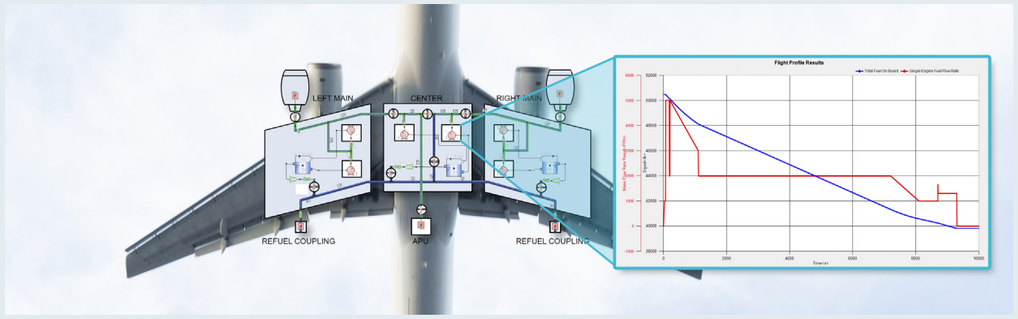
FloMASTER™

System Level Thermo-Fluid Design & Analysis

Mentor®
A Siemens Business

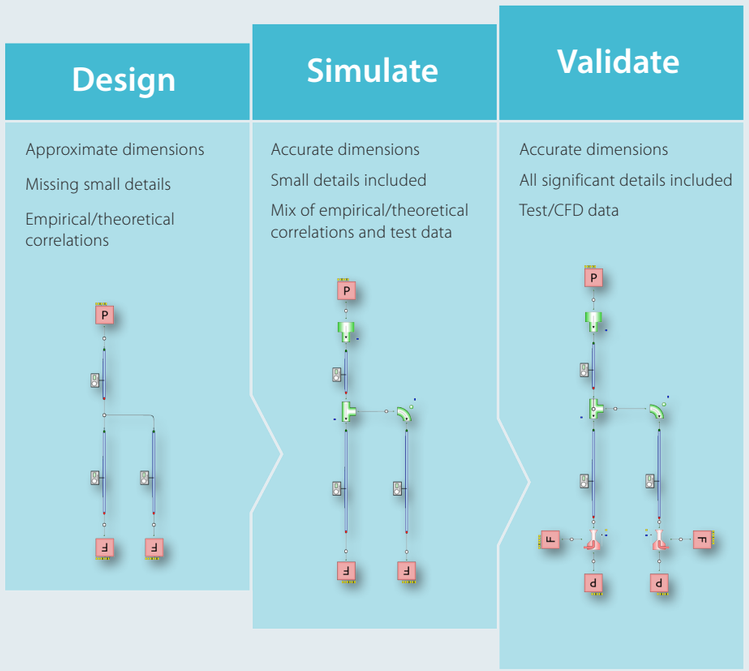
FloMASTER Overview

FloMASTER is a unique thermo-fluid system simulation software tool used by companies across a wide range of industries. FloMASTER offers fast and accurate simulation of thermo-fluid systems; facilitating upfront engineering to reduce cost and lead times in product development and maintenance.



Transient Aero Fuel System Simulating Fuel and Venting Through a Flight Profile

With an extensive library of component models, pre-populated with reliable performance data, FloMASTER allows fluid system design to start before CAD data is available and component suppliers have been selected. The flexibility of the software allows the system model to mature as this information becomes available over the design cycle.

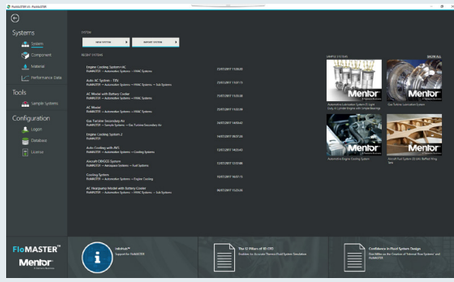


Model Maturity; The FloMASTER model matures as more information becomes available.

Robust and validated solvers, together with an easy to use user interface allows designs to be explored and performance of systems to be optimized across the range of operating conditions expected. The virtual system prototypes built in FloMASTER will reduce or even eliminate the need for physical tests.

ENGINEERS…

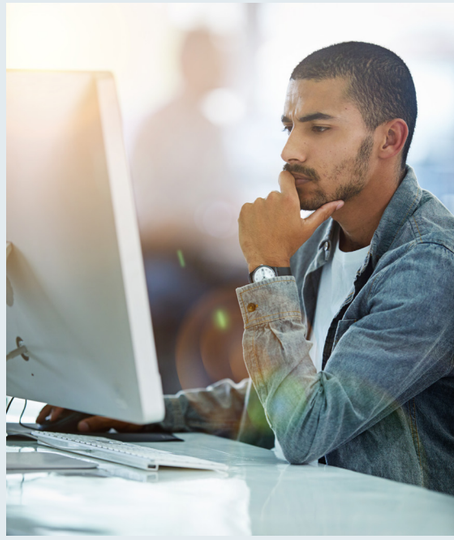
FloMASTER was developed for engineers by engineers. Focus is on achieving accurate simulation results in short timescales. Launchpad is designed to facilitate this with wizards and quick access to existing or shared models. In short, FloMASTER helps you to get on with the business of improving product performance/ functionality and reducing prototyping costs without requiring you to become a full-time fluid dynamics specialist.



FloMASTER Launchpad

CFD SPECIALISTS…

FloMASTER co-exists easily alongside other engineering softwares such as 3D CFD programs and optimization software and will increase your overall productivity. The Open API allows CFD Specialists to import data / models for systems-level analysis. The ability to export curves also enables the specialist to facilitate designers in optimizing their systems. Specialist application areas such as Vehicle Thermal Management (VTM), Gas Turbine and Floating Production, Storage, and Offloading Systems (FPSO) are modeled efficiently with dedicated cataloges and solver technology.



By enabling design engineers to conduct first-level CFD analyses directly in Excel to remove unreasonable options with FloMASTER, you'll be able to focus your time and energy on research and conceptual design. With FloMASTER you can take advantage of our advanced solver technology which makes analysis of real-world problems even faster and more accurate. Also, as the resident analysis expert, you will be able to use your extensive knowledge to help guide the design engineering team at your organization.

MANAGERS…

FloMASTER supports your "lean engineering" efforts directly by reducing the burden on your budget and saving thousands of man-hours. FloMASTER enables the entire team to perform fluid-flow and heat transfer simulations from their chosen interface:

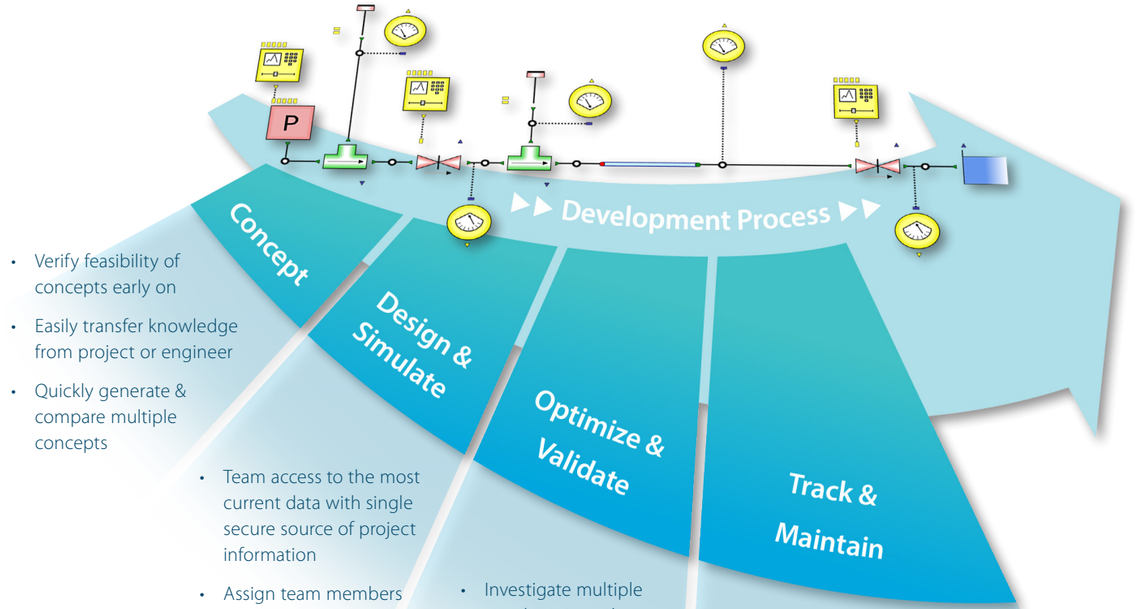
- Reduce prototyping costs drastically by replacing physical tests with virtual tests;
- Increase product quality while reducing production costs by helping your team reduce errors and create better products; and
- Shorten the development cycle by enabling your team to conduct "what-if" tests quickly.

"FloMASTER has allowed us to greatly speed up aircraft development… we have reduced lab testing, ultimately making savings on overall development time and costs."

- Scott Weber, Senior Engineer – Cessna Aircraft Company

Simulate the Whole Thermo-Fluid System from Concept to Validation…

Seamlessly develop your thermo-fluid system model from a steady state component sizing scenario, through design exploration and parametric study all the way to a full transient pressure surge analysis. No rebuilding, all results captured, complete audit trail of changes. Enabling users to easily understand the impact of change as well as the complete lifecycle of the system.



- Verify feasibility of concepts early on
- Easily transfer knowledge from project or engineer
- Quickly generate & compare multiple concepts

- Team access to the most current data with single secure source of project information
- Assign team members project roles
- Enhanced Flow Balancing capability
- Automatically conduct parametric analysis across a range of variables
- Understand system response under steady state and transient conditions
- Create Custom Components via C# scripting or 1D/3D simulation with FloEFD modeling
- Import from and export to Excel
- Link to Matlab Simulink

- Investigate multiple steady state and transient operating conditions
- Easily propagate design changes through virtual prototyping
- Digitally run required test cases
- Visualize the performance of a system and pin point problems
- Signoff facility to protect models.

- Identify previous design iterations via Audit Trail functionality
- Add background images and view sub-systems on layers so systems can be continually extended without the model becoming unmanageable
- Intuitive graphical user interface allows users to be productive straight away

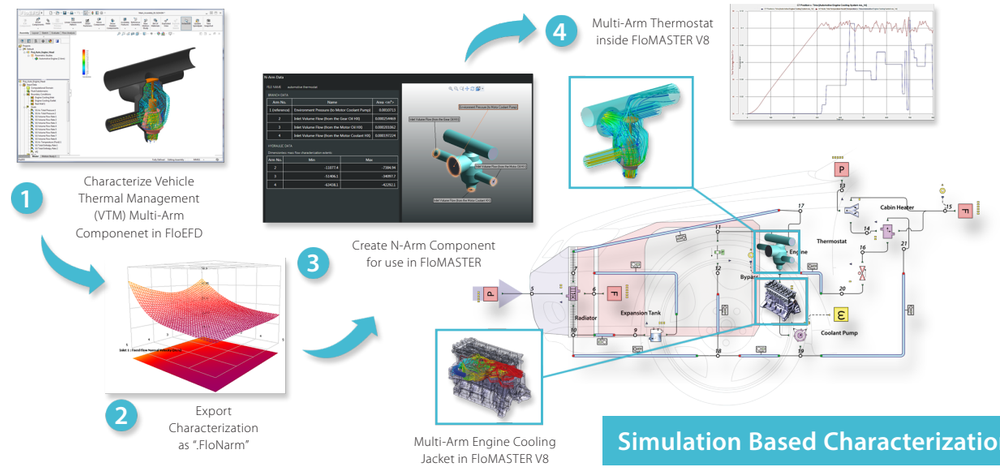
Get Reliable Answers Quickly

Rapidly build your thermo-fluid system model using an intuitive User Interface either by starting from scratch or using one of the built-in sample systems.

A comprehensive library of components pre-populated with the highly respected D.S. Miller empirical data gives confidence and the ability to start without waiting for test data, 3D CFD results or supplier information.

Built-in Sample Systems

Our unique Simulation Based Characterization (SBC) provides a Virtual Test Bench, enabling you to create component performance data when no such data exists.



Simulation Based Characterization (SBC)

The 'method of characteristics' used in tandem with the FloMASTER matrix solver is ideally suited to fast transients in fluid systems by exactly solving the physics. FloMASTER tracks the full system and allows it to be in steady state or transient, flow forward or backward, split or combined in both open and closed loops.

"By using FloMASTER to model locomotive cooling systems, Bombardier has reduced design and verification effort by over 400 man hours per year."

- Pierre Gamba, Cooling Specialist, Bombardier Transport Sweden

Integrate with other Engineering Tools

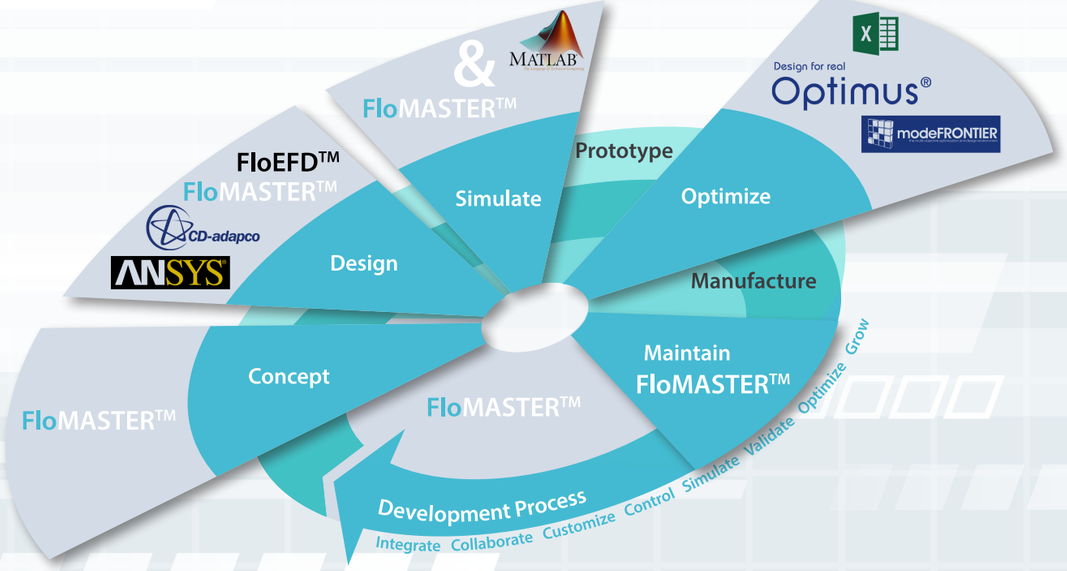
We recognize that your engineering tools ecosystem is diverse and consists of the tools that best suit your development needs. FloMASTER is developed with openness and interoperability in mind such that it can be integrated easily into your process and with your existing and in house developed tools.

Available Commercial Integrations:

- **CAD Integration:** AVEVA PDMS, Bentley Autoplant, COADE CadWorx
- **Pipe Stress Integration:** CAESAR II®, SST CAEPIPE, ROHR2, TRIFLEX®
- **Process Integration and Design Optimization (PIDO):** Esteco modeFRONTIER, Noesis Optimus
- **Integration Platforms:** MPCCI, TLK-Thermo TISC, Functional Mock-Up Interface (FMI), MATLAB® Simulink®
- **3D-CFD:** FloEFD, Ansys Fluent, CD-Adapco
- **Office Products:** Microsoft Excel

Customized Integrations:

- **Customize & Extend** FloMASTER to fit your development processes by embedding your intellectual property to model bespoke systems, or in-house code through FloMASTER's open API.
- **Automate** tasks using FloMASTER's automation capabilities to batch run parametric studies and prototype digital testing procedures.



"We chose FloMASTER, as our fluid systems simulation package, due to its versatility, ease of use and its ability to successfully integrate with our current 3D - CAD and CFD design packages. FloMASTER has also given us the ability to link to a mooring simulation package, completing the Wavegen design Suite."

- Henry Jeffery, Design & Development Engineer, Wavegen Design Group

Engineering Challenges

Systems of Systems

Investigate incompressible liquid, compressible gas and two-phase system flow, pressure drops and temperature. Model multiple systems in the same model to help in understanding the system interactions, such as the effects of the cooling system on the cabin heater interacting with air from the evaporator on the airflow to a passenger.

Heat Transfer

Manage heat flow through fluid systems and the effect that temperature has on fluid properties, flow and pressure distribution.

Transient & Control

Simulate time based scenarios including system start, shutdown and ongoing operation using FloMASTER´s transient capabilities. The full range of scenarios of thermal and rapid transient events can be modeled, such as pressure surge. FloMASTER controllers allow the user to both input into the system causing the change as well as to identify the required control strategies to ensure the system operates within specification. In addition FloMASTER´s open API can be linked to industry standard control modeling applications

System Interaction

Combine systems with incompressible liquid, compressible gas and two phase systems modeling the interactions between them. FloMASTER allows the user to select the most appropriate fluid model for the system and scenario that they are analyzing with the capability to run multiple systems within the same simulation to understand how they interact.

Performance Data Management

Users can begin building a model from day one using inbuilt performance data from Internal Flow Systems by D.S. Miller. As the model evolves the model can be updated to use data from suppliers or to compare the performance of one component to another. This data is then available for the next project.

Process Integration

FloMASTER's open API allows the user to extend FloMASTER to fit within their process, easily export model parameters to Excel for rapid parametric studies in an engineer-friendly environment while the standard component library can be extended through customized or user created components.

Component Characterization

Model components with complex geometry within a system using Simulation Based Characterization (SBC). In SBC, the component is modeled using 3D CFD FloEFD and the resulting performance map imported into FloMASTER for use as a standard system element.

"The accuracy of FloMASTER's results against pre-existing flight data allowed us to design the H-IIB launch vehicle confident in the knowledge that we could rely on the performance figures given from testing the new systems in a 'virtual' software environment."

- Akihiro Sato, Propulsion System Branch Leader, Mitsubishi Heavy Industries

FloMASTER Capabilities

- Steady State and Transient Simulation for Liquid, Gas and Two-Phase Systems,
- Heat Flow into and out of a System including System Interaction,
- Flow Balancing of Liquid and Gas Systems,
- Integrated Performance Data from Internal Flow Systems by D.S. Miller,
- Extensive Component Libraries including Dedicated Industry Vertical Components,
- Rapid Transient Modeling including Vapor Cavities,
- System Start-up including Priming of Pipes,
- Tracking Relative and Absolute Humidity,
- Choking in Compressible Systems,
- Joule-Thomson Effect,
- Heat Capacitance in Transient Systems,
- Fluid Mixing,
- Design of Experiment Parametric and Monte Carlo Study Analysis,
- Gas Turbine Secondary Air Systems including Geometric Cavities and Swirl,
- 3D Characterization of Components through Simulation Based Characterization,
- Link to Common Engineering Tools such as MATLAB and Excel,
- User Written Components,
- Zero Flow Heat Transfer,
- 3D Visualization and Segmentation of Heat Exchanger Cooling Packs,
- Parametric Simulation and FMI Model Generation,
- CAD Import from PCF, and
- Open API for System Integration and Automation.

"The ability to quickly optimize individual components on-screen in key areas within the FloMASTER model enables us to further validate our systems designs and plays a vital part in reducing material wastage and overall development costs, helping to ensure the project stays within budget."

- Tim Wright, Senior Aerospace BWT's Technical Manager

Application Examples

Automotive

HVAC System Modeling & Simulation

Proper system integration of air conditioning systems by suppliers and OEM's is vital in maintaining acceptable performance characteristics as cost and packaging constraints are imposed. Physical testing of design changes is expensive and time consuming. FloMASTER allows you to design and optimize your system during the early stages of design to optimize component selection and overall system design.

Vehicle Thermal Management (VTM) - Airside & Cooling System Modeling & Simulation

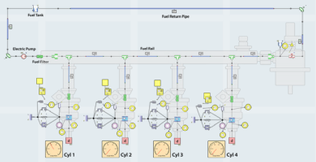
Thermal management is a significant challenge in the design of modern vehicles and a well-designed cooling system is vital in overcoming this challenge. Designing and optimizing for packaging space restrictions, powertrain architecture variations and thermal loads is essential. With FloMASTER you can model your cooling system and optimize its design before building the real thing, whether you vary the design parameters of the thermostat to ensure a constant temperature in the cooling system or resize key components to packaging constraints. You can even investigate the interactions of close-coupled heat exchangers using automatic airflow path segmentation. You can also investigate improving overall vehicle performance though implementation of an Organic Rankine Cycle system to recapture waste heat. FloMASTER allows you to model the entire ORC layout with a wide range of components so that you can identify energy flows and system efficiency quickly and easily.

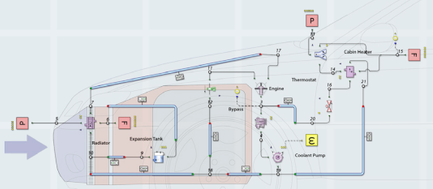
Lubrication & Fuel Modeling & Simulation

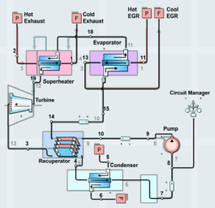
With energy prices rising and both markets and legislation demanding more efficient engines, optimizing the lubrication systems of your powertrain systems is essential to ensuring as efficient and economical vehicle operation as possible. FloMASTER enables you to understand the complex dynamics of an entire lubrication system allowing for quick and easy evaluation of your lubrication design. While for fuel systems, a range of simulation modes enables you to model the complex system in order to predict fuel system behavior for critical design cases to ensure adequate fuel flow and pressure, accurate fuel metering, avoidance of interaction effects and control pressure transients.

Exhaust Modeling & Simulation

The modern automotive exhaust system is critical in enabling powertrain systems to meet their performance, efficiency, weight and packaging targets. However, during the vehicle development process, it is the exhaust system that is often left until the very end to design. Using FloMASTER, you can model entire systems from the engine to the rear silencer/muffler and subsequently run simulations under real operating conditions to accurately predict pressures, losses, flow rates and other performance parameters for a given design.







Aerospace

Environmental Control System (ECS) Modeling & Simulation

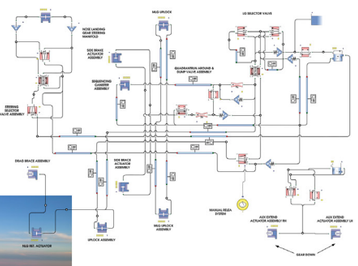
The successful development of an Environmental Control System (ECS) is dependent on maintaining a comfortable environment for passengers and tolerable working conditions for safety and electrical equipment while also ensuring the system is optimized to minimize material wastage and weight. FloMASTER can be used at the concept stage to model and simulate all the sub-systems of an aircraft's entire environmental control system from simple ducting systems to complex cabin design. You can carry out detailed simulations on individual sub-systems and / or simulate them together in a single model to review their interaction as a whole.

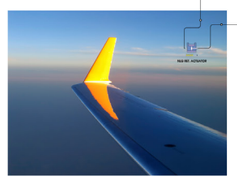
Fuel & Propulsion System Modeling & Simulation

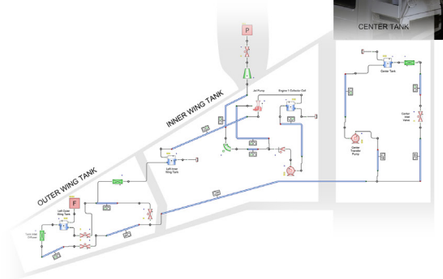
Aircraft fuel systems are complex, involving interaction between the fluid, mechanical and electrical systems on-board an aircraft. It is vital these systems perform as intended and within regulations and without adversely impacting other areas of an aircraft's system performance. FloMASTER can also be used for a variety of rocket propulsion systems. You can use it to evaluate designs for mitigating surge pressures while minimizing propellant tank-to-thruster inlet pressure drop.

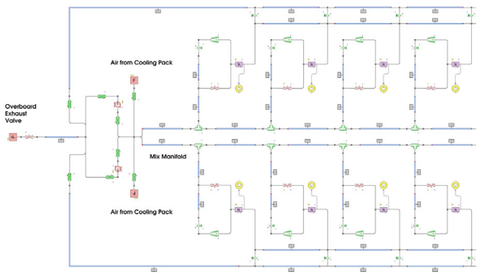
Hydraulic System Modeling & Simulation

Hydraulic systems are becoming ever more sophisticated with complex assemblies of electronic, hydraulic and mechanical components. It is vital that these systems are cost efficient but remain within tight performance and safety regulations. Systems must work correctly first time, requiring engineers to have at hand detailed and accurate information about system performance. FloMASTER enables you to analyze system level models of aircraft hydraulic systems at the concept stage of the design process. The performance of these models can aid in focusing and more tightly defining physical tests.









Power & Energy

Gas Turbine System Modeling & Simulation

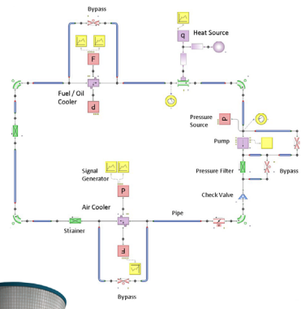
FloMASTER allows gas turbine designers to get an understanding of secondary air flows, blade cooling, lubrication, and fuel systems accurately early in the process. For secondary airflows it is a powerful tool for engineers to understand the effects of swirl and heat transfer within and throughout the cavity. FloMASTER is able to deliver accurate results for complicated fluid networks under high centripetal forces making it an extremely capable design tool for those involved in the design of lubrication systems or blade cooling within gas turbine engines.

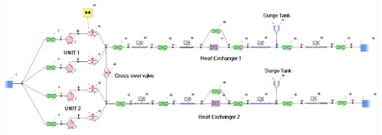
Fossil Fuel System Modeling & Simulation

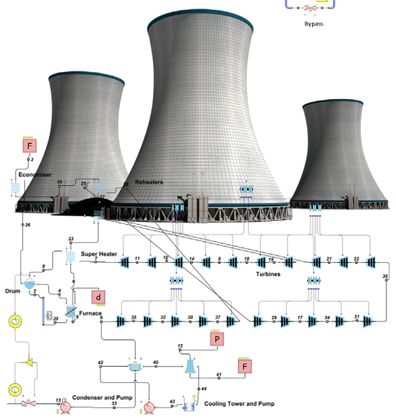
Fossil fuels remain the most common energy source of power for electricity generation, globally. However, concerns over emissions and operating cost demand that the systems become ever more complex. FloMASTER allows you to understand the interaction of steam and flue gas systems and aids the design of efficient plan operation. FloMASTER's advanced two-phase solver enables you to model the entire Rankine cycle giving you accurate pressure drop and heat transfer predictions for your systems. You can also investigate improving overall system performance though implementation of an Organic Rankine Cycle system to recapture waste heat. FloMASTER allows you to model the entire ORC layout with a wide range of components so that you can identify energy flows and system efficiency quickly and easily.

Renewable Energy System Modeling & Simulation

Renewable energy generation is a rapidly evolving and growing field. FloMASTER has proven itself as a valuable tool for evaluating performance of a number of novel generation and power storage schemes thanks to its accurate solver and open architecture.







Process & Marine

Cooling Water System Modeling & Simulation

The laws of thermodynamics make it clear that where we use heat to generate power, there will always be a proportion rejected to a cold sink. Cooling networks can be extremely complex, vary widely in scale and design but they are always critical to the safe and continued use of the installation they support. The design of such networks is thus fundamental to the safe operation of systems. FloMASTER was designed from the outset to aid the design of cooling water networks. The accuracy of the empirical data that underpins the solver ensures that designers can be sure they're sizing their system based on the best information available. The transient solver enables designers to understand the response of their system to changing loads and demands and identify where water hammer is a real risk.

Industry Gas System Modeling & Simulation

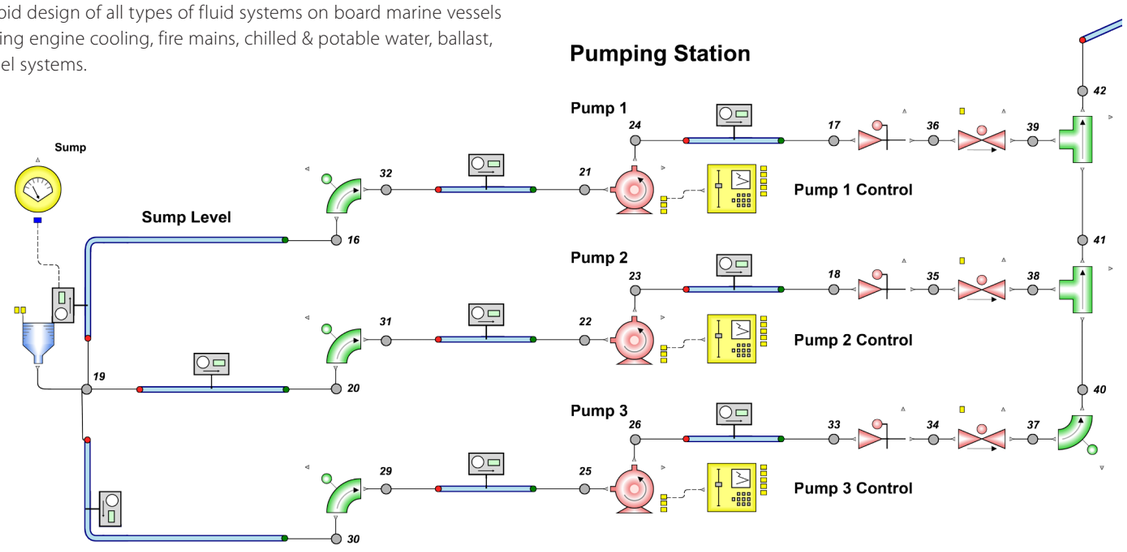
The transportation and handling of gas is an issue present in many industrial processes. These gases may be at elevated temperatures, high flow rates, toxic or any combination of the above. Therefore it is not only essential to understand any proposed network well in order to design the most efficient plant, it is also an absolute requirement for establishing a safe operating environment. FloMASTER enables engineers to build virtual prototypes of their pipelines, enabling components to be sized, different configurations assessed, insulation requirements judged and safety critical scenarios evaluated. Its compressible solver can handle both real and ideal gas models and is complemented by a comprehensive NIST database of fluid properties.

Safety System Modeling & Simulation

Fire mains form the backbone of firefighting strategies for sea going vessels and process plants of any appreciable size. From a hydraulic perspective, they bring together three elements (scale, flow-rate and short response time) that makes them particularly vulnerable to water hammer. FloMASTER enables designers to accurately predict the performance of both open and closed loop systems in steady state and transient. Flow rates to different points of the network can be easily balanced and, if required, surge alleviation measure evaluated and sized.

Marine System Modeling & Simulation

Often containing many miles of pipework transporting high and low pressure liquids and gases, the design of sea going vessels demands that designers understand fluid system performance across a range of operating points and during emergencies. FloMASTER facilitates the rapid design of all types of fluid systems on board marine vessels including engine cooling, fire mains, chilled & potable water, ballast, and fuel systems.



Technical Support

Not just a software company, Mentor Graphics also offers customers comprehensive training as well as online and telephone support. In addition, the Support Center allows licensed users to download the software with the latest documentation and to submit questions and support issues. A wide range of application examples and technical papers are also available on our website: www.mentor.com/mechanical

Design Services

If you prefer to outsource part or all of your physical design, our Mechanical Analysis team is ready to help. When you engage us, you effectively add to your staff some of the world's most experienced engineers in design services. Starting with any design information you have, we will quickly plan and execute an assessment, regardless of the stage of your product.

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Mentor Graphics Corporation, a Siemens business, is a world leader in electronic hardware and software design solutions, providing products, consulting services, and award-winning support for the world's most successful electronic, semiconductor, and systems companies.

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