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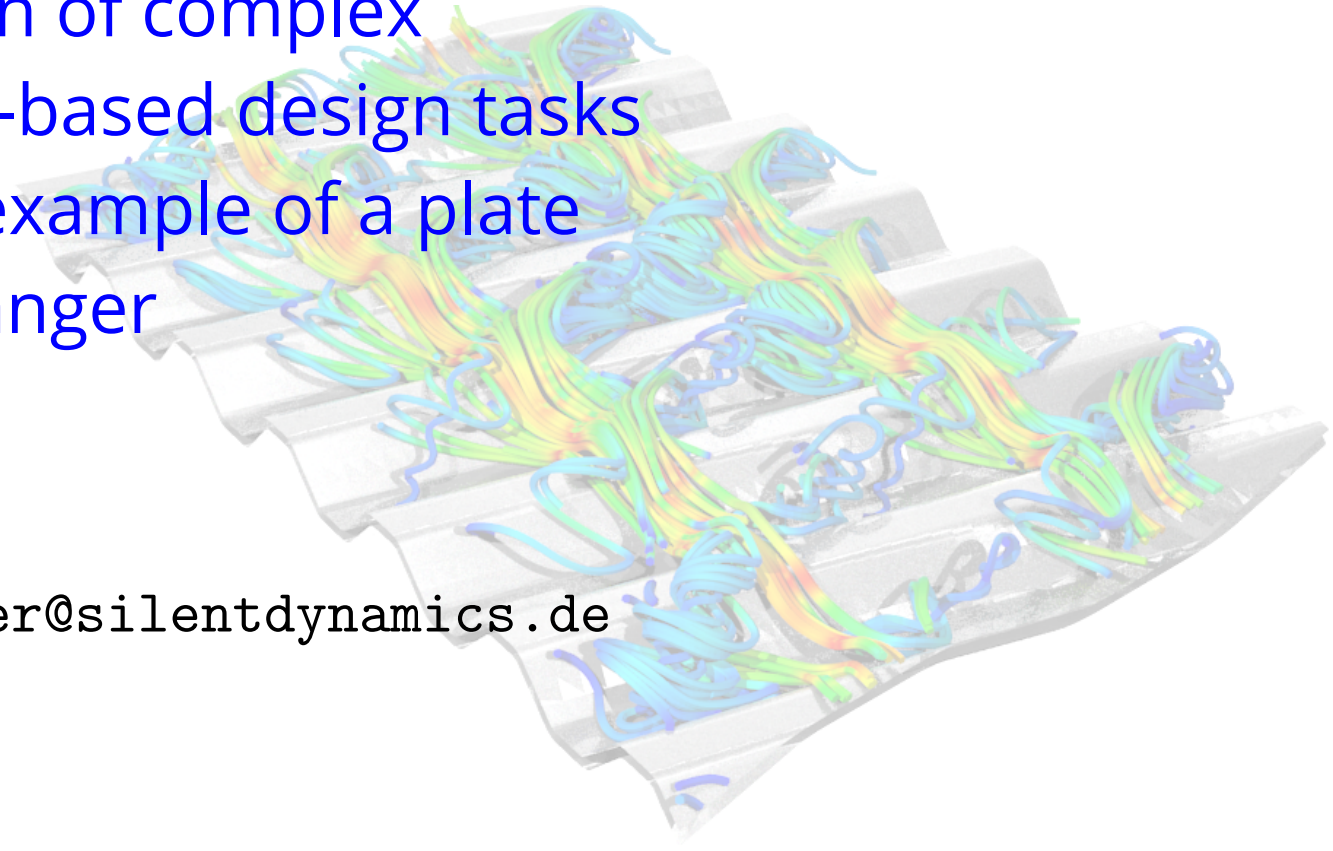
Automation of complex simulation-based design tasks using the example of a plate heat exchanger



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since 2011 Rostock University
Thermo-Fluid-Dynamics
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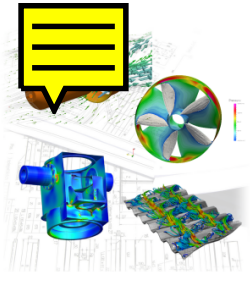
2009-2014 VOITH Turbo
Propeller Design
2014-2020 Rostock University
since 2015 silentdynamics

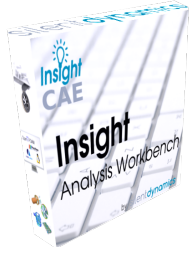
Fields of Business

Simulation Services



- Fluid, Structure (CFD, FEM)

Software Development



- open source software

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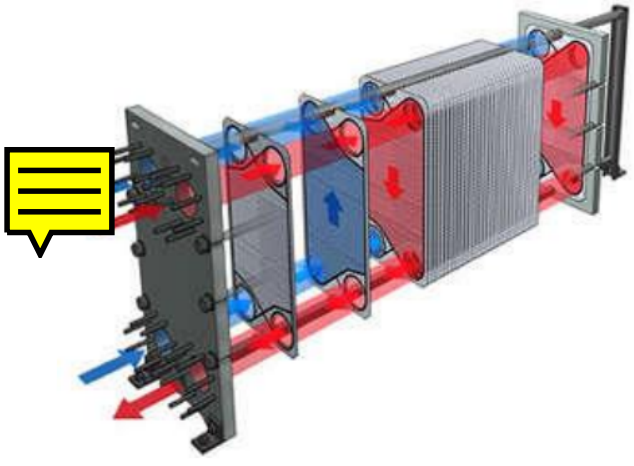
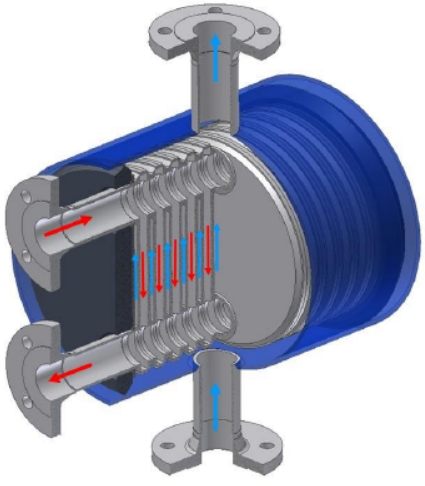
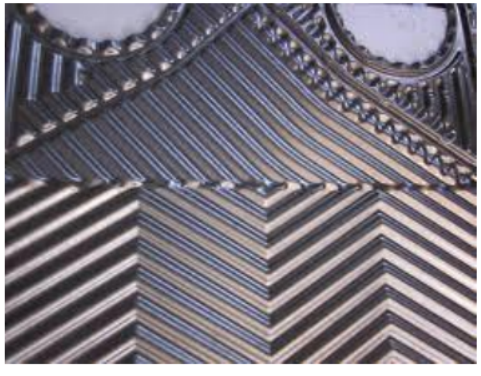
- Customers: Manufacturers of plate heat exchangers
  Complex heat exchangers in circular or rectangular shape in high pressure environment.
- Goal: simulation-based analysis
  - Structural (metal forming)
  - Heat transfer performance (pressure drop and heat transfer rates)

⇒ **Automated workflow for optimization**







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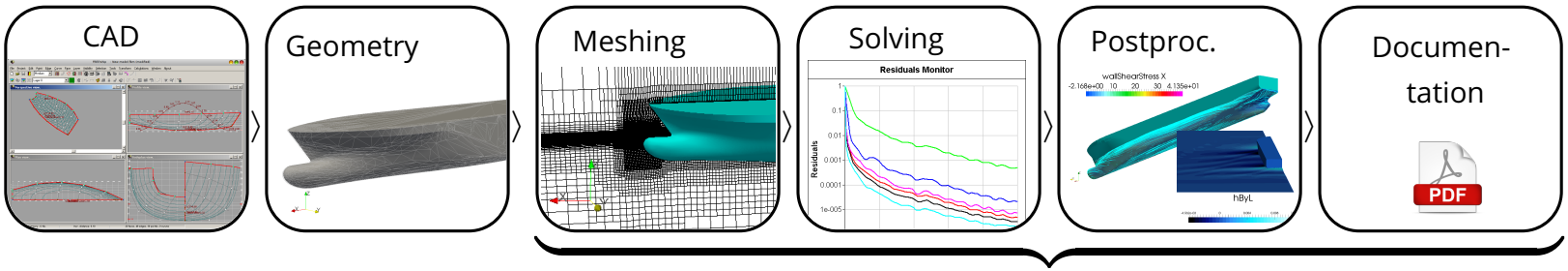
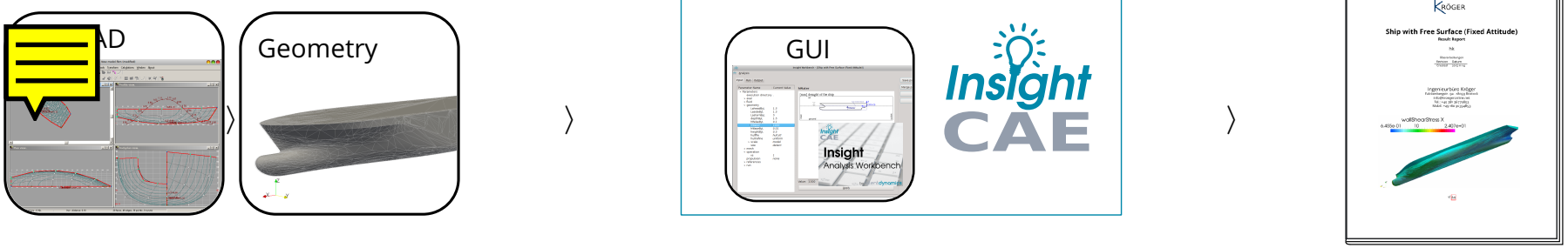
Common practice: *manual* analysis workflow:



- labour intensive
- often complicated, error prone

InsightCAE: *automated* analysis workflow:



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What is the idea of “InsightCAE”?

- conduct an analysis as much automated as possible

- input is a minimum set of required parameters, editable in a GUI
- implementation of a best-practice procedure
- focus on open source software, bundles also required additions to thirdparty software and interfaces.
- deployment: simple installation of all components as installation packages

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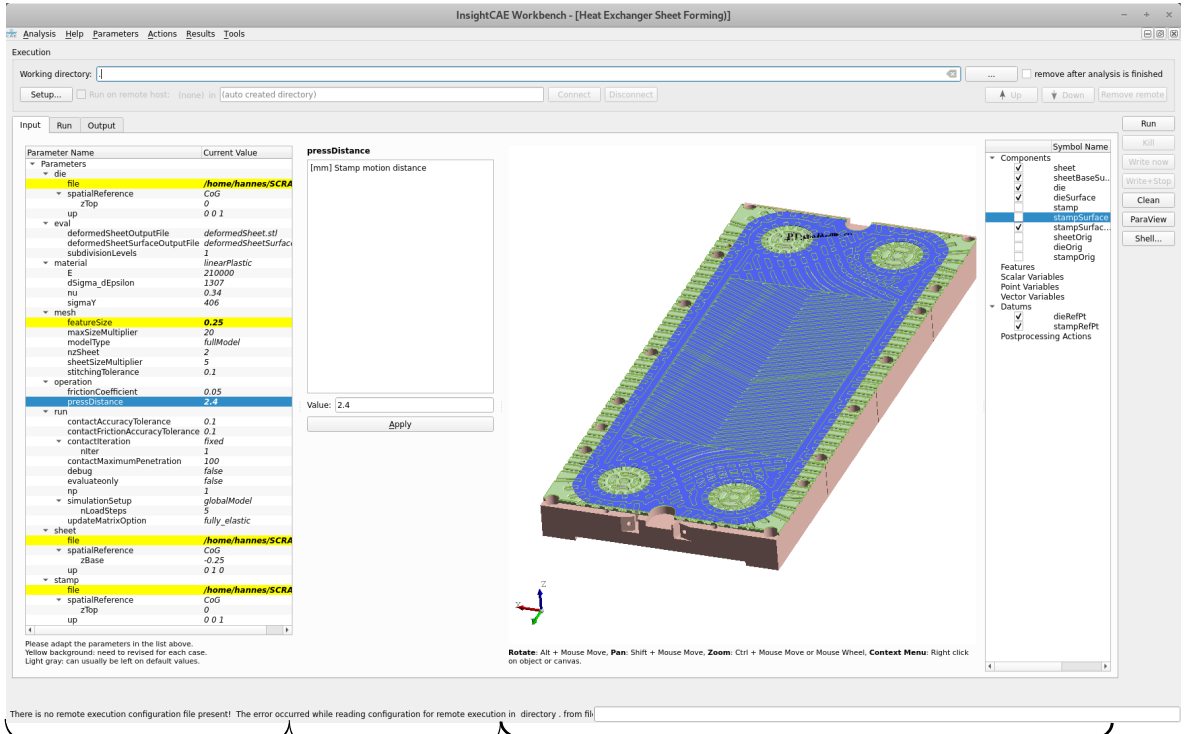
- GUI for analysis configuration / execution / preview of results



- alternative: command line tool for analysis execution

```
$ analyze --int run/np:4 inputfile.ist
```

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First Step - Sheet Metal Forming

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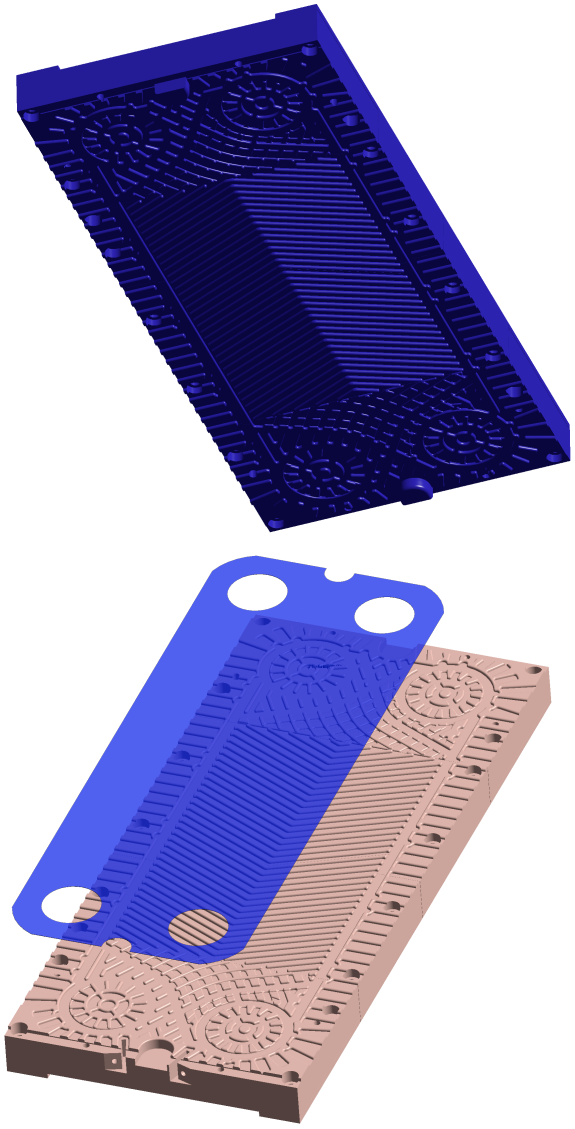
- proper plate geometry required for flow analysis
- generally not possible to design the plate geometry a priori
  ⇒ plate geometry depends on metal forming process
- only the mould and stamp are available as input geometry



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Sheet metal forming simulation required

- in advance of flow simulation
- some properties:
  - plastic deformation, nonlinear problem
  - no symmetry can be exploited
  - very large contact surface
  - thickness of the sheet needs resolution
  - large problem expected,
    long run time
    ⇒ parallel execution needed
- open source tool wanted:
  ⇒ Code_Aster

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- Code_Aster can handle
  - nonlinear isotropic strain hardening ('VMIS_ISOT_TRAC') with a measured stress-strain curve as input
  - or alternatively linear strain hardening ('VMIS_ISOT_LINE')
  - with large strains ('SIMO_MIEHE')

```
RESU = STAT_NON_LINE(...
       CHAM_MATER = CHMA,
       COMPORTEMENT = _F(
              TOUT ='OUI',
              RELATION ='VMIS_ISOT_TRAC',
              DEFORMATION ='SIMO_MIEHE'),
       ...)
```

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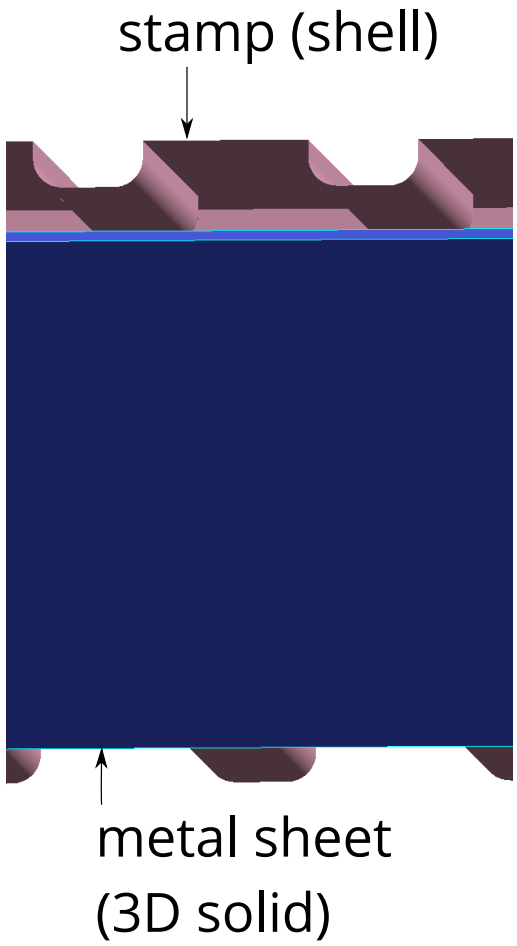
- several formulations for contact available

	Perf	Reliability	DOFs	Robustness
DISCRETE/ 'CONTRAINTE'	+++ Schur	+	Hundreds	++ no_friction
DISCRETE/ 'GCP'	+++	+	Limitless	+ no_friction
DISCRETE/ 'PENALISATION'	+++	+	Thousands	++ with_friction
'CONTINUE'/ 'STANDARD'/ 'PENALISATION'	++	++	Limitless	+++ (with friction)
'CONTINUE'/ 'LAC'	+	++++ Suits for incompatible mesh	Limitless	++ (without friction)

- modeling of stamp and die as rigid shells to reduce mesh size



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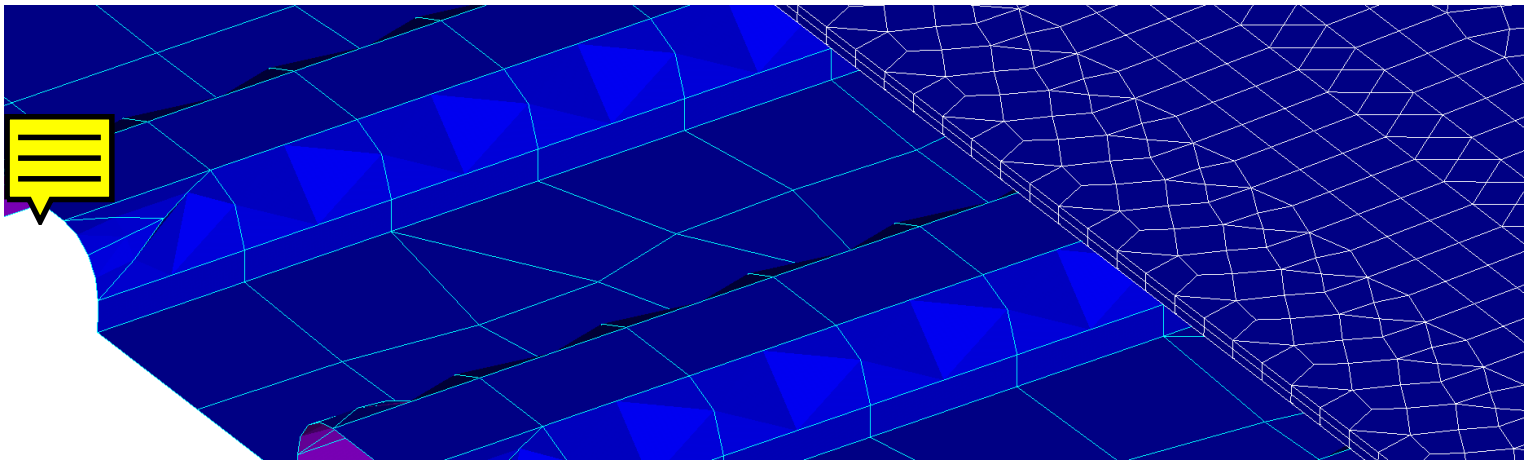
needed:

- surface mesh (shell) of stamp and die surface (triangles ok)
- volume mesh of (undeformed) sheet
  - prismatic (low height but large width)
    $\Rightarrow$ prismatic extruded
  - automatic procedure
    $\Rightarrow$ unstructured mesh of base surface
  - but quad-dominated
- selected tool: Gmsh



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Features added to InsightCAE

- Code_Aster export file creator/solver launcher revised
- Output parser and progress reporter added
  (Special handling for parallel solver runs)
- Gmsh mesher interface has been extended
  - interface for prismatic meshes
  - improved interface to specify names for bottom/top/lateral boundaries
- a MED result file reader (VTK plugin) has been added to InsightCAE
  (port of an older version of Salome's MED reader)

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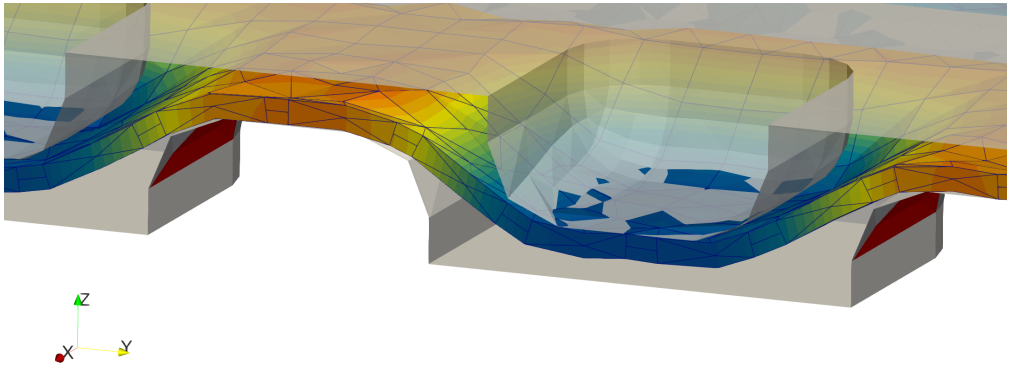
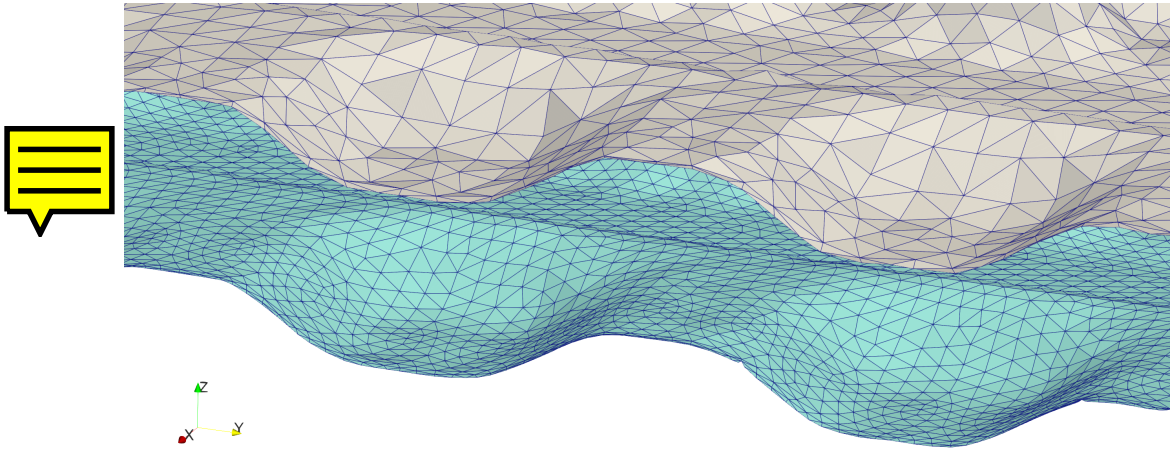
- the final deformed sheet geometry may still be insufficiently resolved for CFD meshing



⇒ smoothing using subdivision



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Second Step - Flow analysis

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Requirements

- CHT simulation, periodic boundary condition (top to bottom)
- at least two channels (one hot fluid, one cold fluid)
- sealings between subsequent plates
  (no gap between sealing and plate!)
- handling of feed pipes
  (trimming on deformed plates!)
- meshing with trimmed mesher `snappyHexMesh`
  (handling of pronounced anisotropy / low channel height)
- optionally:
  - more than two channels with different plates in between
  - different fluid properties in separate channels

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- multiregion support has been added to InsightCAE
  - possible to add fully configured OpenFOAM cases objects (including numerics, BCs, ...) as sub regions of a master case
  - added numerics setup for chtMultiRegion*Foam
- support for multizone setups of snappyHexMesh have been improved
- not yet available in Case Builder
  will be added soon
- boolean operations on triangular meshes: using CGAL library

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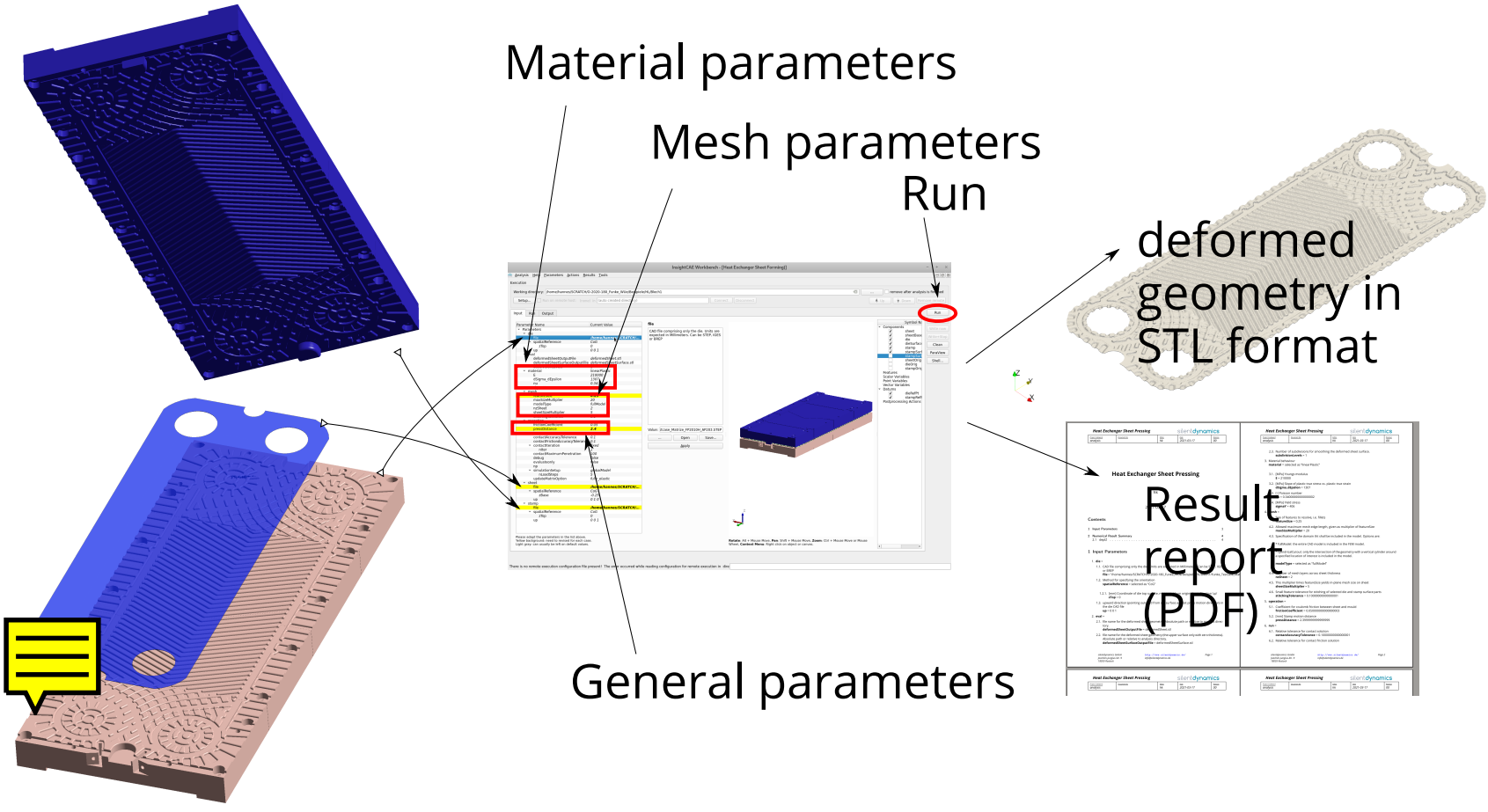
Workflow 1: Sheet metal forming



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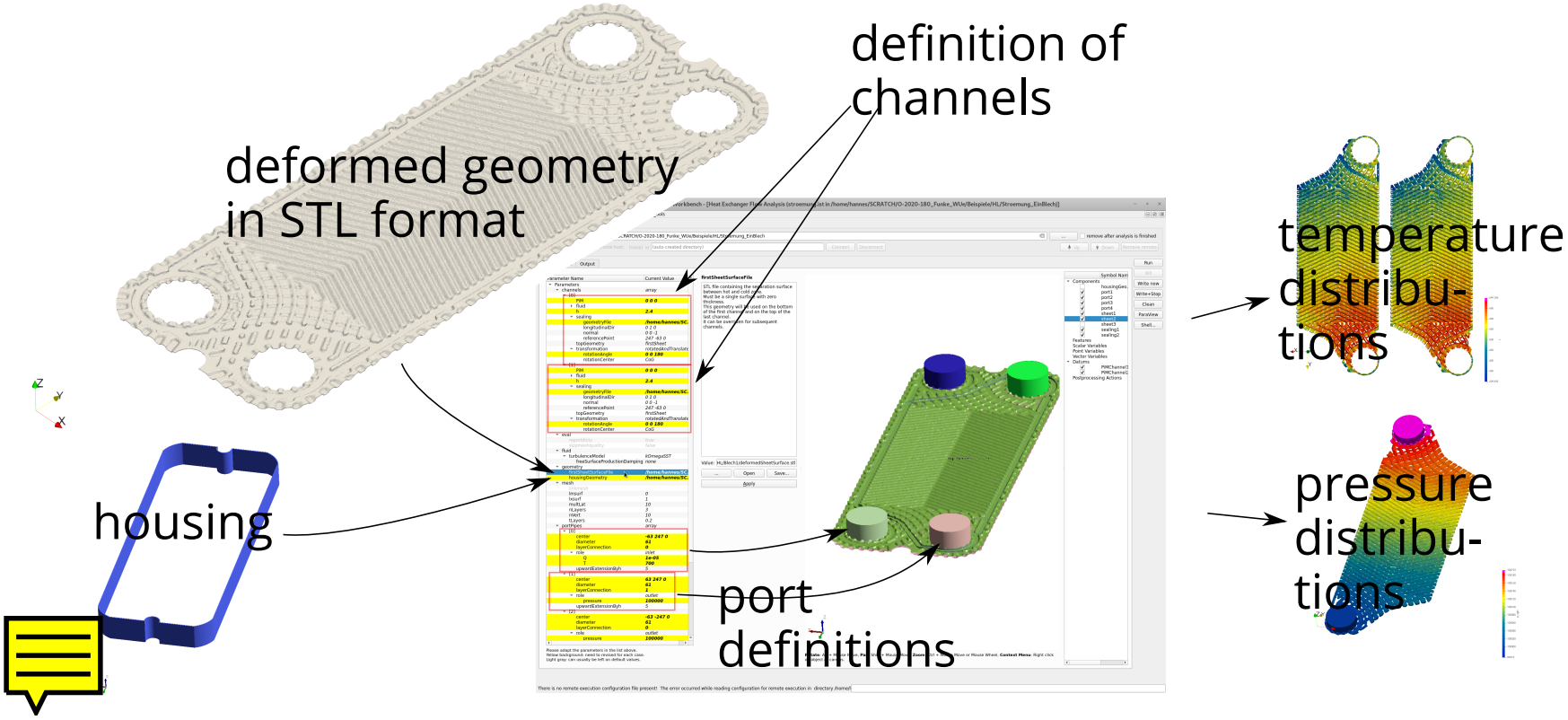
Workflow 2: Flow simulation



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Open for questions

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https://github.com/hkroeger/insightcae

https://silentdynamics.de/en/insightcae-documentation/

```
$ 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
```

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