Ecoulements gaz-particules (ECGP)

Component
École Nationale Supérieure d'Électrotechnique d'Électronique

In brief

- **plugin.odf-inp:PLUGINS_ODF_COURSE_NBHOURS_TXT:** 35
- **Code:** N9EM19A

Presentation

Objectives

Introduction to mathematical modelling and numerical simulation approaches developed for gas-particle reactive flows in dense or dilute regime encountered in the industrial fields of energy, transport and process engineering, but also in the fields of health and the environment.

Qualitative presentation of gas-particle flows encountered in the fields of transport, energy, process, health and environment, and the challenges of modelling, based mainly on the teacher's industrial partnership activities.

Introduction of the macroscopic parameters characterising this type of flow: temperature, pressure, particle diameter, mass density, volume fraction, numerical density, mass load, etc.

Description

Introduction

Qualitative presentation of the phenomena and issues involved in modelling gas-particle flows encountered in the fields of transport, energy, process, health and environment, based mainly on the teacher's industrial partnership activities.

Introduction of the macroscopic parameters characterising this type of flows: temperature, pressure, particle diameter, mass density, volume fraction, numerical density, mass load, etc.

General presentation of the mathematical modelling and numerical simulation methods for dispersed phase flows and their multi-scale articulation by analogy with the kinetic theory of gases: direct or fully resolved simulation on a small scale, deterministic Euler-Lagrange modelling on a mesoscale, statistical modelling and methods of moments (or N-fluid model) on a macro scale.

Deterministic Lagrangian modelling of particles

- Momentum equation and modelling of fluid-particle (drag, Archimedean, jet propulsion) and particle-particle (collision) transfers in dense and dilute regimes.

- Enthalpy equation and modelling of fluid-particle transfers (thermal diffusion and mass transfer).

- Mass equation and modelling of fluid-particle transfers (evaporation/condensation of droplets, pyrolysis and gasification of biomass, heterogeneous catalysis reaction) and particle-particle (coalescence, break-up and attrition).

Statistical modelling of particle clouds

Introduction of the joint distribution function of velocity, mass and enthalpy for a particle ensemble, and of the corresponding averaging operator.

Writing of the Liouville equation (or kinetic or Boltzmann-type) which governs the distribution function.

Closure of this equation in connection with the Lagrangian deterministic modelling of fluid-particle and particle-particle transfers. Semi-empirical introduction of the BGK model for the representation of the effect of collisions between elastic particles.

Macroscopic modelling of particulate flow

Definition of the moments of the particulate phase (numerical density, mean mass, mean velocity, random kinetic energy, mean temperature, kinetic stress tensor, etc.).

General introduction to the method of deriving macroscopic equations from the Liouville equation. Reformulation of the collision term as the sum of a pair modification source term and a collision flow term.

Application to mass balance, numerical density balance and momentum balance equations. Analysis of closure problems and proposal of models: fluid-to-particle mass transfer, mixing of particle species and coalescence, fluid-to-particle momentum transfer (fluid-to-particle turbulent drift velocity) and introduction of kinetic and collisional viscosities.

Application

The exam consists of a work carried out for about 4 hours with the help of the teacher in charge. The aim of this work is to study a real gas-particle flow configuration and to apply the skills acquired in the course to the modelling and simulation of these flows. For example, this could be the application of the course to the modelling of a dust storm or the de-nebulization of fog at an airport.

Pre-requisites

Modelling of transport and transfers in single-phase laminar, anisothermal and reactive flows

Turbulent dispersion and mixing (temporal and spatial scales of turbulence, turbulent viscosity, turbulent dispersion)

Introduction to statistical modelling (multivariate probability density, normal distribution)

Knowledge of the kinetic theory of diluted gases is recommended.

Useful info