**FINAL REPORT GRANT SEED MONEY UMP**

***Research title:***
Numerical Solutions on Non-Newtonian Fluid Model.

***Project Leader:***
Dr. Abdul Rahman Mohd Kasim

***Research background:***
Although extensive research work has been devoted to heat transfer in viscous (Newtonian) fluids, recently, research in non-Newtonian fluids has gained momentum as well. Non-Newtonian fluids are normally defined as fluids that have retention of a fading “memory” of their flow history ((Brujan 2011)). Non-Newtonian fluids typically represent liquids which are formed either partly or wholly of macromolecules (polymers), or two phase materials. For a variety of reasons, non-Newtonian fluids are classified on the basis of their shear properties. There are many types of non-Newtonian fluids exist in this world, among them are pseudoplastic fluids, shear-thinning fluids, viscoelastic fluids and thixotropic fluids. Pseudoplastic fluids are fluids which viscosity decreases with increase in shear rate and hence are often referred to as shear-thinning fluids. These fluids are found in many real fluids, such as polymer melts and solutions or glass melt. Shear-thickening fluids, also known as dilatants, are fluids which viscosities increase with their shear rate. These fluids are less common than pseudoplastic fluids. This type of fluid has been found to closely approximate the behaviour of some real fluids, such as starch in water and an appropriate mixture of sand and water. Meanwhile, viscoelastic fluids are fluids that possess the added feature of elasticity with the addition of viscosity while thixotropic fluids refer to fluids which the shear stress decreases with time at a constant shear rate.

Among the different types of non-Newtonian fluids mentioned previously, the viscoelastic fluids are the most interesting fluid to be researched on due to the nature of the fluids which exhibit the behaviour of viscosity as well as elasticity. Therefore, in this research, a few problems that apply to the boundary layer concept of the viscoelastic fluid will be considered. Viscous materials, like honey, resist shear flow and strain linearly with time when a stress is applied, while the elastic materials strain instantaneously when stretched and just as quickly return to their original state once the stress is removed. The viscous property is due to the transport phenomenon of the fluid molecules while the elastic property is due to the chemical structure and configuration of the polymer molecules.

The simplest model for viscoelastic fluids was formerly proposed by (Rivlin (1949)) that considered the stress deformation relation for isotropic materials. In that research, the theory on equilibrium of large elastic deformation predicts that the torsional modulus at fixed stretch is directly proportional to the axial tension which means on the stress relaxation taking place in viscoelastic materials, the torsional modulus should decrease with the decrease of axial tension. The work on stress deformation relation for isotropic materials has been extended by (Min, Kolsky et al. (1977)). They studied on the viscoelastic response to small deformations superposed on a large stretch in order to provide the general theoretical framework for the organization of data from such experiments.

The idea of viscoelastic fluid was also very well documented by (Co and Bird (1977)), who described the fluid as never moving very far or very rapidly from its initial configuration. In addition, an investigation into the flow of elastic-viscous fluids past a circular cylinder was done by Harnoy (1987). During the last few years the problem regarding viscoelastic fluids has gained considerable importance because of its applications in various branches of science, engineering, and technology, particularly in material processing, chemical and nuclear industries, geophysics, and bio-engineering. The study of the flow of this fluid type is also significant in oil reservoir engineering.

The investigations on this type of fluid have attracted a few researchers in Malaysia as well. Many publications have been produced by researchers in Universiti Teknologi Malaysia, Universiti Kebangsaan Malaysia, Universiti Putra Malaysia and also Universiti Malaysia Pahang (Kasim et al. (2012), Mangi (2013), Salleh (2010), Shafie (2005)). However, there are a lot of interesting topics regarding this field can be discovers. Since, UMP is focusing on the area of industrial application, so this funding is very important in initiating the collaboration with the expertise in Malaysia.

**Activities**

1. Menghadiri bengkel penyelesaian masalah aliran bendalir bukan newtonan pada 22-25 november 2015 di utm skudai,johor
2. Seminar pemodelan matematik masalah aliran bendalir di utm skudai pada 31/7 - 5/8 2016
3. Establishing research meeting ump-utem pada 1 sep 2016
4. Menghadiri perbincangan maslah bendalir Reiner Philipoff di terengganu pada 28-30 september 2016

**Outcome of the grant**

**Grant:**

1. Mathematical modelling of convective boundary layer flow of jeffrey fluid under convective boundary condition (RDU160330)(25/5/2016-24/5/2018)(RM20,000)

**Published paper**

1. H. A. M. Al-Sharifi, L. A. Aziz, A. R. M. Kasim, M. Z. Salleh and S. Shafie, Influence of Slip Velocity and Aligned Magnetohydrodynamics on Convective Boundary Layer Flow of Jeffrey Fluid with Convective Boundary Condition Across Stretching Sheet. The National Conference for Postgraduate Research 2016, Universiti Malaysia Pahang, 886–891 (2016).
2. H. A. M. Al-Sharifi, A. R. M. Kasim, M. Z. Salleh, N. F. Mohammad, S. Shafie and A. Ali, Influence of slip velocity on convective boundary layer flow of Jeffrey fluid under convective boundary conditions, ARPN Journal of Engineering and Applied Sciences 11, 10950–10953 (2016).

**References**

Brujan, E.-A. (2011). Cavitation in Non-Newtonian Fluids. *Non-Newtonian Fluids* (pp. 1-47). Springer Berlin Heidelberg.

Rivlin, R. S. (1949). Large elastic deformations of isotropic materials. *Phil. Trans. R. Sot. Lend*. 242: 173-195.

Min, B. K., Kolsky, H., and Pipkin, A. C. (1977). Viscoelastic response to small deformations superposed on a large stretch. *International Journal of Solids and Structures.* 13(8): 771-781.

Co, A. and Bird, R. B. (1977). Slow viscoelastic radial flow between parallel disks. *Applied Scientific Research*. 33:(5-6): 385-404.

Harnoy, A., (1987). An investigation into the flow of elastico-viscous fluids past a circular cylinder. *Rheol, Acta*. 26: 493-498.

Kasim, A. R. M., Mohammad, N. F., and Shafie, S. (2012). Effect of heat generation on free convection boundary layer flow of a viscoelastic fluid past a horizontal circular cylinder with constant surface heat flux. *AIP Conference Proceedings.* 1450: 286-292.

Mangi, A. (2013). *Unsteady magnetohydrodynamics flow of a micropolar fluid with heat and mass transfer*. Universiti Teknologi Malaysia: Ph.D Thesis.

Salleh, M. Z., Nazar, R., and Pop, I., (2010). Mixed Convection Boundary Layer Flow from a Solid Sphere with Newtonian Heating in a Micropolar Fluid. *SRX Physics 2010.*

Shafie, S. (2005). *Mathematical Modelling of g-Jitter Induced Free Convection*. Universiti Teknologi Malaysia: Ph.D Thesis.