Multiphase Flow

MULTIPHASE FLOW

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Programme Plan 1999 – 2005

Multiphase Flow

Flerfasströmning

Submitted to the
Swedish Foundation for Strategic Research (SSF)
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Multiphase flow:

the simultaneous flow of gas, liquid and/or solid phases in different combinations
Participants:

Chalmers

The Royal Institute of Technology (KTH)

Lund Institute of Technology (LTH)

Swedish Industry

SIAMUF: Swedish Industrial Association for Multiphase Flows
Target areas:

Chemical Processes

Paper and Pulp

Metallurgy
Courses arranged by the Graduate School:

The theory of multiphase flow

The phenomenology of multiphase flow

Experimental methods in multiphase flow
1. An experimental study of aerated stirred bioreactors. (LTH) **Finished**

2. Modeling of two-phase dense dispersed (bubbly) turbulent flow with application to aerated stirred bioreactors. (LTH)

3. Fluidization for chemical and process technology. (Chalmers) **Finished**

4. Transport of particles in gas flow. (Chalmers) **Finished**

5. Modeling column packing for chromatography (Chalmers)

6. Modelling the rheological properties and consolidation of suspensions. (KTH) **Finished**

7. Separation of pulp fibers in a centrifugal field with special application to a hydrocyclone. (KTH)

8. A novel metal spray-forming process. (KTH) **Finished**

9. Numerical methods for dispersed two-phase flow equations of Eulerian type. (KTH) **Finished**
Biochemical reactor

Sugar in

Air in
1. An experimental study of aerated stirred bio-reactors. (LTH)

Simultaneous measurements of concentration, liquid and gas-bubble velocities

Particle image velocimetry (PIV)
Planar laser induced fluorescence (PLIF)

Test cases:
bubbles in grid-generated turbulence
stirred aerated reactor
2. Modeling of two-phase dense dispersed (bubbly) turbulent flow with application to aerated stirred bioreactors. (LTH)

Large-Eddy Simulations (LES)
Lagrangian tracking of bubbles

Effects of bubble volume fraction and size on flow field and scalar concentration field

Effects of scale-up

Comparisons with Eulerian calculations

Bubble deformation (VOF)
3. **Fluidization for chemical and process technology. (Chalmers)**

*In collaboration with AstraZeneca*

**Study of a fluidization process for coating of pellets (Losec)**

*Wurster bed*
3. **Fluidization for chemical and process technology (contd.)**

**Eulerian two-fluid model for gas and particle motion**

**Kinetic theory of granular flow**

**Experimental validation vs optical and capacitance probe measurements**

**Overall flow pattern**

**Particle residence times**

**Particle dispersion**
4. Transport of particles in gas flow.  
(Chalmers)

In collaboration with SCA Hygiene Products

Horizontal pipe flow

Eulerian two-fluid modelling

Hot-film measurements of gas-phase turbulence in dilute suspensions

Optical probe measurements of particle concentration

Turbulence modification
Particle dispersion
Flocculation
5. **Modeling column packing for chromatography. (Chalmers)**

*In collaboration with Amersham Biosciences*

Particles in liquid

*Lagrangian particle tracking*

*Soft-sphere / hard-sphere models*

*Eulerian two-fluid modeling*

*Experiments*
6. Modelling the rheological properties and consolidation of suspensions. (KTH)

In collaboration with STFI

Coating of paper

Two-phase model based on “Stokesian Dynamics” for studying rheological properties and consolidation of coating colours

Validation vs rotational viscometer and oscillatory measurements
7. Separation of pulp fibers in a centrifugal field with special application to a hydrocyclone. (KTH)

In collaboration with STFI

CFD modelling of internal flow

Fiber suspension rheology

Experimental validation
8. A novel metal spray-forming process. (KTH)

In collaboration with Sandvik

The OSPREY™ process

Lagrangian particle tracking

Thermal and thermodynamic behaviour of droplets

Experimental validation

Development of a robust and efficient numerical method for Euler/Euler equations

Well-posedness
Artificial dissipation
MULTIPHASE FLOW

Experiments
- PIV
- PLIF
- ...
- hot-film
- optical probe
- ...

Sub-models
- turbulence
- (bio-) chemical reactions
- dispersion
- particle interaction
- ...

Numerical methods

Eulerian two-fluid

Lagrangian

Industrial Design Tool
Results after six years:

seven PhDs
three Licentiates
50 publications
SIAMUF
Multiphase Process Design

MPD

Vision: create a multidisciplinary research centre with a balance between fundamental and applied research in order to increase expertise in multiphase process and product design

Objectives: to do fundamental research in multiphase processes and develop design tools for industry, facilitating the use of simulation tools to develop new products and processes to shorten the time from idea to production
Multiphase Flow Projects at AM, Chalmers

Fluidization for chemical and process technology
(SSF, AstraZeneca)

Transport of particles in gas flow
(SSF, SCA Personal Care)

Modeling column packing for chromatography
(SSF, General Electric Healthcare)

Characterization of Beds for Chromatography
(General Electric Healthcare)

Fluidization for Energy Production:
Fluid Dynamics and Erosion Corrosion (HTC)

Modelling of turbulent gas-particle flows (STEM,
joint project Dept Mechanics, KTH)

Fundamental modelling and experimental
validation of liquid-liquid flows (VR, joint project
Chemical Reaction Engineering, Chalmers)

Fluidized bed coating (SSF CPDC, AstraZeneca, joint
project Chemical Engineering Design, Chalmers)

Direct numerical simulation of turbulent gas-solid
flow (VR)