ratio of retardation time to relaxation time and τ, the ratio of the diffusivities, are greater than unity. In contrast to the single component system, it is found that a small amount of throughflow in either of its direction destabilizes the system. It is also observed that increase in the value of elasticity parameter Γ, and decrease in the values of Λ, τ and solute Rayleigh number R_s, is to hasten the onset of convection.

M-3A-3. VISCOELASTIC EFFECTS OF POLYMER SOLUTIONS ON OIL RECOVERY ENHANCEMENT IN CHEMICAL FLOODING

Z. ZHANG, J. C. LI, J. F. ZHOU, *Institute of Mechanics, CAS, China,* Polymer is a commonly used chemical reagent to Enhance Oil Recovery (EOR) in chemical flooding. The present dominant view on the mechanism of polymer is that the polymer solutions can improve sweep efficiency by enhancing mobility ratio between oleic and aqueous phases. However, when flowing through porous media, polymer solution tends to display viscoelastic effect. So it is necessary to further examine visco-elastic effect of polymer solution in the process of oil exploitation. In this paper, a constitutive equation of the viscoelastic polymer solution is established at first. In order to study the rheological properties of polymer solution, experiments were performed. The result was that the viscosity measured with viscometer is smaller than the viscosity obtained when the polymer solution flows in porous media pores. It is thought that the viscosity difference comes from the elastic effect of polymer solution. Normally polymer molecules exist in solution as loose, roughly spherical coils. When polymer solution passes through tortuous and converging/diverging pore channels, it may stretch or elongate in the direction of flow. At this time polymer solution exhibits an additional viscosity due to such kind of elastic response, namely, the effect of elasticity. So we call the viscosity difference as elastic viscosity. When the polymer solution flows in porous media, elongational flow coexists with shear flow. So the apparent viscosity of a polymer solution consists of shear viscosity, μ_{vis}, and elastic viscosity, μ_{elas}. Then we apply finite difference method to numerically simulate the visco-elastic flow of polymer solutions in porous media. The result shows that the oil recovery of viscoelastic effect is higher than that of viscous effect in the primary stage of displacement process, but the two ultimate recoveries are basically equal. The reason is that due to the viscoelastic effect of polymer solution; more residual oil left in pores during water flooding is hauled out in the process of displacement at the beginning of the displacement. In the chemical flooding with viscous effect, the residual oil saturation can also be reduced if the injected polymer solution is more enough or injection time is long enough. But the production cost will increase when more polymer solution is injected to the reservoir or the exploitation lasts longer. And we must consider the exploitation costs during oil extraction. So the chemical flooding with viscoelastic effect is more practical than that of viscous effect from the point of saving cost. The paper also analyzes the effect of major physical variable on displacement efficiency in details in visco-elastic polymer flooding. On the basis of numerical simulation, we find that relaxation time of polymer accounting for visco-elastic effect plays a decisive role in chemical flooding.

M-3A-4. FRONTOGENESIS IN NONLINEAR STUDY OF STRATIFIED POORLY CONDUCTING FLUID FLOW THROUGH POROUS MEDIA

C. V. VINAY, *J.S.S.Academy of Technical Education, Department of Mathematics, India,* N. RUDRAIAH and G. RANGANNA, *National Research Institute for Applied Mathematics (NRIAM) Bangalore India and UGC-CAS in Fluid Mechanics, Department of Mathematics, Bangalore University, India,* An analysis is presented in this paper to find the exact solution of modified nonlinear Darcy-Lapwood Forchheimer (DLF) equation governing the motion of a heterogeneous poorly conducting fluid saturated porous media in the presence of an electric field and nonuniform vertical density gradient caused by contaminant. These contaminants allow variation in density having fixed charge density (FCD) making the liquid phase poorly conducting and possess significant vapor pressures. If these vapors are denser than air, then eventually sink down to the capillary fringe to contaminate groundwater and also making non potable. We show in this paper the contaminant transport in a porous medium can be resolved using frontogenesis (i.e., increase in horizontal density gradient) developed in a poorly conducting fluid in the presence of self-generating electric field arising from geomagnetic phenomena. For this we use modified Darcy-Forchheimer equation for heterogeneous fluid, together with the Maxwell equations valid for poorly conducting two dimensional fluid flow with electrical conductivity σ of the form $\sigma = \sigma_0\left[1+\alpha_h\left(T-T_0\right)+\alpha_c\left(C-C_0\right)\right]$, where T is the temperature, and C the concentration of mixture α_h and α_c are the volumetric coefficient for σ. The solution of nonlinear momentum equation is determined using the time evaluation of this system. The streamlines and isopyenals are computed for different values of density discontinuity gradients γ_1, γ_2 and the results are represented graphically for different values of time t and for electric number W_1. We found that the streamlines are closer together for $x < 0$ than for $x > 0$ and the density profiles are crowded at the lower region depicting an increase in density gradient and beginning of frontogenesis. The density profiles reveal the curvature near $x = 0$ which develops a circulation in the transverse plane revealing an increase in the magnitude of the density gradient with an increase in time.

16:30 ~ 17:50 (Room102)

Microfluidics (III)

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

M-3B-1. A NOVEL MODEL FOR HEAT CONDUCTIVITY OF NANOFLUIDS

E. SHIRANI, *Isfahan University of Technology, Iran*, S. NABI, *Isfahan University of Technology, Iran*, In this paper, Brownian motion of nanoparticles and clusters and resulted micromixing are combined with the aggregation kinetics of nanoparticles and formation of clusters to capture the effects of added nanoparticles on k_{eff}. Results show that the observed anomalies reported in experimental works can be well described by taking aggregation kinetics into account. The proposed model, attribute the effective thermal conductivity not only to the intrinsic physical properties such as thermal conductivity of the liquid and nanoparticles, viscosity of the liquid, and density of the nanoparticles, as well as temperature and time, but also to physicochemical parameters which affect stability state of nanofluids such as the Hamaker constant, the surface charge, *pH*, and ion concentration. The more nanofluid is stabilized, the more k_{eff} will increase. We have also demonstrated that the thermal conductivity ratio can also increases with particle size depending on the chemistry of the solution. Consequently, an optimized radius in a suspension with certain temperature and *pH* can be achieved. This behavior is not feasible without including the effects of aggregation kinetics combined with Brownian motion and induced micro-convection.

M-3B-2. ON THREE DIMENSIONAL STRUCTURE OF VISCOELASTIC FLUID FLOWS IN A CURVED MICROCHANNEL

F. -C. LI, *Harbin Institute of Technology, China*, H. KINOSHITA, *The University of Tokyo, Japan*, M. OISHI, *The University of Tokyo, Japan*, T. FUJII, *The University of Tokyo, Japan*, M. OSHIMA, *The University of Tokyo, Japan*, Solutions of flexible high-molecular-weight polymers or some kinds of surfactant can be viscoelastic fluids. The elastic stress is induced in such viscoelastic fluids and grow nonlinearly with the flow rate and results in many special flow phenomena, including purely elastic instability in the viscoelastic fluid flow. The elastic flow instability can even result in a special kind of chaotic flow motion, the so-called elastic turbulence, which is a newly discovered flow phenomenon and arises at arbitrary small Reynolds number. In this study, we experimentally investigated the three dimensional irregular flow structures of viscoelastic fluids in a curved microchannel by means of high-speed confocal micro-particle image velocimetry (PIV) as well as visualization technique. The viscoelastic working fluid was aqueous solutions of surfactant, CTAC/NaSal (cetyltrimethyl ammonium chloride/Sodium Salysilate). For comparison, water flow in the same microchannel was also tested. The Reynolds numbers for all the microchannel flows were quite small (for solution flows, the Reynolds numbers were much smaller than 1) and the flow should be definitely laminar for Newtonian fluid. High-speed confocal Micro-PIV, combining with visualization technique, has been used to investigate the flow structures. Figure shows the schematic of the curved microchannel and the micro-PIV measurement location. Figure 2 demonstrates the measured velocity field in a plane at different height from the channel bottom. It was found that the regular laminar flow pattern for low-Reynolds number Newtonian fluid flow in the curved microchannel was strongly deformed in the viscoelastic solution flows, which behaved an apparently three dimensional flow structures. This phenomenon was considered to be induced by the viscoelasticity of the CTAC solution. Further discussions on the viscoelasticity-induced flow behaviors of the solution flows have been made.

M-3B-3. NUMERICAL SIMULATION OF A MICROCHIP COOLING WITH MICROJET ARRAY

Y. E. SOON and M. G. NORMAH, *Faculty of Mechanical Engineering,*