ON SOME PROBLEMS IN THE TRANSPORT OF CHARGED AND NON CHARGED PARTICLES IN FLUIDS

THESIS

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SUMMARY

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This study deals with some problems describing the path lines of suspended particle in viscous fluid moving in plane channels. Some problems deal with non electric conducting fluids and others are considered electrically conducting.

The thesis contained the solution of five problems.

Chapter one includes an introductory review and the basic equations used in this thesis. Also, a general review of research works related to the proposed point under consideration is presented.

Chapter two contains two problems. The first one is concerned with the study of path lines of a solid suspended particle in non electrically conducting viscous fluid in a plane infinite channel. The second one is concerned with the same situation but for long channels. The particle is assumed initially moving from the mid point of the channel with a velocity equal to the velocity of the fluid.

The main results obtained in this chapter are summarized as follows:

(1) As the parameter (α_d) which depends on the fluid density is decreased, the width and maximum height are increased and the number of collisions with the lower plate is decreased.

(2) As the value of the parameter (α_{sh}) which determines the shape

of the particle is decreased, the width and maximum height are decreased and the number of collisions with the lower plate is decreased.

(3) As the value of the parameter (α_V) which depends on the fluid viscosity is decreased, number of collisions with upper and lower plate is increased and the width and maximum height are increased.

In Chapter three, we consider the case of suspended charged particle moving in a plane channel under the same conditions taken in Chapter two. The motion take place under constant magnetic field normal to the plane of the motion, hence the Lorentz force affects on the motion.

The main results of this chapter are:

As the value of the parameter α_B which depends on the magnetic force is decreased, the width and maximum height are increased and the number of collisions with the upper and the lower plates is increased.

In Chapter four, we consider the same case but for non-Newtonian electric conducting fluid in an infinite channel.

The results obtained in this chapter leads to:

(1) As the value of the parameter α_d which depends on the fluid density is decreased, the width and maximum height are increased and the number of collisions with the upper plate is increased, and the number of collisions with the lower plate is decreased.

(2) As the value of the parameter α_v which depends on the fluid viscosity is increased, the maximum height is increased and the width is decreased, the number of collisions with the upper plate is increased. and the number of collisions with the lower plate is decreased.

(3) As the value of the parameter (α_{sh}) which determines the shape of the particle is decreased, the width and maximum height are increased, the number of collisions with the upper plate is increased and the number of collisions with the lower plate is decreased.

(4) As the value of the parameter (α_h) which depends on the magnetic force is decreased, the width and maximum height are increased, the number of collisions with the upper plate is increased and the number of collisions with the lower plate is decreased.

Chapter five contains the investigation of the flow of two component fluid where a solid charged particle is suspended in it.

The results obtained in this chapter leads to:

(1) As the value of the parameter α_v which depends on the fluid viscosity is decreased, the maximum height and the width are increased, the number of collisions with the upper and the lower plates is increased.

(2) As the value of the parameter (α_d) which depends on the fluid

density is decreased, the number of collisions with the lower plate is increased and the width and maximum height are decreased.

(3) As the value of the parameter (α_h) which depends on the magnetic force is decreased, the number of collisions with the lower plate is increased and the width and the maximum height are increased.

(4) As the value of the parameter (α_{sh}) which determines the shape of the particle is decreased, the number of collisions with the lower plate is decreased and the width and maximum height are decreased.

In all studied cases Runge-Kutta method was used for solving the fundamental equations in every case and the results are shown in tables and graphics.

CHAPTER I

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I.1 - INTRODUCTION

This thesis deals with some problems describing the path lines of suspended particle in viscous fluid moving in a plane channels. Some problems deals with non electric conducting fluids and others are considered electrically conducting.

Multiphase systems consist of a fluid phase or fluid medium and a particulate phase of any number of chemical components. When the fluid medium is a liquid, the particulate phase may consist of solid particles, gas bubbles, or liquid droplets.

The dynamics of multiphase systems include momentum, energy, mass, and charge transfers between the phases whether or not the process is influenced by the presence of a potential field. There are many multiphase systems among engineering equipment and process.

Some of this systems may be obtained as follows:

a. Gas solid particle systems; such as dust collectors, cosmic dusts, and nuclear fallout problems.

b. Gas-liquid droplet systems; such as atomizers, air pollution and compustors.

c. Liquid-gas bubble systems; such as absorbers, air lift pump and aeration.

d. Liquid-liquid droplet systems; such as extraction.

e. Liquid-solid particle systems; such as sedimentation.

Studies of dynamics of multiphase systems have followed two methods of approach [1]:

1- Treating the dynamics of single particles and then trying to extend to a multiphase particle system in an analogous manner as in molecular (kinetic) theory.

2- Modifying the continuum mechanics of single-phase fluids in such a way as to account for the presence of particles.

Dynamics behaviours of single particles (solid particles, liquid droplets, or gas bubbles) have been studied extensively in a number of books [2, 3].

Extension to a multiphase particle system from dynamics of single particles has not been particularly successful except in an isolated cases.

However, qualified analogies to molecular theory and free molecule flow [4] where shown to be very useful in determining pertient parameters of interaction among particles, and interaction of particles with a boundary.

The motion of a medium consisting of an incompressible viscous fluid and suspended solid particles was analyzed from the stand point of continuum mechanics [5]. It was assumed that the particles' translational and rotational velocities were different from those of the fluid.

1.2. Basic equations used in this thesis:-

In this thesis we are interesting in obtaining the path lines of a solid particle suspend in viscous fluid. The fluid is considered moving in a plane channel. The equation of motion of the suspended particle was suggested by Closkin N. A. [6] in the form

$$\rho_p \frac{d\vec{c}}{dt} = - g(\rho_p - \rho_f)\vec{j} - K_v(\vec{c} - \vec{u}_f) + K(\vec{u}_f - \vec{c}) \wedge \text{rot } u_f - \text{grad } P$$

where ,

ρ_p : is the particle's density.

ρ_f : is the density of the fluid.

$\vec{c}$: is the particle's velocity.

$\vec{u}_f$: is the fluid velocity.

P : is the pressure.

g : is the gravitational acceleration which is vertical.

K_v : is the resistance coefficient of motion in viscous fluid.

K : is the so called the form coefficient.

The velocity of the fluid is considered satisfying Navier-Stokes equation.

In chapter (V), we considered the case of a particle suspended of two component fluid. The velocity such fluid is considered satisfying Rakhmatolin equation for multiphase fluids (these equations are given in Appendix (b)).

1.3. General Review:

In 1974, Umeya K. and Tanifuji S. [7], Studied the flow patterns of disperse systems such as Tio_2-water and Zno-water suspensions were investigated over a wide shearing range both in laminar and in turbulent regions. f-Re relations were also investigated for the systems which possessing varying non-Newtonian parameter n.f-Re diagram was revealed to be affected by varying n-values both in laminar and in turbulent regions.

In Jan., 1975, Ganiev R. F. and Ukrainskii L. E. [8] shown that for angular triaxial vibration, for sufficiently large amplitudes and high frequencies of applied vibration, quasistable situation can occur, attracting particles less dense than the liquid and repulsing the denser particles.

In 1975, Hamed A. and Tabakoff W. [9] obtained a numerical method to analyze the Unsteady two-dimensional motion of incompressible viscous gas and suspended solid particles is presented. This method is used to study the particular flow due to the impulsive motion of an infinite flat plate in an otherwise stationary suspension.

In Aug., 1975, Bauckhage K. [10] investigate a theoretical analysis of a suitable model of the hydraulic transport of a suspension of solid particles in a circular tube, leads to a closed representation of the transverse (shear) force distribution over both tube radius and particle Reynolds number.