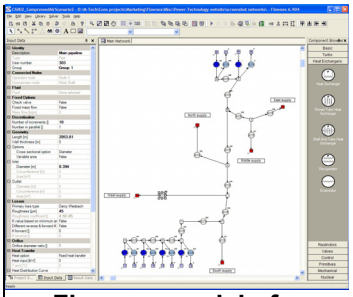
FLOWNEX – SYSTEMS CFD SOFTWARE FOR THE DESIGN, ANALYSIS AND OPTIMIZATION OF FLUID FLOW SYSTEMS

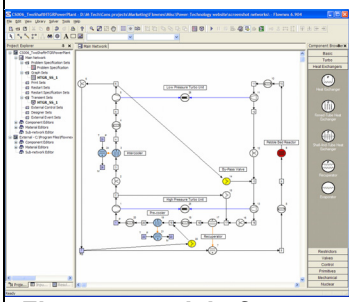
Flownex is an integrated systems CFD code used for the **design, simulation** and **optimization** of complete thermal-fluid systems such as:

- Gas, steam or combined cycle power plants
- High temperature gas-cooled nuclear power plants
- Gas and compressed air networks
- Oil and gas distribution networks
- Gas turbine combustion chambers
- Aircraft air conditioning systems including the distribution networks
- Heat exchanger networks
- Water or fuel distribution networks
- Ventilation systems



Flownex model of a reticulation system with check valves in some pipes and pressure and mass flow as outlet boundary specification

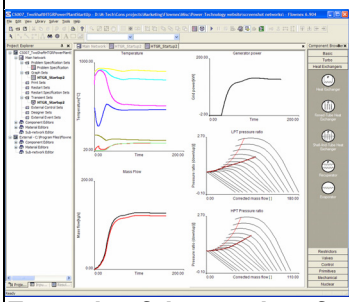
The ability to model the complete integrated system gives engineers the capability to quickly and accurately size components, do flow balancing and test different control methodologies in real time. Standard components with different levels of complexity are linked together in an arbitrary way to build any flow system. This is facilitated through an easy-to-use graphical user interface and the results are presented in a powerful graphical output.



Flownex model of a two-shaft high temperature gas cooled reactor nuclear power plant.

Distinguishing features of Flownex are:

- Steady-state and dynamic analyses.
- Water Hammer analyses.
- Simultaneously solve multiple gas and liquid networks that are connected through heat exchangers.
- Fundamental principle approach that allows the prediction of phenomena such as choking, natural convection and Joule heating.
- Heat transfer through solid structures.
- Ability to perform real time simulations.
- Variety of fluid models – gasses, liquids, two-phase or gas mixture.
- Monte Carlo sensitivity analyses.
- Standard interface with 3rd party software.
- Capable of coupling with 3D CFD code, e.g. for including boiler combustion simulations.



Example of the results of a dynamic simulation of the start-up of the gas cooled reactor power plant. The movement of the operating point on the compressor maps is also shown.

EASILY PERFORM CONCEPTUAL DESIGN OF FLOW SYSTEMS

Several conceptual designs can be evaluated easily and quickly by connecting the flow components in different configurations and observing the effect on the system pressure, temperature and mass flow distribution. Components such as pumps, compressors, turbines can also easily be sized and matched in order to obtain the most cost effective and efficient system layout.

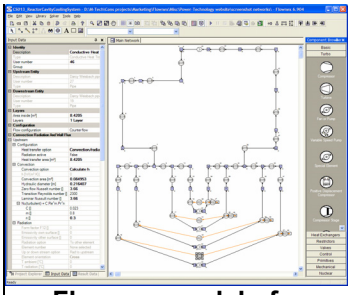
Flownex also features a designer functionality where automatic calculation of component sizes and capacities are possible to obtain a specified system operating condition. For instance to determine the orifice sizes for flow balancing in a system or determining the shaft speed or turbine guide vane angle in a power matched turbo-unit.

SAVE TIME AND MONEY BY QUICKLY PERFORMING SEVERAL WHAT-IF STUDIES ON SYSTEMS

Flownex allows engineers to perform real time investigations on systems to determine, for instance, what happens if:

- Valves are opened or closed in different parts of the system (phenomena like choking or the water hammer effect are also simulated)
- A pipe break occurs somewhere in the system
- The generator connected to the turbine is suddenly disconnected from the grid
- The boiler temperature or reactor reactivity is increased or decreased

Knowing the system response to various events allows engineers to test different control methodologies. Flownex features a controller model and also interface to external control software such as Matlab, Simulink, UNAC and LabVIEW.



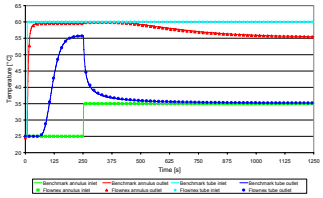
Flownex model of a passive reactor cavity cooling system relying on buoyancy driven flow. Model includes conduction, convection and radiation between pipes and reactor.

IT'S IN THE DETAILS

Flownex's implicit solution algorithm is fast, accurate and robust and resembles that of a conventional CFD code. The system is discretized into a number of spatial or conceptual control volumes to which a set of conservation equations are applied and then solved. This fundamental approach allows the prediction of phenomena such as choking, pressure surging, natural convection, Joule heating and buoyancy effects in packed beds.

Flownex uses nodes and elements to represent a thermal-fluid network graphically. Elements are components such as pipes, pumps, valves, compressors or heat exchangers, while nodes are the end points of elements. Elements can be connected in any arbitrary way at common nodes to form a network.

Flownex solves the momentum equation in each element and the continuity and energy equation at each node. Although components may be represented on the systems level as a single entity they may in actual fact be complex sub-networks. The main network with embedded sub-networks is treated as one large network in the solution algorithm.



Flownex is developed within the ISO9001 framework and is extensively validated and verified. Here is a comparison of a recuperator response comparison to experiment with a transient pressure and temperature boundary variation. The thermal inertia of fluid and thermal capacitance of the solid material is included.

VERIFICATION AND VALIDATION

M-Tech Industrial (Design Authority) and Pebble Bed Modular Reactor (Pty) Ltd. have embarked on a rigorous verification and validation (V&V) process to guarantee the integrity of engineering analyses and to satisfy statutory requirements regarding the licensing and operating of nuclear High Temperature Gas Reactor (HTGR) plants in South Africa and abroad. The National Nuclear Regulator (NNR) reviewed the Flownex Software Verification & Validation (V&V) status and found it to be acceptable to be used to support the design and safety case, provided that the comments made were addressed.

SUPPORT AND TRAINING

Each sale of Flownex is backed by extensive training and support to enable the allocated resources are ready to produce real solutions.

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Feature	Description	Standard*	Premium*	Nuclear†
Unlimited number of nodes and elements in a single network	A steady-state network of 1000 elements and 1000 nodes typically solves in less than 3 seconds.	X	X	X
Flow solver	Flownex solves networks quickly and accurately by employing an implicit solver.	X	X	X
Energy solver		X	X	X
Compressible fluids	User defined fluids or predefined fluids including: Air, Nitrogen, Methane, Helium	X	X	X
Incompressible fluids	User defined fluids or predefined fluids including: water	X	X	X
Custom loss components	Including general empirical, lumped resistive duct, user specified pressure drop and user specified pressure ratio components.	X	X	X
General Piping and Nodes	Including accumulator, pipe (with pipe schedules), bend, reservoir, node, reservoir, junction and mine tunnel component.	X	X	X
Heat exchangers	Including evaporator, discretised finned tube heat exchanger, discretised shell and tube heat exchanger, recuperator and lumped heat exchanger.	X	X	X
Restrictors and Valves	Including orifices, restrictor with discharge coefficients, restrictor with loss coefficients, ANSI valves and pressure regulating and relief valves.	X	X	X
Turbo machines and pumps	Including compressor, turbine, fan, pump, positive displacement compressor, gearbox and shaft components.	X	X	X
Controllers	Including PID, open loop and time dependent controllers.	X	X	X
Equation element	User coded models		X	X
Advanced turbo machine components	Including compressor stage, rotating annulus, rotating pipe and labyrinth seal.		X	X
Designer	Used to size components, balance turbo trains, balanced flow distribution, etc.		X	X
Stochastic routines for probabilistic analyses	Parametric studies, Monte Carlo analyses		X	X
Automatic Programming Interface	Functionality to integrate and automate Flownex from most existing Windows applications that allows scripting of COM, DCOM or ActiveX components.		X	X
Concentration solver	Gas mixture composition throughout an integrated network is calculated from a mixture of compressible gasses.		X	X
Combustion	Can typically be used to model the air flow and temperature distribution in aircraft combustion chambers.		X	X
Two phase fluids	A homogeneous two phase flow model with predefined fluids such as hydrocarbons, refrigerants, CO2, Helium, Hydrogen, Nitrogen, SO2, Steam and many more.		X	X
Heat transfer components	Including conduction, convection and radiation heat transfer components		X	X
Nuclear reactors	Two pebble bed reactor models with 2-D axi-symmetric modeling capability including discretised pebbles and point kinetic neutronics.			X

* Available in both Steady State and Transient version

† Available in Transient version only

"Pebble Bed Modular Reactor (Proprietary) Limited (PBMR) utilizes modern analyses and simulation methods and software as part of the design process for the PBMR Demonstration Power Plant and other projects. As in any design environment, analyses play a significant role in cost and time optimization. In the Nuclear industry this is even more evident.

PBMR is currently focused at delivering a demonstration nuclear power plant to be built on the Koeberg site in Cape Town RSA. PBMR is also exploring a multitude of other applications for its High Temperature nuclear reactor technology, which is characterized by inherent safe features.

At PBMR Plant Simulation and Analysis, analyses are performed using systems CFD (1D and 2D), 3D CFD and structural analyses. Analysis results are exchanged between the disciplines to serve as boundary conditions or detailed input for analyses. Using Flownex Nuclear as systems CFD code gives us the flexibility to perform thermal-hydraulic analyses of the entire integrated plant in seconds, with accuracy that is adequate for detail design calculations.

Flownex plays a very important role in our analysis capability. The ease of use and speed at which models can be created together with the complexity that can be modeled means that Flownex can be used from the beginning of the concept through to the detail design, commissioning and finally operation of a system.

Flownex is used to evaluate both steady state and transient conditions. Flownex's ability to model the integrated plant with all of its components and subsystems makes it ideal to predict transient behavior. Flownex can be linked to Matlab, where complex control algorithms are implemented, to enable transient simulation with complex control. The transient model is thus also used in the derivation and testing of the control logic. The methodology on which the powerful transient solver is based enables faster than real-time simulation. This also gives the opportunity for transient Monte Carlo studies.

Some of the analyses that Flownex is used for includes; component sizing analyses, transient behavior and accident event analysis. These include water hammer and pump sizing; turbine, compressor and heat exchanger sizing; reactor response using point kinetics; pipe break analyses and pressure relief through the building's specialized doorways and stack. The verification and validation status of the software enables us to use these analyses in our design to comply with regulatory requirements.

PBMR has committed to the use of Flownex for assisting in the design and commissioning of the demonstration power plant and is looking forward to continue using world class software for future projects."

H.J. Stander, Manager: Plant Simulation and Analysis; Pebble Bed Modular Reactor (Pty.) Ltd.

FLOWNEX®
Systems CFD Code