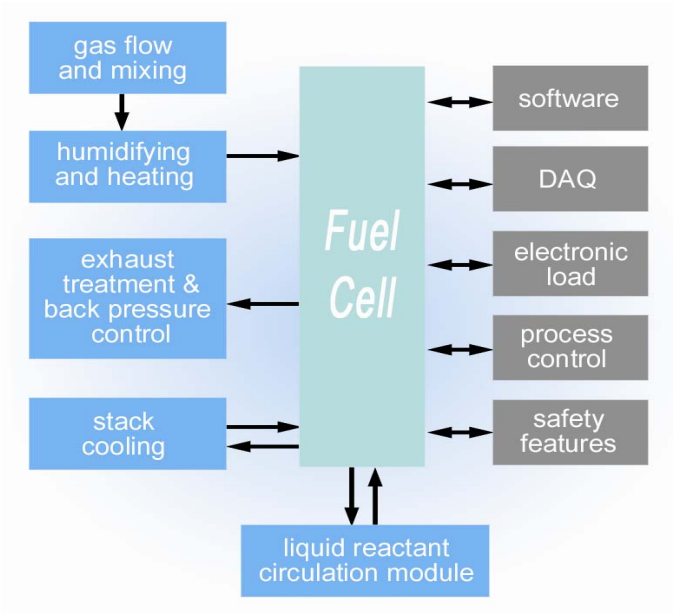
Focus on Fuel Cell Testing Systems

ARBIN INSTRUMENTS SPECIAL EDITION NEWSLETTER

Summer 2004

General Description of Arbin Fuel Cell Testing System

Arbin's fuel cell testing systems are designed for electrochemistry testing of all types of fuel cells, including proton-electrolyte-membrane , direct-methanol and solid-oxide fuel cells. Testing range covers from micro fuel cell to a very large automobile fuel cell of over 100kW power. The systems are designed to be fully integrated and automatic. All aspects of material handling and conditioning, electronic load and data acquisition, as well as process control and measurement are built with modular structures and integrated seamlessly to provide one compact testing system that is easy to operate and maintain.



Below is a brief description of a general fuel cell testing system components (specific system may/may not have these components):

Gas Flow & Mixing
Flow rate can be ramped at adjustable rate and is controlled at 1% full scale accuracy. Unlimited gas inlets for reformate gas simulation with programmable mass flow controllers.

Gas Humidification & Heating
Patented dew point humidifier to humidify and heat/cool reactant gases. Provides precise dew point temperature control within short response time. Control range is from coolant temperature T+20°C up to 140°C with temperature transition time of 1~5°C/min. Fully automated features facilitate long term operation.

Exhaust Treatment & Pressure Regulation
Treatment of exhaust gas without causing pressure interruption to the system. Back pressure regulation is automatic and programmable.

Stack Cooling
Provides automatic heating/cooling of the fuel cell stack according to user-defined test schedules.

Liquid Reactant Circulation
Handles liquid reactant and treatment of byproducts. The temperature and flow rate of the liquid is programmed through test schedules.

Electronic Load & Data Acquisition
Patented electronic loads in wide current, voltage and power ranges. Various I/O signals are incorporated to facilitate data acquisition and communication.

Process Control & Measurement
Handles the control and measurement of devices involved in the handling and conditioning of reactants in and out of the fuel cell. Automatic 24/7 dynamic profile testing can be programmed for autonomous test run.

MITS Pro Fuel Cell Testing Software
Operating software for Arbin's fuel cell testing systems. Allows for manual or automatic control of test parameters.

Safety Features
Comprehensive hardware– and software-controlled safety protection features. More details in the article "Focus on a Safe System" inside this newsletter. ■

Inside this issue:

An Arbin machinist stands next to a 4000slpm humidifier unit to be completed into a humidifier system. The 4000slpm humidifier unit requires 40kW boiling power and 10kW heating power.

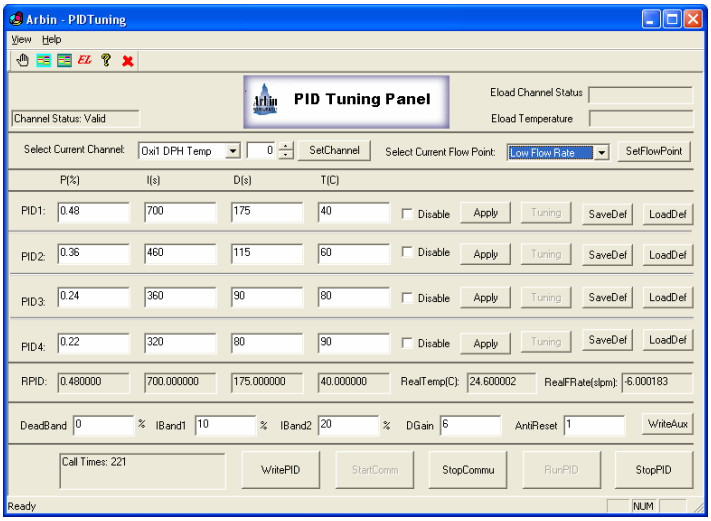
Under Control with PID Tuning

Almost transparent to the end-user is software and hardware PID (proportional integral derivative) control implemented in Arbin's fuel cell testing system (FCTS). This advanced control system is an integral part in achieving stable and accurate set point of flow rate, pressure, and temperature of Arbin's proprietary dew point humidifier for the humidification of reactant gas streams.

Humidity and temperature control is realized through zoned-PID control to achieve good continuous performance over a wide range of flow rates, temperature and pressure. The dew point temperature and gas temperature control accuracy of Arbin's humidifier is ± 1~3°C. The control range is from coolant temperature +20°C to 90°C. The temperature transition time is about 1~5°C per minute with a low overshoot of less than 20% of the temperature set point change.

Zoned-PID is a simple variation of gain-scheduling control based on the PID-matrix. The technique is very efficient to adapt system changes and counteract load disturbance, and thus improve the system performance.

The control engineers at Arbin perform the tuning of the PID control to achieve user-defined optimal performance of system response according to each specific system's requirements. Advanced PID control with gain-scheduling and auto-tuning is currently under development to achieve even better temperature control within wide range of other parameters in effect. ■



Interface panel for zoned-PID control in Arbin's MITS Pro software for the FCTS systems.

Featured Customer

An order of a 300W fuel cell testing system to test both PEMFC and DMFC was placed by University of Surrey, UK, near the end of last year.

The fuel cell research group at the university intends to use the system for polymer membrane research. More information about the group's research interest can be found on the university's Materials Chemistry Laboratory web page at: www.surrey.ac.uk/Chemistry/laboratories/mc.shtml ■

Arbin Exhibition—Fuel Cell 2004

Performance Results of PEMFCTS-10kW

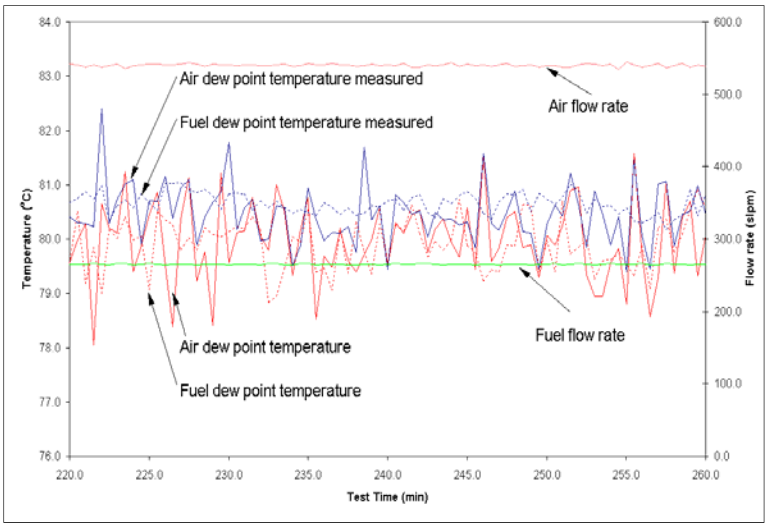


Figure 1. Dew point temperatures controlled and measured at 80°C ± 2°C.

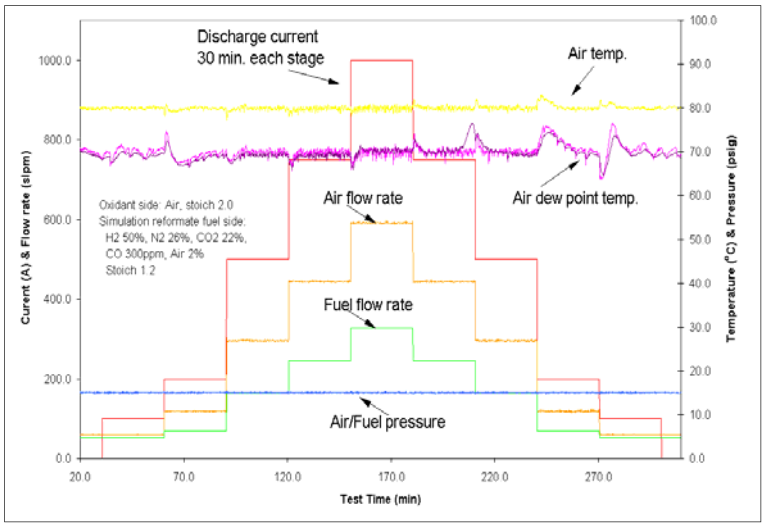


Figure 2. Temperature, pressure and stoichiometric flow rate control during simulated discharge.

Testing System for PEMFC and DMFC

PEMFC (proton electrolyte membrane fuel cell) and DMFC (direct methanol fuel cell) are similar in that the electrolyte is a polymer membrane and the charge carrier is the hydrogen ion. While the PEMFC uses pure hydrogen or fuel reformate, the DMFC uses a mix of methanol and water solution to feed into the anode of the fuel cell.

Both types of fuel cells use oxygen or air for the oxidant. As such, a combination of PEMFC/DMFC testing system is feasible with the sharing of the electronic load and gas humidification of the cathode line. In this case, the operator needs to adjust the operating software and switch the fuel line from using the hydrogen to using the methanol solution to test one type of fuel cell at a time.

Separate systems for testing PEMFC and DMFC are sometimes preferable for the convenience of testing multiple fuel cells at the same time or for some other design concerns. These include testing systems with single electronic load channel and gas humidification unit in one chassis or multiple electronic load channels and gas humidification units in one chassis. The final choice of design comes down to each specific customer's requirements.

Shown to the right are pictures of different system configurations Arbin has designed and manufactured to test PEMFC and/or DMFC. ■

PEMFCTS-1ch eload at 30V/100A/3kW-50slpm anode humidifier-200slpm cathode humidifier

PEM/DMFCTS-1ch eload at 50V/100A/1kW-1.3lpm methanol line-20slpm anode humidifier-50slpm cathode humidifier

DMFCTS-2ch eload at 2V/20A/20W-60ccpm methanol line– 2 sets of 2slpm cathode humidifier

Focus on a Safe System

Extensive safety protection features, both in the hardware and in the software, are installed or available on Arbin's fuel cell testing system, the FCTS.

A local hardware interlock provides immediate shut-off of the electronic load control on the fuel cell and purges the gas line with inert gas, without the necessity of a PC or micro controller present. A higher-level signal interlock accepts and reacts to an alarm signal from internal or external devices, which includes digital output (TTL or relay). In most cases, this function has to be carried out with PC and/or micro-controller.

These hardware interlocks are triggered to react to the gas sensor alarm, water-level sensor alarm, overheating of boiler/gas heater, emergency push button, and other monitored devices/parameters.

Software interlocks check for violations of preset safety limit parameters. The monitored parameters include temperature, pressure, stack's/cell's voltage/current/power, and water level.

Automatic water leveling with a high and low water-level alarm is standard in the humidifier. Low water-level may damage heater or wires; while the high water-level cause flooding of the fuel cell. For exhaust gas treatment, water-level sensor can also prevent from pressure control problems.

It is also recommended that an uninterruptible power supply (UPS), which can support the entire FCTS, be used for unexpected power outages.

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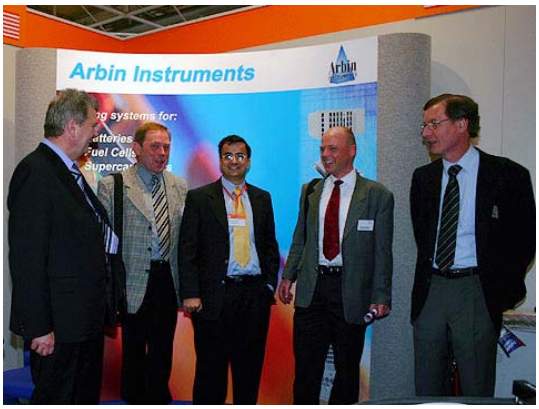
Conference News



Picture of Arbin's sales engineer, Puneet Modi (middle), with delegation from SWB Enordia at Hydrogen + Fuel Cells Hannover Fair 2004-Germany.

Photo credit: www.fair-pr.com

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Advancing Fuel Cell Technology

ARBIN INSTRUMENTS SPECIAL EDITION NEWSLETTER

One-Kilowatt and Ten-Kilowatt PEMFC Testing Systems Delivered

Recently delivered to a global automaker is Arbin's 1kW integrated fuel cell testing system for testing proton-electrolyte-membrane fuel cell. The system is one of the series of the half-million US-dollar order placed by the automaker in the last quarter of 2003. Also just delivered is a high power, high flow rate, 10-kW PEMFC testing system to a US government institution. Test results of the 10-kW system can be found on page 2 of this newsletter.

The fulfillment of these orders mark another level of achievement for Arbin as stringent and comprehensive technical system requirements are implemented in the design. Focus on safety is paramount with the implementation of multi-levels hardware and software safety features. ■

PEMFCTS-500A/5A-0/6V-1kW-20slpm anode humidifier-50slpm cathode humidifier

PEMFCTS-1000A/100A-0/50V-10kW-200slpm anode humidifier-600slpm cathode humidifier

DEW POINT TEMPERATURE CONTROLLED WITHIN ±1-3°C WITH RESPONSE TIME WITHIN 1-5°C/MINUTE