OpenFOAM Turbomachinery Working Group:

Progress report

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About the OpenFOAM Turbo WG

- **Initiated at the Second OpenFOAM Workshop in Zagreb, June 2007**
- **Steering committee:**
  Maryse Page, Martin Beaudoin (Hydro-Québec) and Håkan Nilsson (Chalmers)
- **Homepage:**
  - **OpenFOAM Wiki:**

    http://openfoamwiki.net/index.php/Sig_Turbomachinery
- **Code sharing:**
  - **A branch of the OpenFOAM-extend project on SourceForge.net**
- **Contact:**
  openfoam-extend-turbowg@lists.sourceforge.net

Objectives of the Working Group

- Identify common interests with OpenFOAM for turbomachinery, and plan joint activities
- Develop OpenFOAM for turbomachinery applications, including pre-processing, solution methods, and post-processing.
- Provide tutorials on how to produce accurate results using OpenFOAM in turbomachines.
- Distribute relevant validation test cases and corresponding OpenFOAM applications.
- Use OpenFOAM to develop Best Practice Guidelines for CFD in turbomachines.
- Connect people with the same interest: OpenFOAM and turbomachinery.
- Organize meetings, workshops and collaborations

Contributions to OpenFOAM Wiki

- **Developments**
  - **Descriptions of contributed solvers, utilities and libraries.**
- **Tutorials**
  - **How to implement (new application, boundary condition, turbulence model)**
  - **Cylindrical coordinate systems**
- **Howtos: mergeMeshes, GGI, MRFSimpleFoam, etc.**
- **Validation test cases**
  - **ERCOFTAC conical diffuser**
  - **ERCOFTAC centrifugal pump**
  - **Dellenback Abrupt Expansion (in turbulenceWG wiki)**
- **List of publications**

OpenFOAM-extend on SourceForge.net

- **Contributions to Turbomachinery branch:**
  - **Source codes:**
    - **Mesh converters:**
      - **cgnsToFoam**
      - **foamToCGNS**
    - **Pre-processing tools:**
      - **addSwirlAndRotation**
    - **Specialized BC:**
      - **profile1DfixedValue**
  - **Case-studies/tutorials/validation**
    - **ercoftacCentrifugalPump**
    - **ercoftacConicalDiffuser**

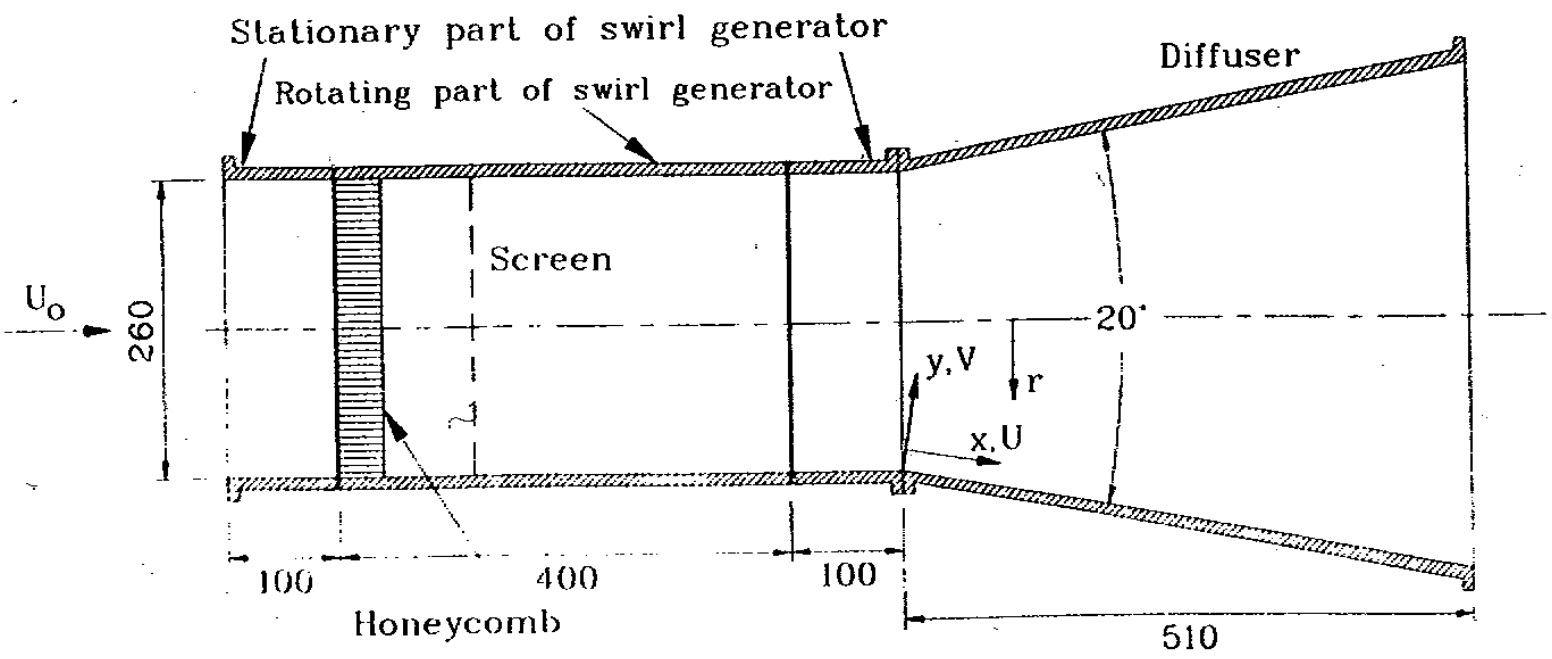
Work in progress

- **Development:**
  - **Mixing plane interfaces**
  - **Automated test-loop**
- **Validation and testing:**
  - **GGI, cyclicGGI, GGI in parallel**
- **Automatic parallel benchmarking for hydraulic turbines applications on large clusters**
- **Also, contributions from University of Munich:**
  - **Mixing plane implementation**
  - **New BCs for calculations in rotating reference frame (compressible flow)**

Case-studies

- Instructions and comments on OpenFOAM Wiki
- All files available on OpenFOAM-extend
  - cases set-up
  - experimental data
  - applications, libraries
- Mesh parametrization for blockMesh using m4 (O-grid, radial grid)
- Automatic post-processing (sample, gnuplot)
- Space for documentation

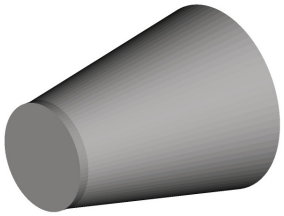
ERCOFTAC Conical Diffuser



Ref: P.D. Clausen, S.G.Koh and D.H.Wood,
Measurements of a Swirling Turbulent Boundary Layer Developing in a Conical Diffuser,
Experimental Thermal and Fluid Science 1993, 6:39-48

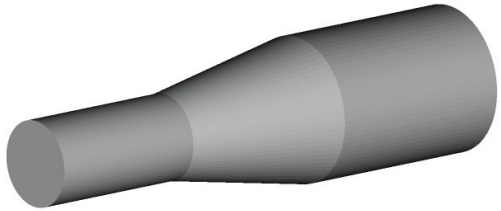
Cases in OF Wiki and OpenFOAM-extend

Case0



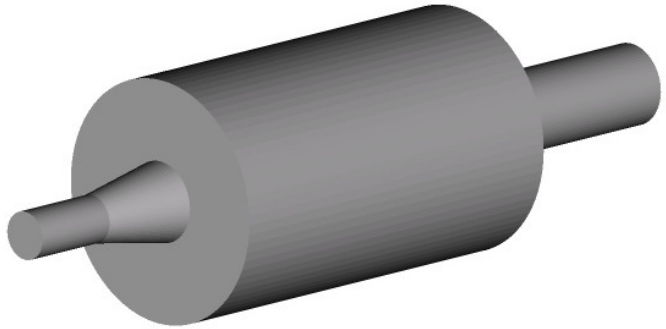
Case0: Base case

Case1



Case1: Extended base case
Case1.1: Radial mesh
Case1.2: MFRSimpleFoam
Case1.3: 2D wedge mesh

Case2

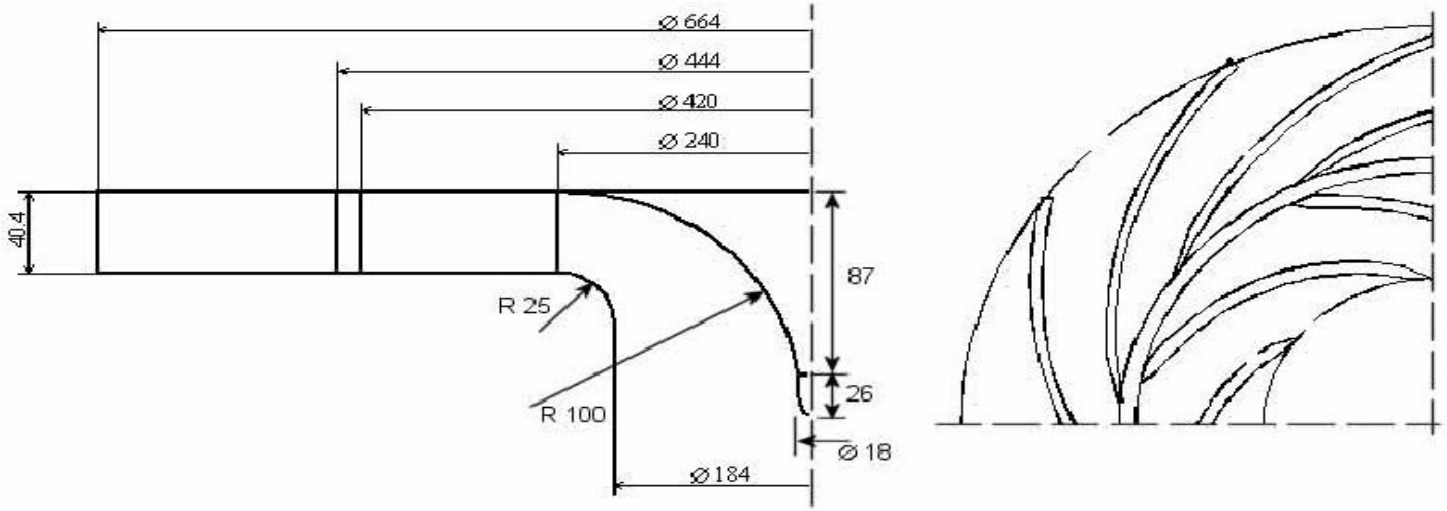


Case2: Case1 with a dump
Case2.1: Inlet velocity profile
Case2.2: Radial mesh

- All cases except Case1.2 use simpleFoam
- k-ε with wall functions, average y^+: 25-27
- div(phi,U) Gauss linearUpwind Gauss;
- div(phi,k) Gauss upwind;
- div(phi,epsilon) Gauss upwind;

ERCOFTAC Centrifugal Pump

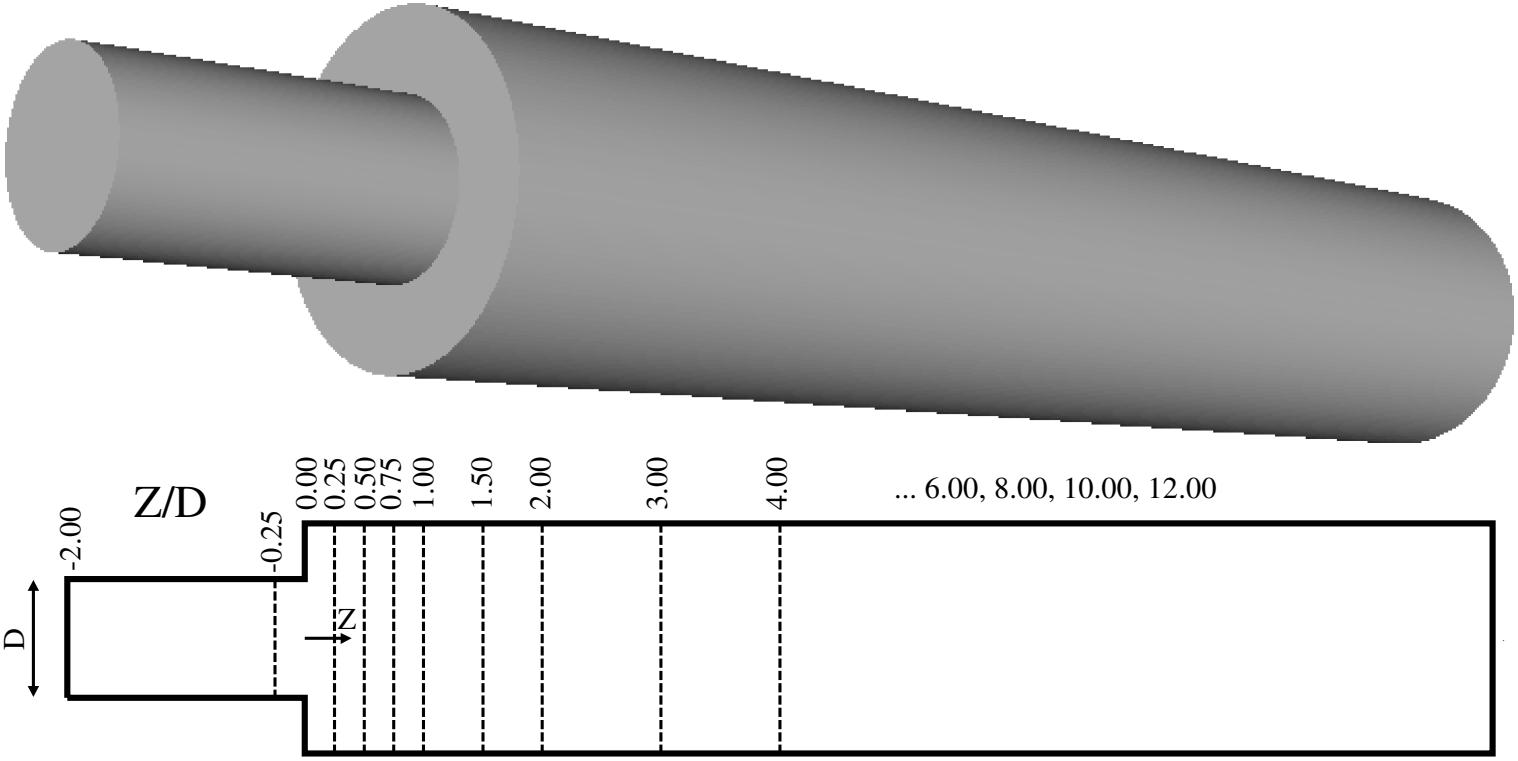
- The centrifugal pump has 7 impeller blades, 12 diffuser vanes and 6% vaneless radial gap. The pump operates on air, and at constant rotational speed of 2000 rpm.



Ref: Ubaldi, M., Zunino, P., Barigozzi, G. and Cattanei, A.,
"*An Experimental Investigation of Stator Induced Unsteadiness on Centrifugal Impeller Outflow*",
Journal of Turbomachinery, vol.118, 41-54, 1996

The Dellenback Abrupt Expansion case-study

- Dellenback, P.A., Metzger, D.E., and Neitzel, G.P., 1987, Measurements in Turbulent Swirling Flow Through an Abrupt Expansion, AIAA J., 26(6), pp.669-681
- http://openfoamwiki.net/index.php/Sig_Turbulence_/_Dellenback_Abrupt_Expansion



Hydro Québec Institut de recherche

CHALMERS SWC

Proposed Agenda for Turbo WG in Mtl

- **The intelligent pump impeller: A future turbomachinery testcase for OpenFOAM**
  - **K. Skriver Dahl and N. Pedersen (Grundfos)**
- **Flow analysis of a single-based pump with OpenFOAM**
  - **M. Auvinen (Helsinki Univ. Of Technology)**
- **Validation of OpenFOAM for draft tube**
  - **F. Guibault (Polytechnique Montreal) and T. Vu (Andritz Hydro)**
- **TBA**
  - **I. Buntic-Ogor (IFMHM Stuttgart)**
- **ERCOFTAC centrifugal pump case-study**
  - **O. Petit, H. Nilsson (Chalmers), M. Page and M. Beaudoin (Hydro-Québec)**
- **Discussion and future work**