Integrated dynamic system study

Dynamical assessment with an integrated model of a Post Combustion Capture Plant at a Pulverized Coal Plant and CO_2 downs stream compression unit.

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Why an integrated dynamic simulation ?

Capture → **Transport** → **Storage/ Utilization**

Complex integrated system

Power plant integration:
- Steam and flue gas
- Operational flexibility
- Emergency shutdowns
- Operational start-up and shutdowns

Capture plant:
- Water management and solvent inventory
- Stripper reboiler and steam cycle dynamics
- Supervisory control optimisation (minimizing energy footprint)
- CO_2 quality

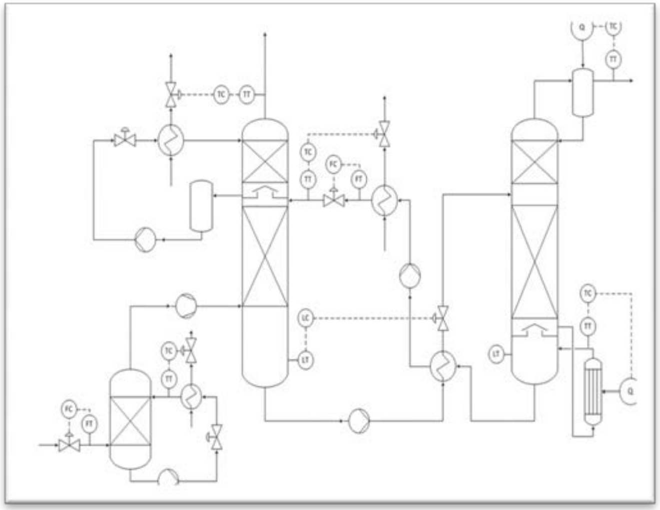
Capture plant integration:
- CO_2 quality from capture plant
- Operational flexibility of capture plant and storage
- Emergency shutdowns
- Operational start-up and shutdowns

Transport:
- Accidents / maintenance
- Higher transport pressures
- Transport efficiency optimization
- Gas composition (impurities)
- Heat loss and temperature dynamics
- Formation of gas phase CO_2

Transport integration:
- CO_2 quality from Transport
- Operational flexibility of upstream process units
- Emergency shutdowns
- Operational start-up and shutdowns

Storage/Utilization:
- Injectivity pressure and temperature
- Accidents / maintenance
- Dry-out near well zone
- Storage efficiency

Integrated dynamic simulation of the CCS chain



TNO pilot plant at EON is used and steady-state models of the demonstration post-combustion plant (250 MWe) process.

Dynamic model of an absorber/stripper is presented and the results different relevant transient operational scenarios.

Issues regarding the operability of the absorber column in case of load-varying, water management ,upstream power-plants and downstream CO2 compression has been analysed and discussed.

Model development

- Modelica: object oriented, open source modeling language

- Used/adapted Modelica libraries:
  - Thermal Separation (TU Hamburg)
  - Thermopower (TU Delft and Politecnico di Milano)

- Model based on pilot plant properties/geometry

- Validation and parameter fitting with TNO pilot plant

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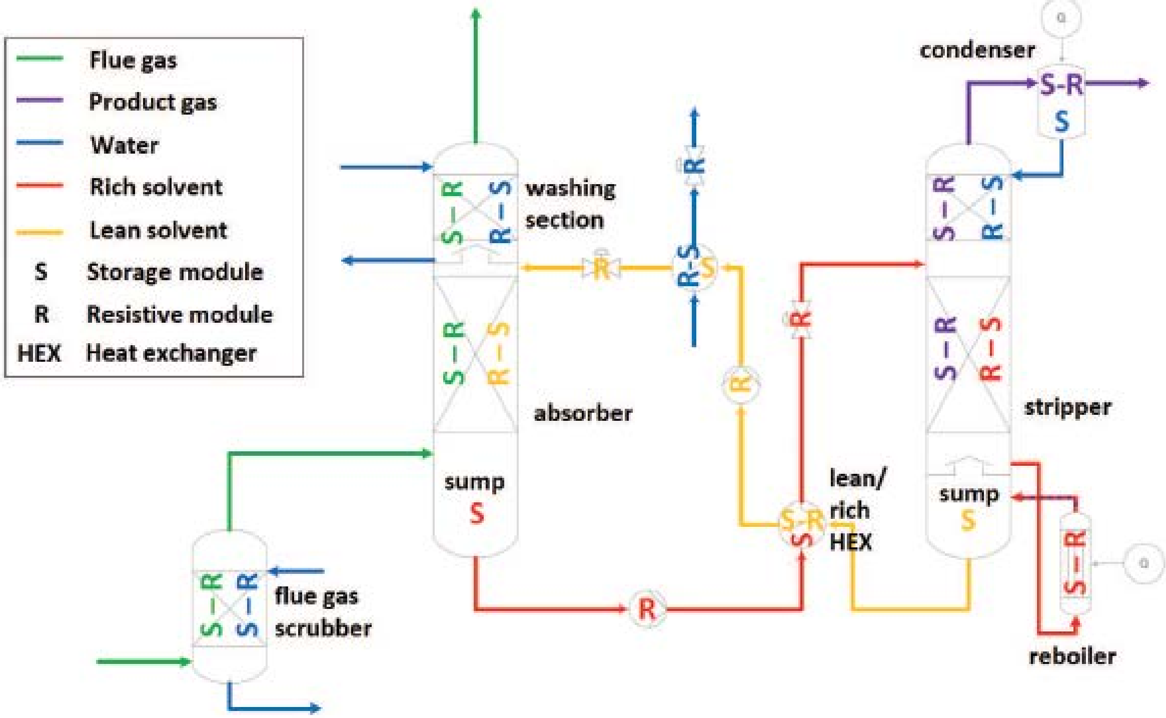
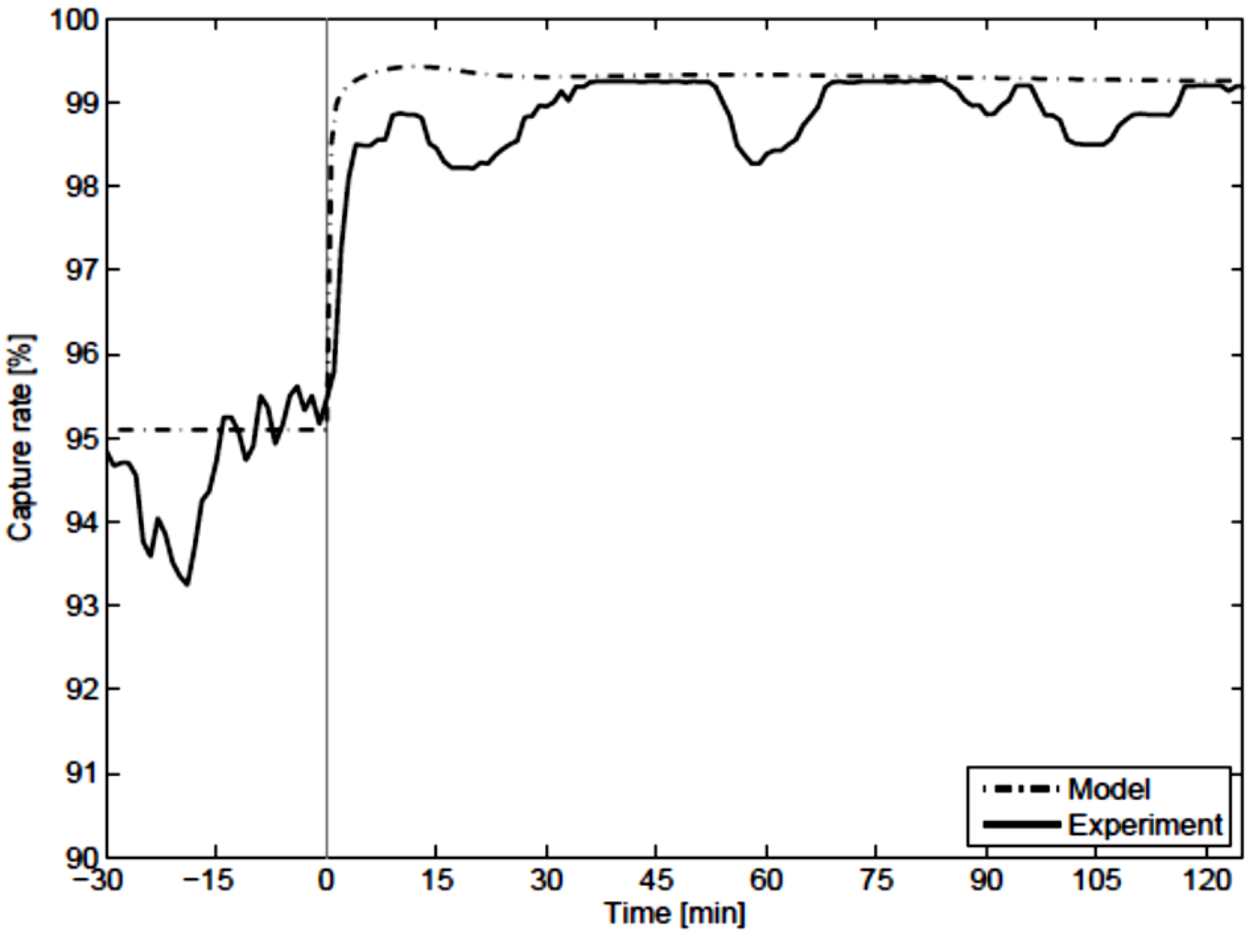
Model development



Model validation Capture Plant

e.g.: Case A→ Decrease in flue gas flow rate



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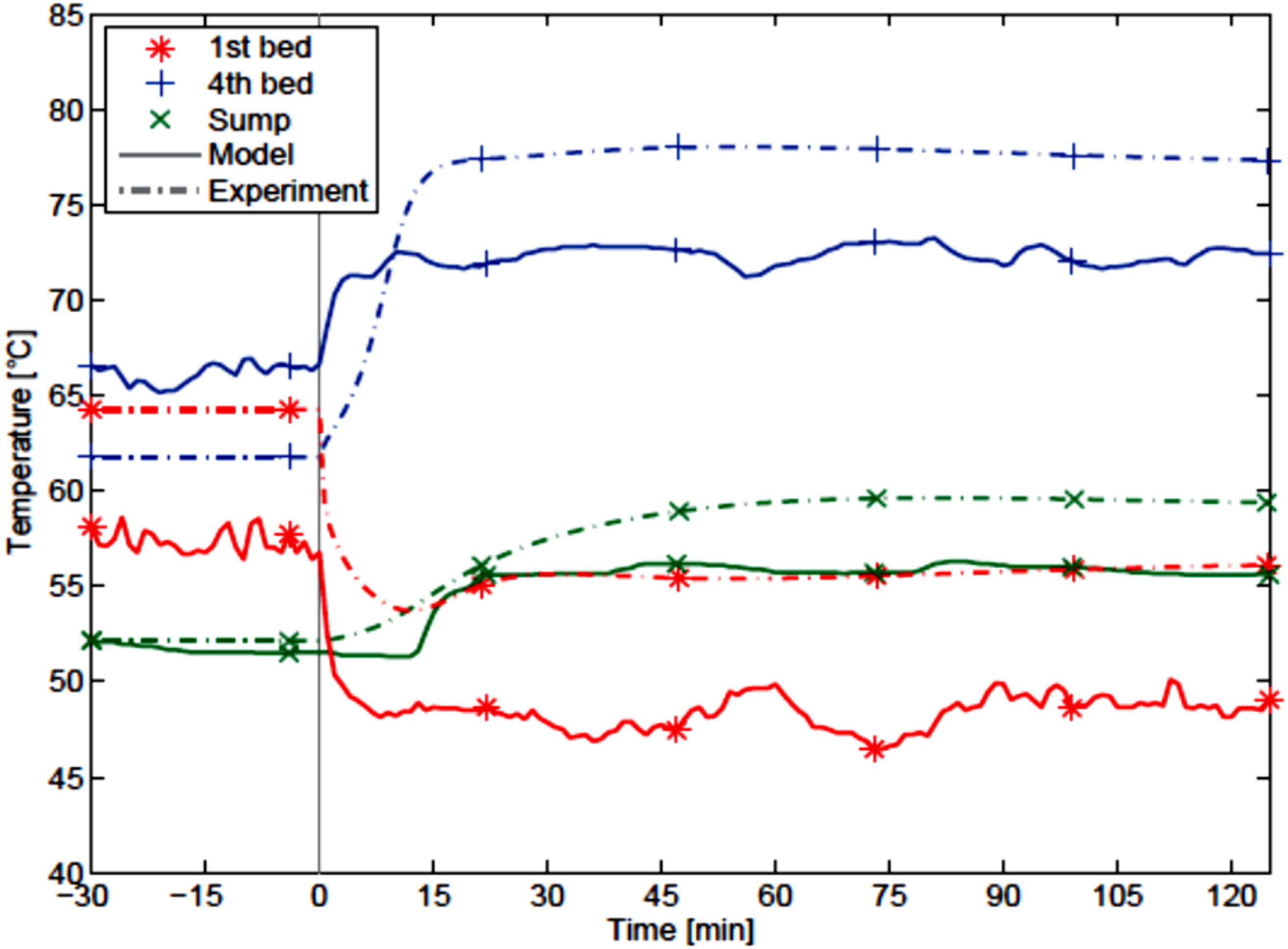
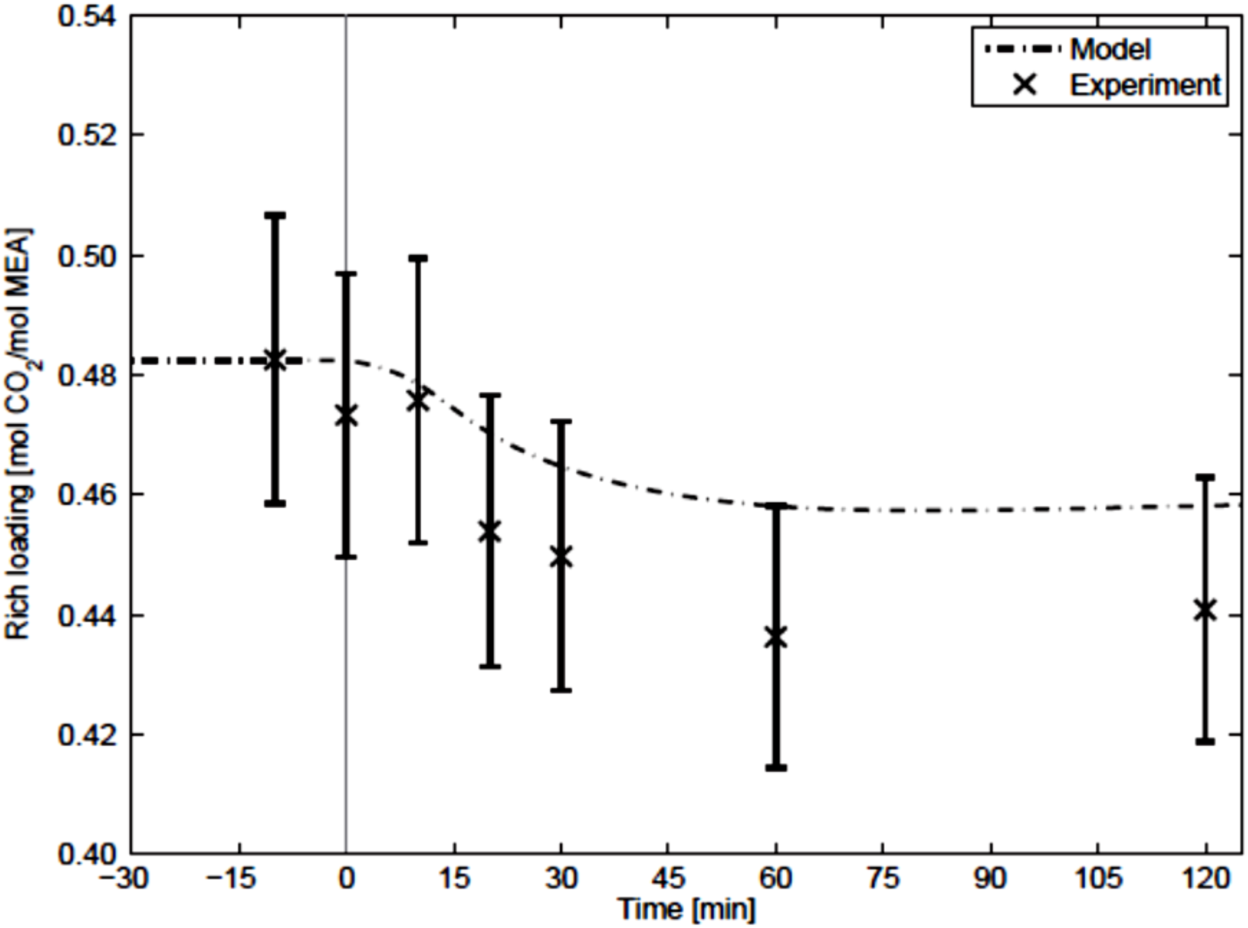
Model validation Capture Plant



Model validation Capture Plant

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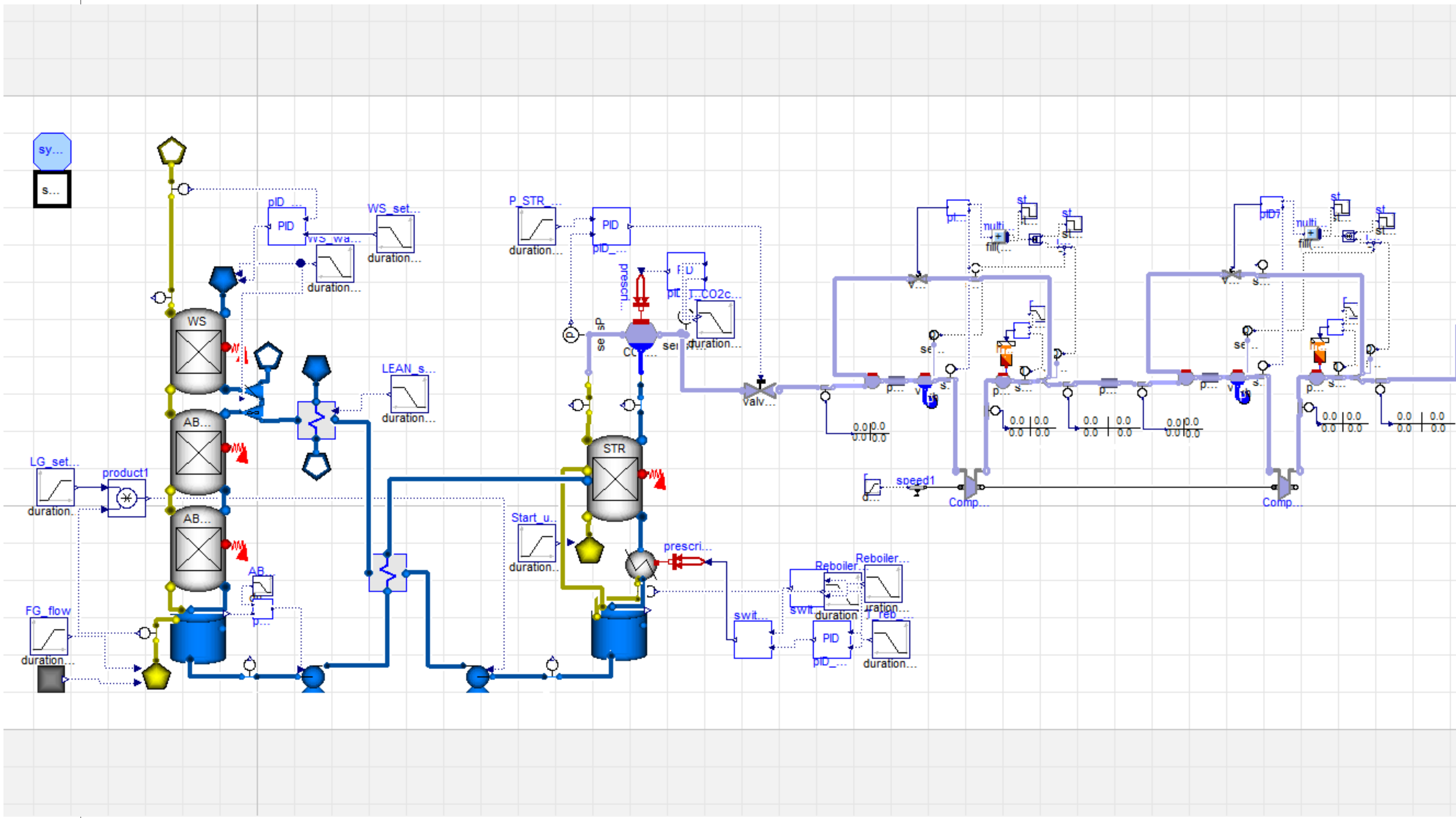
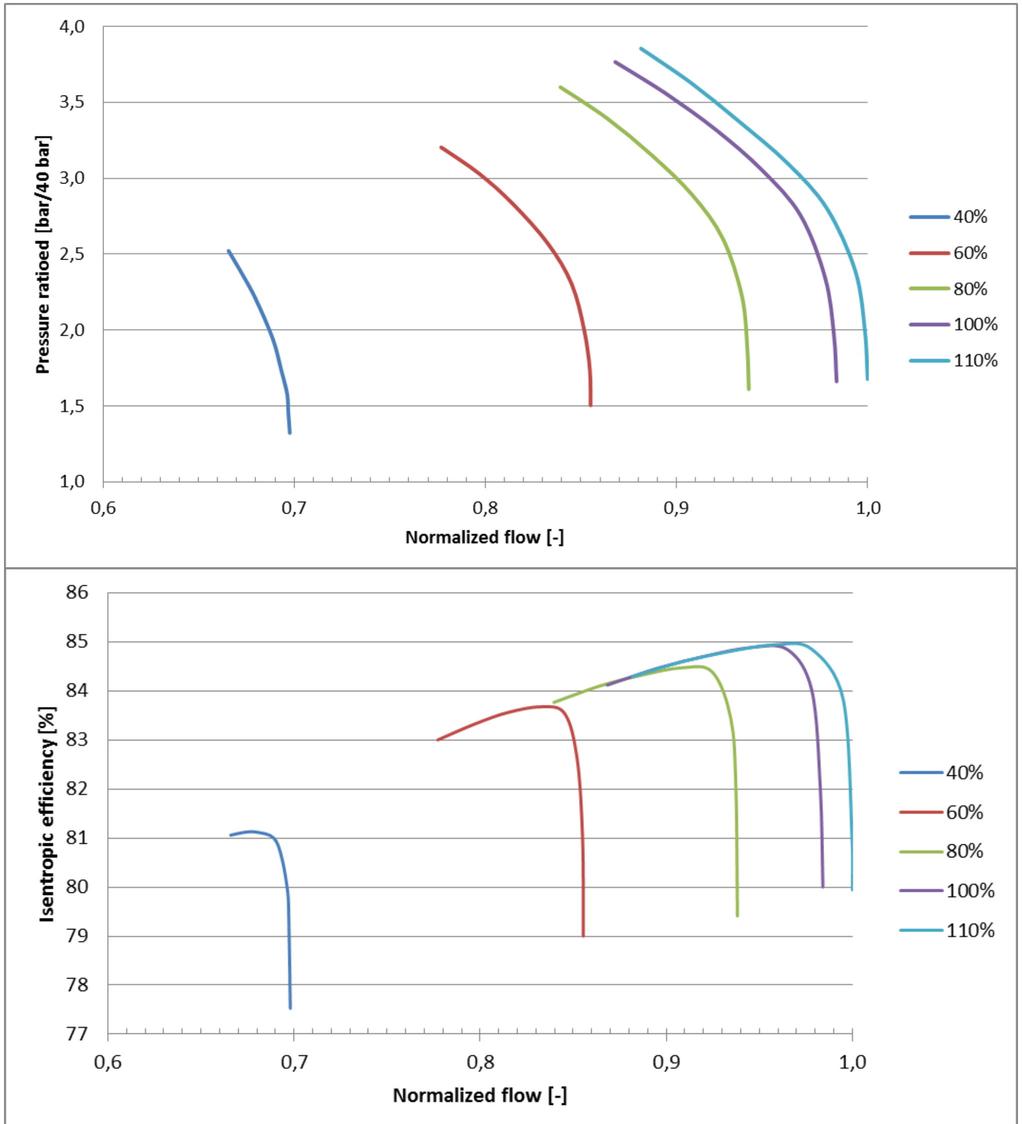
System model Post Combustion Capture



Capture plant including CO2 Compression (Modelica)

CO_2 Compression generic compressor model




E.g.: Increase in flue gas flow

	0h	**2h**	**2h15m**	**5h**
Flue gas flow [kg/s]	97.8	97.8	244.6	244.6
CO2 in flue gas [mol/mol] (absorber inlet)	0.1146	0.1146	0.1434	0.1434
Flue gas temperature [°C] (absorber inlet)	45.9	45.9	45.9	45.9
Reboiler duty [MW]	Control of reboiler temperature			


Model main parameters

	Dynamic model	Aspen model
Flue gas flow [kg/s]	244.6	244.6
Lean solvent flow [kg/s]	1079	980
Capture rate [%]	90.04	90.25
Reboiler duty [MW]	172.86	160.74
Specific heat duty [kJ/kgCO2]	3692	3422
MEA wt.% (lean)	28.2	30.8
Lean loading [mol/mol]	0.273	0.273
Rich loading [mol/mol]	0.486	0.489

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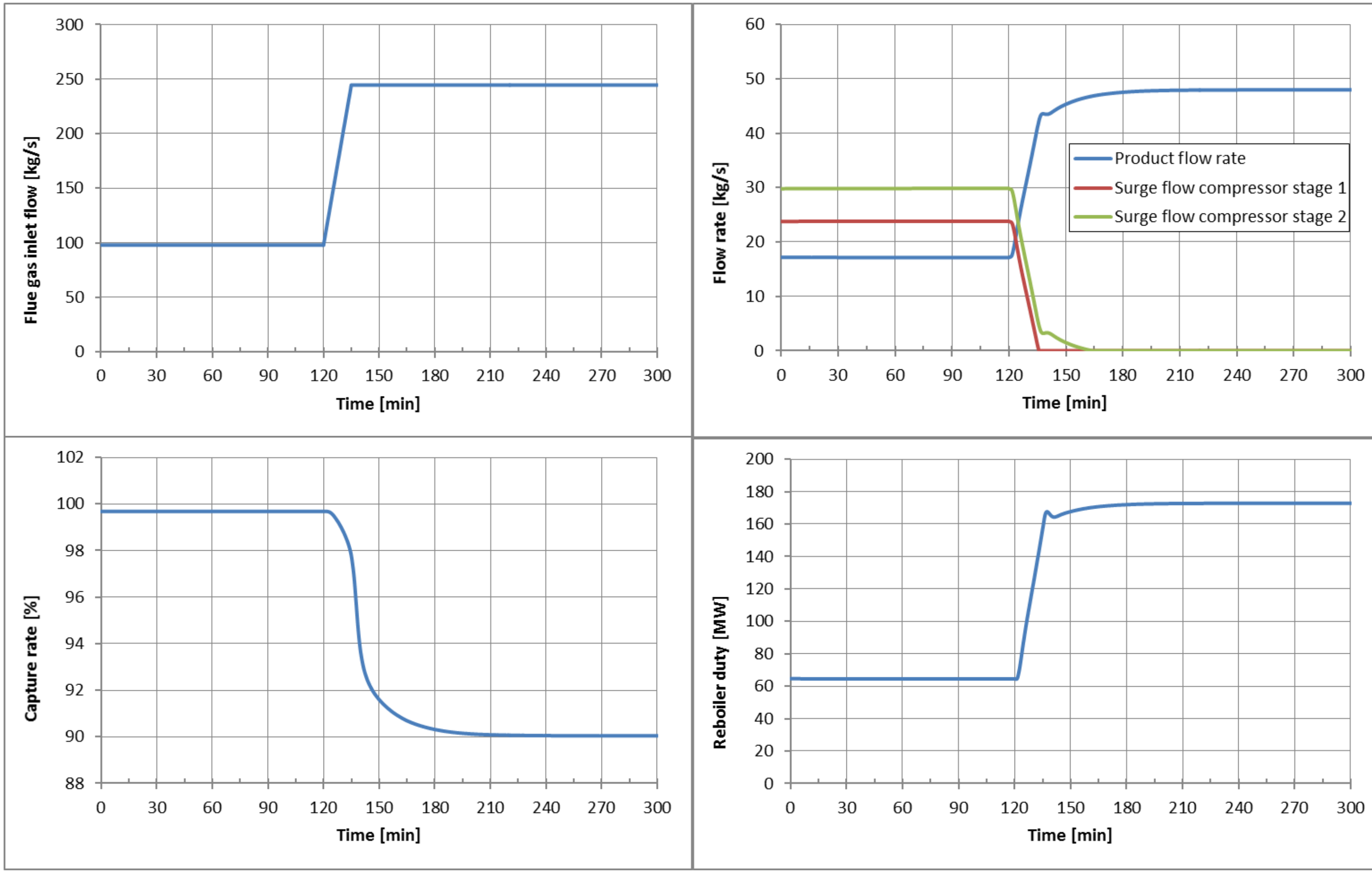
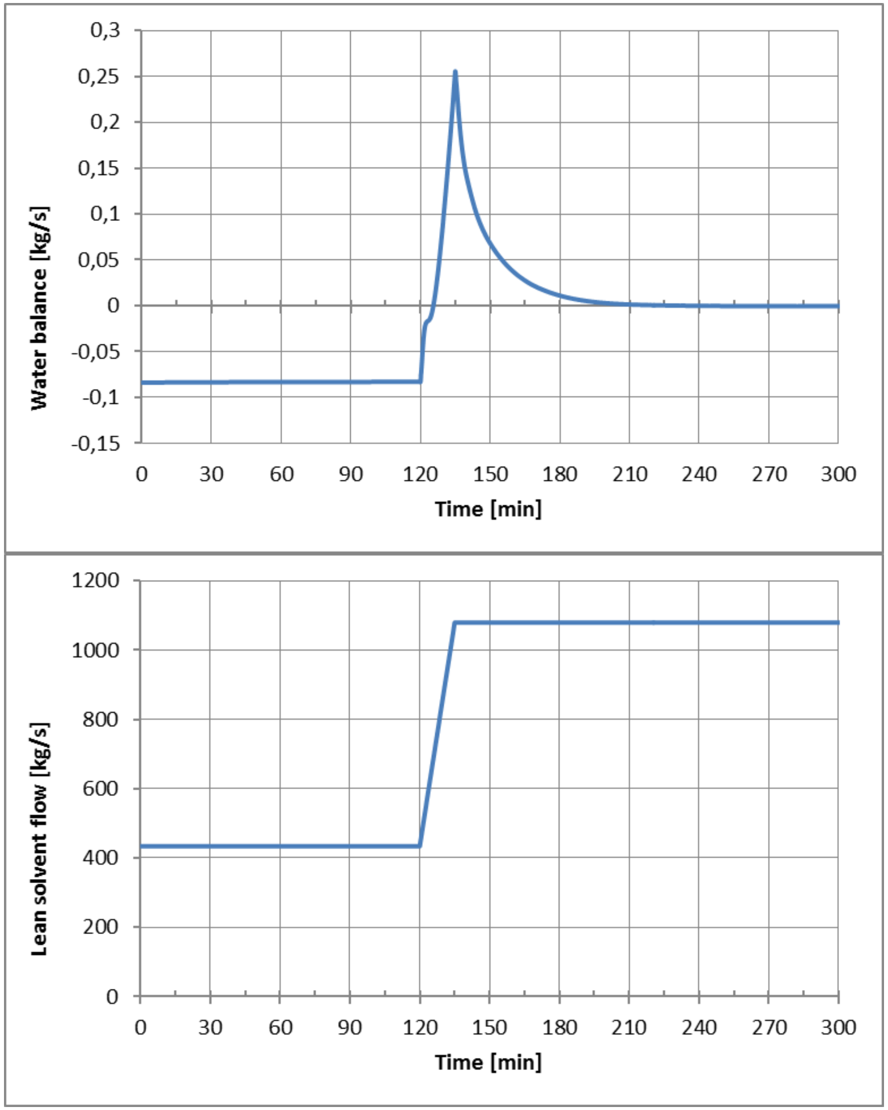
Increase in flue gas flow



Increase in flue gas flow




Final steady state value

Variable	Unit	Base	Case A
Capture Rate	%	90.0	90.0
Reboiler duty	MW	172.9	172.8
L/G	kg/kg	4.41	4.41
V_liq total	m^3	1995.7	1994.0
Rich loading	mol/mol	0.486	0.485
Lean loading	mol/mol	0.273	0.269
Specific heat duty	kJ/kg CO_2	3692	3691

Summary

Simulation model provides technical insight in dynamic transients and can be used as a engineering design tool to:

- ✓ **evaluate control strategies**
- ✓ **review equipment sizing**
- ✓ **address interface issues**
- ✓ **evaluate operational optimisation**
- ✓ **identify risk wide range of operational conditions**

Integration with transport and storage infrastructure a must!

Acknowledgements

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THANK YOU!

Questions ?