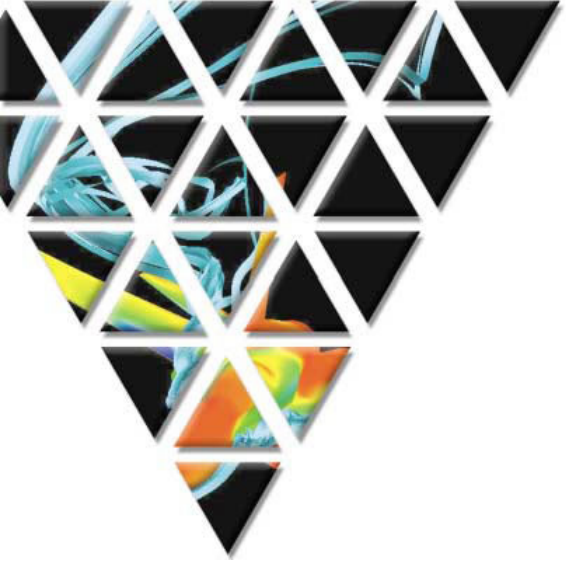


NAFEMS

Practical CFD Analysis

September 23rd, 2008

Agenda

Practical CFD Analysis

September 23rd, 2008

10am EDT (New York) / 4pm CET (Paris)

- Welcome & Introduction (Overview of NAFEMS Activities)
  - Matthew Ladzinski, *NAFEMS North America*
  - Roger Oswald, *NAFEMS DACH and Nordic Countries*
- Practical CFD Analysis
  - Prof. Uwe Janoske, *University of Cooperative Education, Mosbac*
- Q&A Session
  - Panel
- Closing


Ladzinski


Oswald


Janoske

NAFEMS

An Introduction to NAFEMS

The International Association
for the Engineering Analysis Community

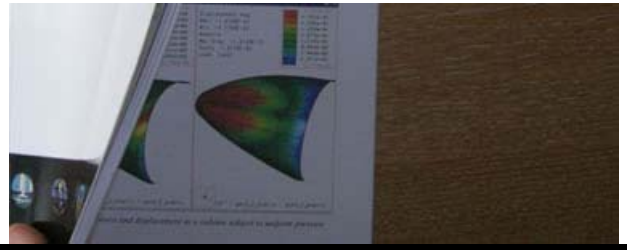
Roger Oswald
NAFEMS representative for Germany, Austria, Switzerland
and Nordic area: Denmark, Finland, Norway and Sweden
NAFEMS World Congress Manager

What is NAFEMS?

- NAFEMS is an international not-for-profit membership association of more than **900 companies / organisation** from all over the world.
- We are the:
  - International Association for the Engineering Analysis Community
  - Information source for the latest CAE technology developments
  - Source of Best Practice guides for the use of Analysis Technology
  - Provider of independent events where practicing Analysts exchange knowledge and experience
  - Voice of the CAE world

What do NAFEMS Members receive?

- A copy of all new **NAFEMS publications**
- Welcome **joining pack**
- Quarterly magazine “**Benchmark”**
- Free attendance at **various seminars** in different regions (seminar credits)
- Access to the **Member’s area** of the NAFEMS **web site** and to the NAFEMS community of providing **excellent networking** opportunities.



Flexible NAFEMS Membership Options

- Site Membership applies to a company with a number of CAE users at a single site.
- Corporate Membership applies to multi-site organizations with many CAE users.
- Small Company Membership applies to a company with only a few CAE users at a single site.
- Academic Membership applies to recognized educational institutions.

How to find out more about NAFEMS?

- **Website:** www.nafems.org

- Paul Steward, Global Business Development
  Phone: + 44 (0) 1355 225 688
  Email: paul.steward@nafems.org

Regional Summits and World Congress

- **NA North American Regional Summit 2008**
  29th – 31st October 2008, Hampton, Virginia, USA
  agenda is available

- **NORDIC Regional Summit 2008**
  17th – 18th November 2008, Gothenburg, Sweden
  deadline to submit abstracts (extended): 6th October

- **NAFEMS World Congress 2009**
  16th – 19th June 2009, Crete, Greece
  deadline to submit abstracts: 6th October

www.nafems.org

CFD Training Course

- CFD Training Course

  “Practical CFD Analysis”

  by Prof. Uwe Janoske

  10th – 11th November, Wiesbaden, Germany

  Course language: English

…..more information: **www.nafems.org**

NAFEMS

Practical CFD Analysis

Prof. Uwe Janoske
University of Cooperative Education, Mosbach

Practical CFD Analysis

- Aims and contents
  - Why simulations?
  - Advantages and disadvantages of CFD simulations
  - Contents of course “Practical CFD Analysis”

  - Questions and close

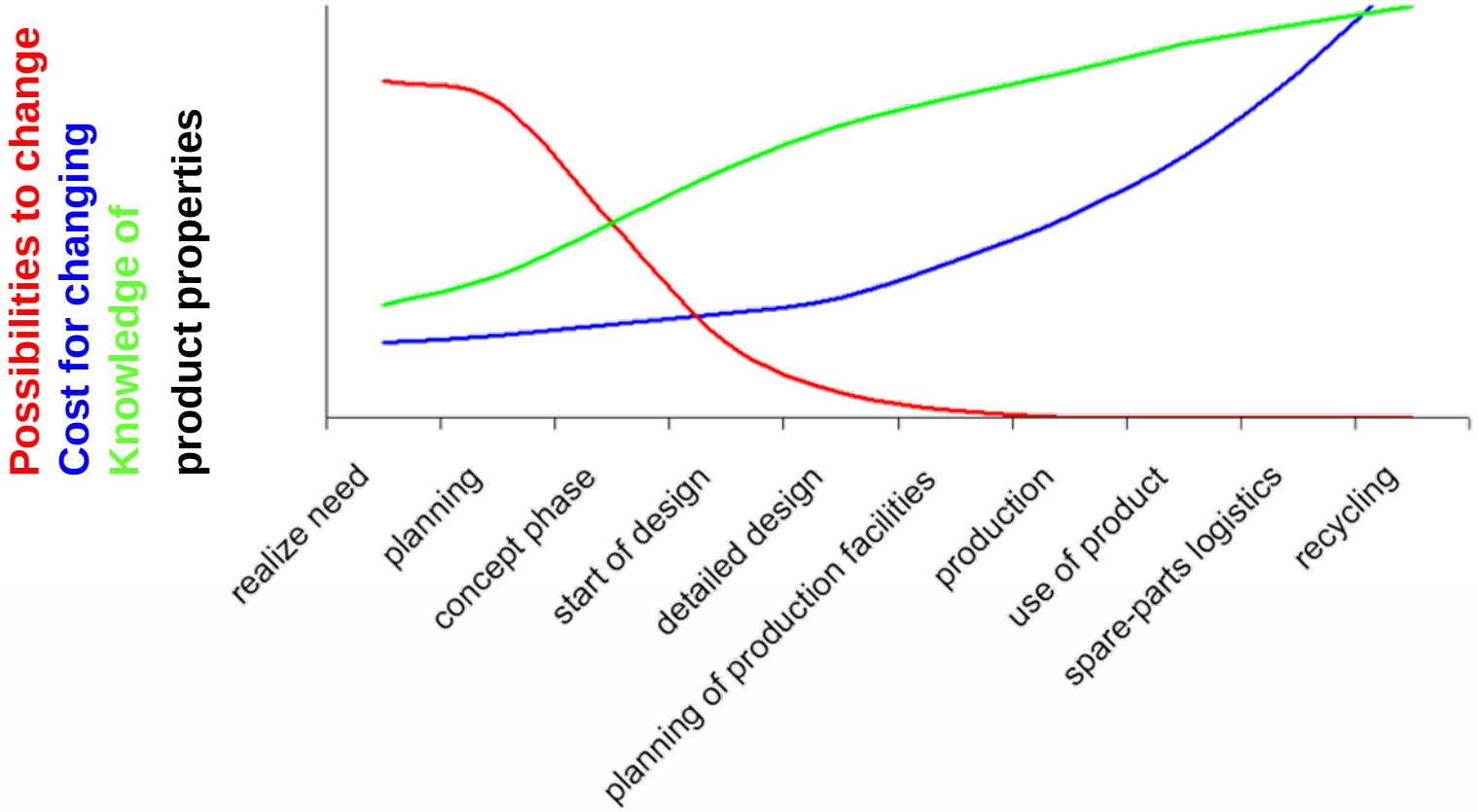
Why simulation?

- Product changes frequently in late phases of product development, e.g.
  - Release of a product / Start of production

  due to **quality problems**
- **Reason:** In most cases, lack of knowledge concerning product behavior / product properties in early phases of the development

↳ Strong impact on
  - cost of change
  - Possibilities of modifications

Actual situation in product development



Actual situation in product development

- Improvement of product development in early stages of product development
- Result of survey on 20 companies
  - 66% of the companies spend 10-20 %
  - 24% of the companies spend 20 %

  of their total R&D budget for modification [source: Wildemann]
- *Use of simulation methods to increase the knowledge in early stages of product development*

What is simulation?

Definition according to Shannon (1975)

- Simulation is the process of designing a **model** of a real system and conducting **experiments** with this model for the **purpose** either of **understanding the behavior** of the system and its underlying causes or of **evaluating various designs** of an artificial system or **strategies for the operation** of the system.

Application of CFD

- Applications of CFD are numerous
  - Flow and heat transfer in automotive applications Aerodynamic of vehicles, airplanes, etc.
  - Heat and mass transfer in apparatuses and pipes of process engineering
  - Applications in
    - Multiphase flow simulation
    - Biofluidmechanics
  - …

↳ ***Number of applications increases rapidly***

Advantages of CFD (1)

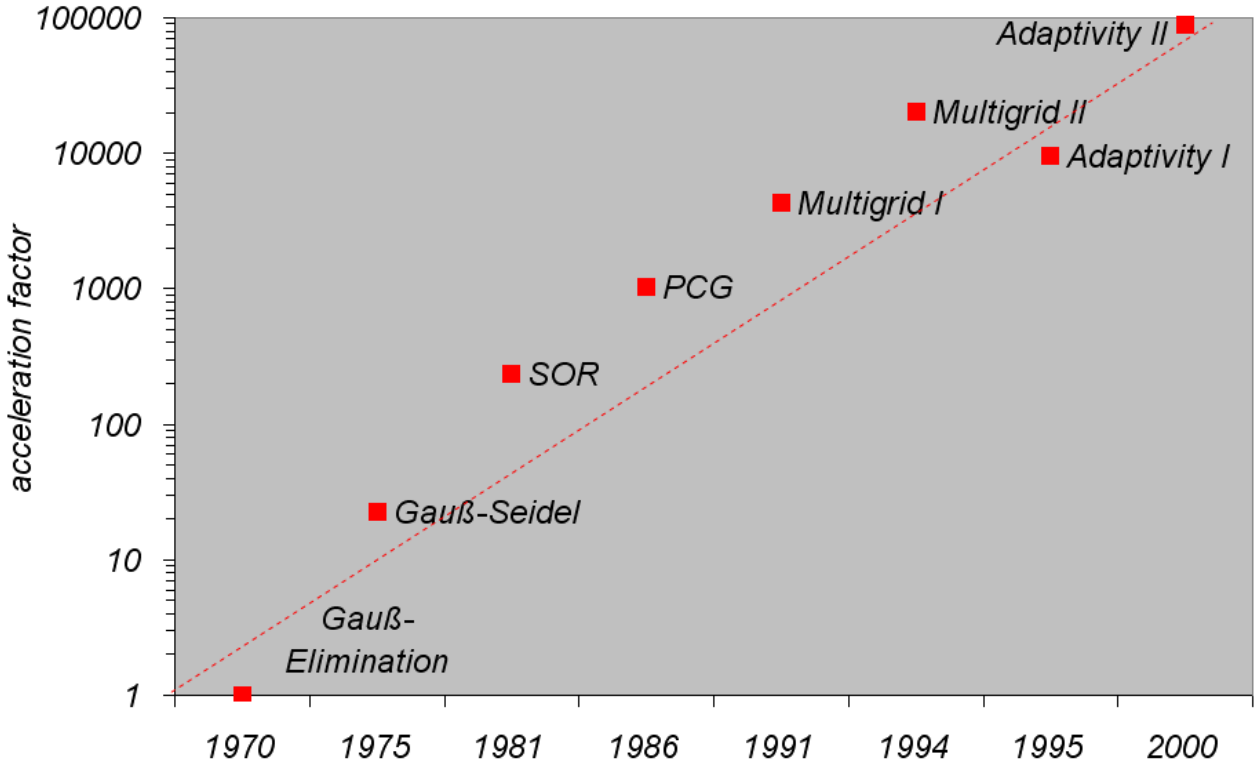
- **Simulation in a lot of cases faster and less expensive than experiments on real (and not easy to handle) objects**
  - A lot of experiments make no sense due to
  - o High costs for experimental setup
  - o No measurement possible in explosive areas,…
  - o Experiment not possible in small devices,…
  - ↳ Using CFD the values can be obtained without any risk.

Advantages of CFD (2)

- **Fast studies of different parameters are possible**
  - In an early phase of the development process, studies of different designs can be evaluated. Expensive and time-consuming manufacturing of prototypes is obsolete.

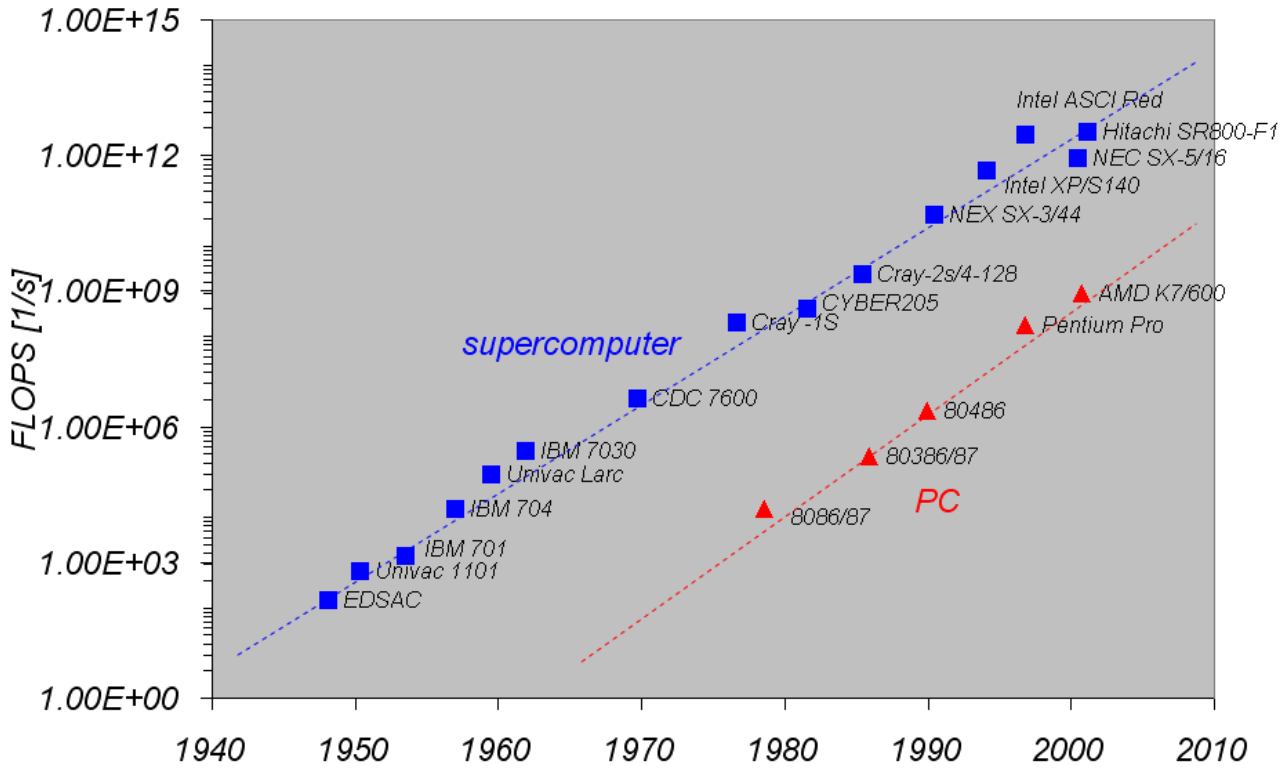
  ↳ CFD offers a possibility for fast studies of parameters and optimization in the development process.

Development of solvers



[source: F. Durst, LSTM Univ. Erlangen]

Development of computers



[source: F. Durst, LSTM Univ. Erlangen]

Advantages of CFD (3)

- **Comparison under reproducible conditions**
  - A lot of experiments (e.g. in combustion engine testing) depend on a huge number of different parameters. The parameters can vary during the experiment leading to misinterpretations of the influence of single parameters.

  ↳ Using CFD the influence of one parameter, e.g. of the geometry, can be obtained.

Advantages of CFD (4)

- **“Total“ information**
  - Experimental values are normally determined for a few positions (e.g. measurement of pressure, velocity by LDA/PDA-measurements)
  - ↳ In CFD simulations the values for pressure, velocity, etc. are known for the whole domain simplifying the interpretation and analysis of the results

Disadvantages of CFD (1)

- **Empirical modeling in CFD**
  - Flow phenomena can be sometimes very complex (turbulent flows, multiphase flows) requiring the mathematical modeling of complex physical phenomena
  - ↳ The accuracy of the simulations is strongly dependent on the quality of the mathematical model and the assumptions behind the model.

Disadvantages of CFD (2)

- **Accuracy of the solution techniques**
  - The numerical solution is always an approximation which is dependent on the mesh quality
  - ↳ Critical eye on the computational mesh, i.e. the solution should be the result of physical phenomena and not the result of different mesh sizes!

Disadvantages of CFD (3)

- **Boundary conditions**
  - The numerical solution will be defined by the boundary conditions which are often not easy to formulate resp. are not known.
  - ↳ Careful analysis of the boundary conditions. Often, the difference between experimental and simulation results is due to wrong assumptions in the definition of boundary conditions.

Disadvantages of CFD (4)

- **Example: Measurement of the pressure drop in pipes**

CFD

Assumptions:
plug flow at the inflow

experiment

Developed flow due to
“history” of flow

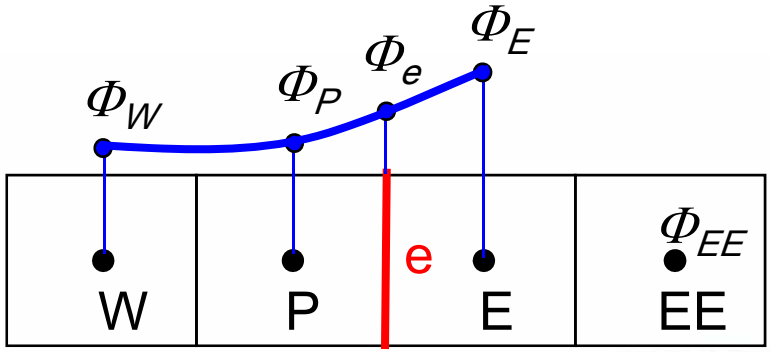
Contents of course (1)

- **Introduction / motivation**
  - Examples for CFD simulations / advantages and disadvantages of CFD
- **Basics of fluid mechanics**
  - Basic equations of fluid mechanics (continuity, momentum and energy equations)

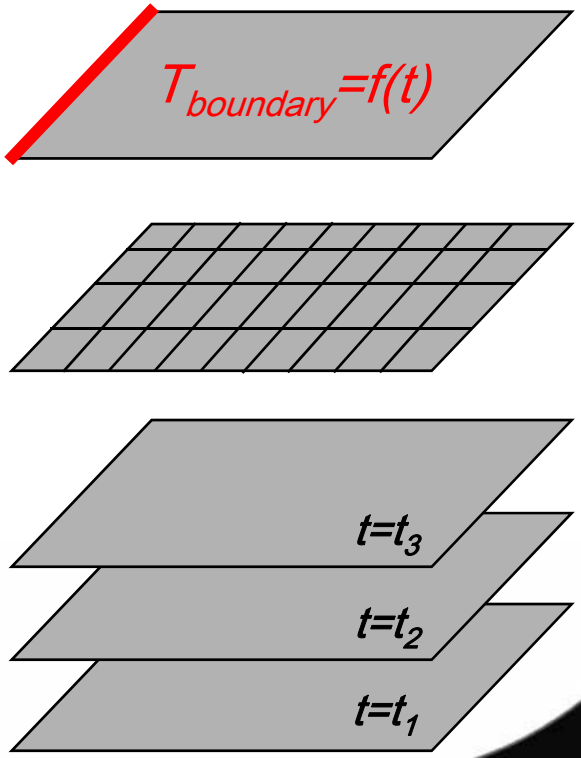
$$\frac{\partial}{\partial t}\left(\int_V \rho\Phi\, dV\right)+\int_S \mathbf{n}\cdot\left(\rho\Phi\mathbf{u}\right) dS=\int_S \mathbf{n}\cdot\left(\Gamma\cdot\nabla\Phi\right) dS+\int_V S_\Phi\, dV$$

Contents of course (2)

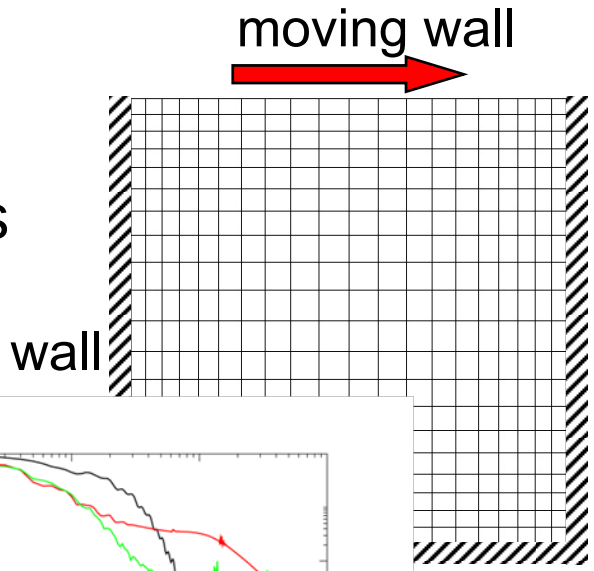
- **Introduction numerical methods**
  - Mathematical background
  - Finite Volume Method
  - spatial discretization
  - temporal discretization
  - discretization schemes



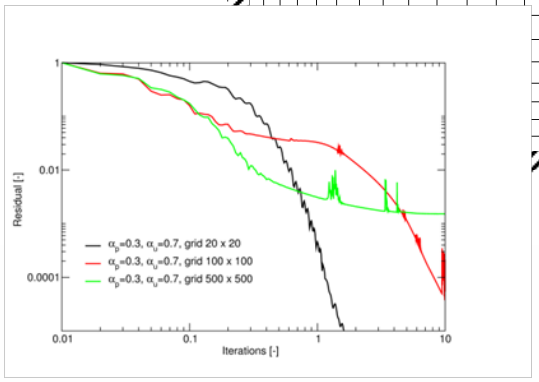
Example: Heat conduction in plate



Contents of course (3)

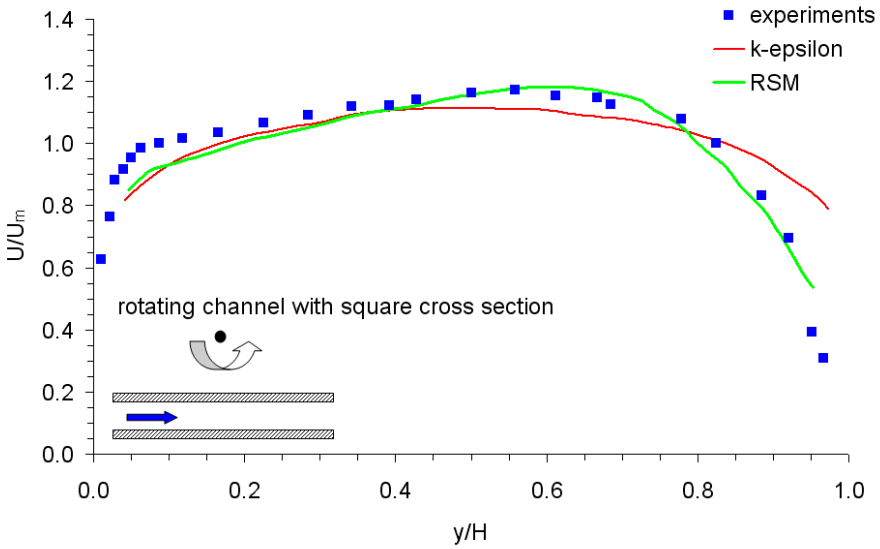


- **Introduction numerical methods**
  - Solution of the Navier-Stokes Eqns (pressure correction)
  - Grid generation
    - Different grids
    - How to check grids
  - Solution of systems of linear equations
    - Theory
    - Solvers (gradient solvers, multigrid)



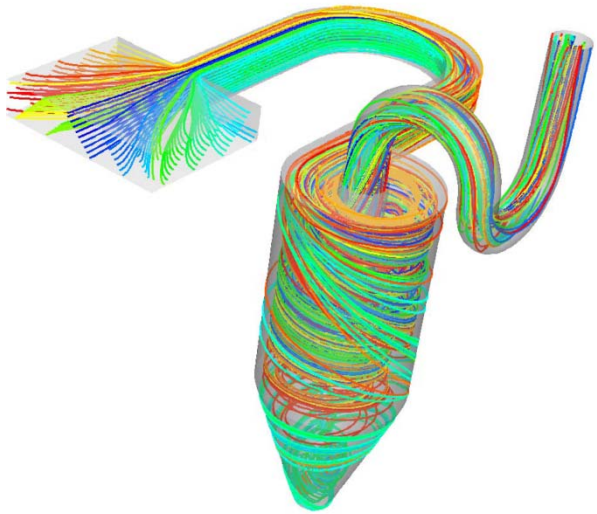
Contents of course (4)

- **Special flows**
  - Turbulent flows
    - Theory of turbulent flows
    - Turbulence modeling in CFD
    - Comparison of turbulence models
    - Influence of turbulence model on CFD results



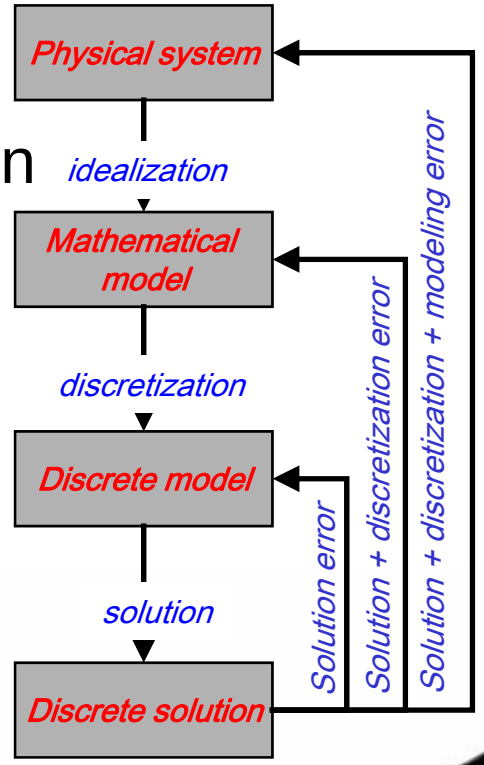
Contents of course (5)

- **Special flows**
  - Multiphase flows
    - Theory of multiphase flows
    - Problems in multiphase flow simulations
    - Available models for CFD simulations
      - Lagrangian
      - Eulerian
      - VOF
      - Examples for models



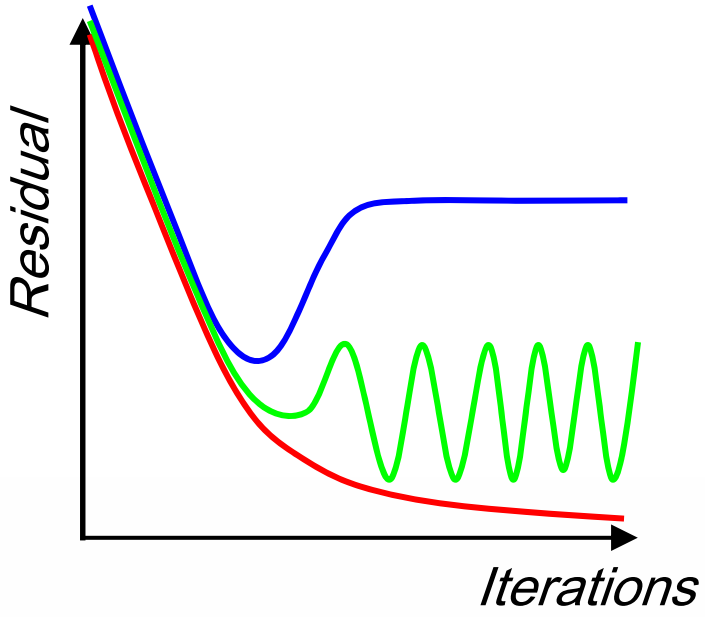
Contents of course (6)

- **From the real to the simulation model**
  - What to do before starting a simulation
  - Errors in CFD simulations
  - Assumptions? Why?
  - Effect of assumptions?
  - Boundary conditions? Which?
  - Grid generation? How?
  - Examples



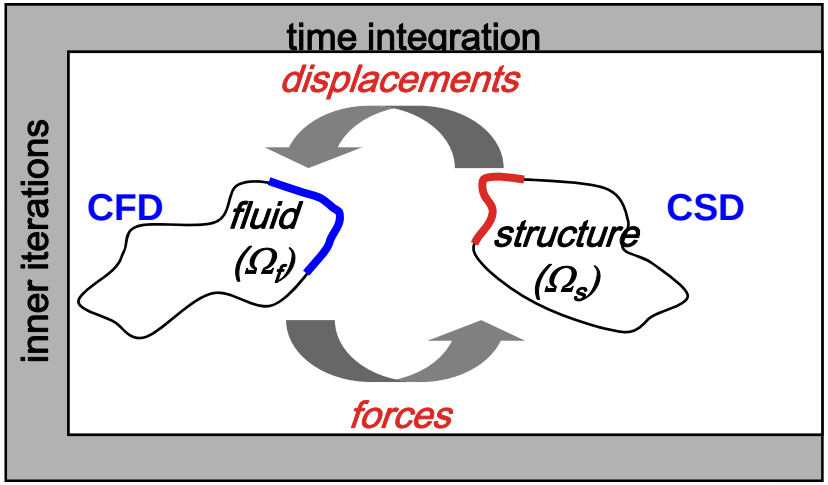
Contents of course (7)

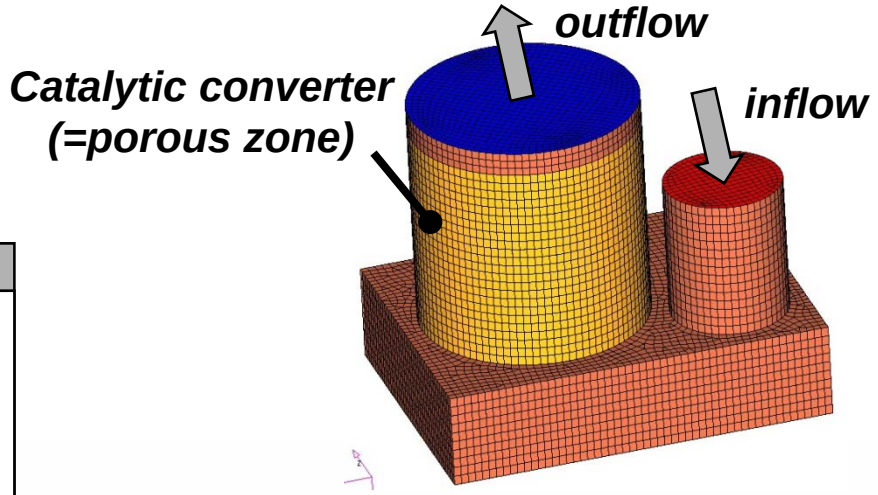
- **Quality of CFD simulations**
  - Checking of CFD results
  - Interpretation of CFD results
  - Improvements / what to do?
  - Summary and perspectives



Contents of course (8)

- **Outlook, trends in simulation methods**
  - Optimization
  - Coupled simulations





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Q&A Session

Using the Q&A tool, please submit any questions you may have for our panel.

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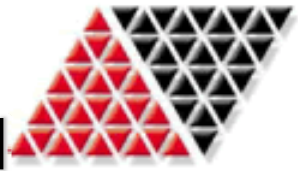

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Thank you!