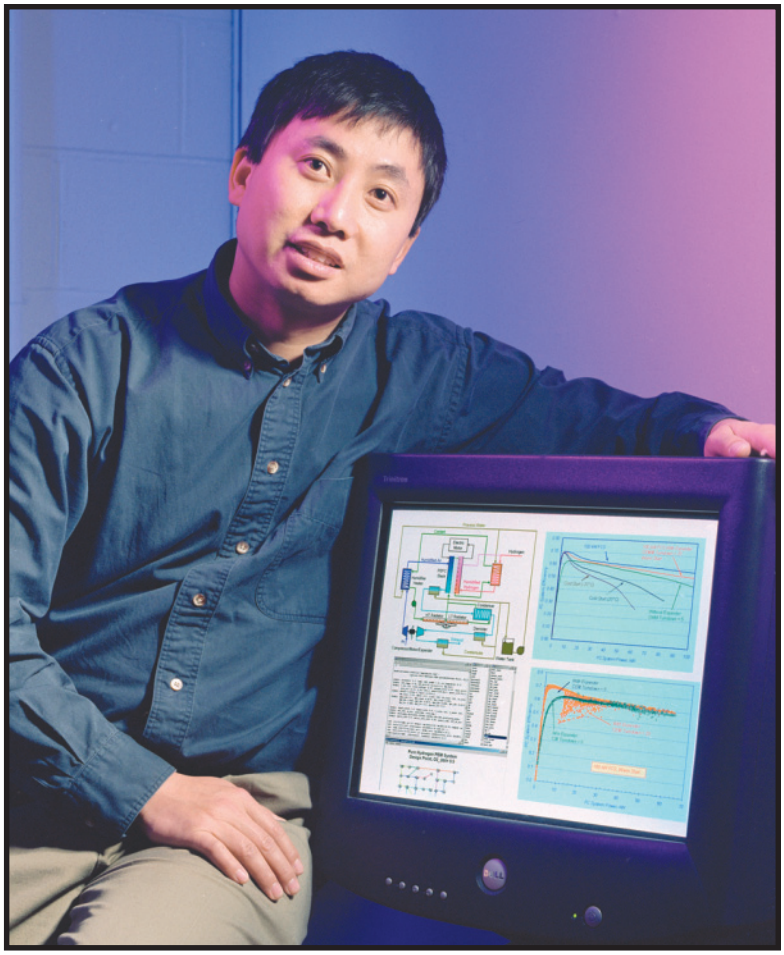
GCtool (GENERAL COMPUTATIONAL Toolkit)

A Powerful Tool for Optimizing Fuel Cells and Other Power Systems

GCtool (General Computational Toolkit) is a software package that helps design, analyze, and optimize fuel cell and other power-plant configurations, including automotive and stationary distributed power generation systems. Dynamic, total-system fuel cell modeling is one of its major strengths. Modules for polymer electrolyte and solid oxide fuel cells are available. GCtool provides a convenient, flexible framework for configuring various fuel cell and balance-of-plant components into simple or complex system configurations. An extensive library of component models and properties is available, and users can add their own models, if needed.



"TRYING OUT" VEHICLE DESIGN

The automotive industry is being challenged to design and bring to market highly efficient, environmentally friendly, affordable cars and trucks. GCtool lets designers "try out" different system configurations, without the expense and time involved in actually building physical prototypes. This software package, developed at Argonne National Laboratory, is especially suitable for designing, analyzing, and optimizing different fuel cell systems and system configurations.

FEATURES

GCtool can be used to define arbitrary system configurations. It is able to handle models of any level of detail. It allows both steady-state and dynamic analyses, unlimited parameter sweeps, and constrained optimizations. It includes nested looping statements and other logical functions to automatically examine the effects of changes in system parameters.

GCtool's C-language interpreter and model design support rapid system prototyping. System configurations are set up with the help of on-screen graphics. Model parameters can be easily changed, and pop-up windows are used to display configurations and for line and surface plots.

Other features include:

- **A model library** that offers four different types of fuel cells — polymer electrolyte (PEFC, often referred to as proton exchange membrane, or PEM), molten carbonate, phosphoric acid, and solid oxide fuel cells. Other ready-to-use component models include various types of heat exchangers (heat pipe, condenser, thermal radiator, etc.); fluid devices (splitter, nozzle, diffuser, gas turbine, pump, etc.); reactors and reformers; and vehicle systems (including electric motor/generator).

- **Property codes** that include a fast, gas-phase chemical equilibrium code capable of handling an arbitrary number of species; a multiphase chemical equilibrium code; a code for condensable pure substances; and a steam/water code.

- **Mathematical utilities** that include a nonlinear equation solver, a constrained nonlinear optimizer (for both linear and nonlinear constraints), an integrator, and a solver for ordinary differential equations.

APPLICATIONS

This software tool has been used successfully in analyzing a variety of polymer electrolyte fuel cell (PEFC) systems using different fuels, fuel storage methods, and fuel processing techniques. Fuel cell systems have been analyzed for hydrogen, methanol, natural gas, and gasoline fuels. The analyses included off-design operation, dynamic and transient performance, and the effects of operation at extreme temperatures. Important issues involving heat, water, and air management have been identified, and alternative approaches to addressing those issues have been evaluated. Users have also analyzed system start-up from cold and warm conditions and determined system performance and efficiency during ramp-up and ramp-down transients.

GCtool_ENG

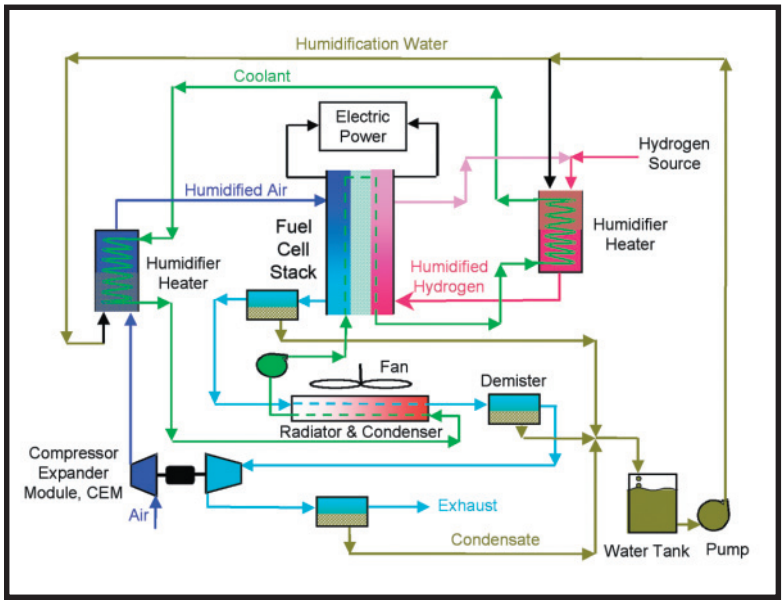
GCtool_ENG is a special version of GCtool suitable for producing and exporting executables that can be linked to vehicle performance codes, such as the Powertrain Systems Analysis Toolkit (PSAT), that are written for the MATLAB/Simulink platform. The linked code can be used to analyze the transient response of fuel cell systems during drive cycle simulations of stand-alone and fuel cell hybrid vehicles. GCtool_ENG has the capability to model fuel cell systems with stored hydrogen as well as on-board fuel processors.

TECHNOLOGY TRANSFER

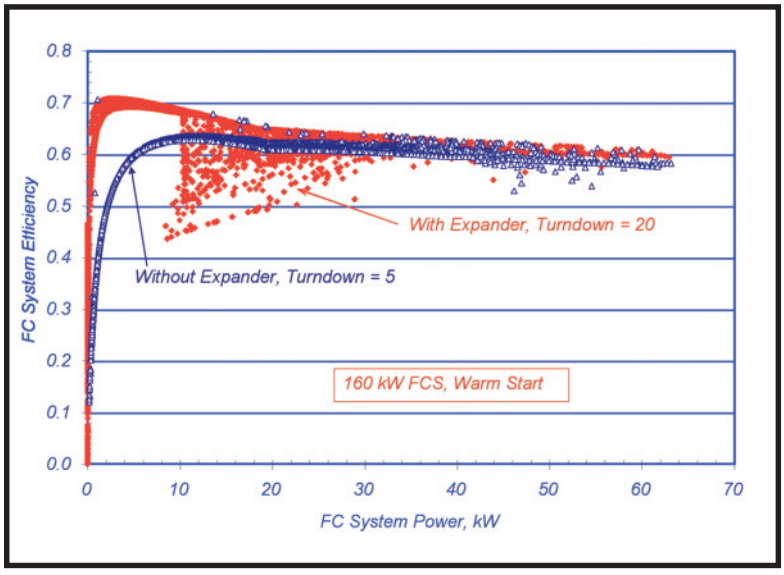
At present, numerous organizations outside of Argonne are using GCtool for systems design, analysis, and evaluation. These users include private-sector fuel cell companies and universities developing new fuel processing technologies and fuel cell systems for automotive and stationary applications. The software includes an on-line manual with a set of examples that range from a very simple system to a rather complex power system that includes multiple recycle loops.

FOR MORE INFORMATION

More on GCtool, including licensing information, is available on Argonne's software licensing web site (http://www.softwareshop.anl.gov/). If interested in licensing the software, contact Paul Betten, Argonne Office of Technology Transfer (630/252-4962, betten@anl.gov). For more technical information, contact Romesh Kumar (630/252-4342, kumar@cmt.anl.gov).



Schematic diagram of a hydrogen-fueled polymer electrolyte fuel system for automotive applications



Effect of expander on dynamic system efficiency over an urban drive cycle