EcosimPro

Modelling and Simulation Software

CRYOLIB LIBRARY

The CRYOLIB library has been jointly developed with CERN to perform dynamic simulations of large cryogenic installations. Complex fluid systems where heat transfer is coupled with control processes are easy to evaluate.

EcosimPro

EcosimPro is a powerful **modelling** and **simulation** tool with a simple interface that makes the design of **multi-disciplinary** dynamic systems easy and intuitive using graphic diagrams.

For users with specific needs, EcosimPro provides an object-oriented, non-causal approach towards creating reusable component libraries. It is based on very powerful symbolic and numerical methods capable of processing **complex systems** represented by differential-algebraic equations (DAE) or ordinary-differential equations (ODE) and discrete events. Low-level problems like programming calls with numerical solvers, equation handling, etc, are solved automatically or using simple wizards.

Features

CRYOLIB is a professional EcosimPro library which provides typical components of cryogenic systems. The library is based upon a previous library of CERN, that holds all rights to the library. The following are the most important features of the library:

- Several cryogenic fluids are available: **He,N_2, Xe, O_2, Ar**
- Gas, liquid, supercritical and two-phase flow regimes for **real fluids**
- **Reverse flow, inertia** and **high speed phenomena** are considered in pipes,volumes and junctions
- Calculation of concentrated (valves) and distributed (pipes) pressure losses
- Heat transfer between walls (pipes and tanks) and the fluid
- Several configurations of multistream heat exchangers are available
- Single tank models are available with the option of liquid level calculation
- Other special components of cryogenic systems like cold compressors
- The library is validated with experimental data from CERN installations

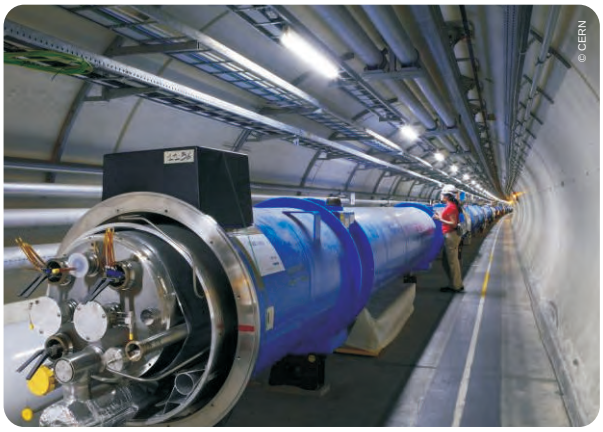
Using drag & drop methodology, the user can quickly create the system to be analysed; moreover, its representation is very similar to the physical system. The CRYOLIB library provides a large palette of components for insertion (drag & drop) in a model. Other components that a user may require can be easily built by means of inheritance and aggregation.

Thanks to EcosimPro's features, libraries are easy to configure and extend, by simply adding components and characteristics as needed. You can do this graphically through a simple, user friendly interface, or through EcosimPro's object-oriented language which makes it possible to re-use existing codes. CRYOLIB library is delivered along with the source code, thus allowing the users to either modify or reuse any of the library components.

One of the library's biggest advantages is that it can be used in the multidisciplinary facet of EcosimPro. This means that we can study jointly, for example, dynamic fluid systems together with heat transfer processes and control diagrams.

The components

Components of CRYOLIB are based on the bond graphs modeling paradigm adapted to an object oriented environment.



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The causality of energy in the model is defined by alternating two types of components:

- **Capacitive components (C)**: these integrate the mass and energy conservation equations
- **Inductive components (I)**: these calculate the mass flow as a function of the pressures on both sides

This approach yields explicit models that are easily calculated with the specialised EcosimPro's numerical solvers.

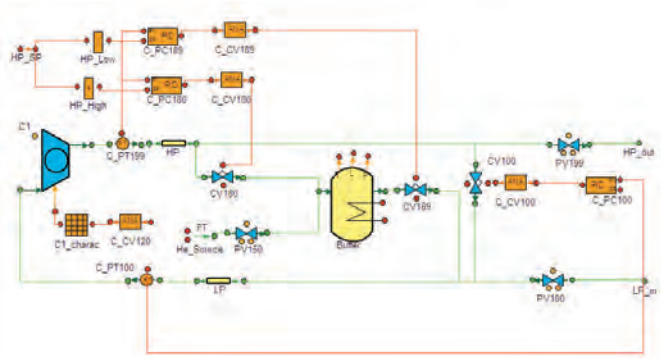
The CRYOLIB library contains the following component types:

- Tanks, 0D pipes, 1D pipes (discretised pipes), phase separators, filters, adsorbers
- Isopercentual / linear valves, valves On Off
- Topological components such as heat exchangers, turbines, compressors, cold compressor, pumps
- Measure components: pressure, mass flow and temperature sensors

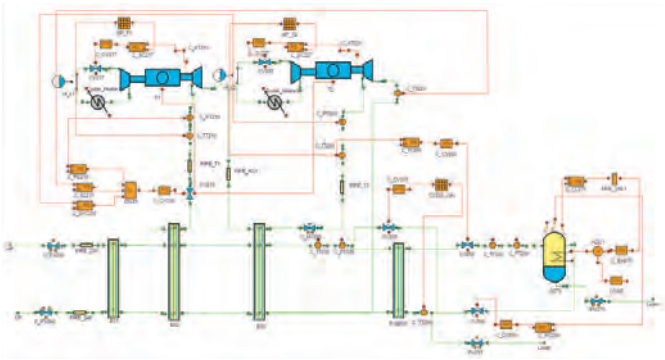
Finally, the use of thermodynamic functions is another basic technique using CRYOLIB. Real fluid tables are generated with HEPAK and REFPROP, renowned fluid property programs. All possible zones of operation (liquid, superheated, supercritical and two-phase flow) are covered. The library also provides interface functions to connect directly with HEPAK.

Example

The following example shows some of CRYOLIB's capabilities for modelling a cryogenic system. The model represents a simple compressor station composed of a compressor and a tank with pressure regulation.



The compressor station is connected to a coldbox that contains four heat exchangers, two turbines and a phase separator. The system is controlled by several PIDs.



The experiment simulates the cooldown sequence from 300K to 4.5K in 70000s. The compressor station starts 100 seconds after the simulation beginning. At time equal to 300 seconds the HP line of the compressor station is connected to the HP line of the coldbox and then the LP line is connected. At the same time, controllers PC290, TC260 and LC270 start to regulate the coldbox. At 500 seconds the compressor is set to full load and 100 seconds later, the turbines are turned on. The system begins to cool at around 38000 seconds (10 hours of cooldown in the real system) and liquid helium will be formed in the phase separator (Figure 2). At time equal to 45000 the buffer is filled in. The cooldown continues until 70000 seconds, when the temperature reached in the phase separator is 4.5K. In Figure 1 we can observe the evolution of temperatures in the cryogenic plant.

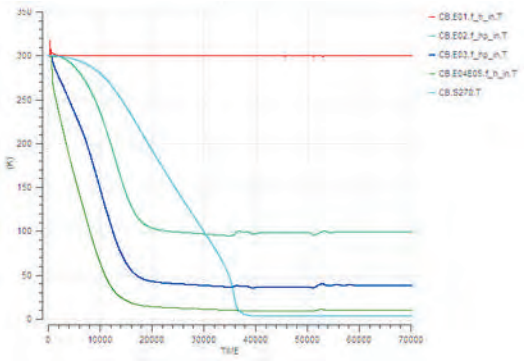


Figure 1: Cryogenic system temperatures

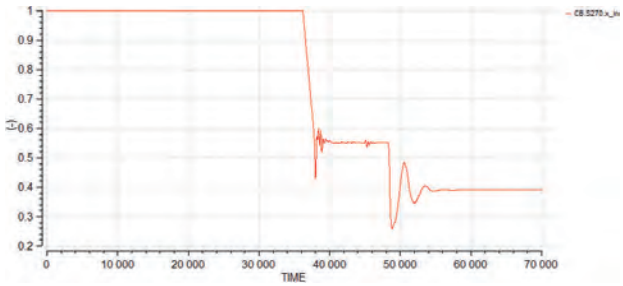


Figure 2: Quality in the phase separator

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