3rd Short Course and Forum
CFD in Positive Displacement Machines
9th-10th September 2017

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Short Course/Forum Objectives

1. To provide forum for discussing wide range of issues on CFD in Positive displacement machines

2. Latest developments in the area from leading experts

3. Industry and academia to meet with CFD and Grid generation vendors

4. To provide directions for future developments in CFD for positive displacement machines
3rd Short Course/Forum on CFD in Positive displacement rotary machines
9th – 10th September 2017
The 3rd Forum

• 13 Lectures / Presentations
• 55 Attendees
• Focus
  • Accurate prediction and sensitivity of clearance size variation during operation on the leakage flow through the machines.
  • How modern CFD tools could be used to predict variation in gap size.
  • Stability and accuracy of Multiphase flow calculations in 3D simulations of compressors.
• Test case provided with measurements on Dry twin screw compressor
Conclusions from the 3\textsuperscript{rd} Forum

**Goals: (2015)**
- Integrated – ‘Button Press’ Solution:
  - Grid – Pre Processing
  - Solver
  - Results – Post processing
- Used by Design Engineer
- Accurate estimation of complex geometry - single phase (gas or liquid)
- FSI, Multiphase flows, novel concepts

**Goals: (2017)**
- Single Screw and Similar mesh solutions
- Better quality mesh
  - Min Face angle / Expansion Ratio
  - Separate Rotation / Grid Size
- FSI (Size of the Gap)
- Start from CAD
- Validation
- Faster designs with less experiment
- Improving lower order models
- Optimisation
- Provide funding
- To run as virtual testing

**Goals: (2019)**
- Leakage Losses
- FSI – Clearance Gaps
- Faster Calculation
- Validation of Multiphase calculation
- Automation – Less human interaction
- Test case
  - Multiphase Twin screw
  - Single Screw, Dry and Multiphase
- Acoustics, Dynamics, Higher order models
- Friction
Conclusions from the 3rd Forum

**Reality: (2015)**

- Best Option – User Defined Mesher
- SCORG – Almost Exclusively Used
  - Automated, generally good mesh
  - Could be improved in capturing leakage flows better
  - Availability for variable geometry rotors
- Many solvers: StarCCM+; CFX; Pumplinx
- Slow to obtain results
- FSI – partly available, Multiphase flows – very rarely analysed,
- If not checked with tests can give mass imbalance
- CFD is suitable for relative comparison

**Reality: (2017)**

- Best Option – User Defined Mesher
- SCORG and Twin Mesh available
- Solvers: StarCCM+; CFX; Pumplinx; FLUENT
- SCORG – Rotor to Rack, best representation of rotor geometry
- FSI – partly available, Size of Gap ??
- Multiphase flows – partly available for Oil injection with single domain Mesh, Slow solver, No phase change!
- Other methods being explored
  - Immersed Boundary
  - Remeshing
  - Overlapping Mesh etc.
- No solution for Single Screw

**Reality:**

- Long calculations – repeating conditions, many cycles
- Mass balance issues
- Need to speed up on desk computers
- FSI – topic for research
- Single model for multiphase
- Adhesion to surface
- Different regimes
- Oil properties not readily available
- Single screw grid generation?
- Pulsations
  - Porous layers
  - Long domains
  - Initial conditions
- Calibrate 1D tools
- Valves and Reciprocating machines
Conclusions from the 3rd Forum

Options: (2015)
- Improve accuracy in pre-processing
  - Refine grid in clearances (sub-grid models, partial re-mesh...)
  - Introduce better initial conditions & restart
- Improve solvers for PD machines:
  - Automate grid inputs
  - Faster solution – different differencing schemes, cloud computing...
  - Multiphase flows, FSI
- Validate use of CFD through benchmark cases

Options: (2017)
- Subgrid model?
- Understand effect of viscosity, density, heat transfer in leakages
- Provide more test cases for multiphase/grid independency
  - Refrigerants
  - Steam
  - Multiphase pumps
- Extend research on influence of solvers on leakage by mesh independent soln
- Combined model (1D- 3D)
- Ensure conservation in soln
- FSI

Options:
- Multiphase:
  - TU Dortmund and City – Droplet distribution
  - Measurements
  - LDV, PDA, High speed camera
- Test Higher order LES, DES turbulence models
- Companies to provide test data
- Coupled model (1D- 3D)
- Acoustics:
  - Resolved DES, PhD Student
  - CFD Vendors – Higher order solvers
- Forum Consortium to promote research in this area
Conclusions from the 3rd Forum

**Will Do: (2015)**
- Form a consortium (committee) to work on promoting CFD for positive displacement machines
- Options for further events and joint ventures:
  - Benchmark cases for leakage flows
  - Benchmark case for oil-free screw compressor
  - Identify more benchmark cases
  - Horizon 2020 – Research network of industry, academia and vendors

**Will Do: (2017)**
- Consortium ?? (committee) to work on promoting CFD for positive displacement machines
- Options for further events and joint ventures:
  - Benchmark for Multiphase
  - Mesh resolved cases
  - FSI
  - Multiphase flows
  - Horizon 2020 – Research network of industry, academia and vendors (Jan + Ahmed)

**Will Do:**
- Test case for Multiphase twin screw
- Test case for Single Screw Dry
  - Multiphase
- Measurements of Roots blower
- Coupling of 1D-3D
- Setup webpage
  - Live Discussion
  - Follow-up
- Characterisation of atomisers
- Meeting at City on 7th – 8th September 2019
Forum board

- Faster Calculation
- Validation of Multiphase
  - A rationalisation (list of unknown inputs)
  - Test case for Multiphase
  - Test case for Single Screw
  - Acoustics - Dynamic - High Order Models
  - Friction

Will do:
- Test case for Multiphase Screw
- Test case for Single Screw
- Measurements of Roots Blowers
- Coupling of HP/LP
- Setup web page to discuss & follow
- Characterisation of attenuators (Giuseppe)
Forum board

- General overview
- Rotor profiling
- What CFD can do in Screw non-axial Compressors
- FSI - and what can be done in future
- Calibrate 1D tools
- Meshing tools and inhomogeneous simulation

- Latest developments in Screw Compressors
- Valves & reciprocating

- Multi-plane compressors
- Transluminescent LES
- Two-plane compressor
- Comparison with experiments

**Reality:**
- Long calculation - repeating conditions, many cycles
- Mass balance ??
- Need to speed up on small computers

**Initial conditions**
- Single model for multi-plane
- Adhesion to surface
- Different regimes
- Oil jet modes (dribble)

**Options:**
- Pulsations: - porous layers
- Large domains
- Coated bush
- Initial conditions

- Single screw expanders for ORC cycles
- Centrifugal pumps
- CFD in general in PD machines
- Vane machines

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