14:50 ~ 16:10 (Room101)

Flows in Porous Media (I)

Session Chair : Prof. Noor Afzal, Alighar Muslim Univ/India

M-2A-1. EFFECT OF MHD ON NATURAL CONVECTION IN A TRAPEZOIDAL ENCLOSURE

M. A. H. MAMUN, M. T. ISLAM, *BUET, Bangladesh*, A. K. M. S. ISLAM, *IUT, Bangladesh,* The effects of magnetic force, acting vertically downward, on natural convection within a porous trapezoidal enclosure saturated with an electrically conducting fluid have been investigated numerically. The bottom wall of the enclosure is subjected to a constant hot temperature and the top wall experiences a constant cold temperature whereas the remaining sidewalls are kept adiabatic. The influential parameters are the modified Rayleigh number, Ra_m, the fluid Rayleigh number, Ra_f, and the Hartmann number, Ha. Ra_m and Ha have been varied from 10^0 to 10^3 and 0 to 20 while Darcy number, Da, and the inclination angle of the side walls have been fixed at 10^{-6} and 45°. The rotation angle of the cavity, Φ is set to 0°. In the present study, the results show that at lower value of Ra_m, the thermal stratification inside the cavity indicates that the convection is overwhelmed by the conduction mechanism whereas the convection-dominated zone is established at higher values of Ra_m. In the absence of the magnetic force, the convection-dominated zone is extended resulting better convective heat transfer performance. Increasing Hartmann number retards the fluid circulation causing the lower temperature gradients throughout the cavity. Therefore, major portion of the heat is transferred mainly by conduction.

M-2A-2. OSCILATORY BEHAVIOR OF FLOW THROUGH A CIRCULAR PIPE LINED WITH A DEFORMABLE POROUS LAYER

P. FOROOGHI, *Amirkabir University of Technology, Iran*, E. DAMANGIR, *Amirkabir University of Technology, Iran,* M. SAFFAR AVVAL, *Amirkabir University of Technology, Iran,* Non-steady laminar flow through a circular pipe lined with a deformable porous layer is numerically investigated. This problem is relevant to some applications among which are blood flow in vessels, filtration, and soil mechanics. Authors believe that this problem could also be interesting from the viewpoint of fluid-structure interactions and could be inspiring for future applications. The flow through deformable porous media is modeled employing the theory of mixtures. The resulted coupled equations for both fluid velocity and solid structure displacement are solved using a finite difference explicit scheme. The problem is solved in two cases: First, a suddenly starting flow, and second, a pulsatile flow. It is observed that the solid structure of the porous layer begins vibrating when exposed to the flow. It leads to oscillatory behavior of flow in the pipe. In the case of starting flow, oscillations get stopped after reaching the steady state. In this state, deformability of porous layer has no influence on the flow. When pressure gradient is pulsatile, at certain frequencies, amplitude of the oscillation of fluid flow increases. This amplification may be relevant to resonance of porous structure at its natural frequency. When frequency is too high or too low deformable porous media acts as a rigid one.

M-2A-3. EFFECT OF ASPECT RATIO ON MIXED CONVECTION IN A MICROSTRUCTURE FILLED VENTED CAVITY

M. H. BANNA, *IUT, Bangladesh,* M. A. H. MAMUN, *BUET, Bangladesh*, A. K. M. SADRUL ISLAM, *IUT, Bangladesh,* In this study we have considered an enclosure filled with fluid saturated porous medium with adiabatic top wall, bottom wall and right wall. The left vertical wall is considered as isothermal at constant temperature. There is an inlet at the left corner of the bottom wall and the vent is on the left corner of the top wall. The widths of the inlet and vent are I and O respectively and in this study we have considered I/O=1.0. Buoyancy effects are induced due to the difference in temperature between the left vertical wall and the through-stream temperature which has a constant velocity at the inlet of the enclosure. The inlet forced flow is fixed and the temperature difference considered here is positive which means it is an aiding flow. The problem is solved using the modified Darcy flow model and energy equation for five different Rayleigh Numbers (1, 50, 100, 500, and 1000) and seven different Pe′clet Numbers (0.1, 1, 5, 10, 20, 50 and 100). The equations are solved using standard Finite Element method for considering three different Aspect Ratios of the cavity (AR=H/W=0.5, 1, 1.5). It is observed that near the isothermal wall the isothermal lines are denser for the lower aspect ratio configuration. This relates to a higher heat transfer rate for the lower aspect ratio case. The effect of Aspect Ratio on Streamline, Average Nusselt Number, Average Entropy Generation Number, Average Bejan Number, Average Energy Flux Density are also analysed in this study for different Rayleigh Numbers and Pe′clet Numbers.

M-2A-4. NATURAL CONVECTION IN A LAYERED POROUS TRAPEZOIDAL CAVITY UNDER APPLIED MAGNETIC FIELD

Md. TOFIQUL ISLAM, *Bangladesh University of Engineering & Technology (BUET), Bangladesh,* The present computational investigation demonstrates the effect of natural convection on the thermal and fluid fields within a trapezoidal cavity, packed with two horizontal porous media and saturated with an electrically conducting fluid under the influence of magnetic force. The bottom wall of the enclosure is subjected to a constant hot temperature and the top wall experiences a constant cold temperature whereas the remaining sidewalls are kept adiabatic. Using Galerkin weighted residual method of finite element formulation; the non-dimensional governing equations are discritized. The important governing parameters are modified Rayleigh number Ra_m, fluid Rayleigh number Ra_f, permeability ratio K_r and Hartmann number, Ha. In order to have a decent comparison between the flow structure and heat transfer, Ra_m is set at layer 1 as the permeability ratios ranges from 0.001 to 0.1 while for K_r = 10 – 1000, Ra_m is fixed at layer 2. The Ha is varied as $0 \leq Ha \leq 5$ for Ra_m =10000. The tilting angle of the cavity and the inclination angle of the side walls are considered to be zero and 45° respectively. In the present study, optimum convective heat transfer is obtained for homogeneous porous medium (i.e. K_r = 1) in the absence of magnetic force. Increase in Ha reduces the convection heat transfer and squeezes the convection-dominated zone. When the permeability gradients are higher, the penetration rate of fluid from more permeable layer to less permeable layer decreases resulting the reduction in thermal boundary layer near the heated wall.

14:50 ~ 16:10 (Room102)

Microfluidics (II)

Session Chair : Prof. S. Honami, Tokyo Univ/Japan

M-2B-1. SLIP FLOW IN MICROBEARINGS

Q. B. LI, S. FU, *Tsinghua University, China,* The flow slip near solid walls plays an important role in microbearings and fascinated many researchers. In the present study it is investigated analytically and numerically. The microbearing is represented as a cylinder rotating in a stationary housing with the Newtonian fluid between them. For the two-dimensional eccentric and three-dimensional concentric case, the analytical solution is deduced with infinite series, through which the flow slip at solid walls is shown to greatly affect the flow field and thus the torque on the journal. The generalized Maxell slip boundary condition, where the difference of the tangential velocity between the fluid and the wall is in proportion to the tangential shear stress, can correctly capture the slip effect, such as the inverted circumferential velocity in the narrow gap region for large slip factor. On the contrary, the conventional one, with slip velocity in proportion to its normal slope, yields clearly different results, with absent of the inverted velocity, and larger pressure and velocity variations, resulting in large value of torque on the journal. The end wall of the microbearing affects the flow field evidently when the bearing axis is not long. Numerical results from multidimensional BGK scheme with kinetic boundary conditions agree well with analytical solution.

M-2B-2. NUMERICAL ANALYSIS OF AC ELECTROWETTING OF A DROPLET

J. S. HONG, *POSTECH, Korea,* S. H. KO, *POSTECH, Korea,* K. H. KANG, *POSTECH, Korea,* I. S. KANG, *POSTECH, Korea,* The electrowetting shows some distinctive features when an AC electric field is applied. They include delay of dielectric breakdown of insulating layer, delay of contact-angle saturation. Those features can be beneficially utilized in practical applications of EWOD (electrowetting on dielectrics) in micro devices. To enhance our understanding on those phenomena yet to be fully explained, we investigated the fundamental nature of AC EWOD, numerically and experimentally. The numerical analysis of electric fields was carried out for a droplet placed on an insulator-coated electrode. A typical system of EWOD was considered and the electric field was analyzed numerically to find the frequency response of the system. The effect of shape change of the droplet was considered using the experimentally obtained shape of droplet in the numerical calculation. The numerical results on the effective electrical wetting tension, which is a motive force of shape change in AC EWOD, showed a good agreement with experimental results. Observed phenomena in AC EWOD, such as a flow inside a droplet are discussed and their minor effects on the droplet shape are explained in terms of time scale.