Business from technology

Combined structural analyses and system level simulation – Cases Apros-PAMS and Apros-Abaqus Co-use

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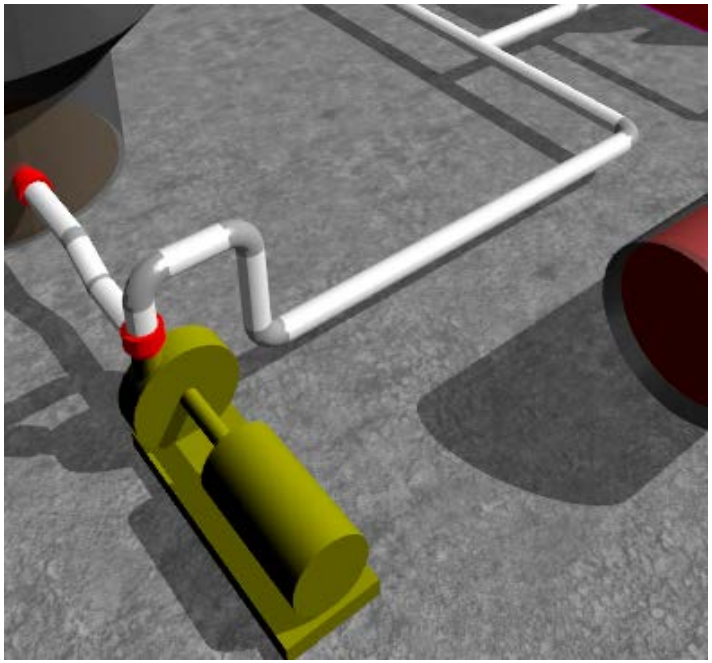
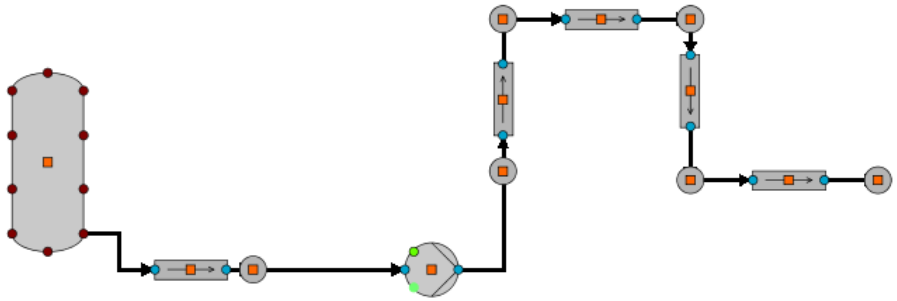
Goal

- Develop a unified modeling and simulation environment combining structural analysis and system simulation





Background

- Structural analysis is used to determine loads on physical structures e.g. loads caused by temperature and pressure changes
- Input for structural analysis typically includes the usage profile including both steady state and time varying transients
- System simulation is used to calculate the transients and define steady states
- Synergies:
  - Same plant model data
  - Structural analysis can utilize simulated transient data
- Related projects
  - ALOAS (2005-2006) – manual data transfer between Apros and Abaqus
  - Dynamo (2012 Pamros tool development) – automatic data transfer between TVO's Pams and Apros

Features/Requirements

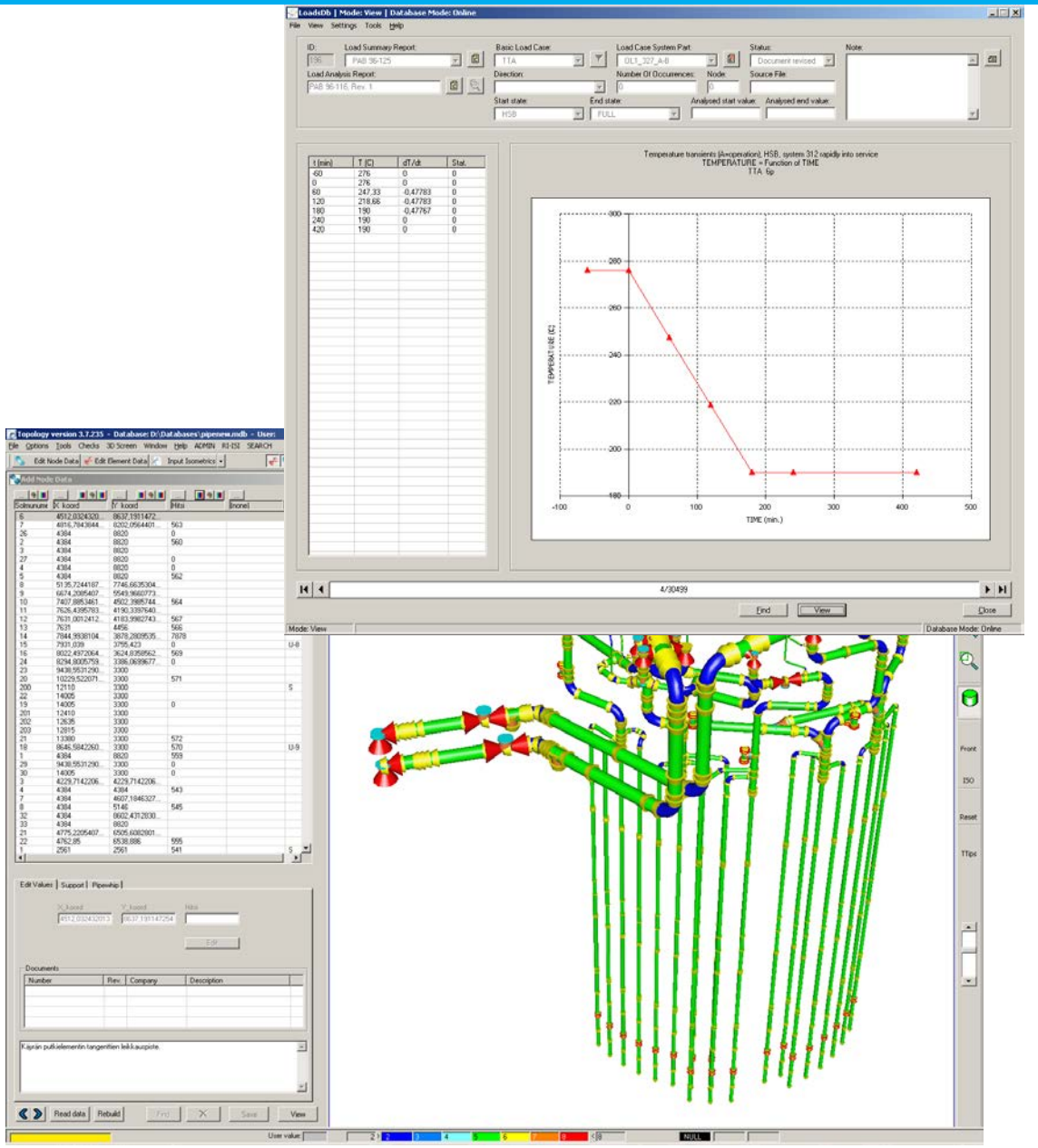
- Integration between structural analysis and simulation plant models
  - useful for users having either Structural analysis (SA) or System simulation (SS) background
- Utilization of simulation results for structural analysis
  - Defining simulation transients and simulation data collectors
- Generation of SS load profiles based on steady state and transient cases
- Execution of simulation runs and structural analysis cases
- 3D visualization can be used also on system simulation side

Tools

- Apros – Accurate dynamic simulation models
- PAMS - TVO's tool for storing plant data and executing and storing simulation run results
- Abaqus – FEM tool that can be used e.g. for structural analysis
- Simantics – Integration platform

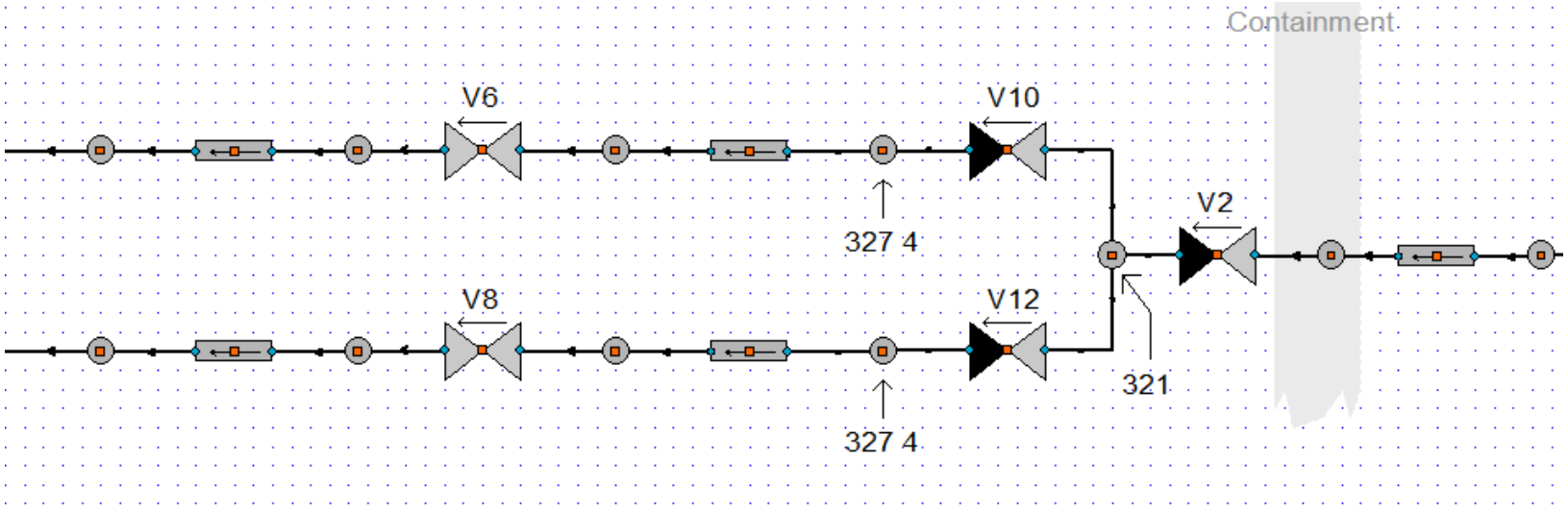
PAMS

- Group of connected databases and tools for administrating them
  - Geometry e.g. pipe dimensions
  - Pipe, insulation and plate Materials
  - Reference documentation
  - Existing connections to other software e.g. Fpipe
  - Transients used for structural analysis



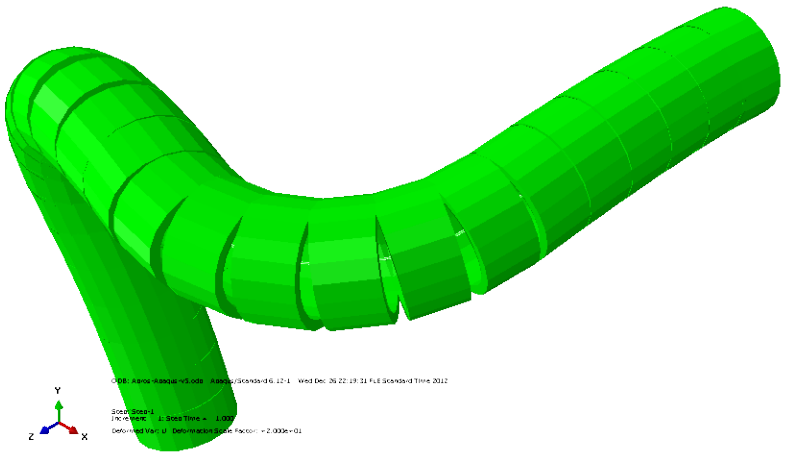
Apros

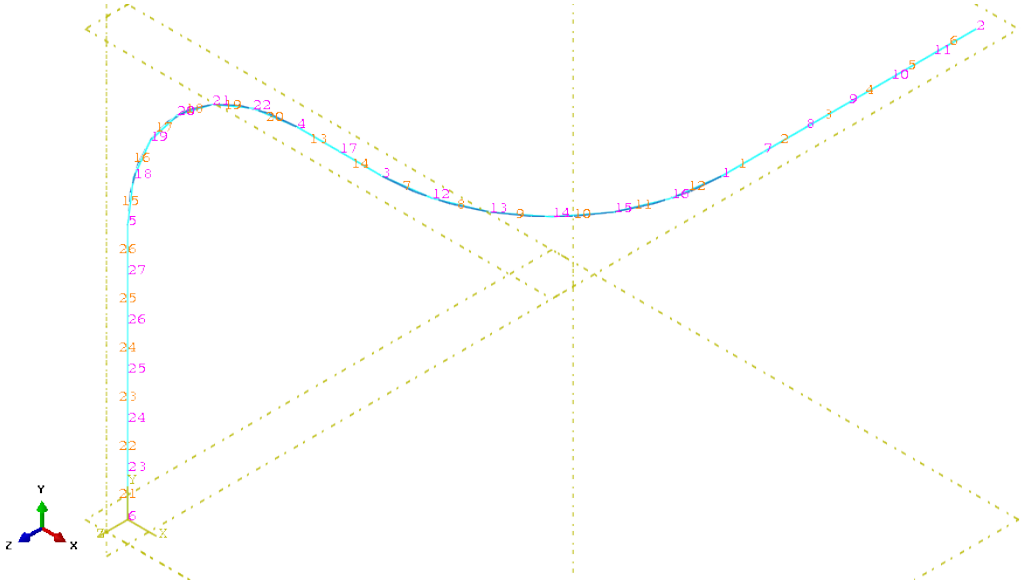
- Accurate dynamic modelling and simulation of power plants
- Simulates the load transients utilising the data from
- Apros 6 utilises Simantics platform



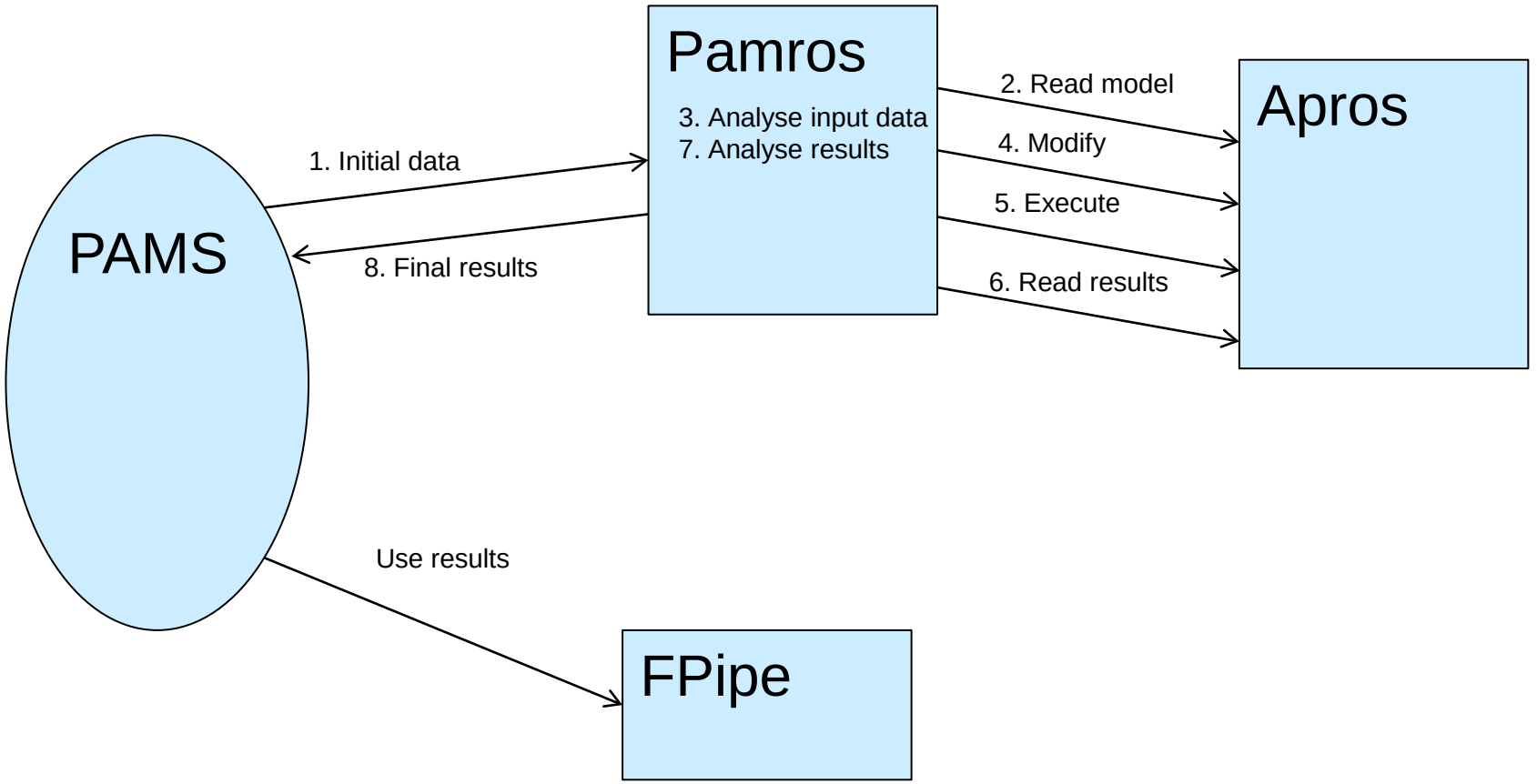
Abaqus

- FEM tool suitable for structural analysis



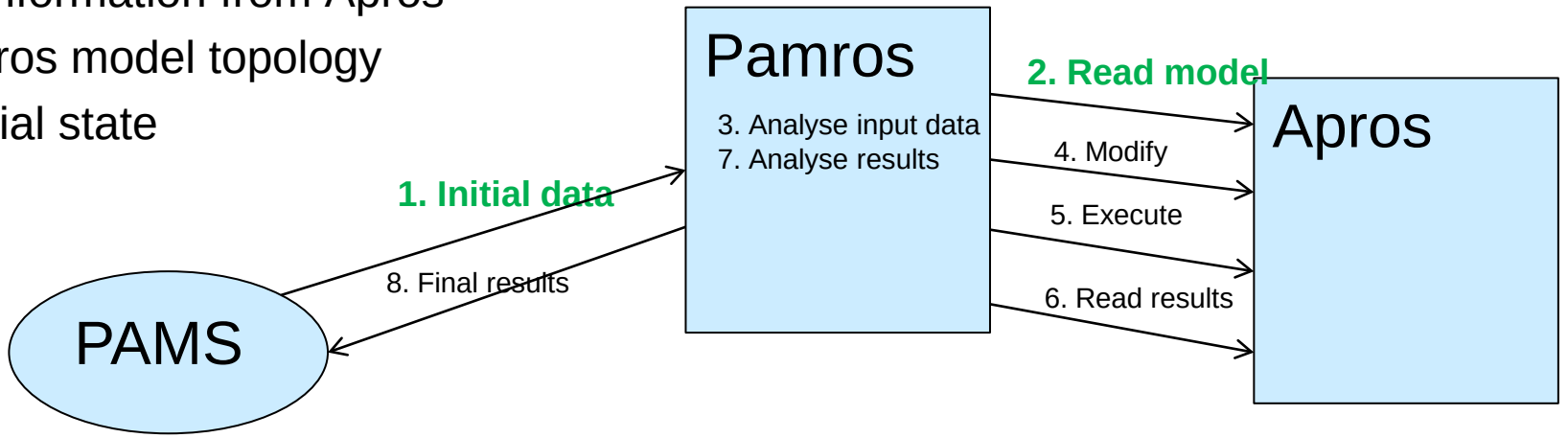


Case 1: Apros-TVO PAMS i.e. Pamros



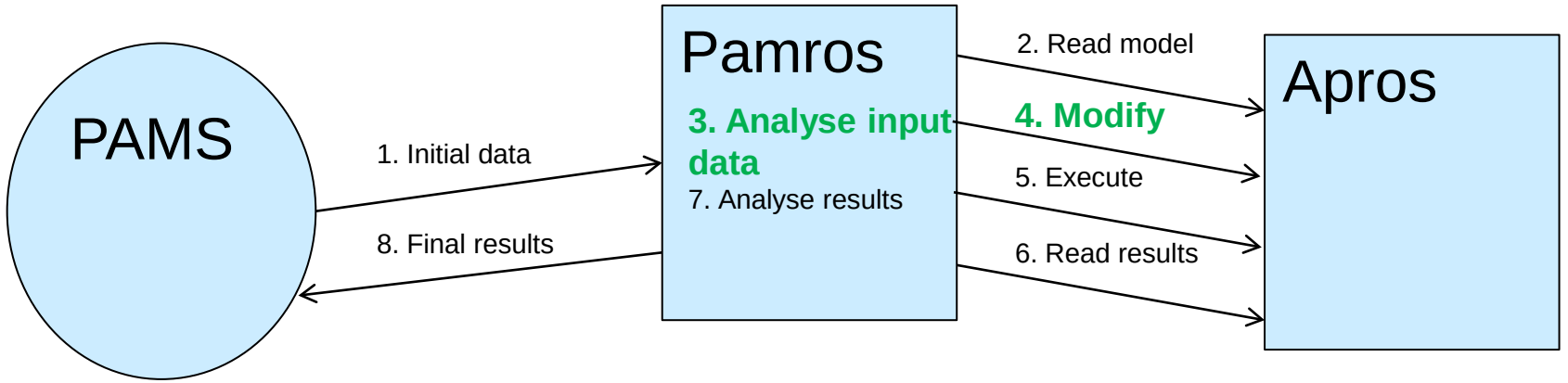
1-2. Initialisation

- Configuration parameters e.g. how simulation data will be reduced
- Initial data from PAMS
  - Initial state name
  - Transient
  - Nodes and elements and data monitoring points
  - Materials and cross sections
  - Key nodes (points recognized in both Apros and PAMS)
- Model information from Apros
  - Apros model topology
  - Initial state



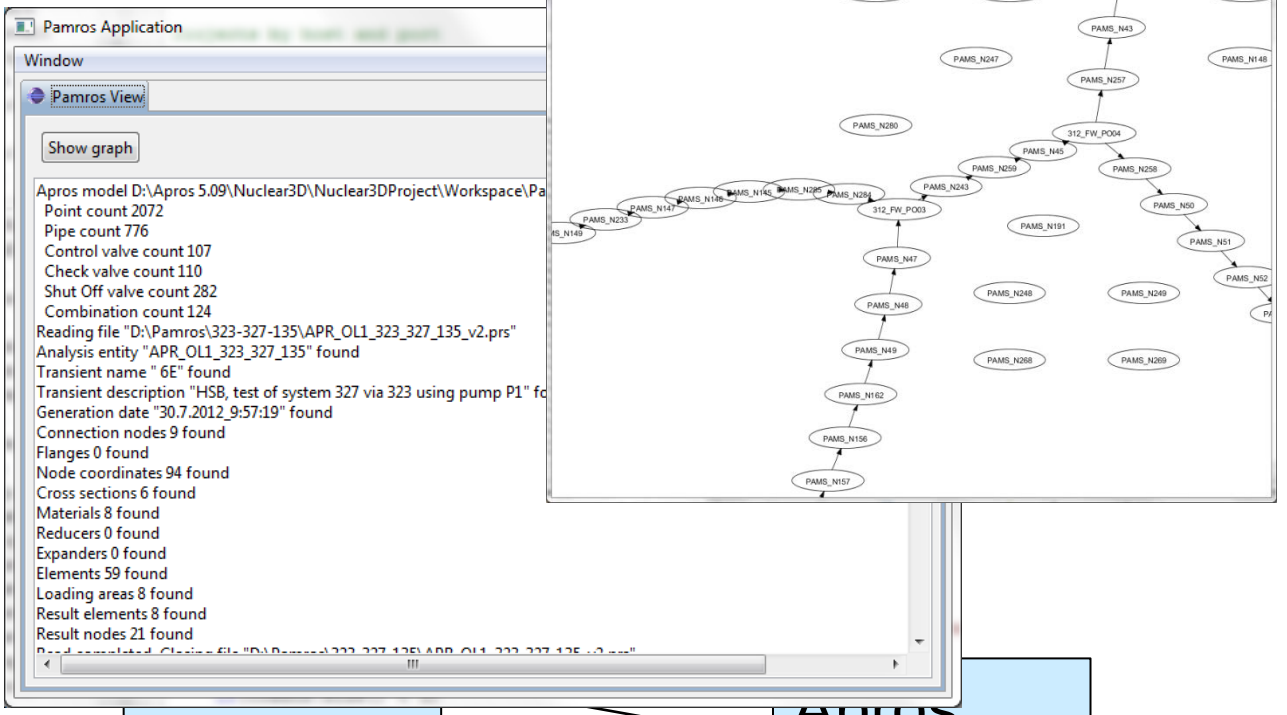
3-4 Analyse data and modify Apros model

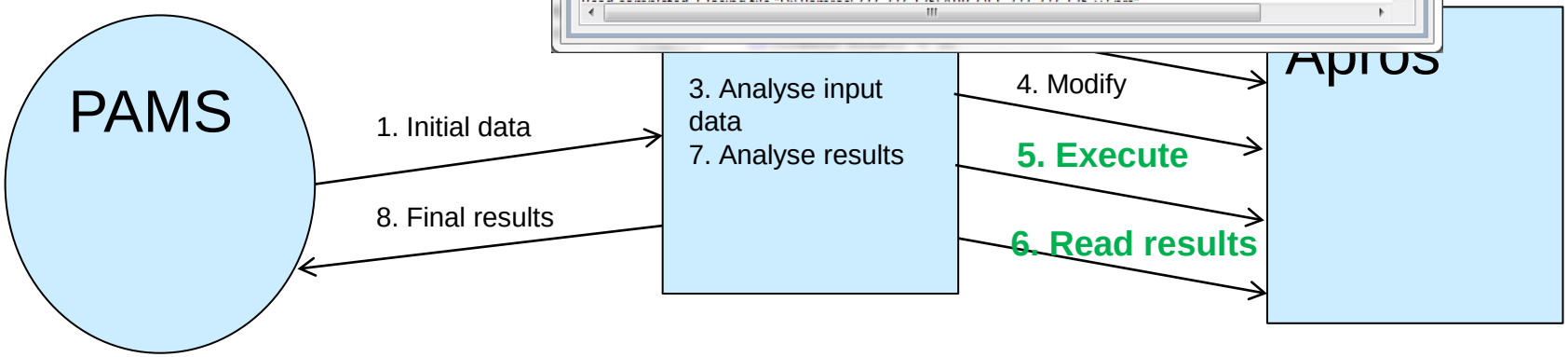
- Key nodes are recognized and kept
- Apros elements between key nodes removed and replaced using information gained from PAMS input file
  - PAMS nodes and elements converted to Apros points and heat pipes
  - Takes into account cross-sections, materials (creates new ones to Apros) and losses caused by bends, reducers and expanders
  - Initial state read from old Apros model and fed to generated one
  - Data collectors are initialized



5-6 Execute and read simulation results

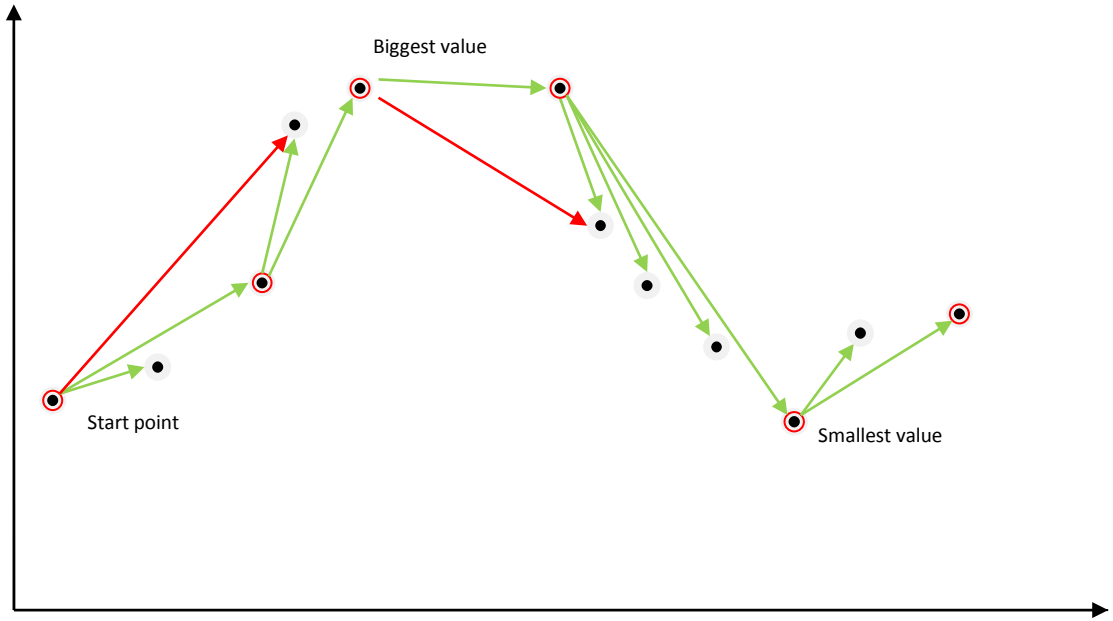
- Simulate the predefined Apros transient. Includes stabilation phase
- Collects simulation results
- Simple visualization





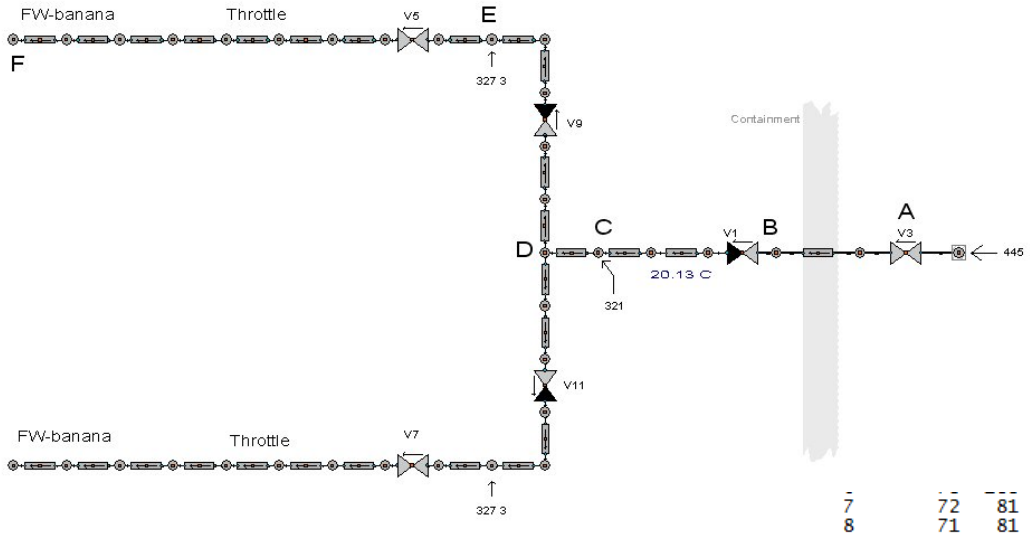
7-8 Analyse and return the results

- Handling of results
  - Lots of raw data (e.g. could be stored every 100 ms)
  - Converted to small set of data relevant for structural analysis
  - Results are given back to PAMS to be used e.g. with FPIPE

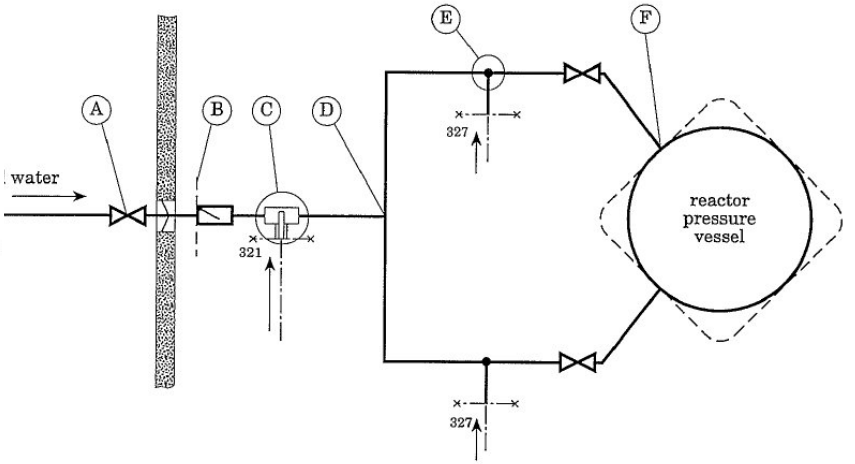


Example case: Cooling on hot stand by

- Original Apros model



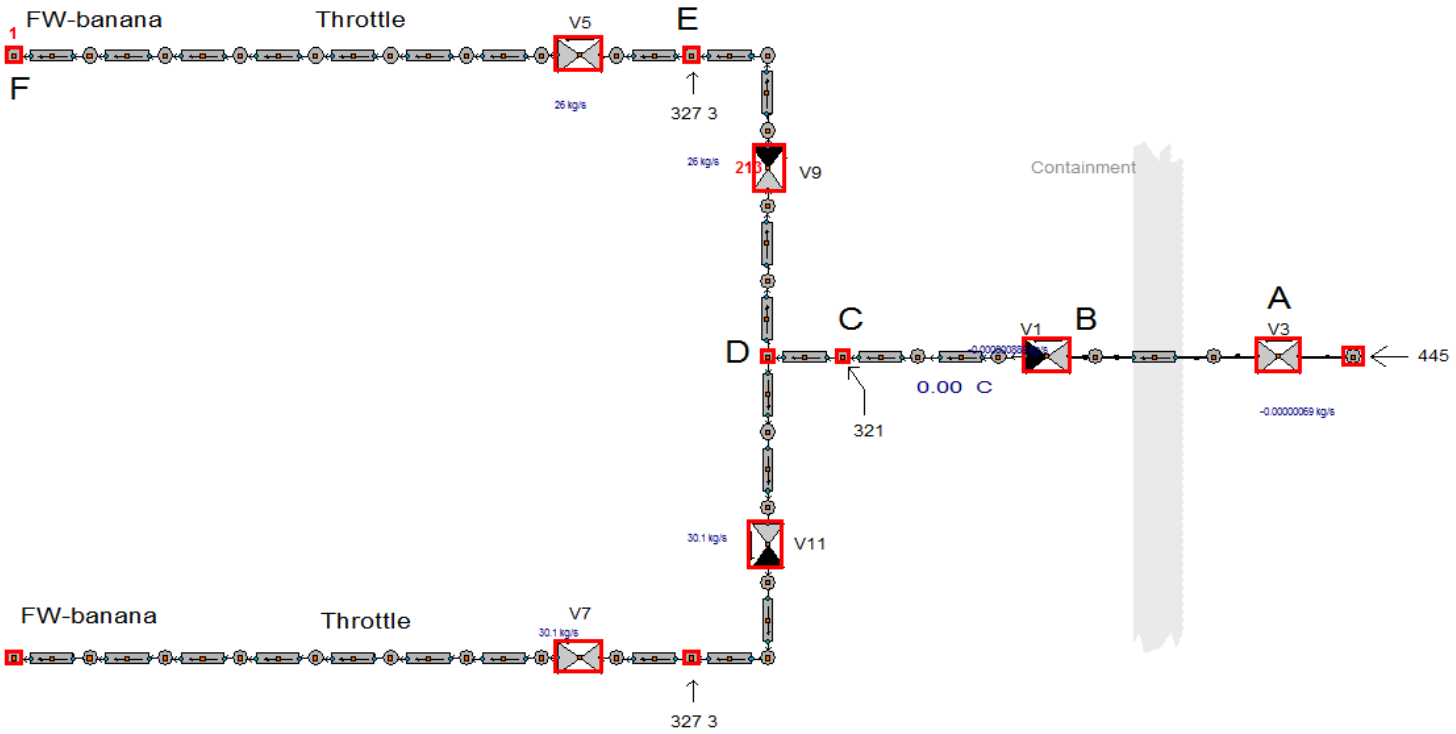
- PAMS input file



7	72	81	73	13	4	301.09	1.00E-02	0	1	Curved pipe
8	71	81	72	13	4	1383.71	1.00E-02	0	1	Curved pipe
9	70	81	71	13	4	423.34	1.00E-02	0	1	Curved pipe
10	69	81	70	13	4	332.16	1.00E-02	0	1	Curved pipe
11	80	182	69	14	5	358.93	1.00E-02	0	1	Bend or elbow
12	68	182	80	13	5	358.93	1.00E-02	0	1	Bend or elbow
13	67	0	68	13	4	1059.00	1.00E-02	0	1	Straight pipe
14	66	0	67	13	4	1200.00	1.00E-02	0	1	Straight pipe
15	216	0	66	13	10	450.00	1.00E-02	0	1	Straight pipe Part of val
16	65	0	216	13	10	450.00	1.00E-02	0	1	Straight pipe Part of val
17	64	0	65	13	4	400.12	1.00E-02	0	1	Straight pipe
18	63	0	64	13	4	400.00	1.00E-02	0	1	Straight pipe
19	62	0	63	13	4	493.10	1.00E-02	0	1	Straight pipe
20	223	168	62	13	5	358.93	1.00E-02	0	1	Bend or elbow
21	61	168	223	13	5	358.93	1.00E-02	0	1	Bend or elbow

Case: Cooling on hot stand by – Fix the model

- Apros modules to be deleted and created

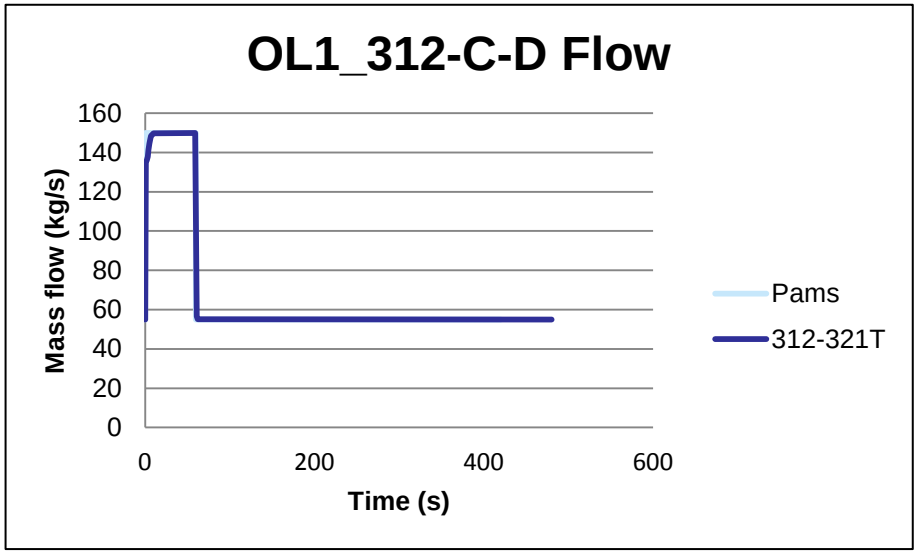


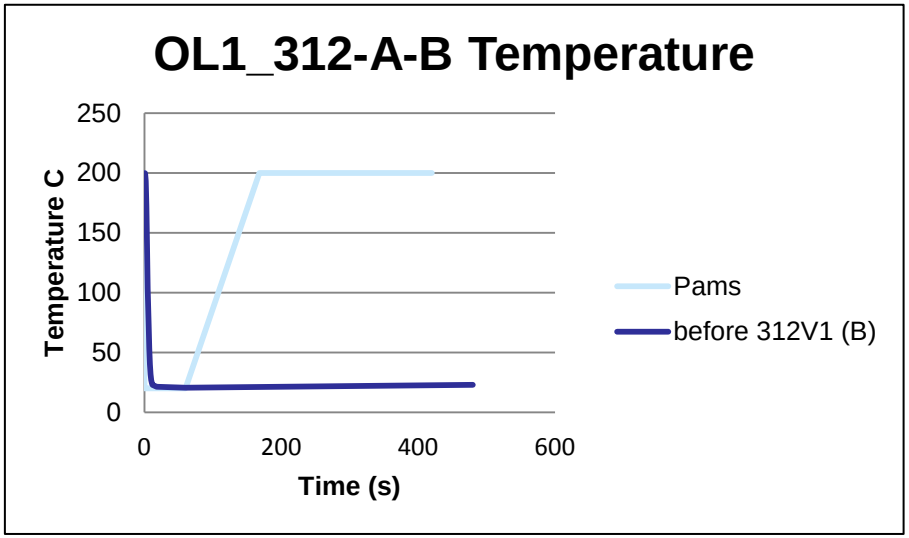
Case: Cooling on hot stand by – Execute run

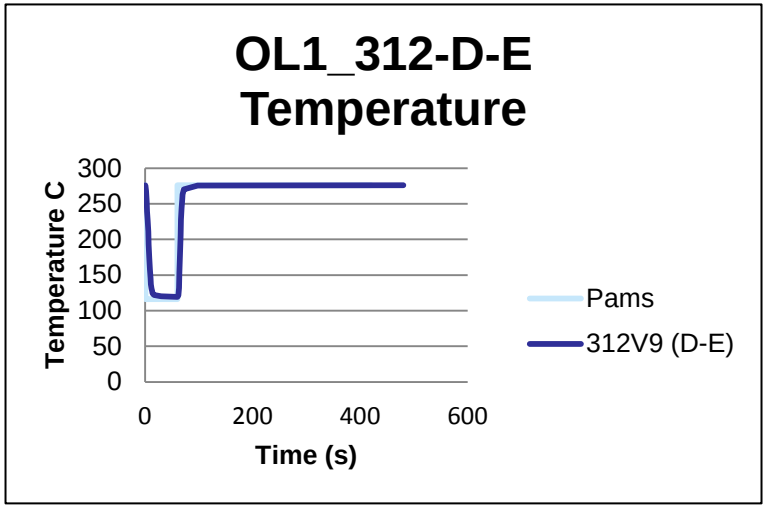
- Stabilize
- Run the defined transient. E.g. in this case small water flow 95 kg/s is turned on for 60 s

```
modi 445L310 PI12_MIX_MASS_FLOW 95
modi 445L310 PI12_LIQ_MASS_FLOW 95
do 60
modi 445L310 PI12_MIX_MASS_FLOW 0
modi 445L310 PI12_LIQ_MASS_FLOW 0
do 360
```

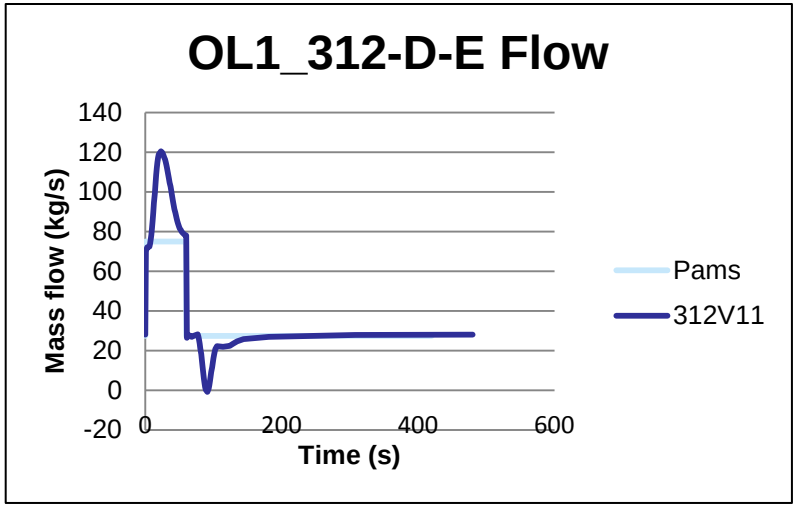
Case: Cooling on hot stand by – Analyze and write results

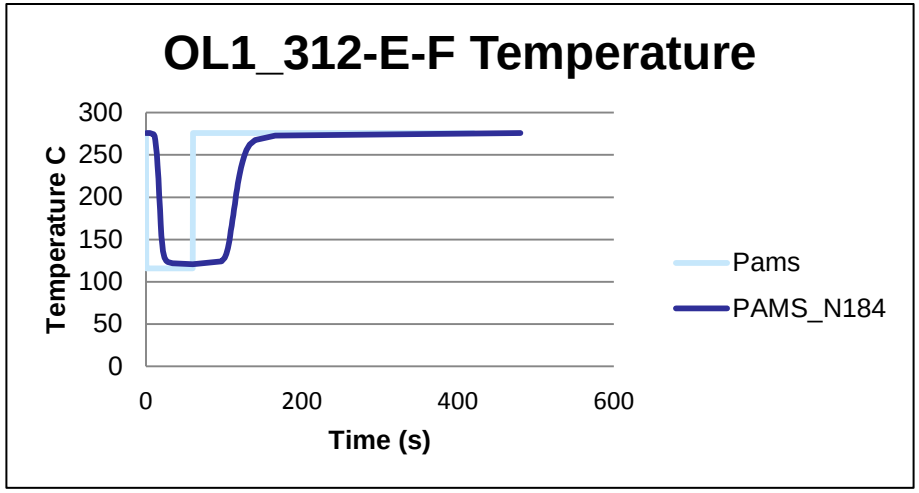


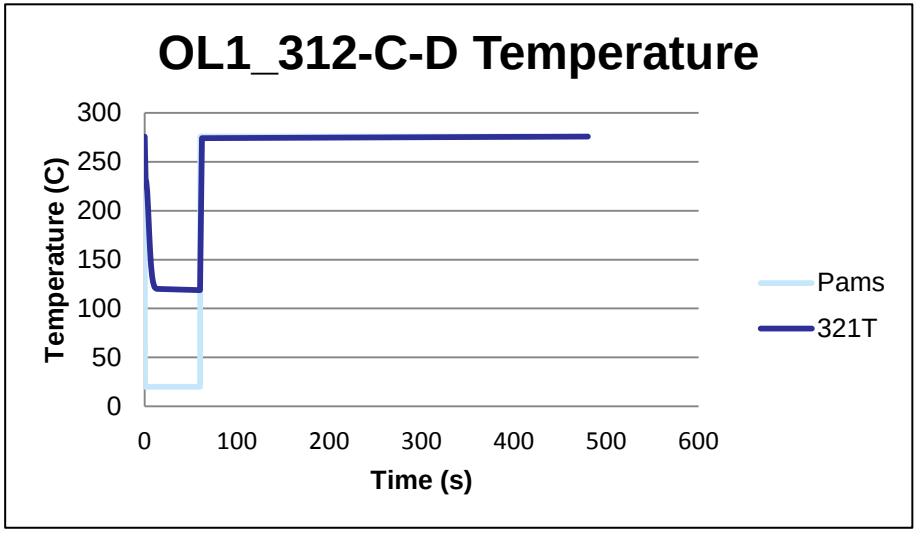




More results





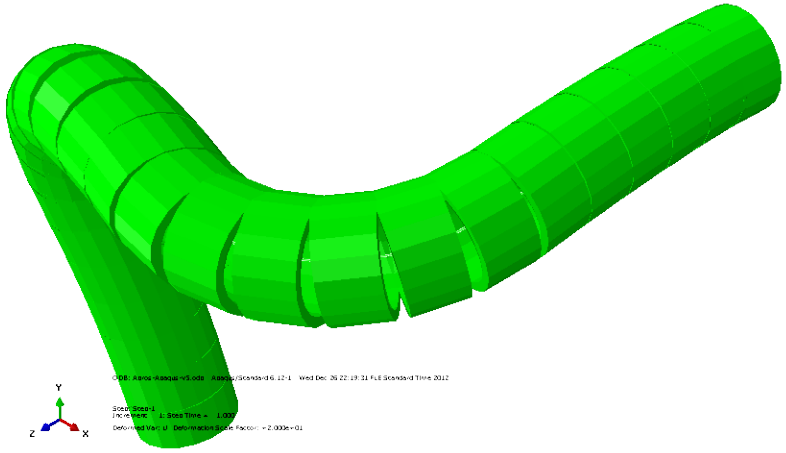


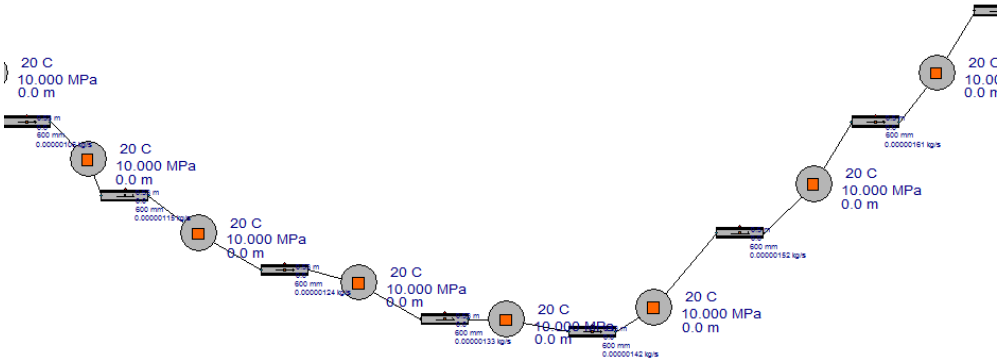
Results and next steps

- Ready – not taken into use yet
- Simple test case executed – More tests needed
- Handling complete plant model has been found laborius

Case 2: Apros-Abaqus

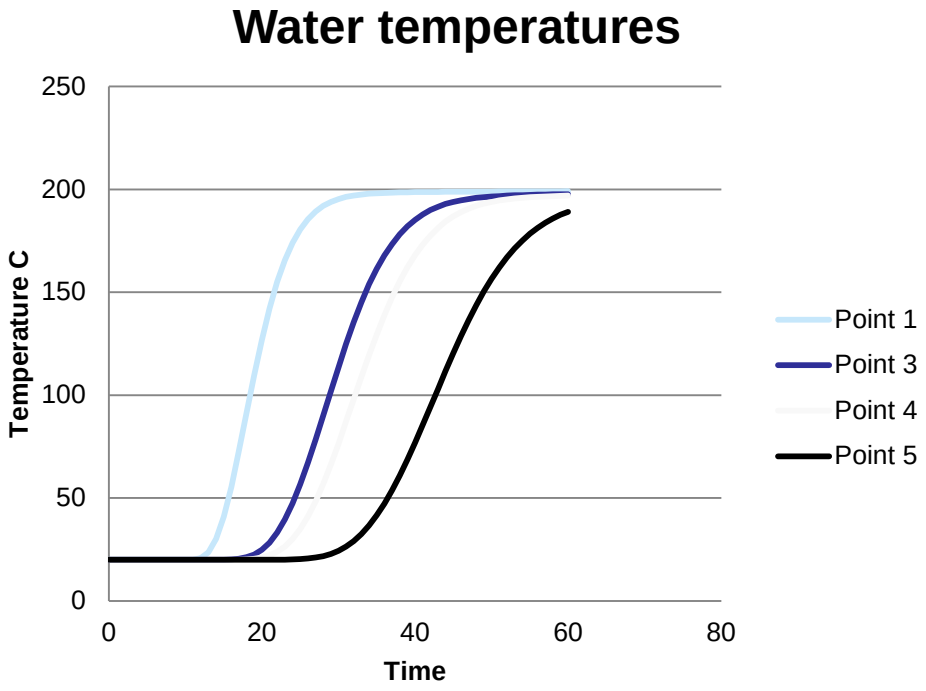
- Manual case done: Abaqus model -> Apros model –> Apros simulation results -> Abaqus analysis
- Requirements under consideration. Phase 1: Apros -> abaqus
- Clear similarities in database formats of Pams and Abaqus

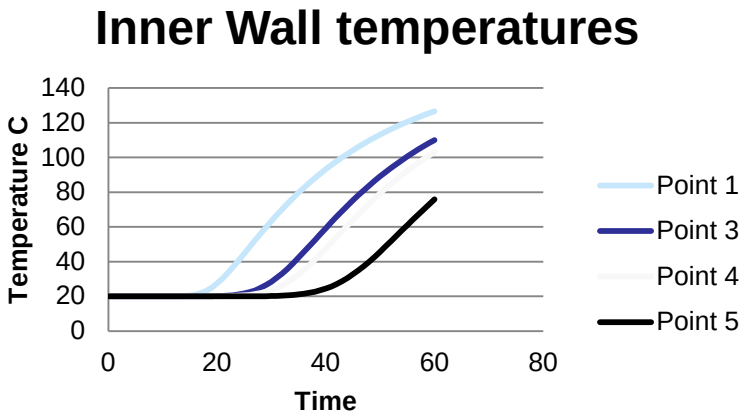


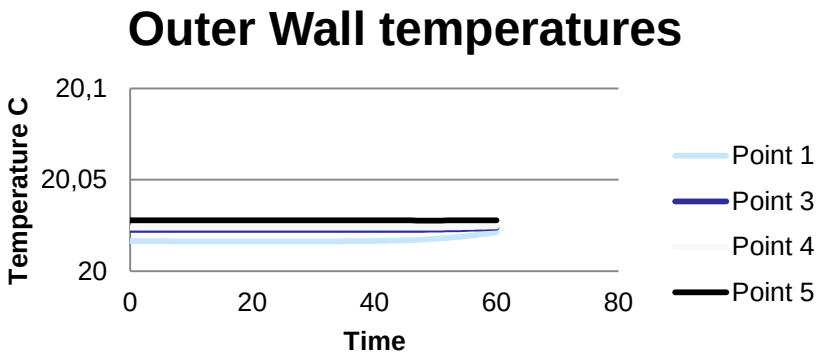


Early results

- Mass flow from 0 -> 300 kg/s, temperature from 20->200







Benefits

- Repeatable “what-if” analysis of different scenarios
- Traceable - The assumptions, models and input/output data stored for later inspection
- Offers realistic process behavior instead of using educated/conservative guesses
  - Makes it possible to simulate cases that can’t be tested in real plant
  - Generates more measurements. No need for interpolation
  - Educated guesses might be hard to make for complex systems
- Utilizing similar plant model makes it possible to automate SS or SA model generation
- **Minimize stress and prolong the life time of plant equipment**

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