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NUMERICAL SIMULATION OF TURBULENT DISPERSION OF FINITE SIZE PARTICLES

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ABSTRACT

The characteristics of a two-dimensional turbulent dispersion of finite size particles (such as sand transported by water) was studied through numerical simulation.

The turbulent flow field was generated numerically by direct integration of the Navier-Stokes equation. The Basset-Boussinesq-Oseen equation which governs the motion of finite spherical particales in a flow field was then solved numerically over that turbulent flow field.

The results suggest an increase in concentration in the interfacial regions between vortices followed by a decrease in concentration in the core of vortices. This results coincide with what one would expect to occur in a two-dimensional fluid flow where vortices play a predominant role: centrifugal forces are responsible for the migration of particles.

INTRODUCTION

The purpose of this work is to predict the concentration of particles released in a turbulent flow field. The applications are fundamental importance to the areas of pollutants in air and water, or the transport of sediment by a river.

Owing to the great mathematical difficulties connected with the solutions of the particle motion equation, the way to a theoretical treatment was limited to a small number of particular cases. The experimental approaches also involve difficulties which are the expense of tracer particles and detection equipment and the lack of reliable sources for purchasing particles. As digital computer become larger and faster the numerical simulation of the particle motion in a flow field seems most feasible.

In order to be able to undertake the task of the numerical simulation of the motion of the particle-fluid system. the following approximations and simplifications are necessary at the present stage:

(1) The particle-fluid system is simplified in the sense of assuming that the presence of the particle does not affect the fluid body.

(2) The size of the particle is many times small than the smallest eddy (the turbulent Taylor microscale λ and the diameter d of the particle is in the ratio $d/\lambda=0.009$), the motion of the particle will depend on the initial values rather than the boundary conditions.

(3) As far as the computational constrains (such as time and storage) are concerned, this work limits its domain to a two-dimensional case with a periodic field.

The mathematical model for the turbulent flow is, of course, the Navier-Stokes equations and the continuity equation, which we assume are valid for describing any general fluid dynamics problem.

The equation of motion of a spherical particle moving slowly in a fluid at rest was first derived by Basset (1888), by Boussinesq (1903), and by Oseen (1927). Tchen (1947) generlized

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