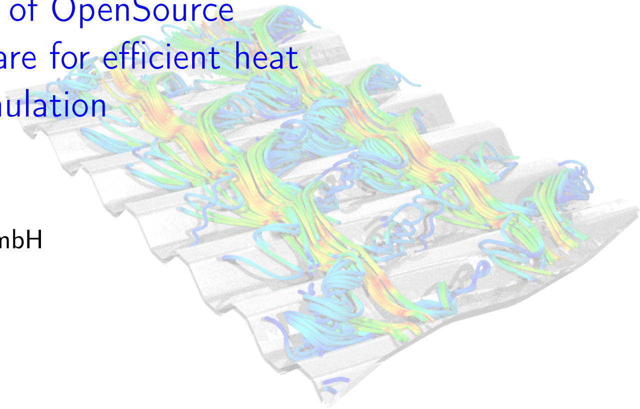
silentdynamics

Application of OpenSource CAE Software for efficient heat transfer simulation



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What do OpenFOAM users expect?

- Use OpenSource Software (OSS) out of the box
- Easy to understand / GUI / simple geometry handling
- Heat transfer related meshing
- Includes all boundary conditions for heat transfer
- Conservative heat fluxes
- Fast and stable radiation handling
- ...

and

- Efficient workflows

Which problems do OpenFOAM users face?

- Which OpenFOAM branch is suitable for me?
- Simple to run simulations ?
- Fast and stable computations ?
- Easy to setup?
- Where to get help?
- Are there any reference/validation cases?
- ....

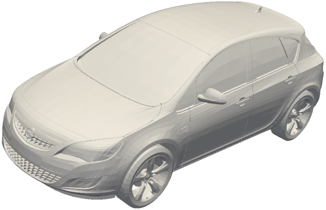
What do OpenSource (OpenFOAM) users do?

- They are going the complete road!
  - Combine different openSource Tools
  - Geometry: FreeCAD / Blender / MeshLAB ...
  - Meshing: OpenFOAM / Netgen / Gmsh
  - Solving: OpenFOAM / Code Aster / Code Saturn
  - PostProcessing: Paraview / Ensight / python
- All tools are available, but:

Is it possible to apply the OpenSource software efficient for complex heat transfer simulations?

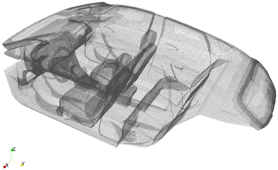
Point of interest

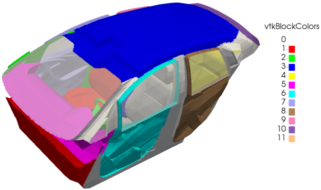
- Analysis of temperature profiles in the car cabin for sensor application
- Evaluation of different sensor positions in combination with climatization strategies
- Energy safing climatization



Workflow

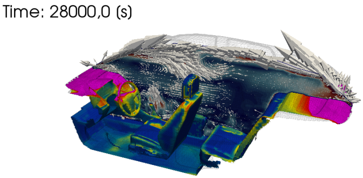
- Meshing of the inner car cabin as full model
  Tools: `Blender` / `snappyHexMesh`

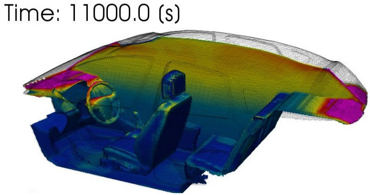




Workflow

- Numerical simulation using heat radiation and unsteady heat capacity extension
  Tools: `OpenFoam`, `Paraview`

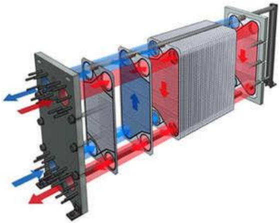


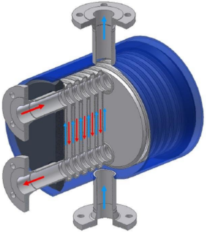


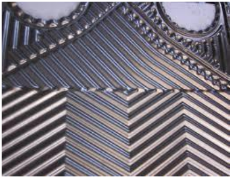
- Comparison to experimental data to experimental data successful!

Point of interest

- Analysis of complex heat exchangers in circular shape in high pressure environment
- Determination of pressure drop and heat transfer rates
- Analysis of fouling probability
- Analysis of flow distribution in different plate sizes
- Inclusion of CFD methods into workflow environment



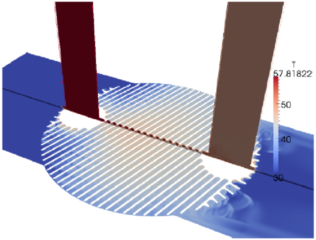


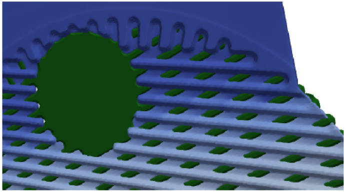


Workflow

- Conjugate Heat Transfer (CHT)
- Direct coupling of hot and cold fluid side
- Analysis: Pressure drop / Heat transfer / Flow structures

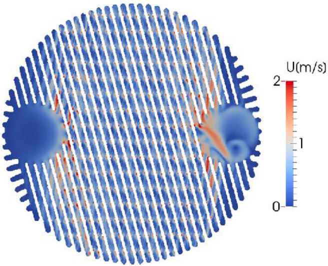
  Tools: `OpenFoam`, `Salome`

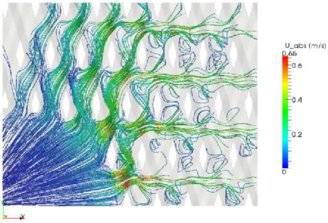




Workflow

- Flow distribution across the plate
- Determination of surface structure influence
  Tools: `OpenFoam`, `Paraview`

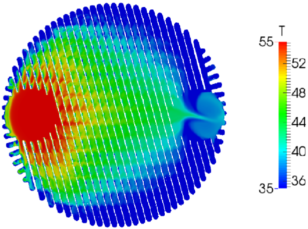




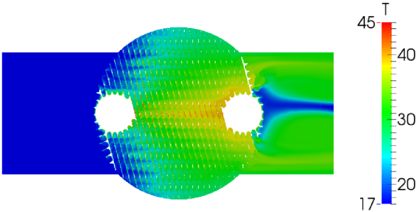
Workflow

- Inlet temperatures
  - Hot side: 55° C
  - Colde side: 17° C
- Temperature distribution in plane

Hot side



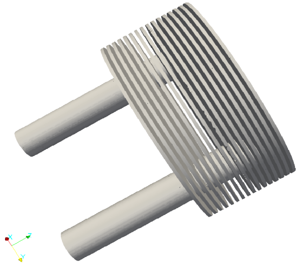
Cold side

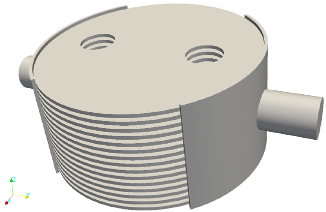


Example - Circular plate heat exchangers

Workflow

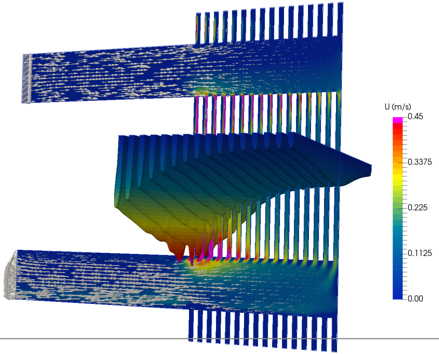
- Example: PHE with 15 Plates and different inlet designs
- Diameter: 340mm
- Inlet/outlet diameter: 50mm
- Question: Thermo-hydraulic performance?





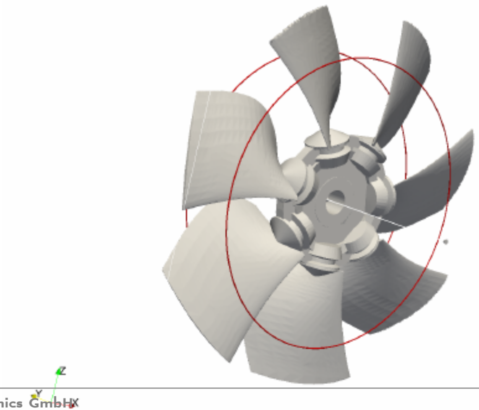
Workflow

- Determination of flow distribution → Design of inlet
- Evaluation of channel performance



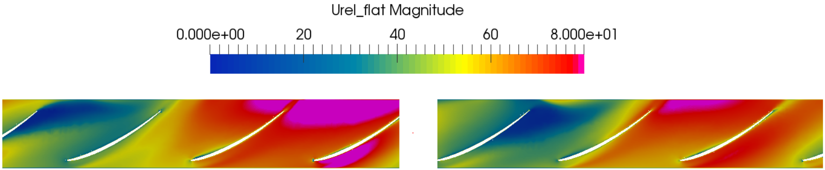
Workflow

- Evaluation of ventilator performance (MRF)
  Tools: `OpenFoam`, `Paraview`



Workflow

- Evaluation of ventilator performance (MRF)
  Tools: `OpenFoam`, `Paraview`



Can we achieve efficient workflows using OSS for complex analysis?

- Yes it is possible, because:

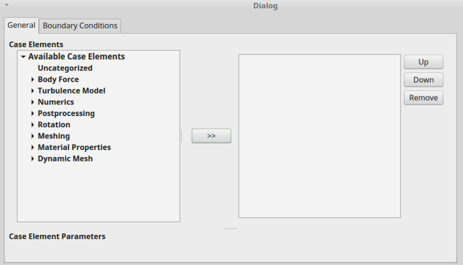
- OSS has an open architecture with many possibilities for automation
- Many independent software tools for similar tasks are available but with different strengths and weaknesses
- Need to combine and support multiple tools
- One quickly ends up in complicated workflows
- $\Rightarrow$Automation can hide complexity of the workflow

What is the idea/aim of "InsightCAE"?

- Conduct an "analysis" as much automated as possible

- Take a minimum of necessary parameters which need to be changed
- Standardization / best practice / testsuites for a given analysis/task
- Bundle addons, extensions and interfaces for all required external software utilities
- Automatic computation of many variants
- Fast case building
- Deployment: Provide one installation package for all workflow-related software components
- `sudo apt install insightcae-base`

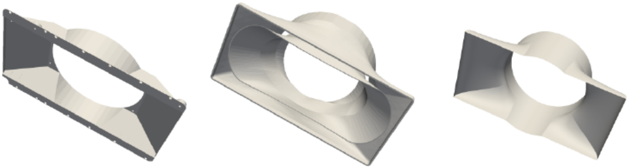
Example module: CaseBuilder of InsightCAE



- Entity: PreProcessing module
  - Using a predefined simulation setup
  - Contains problem specific algorithms
  - Includes all necessary / need steps
  - Meshing setup
- Fast case setup (buoyant, (in)compressible, bc)
- Automatization possible → Let's see an example

Let's try InsightCAE for this classic example

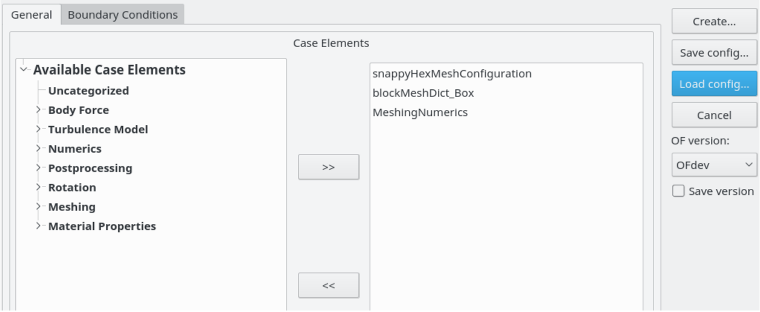
- Task: Generate a duct that combines a rectangular with circle section
- Goals: uniform flow distribution



- So far so good
- Let's start the computation

Mesh setup

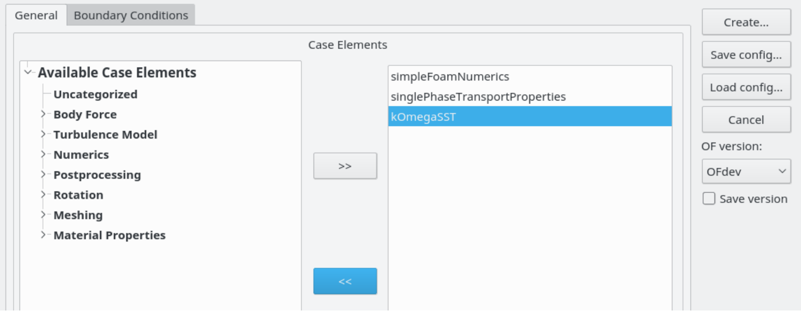
- Generate the mesh setup for `snappyHexMesh`
- Use `isofCaseBuilder`



- Give me the state file for the mesh setup
- Save as `mesh.iscb`

Case setup

- Generate the case setup
- Use `isofCaseBuilder`



- Give me the state file for the case setup
- Save as `case.iscb`

Running the case

- We are almost done
- Now easy automatization run.sh

```
# !/bin/bash
isofCaseBuilder -b mesh.iscb
blockMesh
decomposePar
mpirun -np 10 snappyHexMesh -overwrite -parallel
isofCaseBuilder -b case.iscb
mpirun -np 10 simpleFoam -parallel
reconstructPar -latestTime
rm -rf processor*
```

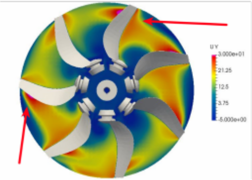
Automated workflow

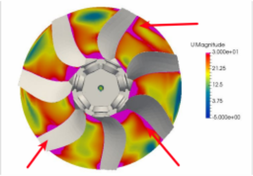
1. Change your sketches / STL geometry
2. Run the `run.sh` file
3. Start `paraview`

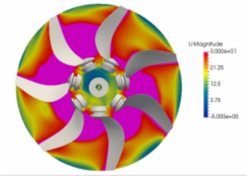
- PostProcessing still takes time
- Start `paraview` → generate layouts → save the state file
- Apply our python script: `isPV.py -b state.pvsm`
- Gives us the pictures as png file for every paraview layout!

Automated workflow - here we go

- Version 1,2,3 ...







Change the Geometry → Start Skript → Get the report

Let's summarize

- Efficient computations are possible using OSS
- InsightCAE connects different OSS using predefined interfaces
- Standardized best practice simulations / reducting of time consuming user mistakes
- Quality is ensured
- No need to edit files in bash
- We get a really **effective** workflow!

Thank you very much!

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```
$ sudo add-apt-repository
http://downloads.silentdynamics.de/ubuntu
$ sudo apt-key adv -recv-key -keyserver keys.gnupg.net
79F5CBA4
$ sudo apt-get update
$ sudo apt-get install insightcae-base
```