing can be prevented, if the eccentricity is above a particular value. For values of eccentricity less than this value, vortexing with an air core occurs. For certain values of eccentricity, the air core appears and disappears more than once. In this study, this phenomenon is investigated using PIV. The results indicate that the appearance and disappearance of the vortex with an air core is due to concentration and diffusion of vorticity alternatively.

T-3B-4. MEASUREMENTS OF MICRO BACKWARD FACING STEP FLOWS WITH A SINGLE CAMERA MICRO 3D-PTV

D. H. DOH, *Korea Maritime Univ.(KMU), Korea*, H. J. SUNG, *KAIST, Korea*, Y. B. CHO, Y. B. PYEON, K. R. MOON, *KMU*, *Korea,* K. R. CHO, *Eyelizer Co. Ltd., Korea*, M. OISHI, *Institute of Industrial Science(IIS), Tokyo Univ., Japan,* H. KINOSHITA, *IIS, Japan*, T. FUJII, *IIS, Japan,* M. OSHIMA, *IIS, Japan*, M. TAKEI, *Nihon Univ., Japan,* Single camera based micro 3D-PTV system has been constructed using GA algorithm. The system has stereo-viewing holes just behind the objective lens of the microscopic system. The system consists of one high-definition camera (1028 x 1024 pixel, 500fps), an Ar-ion laser(500mW) and a host computer. A hybrid genetic algorithm (GA) has been adopted and an epipolar concept has been introduced to eliminate spurious candidates so that calculation loads can be reduced. The constructed system has been adapted for the measurements of a micro backward facing step channel (H x h x W: 36μm x 70μm x 3000μm). Reynolds number with H is 0.017. The performances tests for the system have been carried out using the actual camera parameters. The measurement errors for X, Y and Z coordinates were 0.083μm, 0.045μm and 0.083μm, respectively. The measurement results were compared with that of CFD results. It showed reasonable tendencies qualitatively. A small amount of measurement errors were attributed to the fact that the particle density was too small, the optical conditions was not in optimal, and the errors from vector interpolations couldn't be reduced. In this study, the optimal distance of the two holes was 5mm and their optimal diameter was 3.5mm.

16:00 ~ 17:20 (Room 103)

Separated Flows

Session Chair : Prof. Y. Z. Liu, Shanghai Jiao Tong Univ/China

T-3C-1. NUMERICAL SIMULATION OF ACOUSTIC EXCITATION OF LAMINAR FLOW PAST OF A BACKWARD-FACING STEP

C. BALAJI, S. R. CHAKRAVARTHY, *IIT Madras, India,* Acoustic-like inlet perturbations are introduced in a flow past a backward-facing step at low Reynolds number (Re < 400). The unsteady flow is numerically solved using the finite volume method, and the SIMPLE technique is employed to couple the pressure and velocity fields. A distinct off-band frequency at Strouhal number St = 0.2 is observed in the transverse component of velocity when the flow is perturbed with noise in the range $2.3 < St < 23$. Fourier decomposition of the flow field is done to obtain the velocity field at St = 0.2. Large-scale vortex shedding is observed at this frequency; the recirculation zone is found to lift off and pinch off. With harmonic perturbation, the preferred frequency of the shear layer decreases with increase in distance from the step and matches that with the noise perturbation, signifying that the preferred frequency is independent of the frequency content of the perturbation. Increase in Re increases the response of the transverse component of the velocity for lower excitation frequencies and vice versa. Multiple peaks occur in the stream-wise component of the velocity field because of constructive and destructive interferences of the inlet perturbations propagating along the irrotational and rotational streamlines. The modification to an acoustic-like perturbation at the inlet afforded by the presence of the shear layer