EcosimPro
Modelling and Simulation Software

EDITORIAL

Over the last few months the EcosimPro/PROOSIS team have developed new applications in innovative areas that highlight the tool's ability to handle projects across different disciplines. In fact, one of the great advantages of a multi-disciplinary tool like EcosimPro is its ability to model widely differing systems that can be described using equations. And our long experience has taught us that the best way to do it is to model these systems with the general approach of acausal modelling and object oriented programming.

This new issue also features a project developed this year by EA: the modelling of a complete oxy-combustion plant in great detail. Thermal power generation plants produce a lot of CO_2, which is a problem as it is discharged to the atmosphere. Experimental plants attempt to reduce the quantities of CO_2 discharged to the atmosphere, by isolating it previously and pumping it to a CO_2 storage chamber.

For this European project, a complete model of the CO_2 capturing plant was prepared, including the (very complex) boiler, the cycle, a pure oxygen production unit, a compression unit to isolate the CO_2, etc. This will allow simulations of real situations at the plant before it is built. There is no doubt that this type of work helps the engineers to optimize the design of these types of thermal power plants, as they can simulate realistic operating situations or extreme failure cases before construction. The final model developed in EcosimPro is very complex and includes thousands of equations and variables, demonstrating once again Ecosimpro's ability to solve complex problems.

This issue also contains two new EcosimPro libraries: an electric machine library, and a library for desalination plants.

The new Electric machine library covers an area not previously covered: the modelling of complex electrical systems such as machines, electricity networks, etc. The library includes typical components in this industry such as power converters, single-phase and three-phase transformers, rotary electrical machines, synchronous and asynchronous machines, coordinate converters, etc. There are over 80 new electrical components that can be used to create these types of systems.

The other library is the ROSIM library used to model desalination plants and which was developed by the University of Valladolid for EcosimPro. This new professional library covers the modelling of complete desalination plants. It includes over 80 components such as reverse osmosis membranes, filters, chemical purification systems, power recovery, typical hydraulic components used in this industry and control elements. This library is available already for end-users who want to work in this area.

Lastly, there is a report on one of the latest capabilities of EcosimPro/PROOSIS, which is the exportation of models, almost automatically, to OPC environments that allow connection to other systems, such as a SCADA for remote viewing and control of the model. We believe that this new capability will be very important to the processing industry, as it allows control of the simulation from the final control system of the plant in a very transparent manner for the end-user.

We are currently working on many new areas of EcosimPro/PROOSIS, such as new, more powerful mathematical solvers, parallelization of calculations, connection to databases, etc, that we hope will be implemented in the upcoming versions of EcosimPro/PROOSIS.

Pedro Cobas Herrero (pce@ecosimpro.com)
Head of the EcosimPro/PROOSIS Development Team
**Empresarios Agrupados Internacional S.A.**

LATEST NEWS ECOSIMPRO

New Renewable Energies Library

The University of Valladolid has developed a library on micro-sources of renewable energies in EcosimPro that can be integrated to form low voltage microgrids that can supply electrical power to remote areas that the main or national grid cannot reach on account of the typology or weather.

Generally, the generators and microsources that make up a microgrid are renewable/non-conventional distributed energy resource (DER) systems. In this library, the microsources are represented by photovoltaic sets and a wind turbine, and they are equipped with power electronic interfaces (DC/AC or AC/DC/AC) and a local controller to regulate production levels of active and reactive power. In addition, the library contains a number of different elements of power electronics as needed to control the facilities, as well as diesel motors and generators, sources of wind or sunlight, pumps, tanks, etc. that are found in those facilities.

The model of the photovoltaic set is based on an equivalent cir-
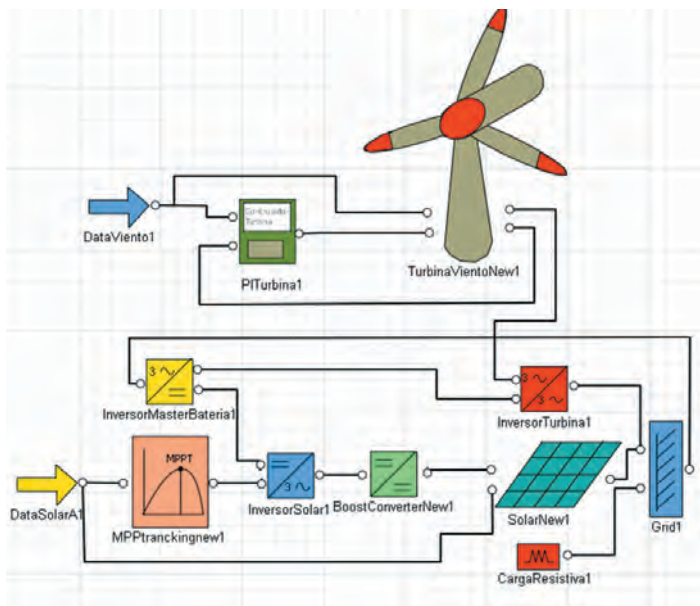
Wind and solar microgrid

cuit from a solar cell depicted by a source of current in parallel with a diode. It includes the effects of changes in temperature and levels of sunlight, as well as considering the specification sheets. The component was made to be general, so that it can be used in other simulation projects considering the technical specifications of the solar panels but without having to modify the existing component.

A model was run on a conventional, three-blade, variable-speed wind turbine equipped with a permanent magnet generator. The control strategy basically consists of controllers that work in different operating areas. The first controller is active when the wind speed is below the rated speed, and its aim is to maximize the output power by adjusting the speed of the rotor. Other control systems activate when the wind speed rises above the rated speed, and their purpose is to limit the power generated by the wind turbine by varying the speed of the rotor and the angle of tilt. A number of different control strategies were used to improve the quality of the power output.

The system was modeled modularly so as to determine the dynamic response of a wind turbine even after modification of the mechanical structure, the electronic configuration, or the control strategy. For example, the permanent magnet generator may be replaced with a dual-power induction generator joined to a multiplier. However, changes in the mechanical structure and the electronic configuration may also require changes in the control strategy.

The microgrids essentially have two operating modes: connected and isolated. Connected mode occurs when the microgrid is connected to the main grid or to a diesel generator in order to take/inject an amount of energy from /to the main grid. In contrast, in isolated mode, the microgrid is disconnected from the main grid or generator, so the microsources and storage elements must cooperate with each other to keep the integrity of the microgrid steady.

The figures below show two examples of simulation: the first consists of a microgrid made up of a wind turbine and some solar panels powering a resistive load, and the second itemizes the electronics associated with the simulation of a wind turbine.
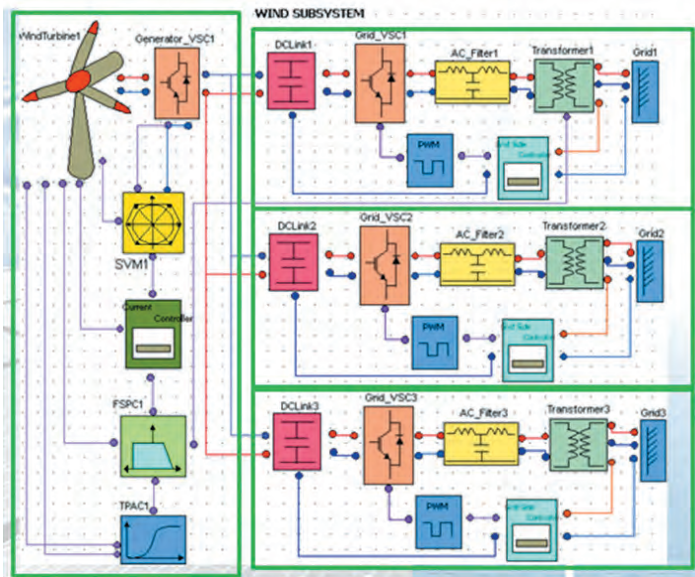
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Electric model of the turbine in EcosimPro

The renewable energy library facilitates the training of technicians and engineers in how to operate microgrids, how to check different configurations and control strategies before implementing them, how to facilitate their design. It is also easy to integrate new components into the library.

For more information, contact Jenifer Serna (esz@ecosimpro.com).
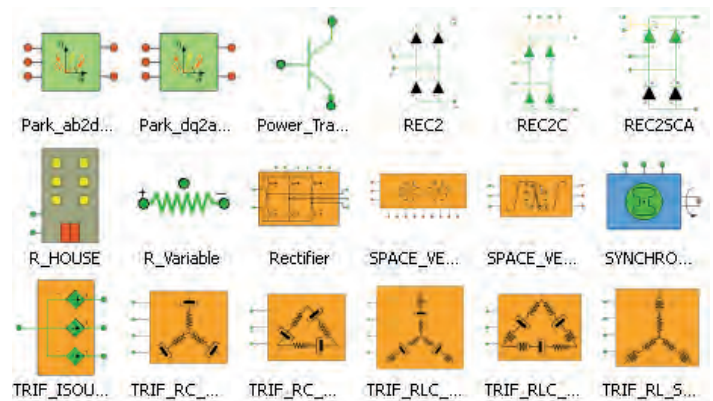
New Electric Machines library

The new Electric Machines library developed for EcosimPro in 2012 integrates a wide range of electrical components such as machines, transformers, power converters, control algorithms, etc, which makes it very useful for modelling multi-disciplinary systems that involve electrical components.

The new library is closely related to the ELECTRICAL library already included in Ecosimpro and has been specially designed for joint use with the CONTROL library and with another new library, still being developed, for renewable energy.

The new Electric Machines library includes the following components:

• The four basic categories of power converters: DC/DC, DC/AC, AC/DC and AC/AC

• Control devices for handling said converters, including PWM and Space vector algorithms

• Set of single-phase and three-phase electric transformers in different configurations based on the analysis of equivalent circuits, including undesired effects

• Set of rotary electric machines: direct current motor, asynchronous induction machine and synchronous machine, all modelled in a reversible manner (motor-generator)

• Mathematical components and coordinate converters suitable for vectorial control of rotary machines and electrical systems

• Electro-mechanical components for increasing the possibility of modelling complete systems with loads and mechanical power sources

The figure below shows the Electric Machines library palette of over 80 components:

Electric Machine library component palette

The new library, apart from allowing the inclusion of electrical systems in other Ecosimpro models, offers the possibility of carrying out simulations of generation systems, responses of drive systems, supply and consumption control, etc.

The use of object orientated programming and the possibilities provided by the EcosimPro simulation monitor constitute a very

suitable environment for developing electrical models in a simple and intuitive way. By joint modelling with the CONTROL and ELECTRICAL libraries, the user can analyze, for example, the current control on an induction motor (see figure below). The asynchronous three-phase motor is powered by means of an active inverter controlled under current. This is achieved using Relays from the CONTROL library which maintain the current consumed by the motor around a reference value and commutes the poles of the inverter when said current reaches the limits of the hysteresis band. Thus, as can be seen in the graphs below, the machine accelerates up to its stationary speed without the consumption current peaking during startup as would happen if no control were imposed on the system.
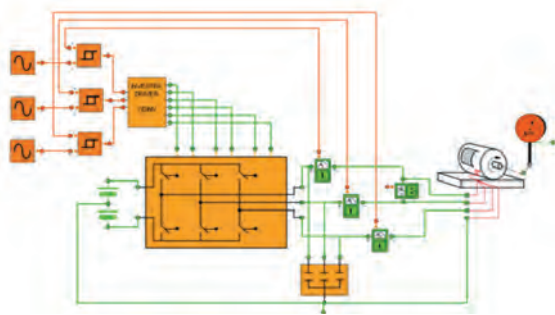
Current control model on an induction motor

It also allows the implementation of complex control algorithms that take into account different variables of the model in order to take the right decisions at each instant. The library includes control techniques such as Space Vector modulation and PWM for different types of converters.

The figure below shows this technique being applied to a 3x3 AC/AC conversion matrix. This control technique allows the generation of an output voltage whose value is easily controlled, and in addition the consumed current can also be controlled, and therefore so can the power of the system. To do this, two rotating vectors are generated in the Park space. One of them is the voltage reference, while the other is the current reference. Once they have been generated, their rotations are followed and the status of the conversion matrix is decided, as is its application time as a function of the position of both vectors at each instant on the basis of a high frequency carrier signal.

For more information, please contact Victor Pordomingo (vpo@ecosimpro.com).

OPC support in EcosimPro

OPC (OLE for Process Control) is a communications standard developed jointly by large industrial groups of industrial software, instrumentation and control via the OPC Foundation consortium.

Thanks to its client-server architecture based on Microsoft's OLE, COM and DCOM technologies, OPC lets different hardware and software be connected easily and without "fighting" with each device driver.

The final aim of OPC is to build systems with servers (usually data-generating hardware) and clients (software to control and monitor the data generated).

EcosimPro uses the standard OPC in its simulations by means of a new software tool called "OPC Toolbox" that integrates in the normal environment as a new plug-in. The main features of this new tool are:

• Producing OPC servers based on DECK simulations: this is a "wizard" type assistant for using DECK previously generated by EcosimPro as OPC servers
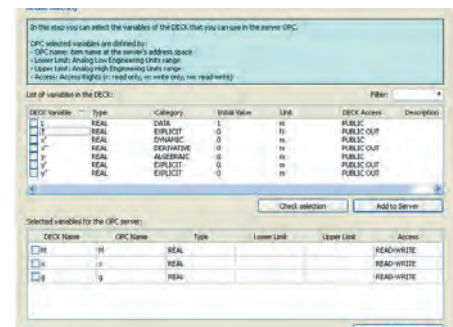
Wizard to generate an OPC sever based on a DECK

On each screen of the wizard, the user can set up general characteristics of the simulation, such as: public variables, initializations, simulation times, type of execution vs time (real time), etc.

The end result of the process is a new OPC server capable of running a simulation autonomously and independently from the EcosimPro environment.

• Generating communications clients between two servers: This is another wizard for building a communications client between two OPC servers

On each screen in the wizard, the user can: configure which ser-

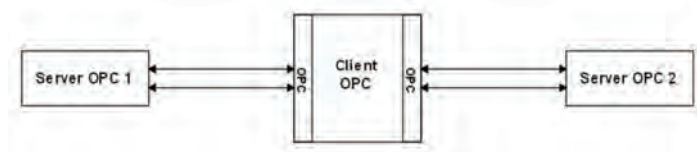vers to connect, which variables to communicate, what types of communication to send, etc.

The end result is an OPC client that can exchange data between two servers.

Communication client generated with EcosimPro to connect two OPC servers

With its new "OPC toolbox" plug-in, EcosimPro's capabilities for use in simulations are myriad, with it being the platform on which are based products such as:

• Complete training simulators

• Testing systems

• Direct simulations with real data read directly at the plant

• Software for control and monitoring (SCADAs, HMI systems, etc.)

• Specific user needs

For more information contact with Antonio Rivero (aiw@ecosim-pro.com)

Modeling an Oxy-Combustion Power Plant in EcosimPro

EcosimPro has been used to develop a complete, integrated dynamic model of a power plant with CO_2 capture based on a supercritical coal-fed circulating fluidized bed boiler.

Oxy-combustion is a process that uses pure oxygen instead of air, which makes it possible to concentrate the CO_2 from the flue gases and lower their mass flow by almost completely eliminating any nitrogen. The composition of the gases at a coal-fed oxy-combustion plant is mainly CO_2 and water. The pure oxygen is normally produced at a conventional technology cryogenic plant called an ASU (Air Separation Unit). Oxy-combustion is a valid process for capturing CO_2 at power plants because of the high concentration of CO_2 and the reduced mass flow of the flue gases. The flue gas is sent to a plant called the CPU (Compression and Purification Unit), where essentially the concentration of CO_2 in the gas is increased and compressed for transport to the storage facility.
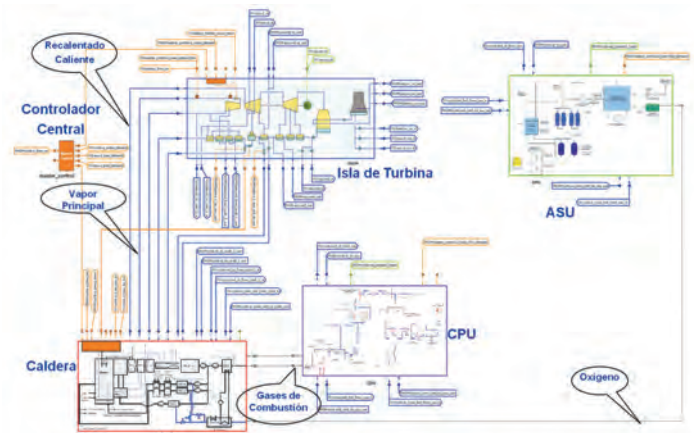
Schematic diagram of the complete oxy-combustion power plant

An oxy-combustion plant is a new kind of industrial facility. At the moment there are only demonstration plants for parts of the process. There is little knowledge regarding how to:

• Control and coordinate the different units making up the plant (boiler, turbine island, ASU and CPU)

• Solve the interface problems with the new units (ASU and CPU)

• Set operating procedures

• Optimize the design and operation

The reason for developing a dynamic model of the oxy-combustion plant in EcosimPro was to have a tool that adds to the creation of knowledge in the areas listed above. This knowledge is essential to trusting that the process works and is controllable before any great investment in building a real plant is made in the future.

The model portrays the boiler and the cycle in full detail. It is one of the most detailed models on the market for this type of boilers and can be used to calculate stationary states of the plant as well as transient scenarios. The scope of the CPU and ASU models takes into account the thermal integration with the cycle,
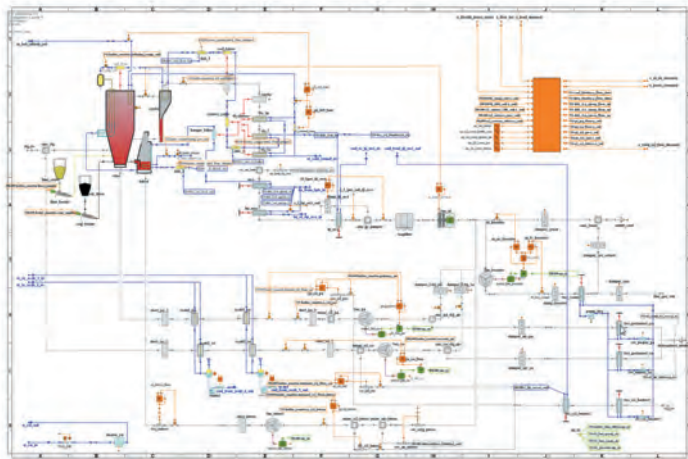
and special emphasis has been placed on detailed modeling of the interfaces with the boiler.

The model was used to successfully simulate and analyze the fo-

Schematic diagram of the EcosimPro model of the oxy-combustion circulating fluidized bed boiler

llowing plant transient scenarios:

• Rise and fall of ramp load from 100% to 40% and back to 100%

• Changing from oxy-combustion mode to air mode and vice-versa

• Trip of the Steam Turbine

• Trip of the ASU plant, which involves loss of production of the low pressure gaseous oxygen and feeding with the auxiliary liquid oxygen vaporization system

• Trip of the CPU plant

• Trip of one of the CO_2 compressors without CPU processing

• Variation of the purity of the O2 in the oxygen stream

In addition, the model was satisfactorily verified by comparing the results of stationary states at different plant loads (100%, 80%, 60%, 40%) with the heat balances of the boiler and the whole plant.

The model has great potential and can be used as a support tool on detail engineering activities of the plant, such as:

• Calculating integral heat balances from the whole plant taking into account the thermal integration between the different subsystems of the plant (boiler, cycle, CPU, ASU)

• Studying different ways of optimizing plant operation

• Optimizing the plant startup and shutdown sequence

• Supporting activities for testing and startup of the plant

• Developing a Training Simulator

For more information, contact Raúl Avezuela (rao@ecosimpro.com).

New library of Desalination Plants

The scarcity of fresh water has been decried in forums and organizations all over the world. It therefore comes as little surprise that considerable efforts are being made to improve water management. One such endeavor is desalination.

Desalination is a process by which salt and other minerals are removed from water to obtain a product apt for human consumption and for irrigation.

Because this type of process requires high energy consumption, one of the objectives of designing and operating desalination
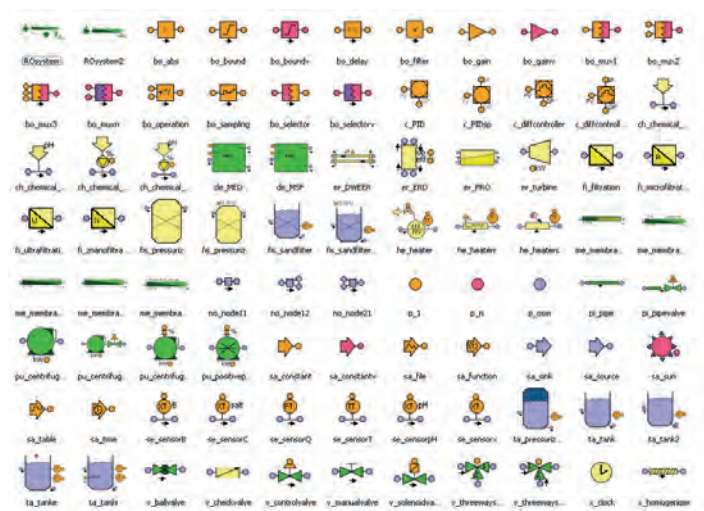
ROSIM library component palette

plants is to minimize energy costs and make the processes for obtaining fresh water profitable.

In this context the usefulness of the new Reverse Osmosis Simulation (ROSIM) library in EcosimPro becomes clear. Developed for EcosimPro by the University of Valladolid, it can be used to simulate desalination processes for studies for optimizing the design and operation of desalination plants.

The library started with the need to simulate reverse osmosis processes, so it has a large number of membranes (simple, with various discharges, discretized, etc.) as well as including components needed for the processes associated with reverse osmosis, the pre- and post- treatment (chemical or pH additives, filtration, pumping, etc.).

But the scope of this library is not limited to processes of reverse osmosis. Rather, it also includes components for simulating thermal desalination processes (Multi Stage Flash (MSF) and Multi Effect Desalination (MED)) as well as energy recovery systems (Dual Work Exchange Energy Recovery (DWEER), Energy Recovery Device (ERD), etc.) and analog components for setting the desired control logic in the process.

Consequently, ROSIM can be used to develop models of complete desalination plants, and by combining their components, hybrid plants, which combine membrane and thermal processes to optimize desalination efficiency.

Some of the most important components are:

• Reverse osmosis membranes: there are several components that represent reverse osmosis membranes to fit the user's needs, including systems with one or two permeated outlets, discretization of equipment or the use of different types of membranes in a single system

• Filters: it contains many types of filters, classified in terms of particle size (micro-filtration, ultra-filtration, etc.) and sand filters

• Chemical addition: chemical compounds for pre- and post-treatment may be added by using specific components to select the compound to add and its conditions, as well as to connect it to a control loop

• Energy recovery systems: models have been developed for systems such as DWEER (Dual Work Exchange Energy Recovery), ERD (Energy Recovery Device), PRO (Pressure Retarded Osmosis) and turbines

• Hydraulic components: due to the need for using this type of components, the ROSIM library also includes the models of tanks, pipes, valves and pumps, including a large variety of components to fit the user's needs

• Control elements: the ROSIM library has an ample collection of analog components for creating control loops using sensors, P&IDs, PLCs, etc.

This makes ROSIM a professional library for handling high-level industrial problems. Thanks to its design and implementation, end-users can solve highly complex problems without having to concern themselves over low-level tasks.

The following figure shows the model of a reverse osmosis plant in which ROSIM components are used to portray the complete process. The saltwater stream must first go through a pre-treatment process involving chemical additives and filtration of the homogenized mixture.

The pressure of the stream is then raised using a positive displacement pump whose discharge goes directly to the membrane in which the reverse osmosis occurs. The permeated stream than undergoes post-treatment with chemical additives before it reaches the storage tanks.

There are various control loops for controlling some of the process variables, such as the pre-treatment loop in which the pH additive varies according to the reading on the pH sensor located after the homogenizer.

For more information, feel free to contact Jenifer Serna (esz@ecosimpro.com).

Official release of CRYOLIB version 1.0

The official version 1.0 of CRYOLIB has been released last October .CRYOLIB is the result of the collaboration between CERN and Empresarios Agrupados in order to provide a comercial library oriented to the design of small and large-scale cryogenic plants. CRYOLIB is a professional EcosimPro library which provides typical components of cryogenic systems. The following are the most important features of the library:

• Several cryogenic fluids are available: He,N , Xe, O , 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

The library was presented at the 24th International Cryogenics Conference last May in Fukuoka (Japan) and is currently available for purchasing.

For more information contact Ana María Veleiro (vbn@ecosimpro.com)

Please feel free to send us any suggestions you may have for the EcosimPro newsletter, whether these have to do with content, articles or interviews that you would like to see published in coming issues to info@ecosimpro.com. We look forward to receiving them. With your collaboration, we can continue to improve and expand the newsletter sections that are most relevant to you.

SUGGESTIONS

FAQs: Reading ASCII files in Ecosimpro/Proosis

Two new classes in EL have been created to be able to read ASCII files and strings simply and intuitively. Until now, an EcosimPro/PROOSIS user who wanted to read these files had to create the functionality in FORTRAN or in C/C++ as an external library; as of this new version they can now be read simply and intuitively in components, functions and experiments using the tool. Two classes were created for that purpose:

PARSER_FILE: to read ASCII files

PARSER_STRING: to read strings

The PARSER_FILE class can be used to read the file token by token and take the results to corresponding EL variables. It of course requires knowing the coding of the file to be read.

The PARSER_STRING class is similar, but instead of associating the reading to a file, it associates it with a STRING/FILEPATH variable. The only difference is that instead of the open() method, it has a set() method to associate it to the string. For example, here is a complete case of using the PARSER_FILE class. The objective is to read a file called "file3.txt" in the following format:

2 1.45 3 3 1 TXT 3 1

2 2.43 3 3 2 TXT 3 0

2 2.24 2 3 3 ART 3 1

2 3.19 3 3 4 ATR 3 0

Suppose we are only interested in the fields 2 (REAL), 5 (INTEGER), 6 (STRING) and 8 (BOOLEAN). The program to read this file could be modelled in a function as follows:

```
FUNCTION BOOLEAN parseFile()
DECLS
    REAL vr=0
    INTEGER vi=0
    BOOLEAN vb= FALSE
    STRING vs=""
OBJECTS
    PARSER_FILE fi
BODY
    -- set the contents
    fi.open("file3.txt")
```

```
    -- parse columns 2(REAL) 5(INTEGER) 6(STRING) 8(BOOLEAN)
    WHILE( fi.is_end() == FALSE )
        fi.skipTokens(1)
        fi.getReal(vr)
        fi.skipTokens(2)
        fi.getInteger(vi)
        fi.getString(vs)
        fi.skipTokens(1)
        fi.getBoolean(vb)
        WRITE("vr=%g vd=%d vs=%s vb=%s\n",vr,vi,vs,gvalBool(vb))
    END WHILE
    RETURN TRUE
END FUNCTION
```

If we run the function we get the following output:

```
vr=1.45 vd=1 vs=TXT vb=TRUE
vr=2.43 vd=2 vs=TXT vb=FALSE
vr=2.24 vd=3 vs=ART vb=TRUE
vr=3.19 vd=4 vs=ATR vb=FALSE
```

This is the desired result, since it has correctly read all the fields in the file and has skipped over the fields we were not interested in.

Not only do these classes allow this type of reading, they also allow other more advanced capacities such as:

- read(). reading a fixed number of bytes

- seek(). Skip to any position in a file

- size(): Obtain the size of the file or string

- nlines(): Obtain the number of lines in a file

- position(), getLineColumn(): Obtain the current position in the file/string

- str(), obtain all the contents in one string

- getLIne(), obtain a complete line

- getReal(), getInteger(), getBoolean() and getString() to read different types of fields If they cannot be read, they return FALSE

- skipTokens(), to skip fields in the file/string