

Numerical simulation of non isothermal viscoelastic flows in non circular pipes

Localisation :

Centre d'Energétique et de Thermique de Lyon (CETHIL)
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Mots clés : Heat transfers, polymer materials, numerical modeling and simulation, continuum mechanics, viscoelastic fluids

Sujet de thèse :

Context: Convective transfer in laminar flow of nonlinear fluids has not been the subject of many investigations with the exception of round pipes and the case of inelastic shear-thinning fluids in tubes of rectangular cross-section. Heat transfer with viscoelastic fluids has been declared to be a new challenge in heat transfer research in the early nineties (Hartnett, 1992), but only limited progress has been made. The physics of the phenomenon has not been entirely clarified.

Signer and co-workers have recently investigated convective heat transfer behavior of a class of non-affine and non-linear viscoelastic fluids in straight tubes of non-circular contour in pressure gradient driven laminar flow and under constant wall flux conditions. They developed analytical calculations based on an asymptotic series in terms of the Weissenberg number Wi . Their results, valid only for very low Weissenberg number, showed an interesting asymptotic behavior of the heat transfer coefficient versus the fluid elasticity.

Objectifs : The PhD thesis proposed aims at performing similar studies by using numerical simulation. Finite Differences methods will be used to develop a specific 3D numerical model. Due to the constitutive models of viscoelastic fluids, the hyperbolic nature is added to the governing equations which are the incompressible Navier-Stokes equations based on the extra stress tensor. Numerical methods used for both the elliptic and hyperbolic equations should be used. It is expected that the numerical approach can overcome the difficulties encountered in the analytical calculation and extend to the cases of higher Weissenberg. The results obtained can be used to design an experimental bench, allowing to confront the theoretical results with measurements on the one hand, and on the other hand they can lead to original technical solutions for the heat transfer enhancement in polymer processing, electronic system cooling, etc.

Prérequis : Mécanique des fluides, Rhéologie des fluides non linéaires, méthodes numériques, transferts thermiques,

Encadrement de la thèse :

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Procédure : Transmettre par e-mail votre CV, votre lettre de motivation ainsi que les noms de références qui pourront vous recommander

References:

- Signer, D.A., and Letelier, M.F., Laminar Flow of Non-Linear Viscoelastic Fluids in Straight Tubes of Arbitrary Contour , Int. J. Heat Mass Transfer, 2010.
- Letelier, M.F., and Signer, D.A., Secondary flows of viscoelastic liquids in straight tubes, [International Journal of Solids and Structures Volume 40, Issue 19](#), 5081-5095, September 2003,
- Letelier, M.F., Signer, D.A., Rouliez, J.P. and Corral, O.F., Inverse Modeling of Magneto-Hydrodynamic Dampers with Time Varying Fluid Properties, Inverse Problems in Science & Engineering, 2010.
- Signer, D.A., and Letelier, M. F., The Physics of the Secondary Flows of Non-Newtonian Fluids in Straight Tubes, chapter in the book "Advances in the Rheology, Process Modeling and Simulation of Polymers", in press, ASME Books, New York, NY, 2010.
- M. Boudaous. M. Zinet, P. Bourgin, "Thermally and flow induced crystallization of polymers at low shear rate", J. Non-Newtonian Fluid Mech. Volume 165, Issues 5-6, pp. 227-237, 2010.
- M. Zinet, R. El Otmani, M. Boudaous, P. Chantrenne, "Numerical Modeling of Non-Isothermal Polymer Crystallization Kinetics: Flow and Thermal Effects", Polymer Engineering & Science, Vol. 50, pp 2044 -2059, 2010.
- R. El Otmani, M. Zinet, M. Boudaous, H. Benhadid, "Numerical simulation and thermal analysis of the filling stage in the injection molding process: role of the mold-polymer interface", Journal of applied Polymer sciences, 2011, DOI: 10.1002/app.33699