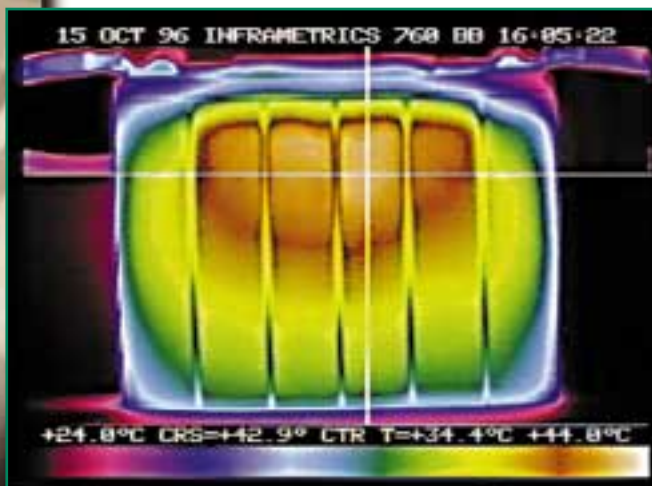


# Novel Thermal Management Techniques

The National Renewable Energy Laboratory's (NREL) Center for Transportation Technologies and Systems (CTTS) has direct experience with solving numerous thermal management and heat transfer problems. CTTS has executed projects with industry to develop innovative thermal management techniques and create cutting edge assessment tools. The capabilities and tools developed at NREL can be applied to a variety of applications and heat transfer problems. CTTS is expert in the following areas:

- Thermal and fluid flow analyses
- Steady-state and transient analyses
- ANSYS, Pro/Engineer, CAD-Key, FLOTTRAN, and Fluent software/ computer expertise
- Pressure drop and power requirement assessment
- Heat transfer coefficient analysis
- Hot wire anemometry and turbulence intensity measurements
- Infrared thermal imaging
- Thermal management system design
- Flow visualization
- Surface temperature characterization using liquid crystal paints.



*CTTS uses thermography to assess battery heat generation and temperature distributions*



Warren Gretz, NREL/PIX 04468

*CTTS uses advanced smoke tests to determine air flow distribution within a battery pack and cells*

Proper thermal management is a necessity for making dependable components that perform optimally and for improving equipment processes. The life of your components will increase, your customers will be better satisfied, and we may even help increase sales.

## Our Success Stories

- CTTS solved complex battery thermal management problems for General Motors by working with its lower-tier suppliers, Optima Batteries, AeroVironment, Bipolar Batteries, and Arias. We analyzed thermal and fluid flow behavior of hybrid vehicle battery packs and provided a specific design for the distribution system so that cool air could be distributed to all the batteries uniformly while meeting the fan power requirements.
- CTTS designed and fabricated a battery enclosure for temperature control of sodium sulfur batteries for the USABC. Using vacuum insulation, we were able to fabricate and test enclosures that met and exceeded the requirements of the USABC.

# Novel Thermal Management Techniques

Warren Gretz, NREL/PIX 04317

- CTTS invented a catalytic converter that uses variable conductance insulation to maintain warm temperatures and reduce automobile cold start emissions. The technology is being transferred to industry through a cooperative working agreement with Benteler Industries.
- CTTS worked hand-in-hand with Ford's lower-tier supplier, Johnson Controls Battery Group, to assess packaging, fluid flow, and thermal behavior of a battery pack for a low storage hybrid vehicle. We successfully provided solutions for structural components for staking batteries, battery spacing, and pressure drop/fan power requirements and fabricated a battery pack enclosure that "fit like a glove."



*CTTS conducts numerous hands-on battery tests in the laboratory to determine optimal battery thermal management for various industry partners.*



Dave Parsons, NREL/PIX 03616

*Benteler and NREL team together to develop pollution reducing catalytic converter*

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*"This is a once in a lifetime opportunity to broaden our product line and develop a product that is synergistic with other aspects of our growing business."*

*- Gary Wells; Vice President - Benteler Industries*

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## Why Choose CTTS for Your Thermal Analysis Needs?

CTTS excels in working with industry to solve tough problems. Our team is currently assisting U.S. auto manufacturers with hybrid vehicle battery pack thermal management issues. We are responsible for managing the Chrysler, Ford, and General Motors subcontracts for the Department of Energy's \$375M Hybrid Electric Vehicle Propulsion Systems Program. We have experience working with Johnson Controls Battery Group, Optima Batteries, GNB Industrial Battery Company, Arias Research, the United State Advanced Battery Consortium (USABC), and AeroVironment.

Our laboratory expertise, capabilities, and facilities are available and we look forward to working with you. We will take your thermal management problem, provide quick assessment and work to solve your problems.

*For more information on how to work with CTTS, contact:*

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