Flow of Visco-Elastic Fluids with Heat and Mass Transfer inside Varies Geometric Shapes in The Presence of External Forces

Thesis
Submitted in Partial Fulfillment
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BY

Magdy Ahmed Mohamed Ahmed Eltaweel

Assistant Lecturer in Mathematics Department
Faculty of Science, Ain Shams University

Supervisors

Prof.Dr. Ahmed Galal Elsakka
Professor of Applied Mathematics
Faculty of Science,
Ain Shams University.
Cairo, Egypt.

Prof.Dr. Nabil Tawfik Eldabe
Professor of Applied Mathematics
Faculty of Education,
Ain Shams University.
Cairo, Egypt.

Prof.Dr. Ahmed E. Radwan
Professor of Applied Mathematics
Faculty of Science,
Ain Shams University.
Cairo, Egypt.

SUBMITTED TO
Mathematics Department,
Faculty of Science, Ain Shams University,
Cairo, Egypt

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Ain Shams University
Faculty of Science
Mathematics Department

Name: Magdy Ahmed Mohamed Ahmed Eltaweel
Degree: Ph.D. (Applied Mathematics)

The title of the Thesis:

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Thesis Supervisors

١. **Prof. Dr. Ahmed Galal Elsakka**

Professor of Applied Mathematics
Faculty of Science,
Ain Shams University,
Cairo, Egypt.

٢. **Prof. Dr. Nabil Tawfek Eldabe**

Professor of Applied Mathematics
Faculty of Education,
Ain Shams University,
Cairo, Egypt.

٣. **Prof. Dr. Ahmed E. Radwan**

Professor of Applied Mathematics
Faculty of Science,
Ain Shams University,
Cairo, Egypt.

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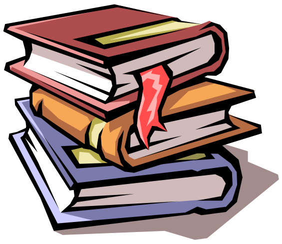

To
My Great Parents
, My Family
and Aya

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* List of Publications*

١- A. G. Elsaka, Nabil T. M. Eldabe, A. E. Radwan and Magdy A. M. Eltaweel, Magnetohydrodynamic flow of non-Newtonian viscoelastic fluid with heat and mass transfer through porous medium past an infinite porous plate with a heat source/sink, ***have been accepted to publish in the Bulletin of Faculty of Education, Ain Shams University, in (2010).***

٢- Nabil T. M. Eldabe, A. G. Elsaka, A. E. Radwan and Magdy A. M. Eltaweel, Effects of chemical reaction and heat radiation on the MHD flow of viscoelastic fluid through a porous medium over a horizontal stretching flat plate, ***The journal of American Science, ٦(٩), ١٢٦-١٣٦, (٢٠١٠).***

٣- Nabil T. M. Eldabe, A. G. Elsaka, A. E. Radwan and Magdy A. M. Eltaweel, Three-dimensional flow over a stretching surface in a viscoelastic fluid with mass and heat transfer***, Nature and Sciene, ٨(٨), ٢١٨-٢٢٨, (٢٠١٠).***

٤- Nabil T. M. Eldabe, A. G. Elsaka, A. E. Radwan and Magdy A. M. Eltaweel, Flow of viscoelastic fluid through a porous medium over a horizontal stretching sheet with mass and heat transfer under variable magnetic field, ***have been submitted to the International journal of Non-Linear Mechanics.***

٥- Nabil T. M. Eldabe, A. G. Elsaka, A. E. Radwan and Magdy A. M. Eltaweel, Fully developed mixed convection flow of a viscoelastic fluid between permeable parallel vertical walls with mass transfer, ***have been submitted to the International journal of Heat and Mass Transfer.***

Introduction

١،١. *Newtonian and non-Newtonian fluids*

١،١،١. *Introduction*

Many researches have been done in the field of fluid dynamic not only for its academic interest, but also for its industrial applications. The simple Newtonian fluid model has been considered as the standard fluid behavior for along time. Though most gases and low molecular weight substances to exhibit this kind of fluid behavior, in recent years, there has been an increasing recognition of anther kind of fluid called non - Newtonian fluid. Characteristics displayed by most materials encountered in every day life, both in nature (proteins, biological fluids, etc.) and in technology (polymers and plastics, slurries, etc.) are some examples of such fluids.

١،١،٢. *Definition of Newtonian fluids*

A fluid whose stress at each point is linearly proportional to its strain rate at that point is called Newtonian fluid, that is

$$\tau = \mu \frac{d\gamma}{dt} \qquad (١،١)$$

τ is the shear stress, $\dot{\gamma}$ is the strain rate and μ is the viscosity coefficient. Therefore, the graph of this equation is a straight line of slope μ passing through origin. The single constant μ completely characterizes the laminar flow behavior of a Newtonian fluid at a fixed temperature and pressure.

١,١,٣. *Definition of non Newtonian fluids*

A fluid that departs from the classic linear Newtonian relation between stress and shear rate is called non-Newtonian fluid thus the flow curve of non-Newtonian fluid is nonlinear or it is linear but it does not pass through origin, that is, where "viscosity" (Shear stress divided by shear rate) is not constant at a given temperature and pressure but depends on the rate of shear or, more generally, on the previous kinematic history of the fluid.

On the other hand Fluids, which do not obey Eq. (١,١), are called non-Newtonian, which differ from Newtonian fluid in the relation ship between the shear stress and the flow field is more complicated. Examples include various suspensions such as coal-water or coal-oil slurries, food products, inks, glues, soup, polymer solutions, etc. An interesting characteristic of rheological fluids is there large "apparent viscosities", these results in laminar flow situation in many applications, and consequently the engineering literature is concentrated on laminar rather than turbulent flows. It should also be mentioned that knowledge of non-Newtonian fluid mechanics and heat transfer is still in an early stage and many aspects of the filed remain to be clarified.

١,١,٤. *Classification of non-Newtonian fluids:*

Non-Newtonian fluids may be classified into three categories:

١-Substance for which the rate of shear is dependent only on the current value of shear stress; this class of materials is variously known as "purely viscous", "time independent", or "generalized Newtonian fluids (GNF)".

٢-Morecomplex materials for which the relation between shear stress and shear rate also depends upon the duration of shearing; these are known as "time dependent systems".

٣-Materials exhibiting combined characteristics of both a solid and a fluid, and showing partial elastic recovery, after deformation; these are known as "viscoelastic" fluids.

By the other words, the non-Newtonian fluids can be classified into two general categories as in figure (١،١).

١- Time Independent Behavior (T.I.B.) or no-Memory fluids.

٢- Time dependant Behavior (T.D.B.) or Memory fluids.

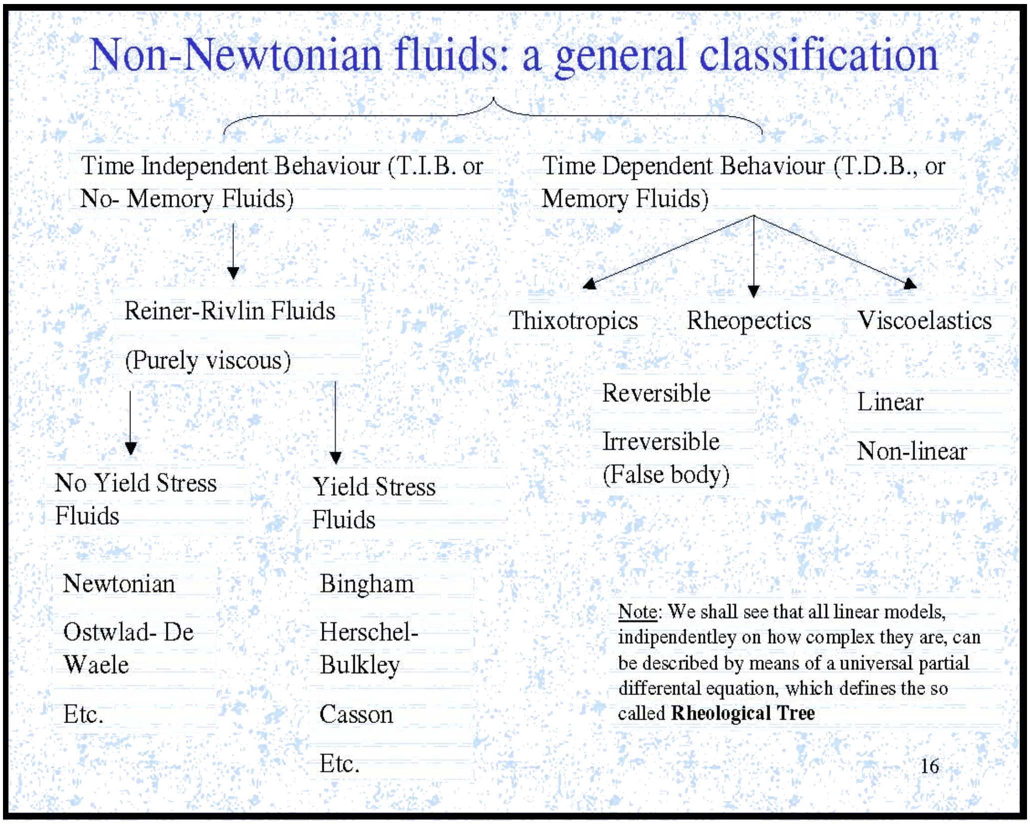

Figure (١،١) Classification of non-Newtonian fluids

Each type of non-Newtonian fluid behavior will now be described in details.

1.1.4.1. Time independent fluid behavior

Fluids of this type flow properties are independent of time may be described in a simple shearing experiment, where the only velocity component u is in the x-direction and all velocity variation in y-direction, by a rheological equation of the form

$$\frac{du}{dy} = \dot{\gamma} = f\ (\tau) \qquad (١,٢)$$

or its inverse form,

$$\tau = f\left(\dot{\gamma}\right) \qquad (١,٣)$$

Equation (١,٢) implies that the rate of strain γ at any point in the fluid is a function of the shear stress τ at that point or vice versa. Such fluids may be termed non-Newtonian viscous fluids, or generalized Newtonian fluids. Depending upon the form of equation (١,٢), these fluids may be further subdivided into three distinct types:

(i) Viscoplastic fluids

(ii) Pseudo-plastics fluids or shearthinning

(iii) Dilatant fluids or shearthickening.

Qualitative flow curves for these three fluids are shown in Figures (١,٢) and (١,٣); the linear relation typical of Newtonian fluids is also included.