ClaRa$^+$

Detailed Description of the software

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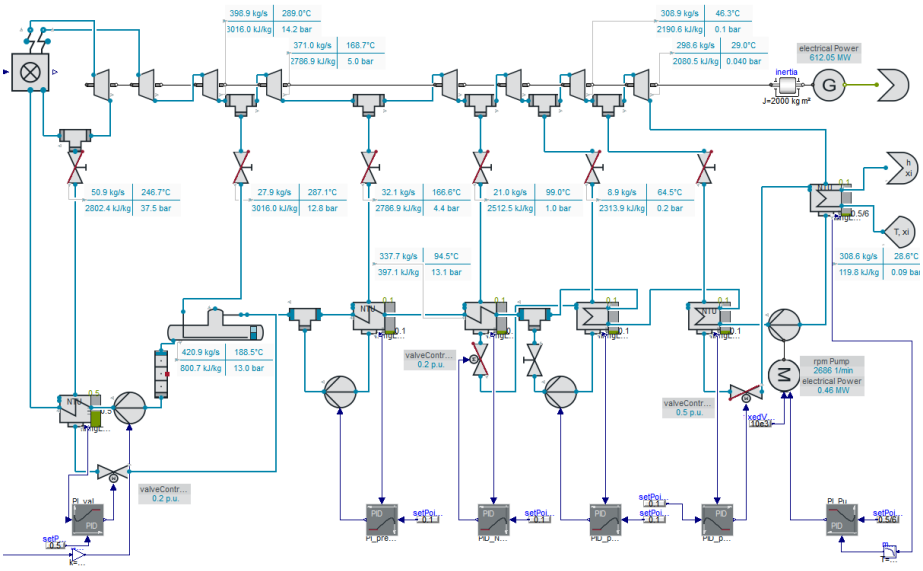
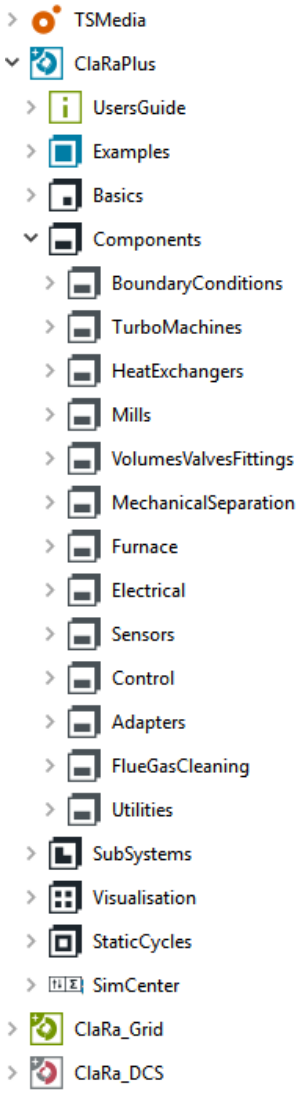
Overview

Create a digital twin of your power plant, investigate transient behaviour and gain greater understanding to optimize your processes for use in the future energy market. Use ClaRa⁺ to support all project phases: from evaluation of concept variants to component design, optimization of control technology, virtual commissioning and optimization during operation.





Use ClaRa⁺ to Analyse Your

- Hard coal power plants - from the coal grinding to the grid
- Combined cycles - catch transients of drum swelling
- Industry power plants - always on demand of your process
- District heating systems - track critical pressure oscillations
- Controller system - optimize your plant efficiency
- Organic Rankine cycles - optimal integration into your process
- Natural circulation boiler - be aware of unwanted evaporation

The ClaRa⁺ bundle consists of four main packages: The TSMedia package, an extensive media library including sCO_2 and ORC Media. The ClaRa⁺ main package, providing models for the complete power plant equipment and detailed models for pressure loss and heat transfer. The ClaRa_DCS, a library for modelling state-of-the-art control systems. The ClaRa_Grid, providing models for the electrical grid.

Your benefits

- Create a virtual image of control technology quickly and efficiently
- Create your own models according to your requirements
- Design components taking into account extreme dynamic operating conditions
- Increase the safety and reliability of your processes
- Efficiently evaluate concept variants
- Save time and money during commissioning
- Use ClaRa$^+$ in all project phases
- Increase the efficiency of your power plant site

Key Features

- Stationary and transient simulation
- Modelling bases on first principle laws
- Transparent set of equations, well documented
- Easy creation of tailored models according to costumer's requirements
- Extensive model library for the complete power plant equipment
- Validated against literature and measurement data

Model overview

- Extensive Media Library – including ORC Media and steel data base
- Detailed models for heat transfer and pressure drop – for piping, heat exchangers and boiler
- Turbo Machinery package – models for steam and gas turbines, compressors and pumps
- Heat Exchanger package – covering all relevant heat exchanger on the water steam cycle
- Coal Mill package
- Mechanical Separation – including models for drums, separators and tanks
- Valve and Fittings package – detailed models of different valve types and fittings like bends
- Furnace package – modelling conventional and heat recovery boilers
- DCS package – ready-to-use state of the art control blocks and controller examples
- Grid package – enables investigations of interactions with the electrical grid

Scope

- Coal fired power plants
- Gas turbine units
- Combined cycle power plants

- Heat recovery steam generators
- Cogeneration power plants
- Organic Rankine Cycles
- Natural circulation boilers
- Grid emergency failures
- Island grid operation

References

Optimization of the control and process technology of the 'Schwarze Pumpe' lignite-fired power plant

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In this project a detailed model of the 'Schwarze Pumpe' power plant was created with ClaRa. This model included the entire water-steam cycle, the flue gas and air path, the coal mills and a digital image of the control technology. It enabled the rapid analysis and evaluation of control and process engineering changes, such as increased load change gradients, optimized controller parameterization in partial load or increased provision of control power.

Project manager Sebastian Meinke says, "ClaRa is ideal for creating a digital twin of the power plant and quickly identifying optimization potential. The possible savings exceed the costs many times over." (translated)

Design and transient analysis of a supercritical CO2 Brayton cycle

Centrum výzkumu Řež s.r.o.
Research Centre Rez

The ClaRa software was successfully deployed in the Horizon 2020 project sCO2-HeRo for component design and transient system analysis. The objective of the project was to develop a technology based on a sCO2 simple Brayton cycle that safely, reliably and efficiently removes residual heat from nuclear fuel without the requirement of external power sources, making it an excellent backup cooling system for the reactor core in the case of a station blackout and loss of ultimate heat sink.

Ales Vojacek, CVR: "With the ClaRa I have designed a finned-tube air-CO2 heat exchanger fast and efficiently and could right afterwards evaluate its transient behaviour in the total system."

Publications

[1] **Johannes Brunnemann , Friedrich Gottelt, Kai Wellner, Ala Renz, André Thüring, Volker Röder, Christoph Hasenbein, Christian Schulze, Gerhard Schmitz, Jörg Eiden:** „Status of ClaRaCCS: Modelling and Simulation of Coal-Fired Power Plants with CO_2 capture“, 9th Modelica Conference, München, 2012 // Download (pdf)

[2] **Volker Roeder, Christoph Hasenbein, Alfons Kather, Kai Wellner, Gerhard Schmitz, Johannes Brunnemann, Friedrich Gottelt, Ala Renz, Christian Schulze, André Thüring:** „Das Projekt DYNCAP: Untersuchung des dynamischen Verhaltens von Dampfkraftprozessen mit CO_2-Abtrennung zur Bereitstellung von Regelenergie“, Proceedings of the 44th Conference on Power Plant Technology, Dresden, Oktober, 23–24, 2012

[3] **Alfons Kather, Volker Roeder, Christoph Hasenbein, Gerhard Schmitz, Kai Wellner, Friedrich Gottelt, Lasse Nielsen:** „DYNCAP Dynamische Untersuchung von Dampfkraftprozessen mit CO_2-Abtrennung zur Bereitstellung von Regelenergie“, Abschlussbericht, Technische Universität Hamburg-Harburg, TLK-Thermo GmbH, XRG Simulation GmbH, 2015 // Download

[4] **Friedrich Gottelt, Kai Wellner, Volker Roeder, Johannes Brunnemann, Gerhard Schmitz, Alfons Kather:** „A Unified Control Scheme for Coal-Fired Power Plants with Integrated Post Combustion CO_2 Capture“ Proceedings of the In 8th IFAC Conference on Power Plant Power System Control, Toulouse, Frankreich, 2012 // Download

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[6] **C. Gierow, M. Hübel, J. Nocke, E. Hassel:** „Mathematical Model of Soot Blowing Influences in Dynamic Power Plant Modelling“ Proceedings of the 11th Modelica Conference, Paris, 2015 // Download (pdf)

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[8] **Friedrich Gottelt, Timm Hoppe, Lasse Nielsen:** „Applying the Power Plant Library ClaRa for Control Optimisation“ Proceedings of the 12th Modelica Conference, Prag, 2017 // Download (pdf)

[9] **J. Prause, M. Hübel, D. Holtz, J. Nocke, E. Hassel:** „Local steam temperature imbalances of coal-fired boilers at very low load“ Energy Procedia 120, 2017 // Download

[10] **Marcel Richter, Gerd Oeljeklaus, Klaus Görner:** „Improving the load flexibility of coal-fired power plants by the integration of a thermal energy storage“, Applied Energy, Volume 236, 15 February 2019, Pages 607-621

[11] **Ales Vojacek:** „Performance test of the air cooled finned-tube supercritical CO2 sink heat exchanger“, Journal of Thermal Science and Engineering Applications, not published yet