Development and Demonstration of Nanofluids for Industrial Cooling Applications

High Thermal Conductivity Nanofluids Offer Productivity Gains and Energy Consumption Reductions

Heat transfer fluids are a ubiquitous component of many industrial applications. The U.S. electric power industry and other industrial applications also use a significant volume of fluids each year for closed-loop cooling. This project targets improvements in the thermal properties of nanofluids for use as industrial-grade coolants.

Nanofluids are nanotechnology-based heat transfer fluids that are engineered to possess unique thermal properties that are drastically different from those of conventional heat transfer fluids. These properties include significantly enhanced heat transfer coefficients and strong temperature-dependent thermal conductivity. Because they possess these properties, nanofluids can be used to improve heat transfer and energy efficiency in many thermal control systems. Nanofluids are made by suspending nanometer-sized particles (such as copper oxide or aluminum) in conventional heat transfer fluids (such as water or ethylene glycol).

This project seeks to develop nanofluids that achieve thermal conductivity enhancements of 10%–50% compared to traditional fluids and develop the chemistry to scale up from one liter to the pilot-production scale of 100 liters. If successful, this project will be the first to demonstrate large-scale nanofluids production for an industrial application.

Benefits for Our Industry and Our Nation

This project will result in significant energy savings and associated emissions reductions.

Applications in Our Nation's Industry

Industrial-grade coolants are used in public utilities; the oil and gas industry; the food and beverage processing industry; the chemicals and plastics industry; solar energy conversion to electricity; and heating, ventilation, and air conditioning (HVAC) systems for buildings. In addition these fluids are commonly used as coolants in a wide variety of applications such as cooling radiators for automobiles and trucks, and power electronics for hybrid electric vehicles.

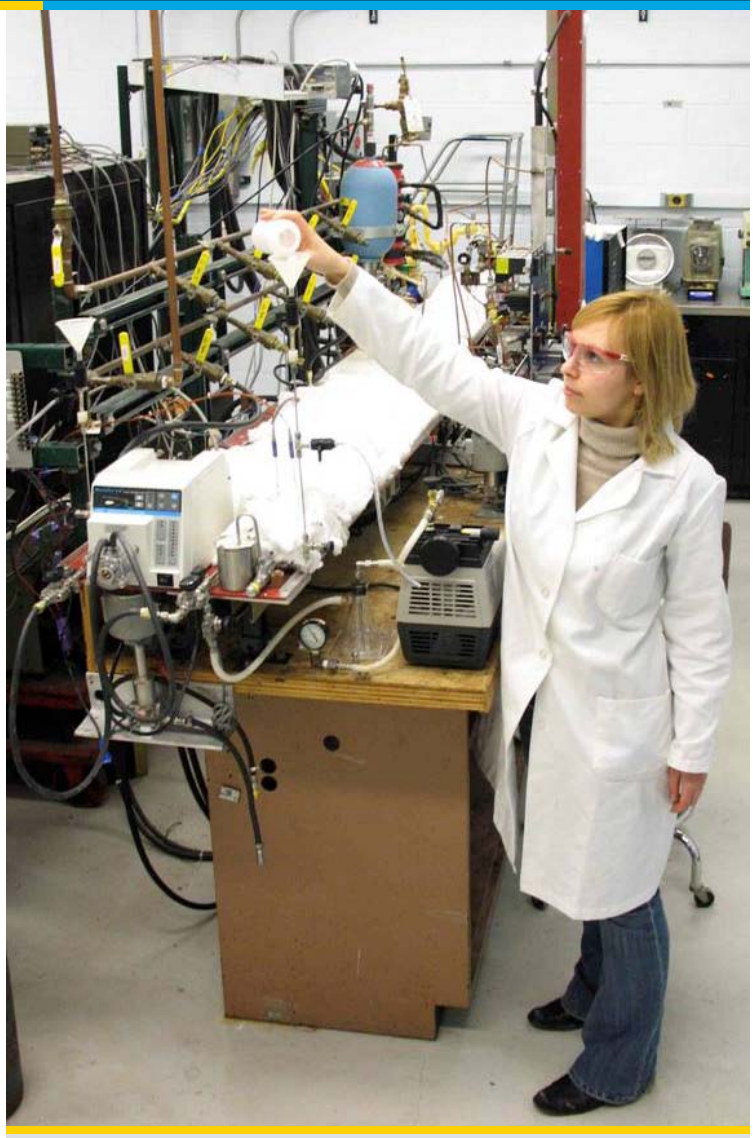

Figure 1. Chemist filling an apparatus designed to measure heat transfer coefficients in fluids

Photo courtesy of Argonne National Laboratory.

Project Description

The goal of this project is to develop a production procedure for a high heat transfer nanofluid with improved thermal properties. The procedure will be transferred to industry so that it can be scaled up to cost-effective commercial quantities while maintaining nanofluid properties.

Barriers

- Developing water-based nanofluids with the desired enhanced thermal and mechanical properties
- Ensuring that the nanofluids will consist of uniformly suspended nanoparticles

- Demonstrating that nanofluids will not adversely affect fluid viscosity or clog the flow
- Scaling up nanofluids production
- Ensuring the economic viability of nanofluids production at a commercial scale

Pathways

The nanoparticles' surface chemistry will be modified to achieve suspension, while viscosity modifiers will be utilized to maintain a low fluid viscosity. Metal, silicon carbide, oxide, and silicon nitride particles of varying shapes and sizes will be used to form nanofluids, which will then be tailored for industrial cooling applications. The nanofluids will be characterized with particular emphasis on their thermal conductivity, heat transfer enhancements, and erosion resistance. Nanofluids that have the highest thermal conductivity and heat transfer coefficients and exhibit no deleterious erosion will be down-selected for measurement of thermal resistance. The laboratory-scale production (~1 liter) of the most promising nanofluid will then be used to develop and refine a pilot-scale production process (~100 liters).

Milestones

This project started in September 2008.

- Development of candidate water-based nanofluids with optimized compositions (particle type, size and distribution, and loadings) and appropriate heat transfer properties. Decision to continue with silicon carbide (SiC)/water nanofluids (Completed)
- Measure heat transfer of nanofluids containing larger SiC particles (Completed)
- Modification of viscosity of larger particles of a SiC EG/H_2O nanofluid (Completed)
- Measurement of thermal and fluid properties of the selected nanofluid(s) and use of the results to develop the scale-up of nanofluid production facilities (Completed)
- Develop nanofluids with large thermal properties enhancements
- Transfer technology to Saint Gobain and Valvoline to enable manufacturing of sufficient nanofluids for demonstrations

Commercialization

This project aims to transfer technology to Saint Gobain and Valvoline to enable manufacturing of sufficient nanofluids for demonstrations.

Project Partners

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