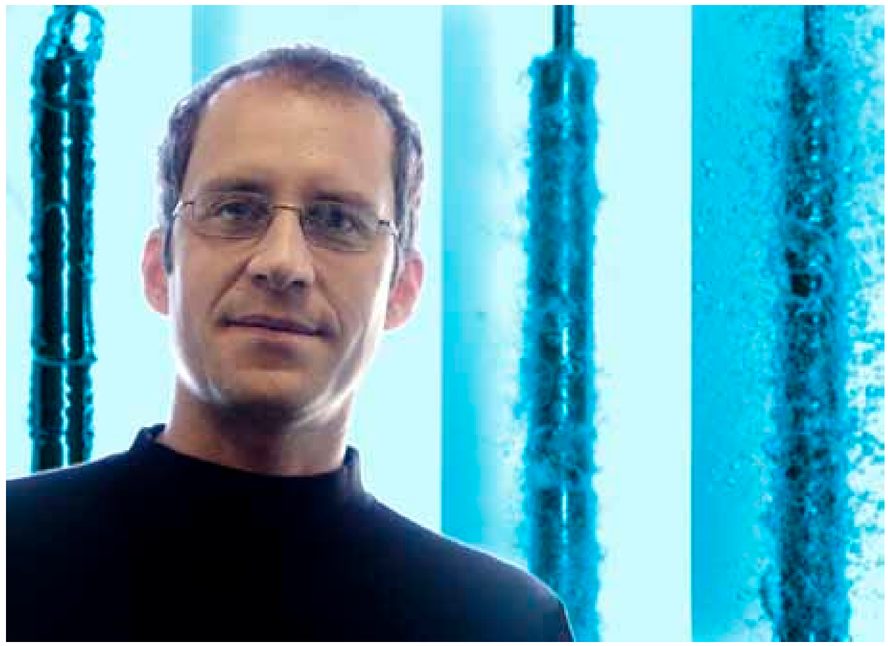
Department of Nuclear Science and Engineering
Massachusetts Institute of Technology

SPOTLIGHT ON NSE

RESEARCH

The Power of Nanofluids



One of engineering's most powerful capabilities is the improvement of existing systems through innovation—taking something that works and making it better, faster or cheaper.

Associate Professor Jacopo Buongiorno and his team at NSE, in collaboration with Dr. Lin-wen Hu of the Nuclear Reactor Laboratory, provide a perfect example. With support from donor Douglas Spreng, they are applying new materials science to the task of heat management in nuclear reactors, and making significant practical advances in reactor performance and economics.

To learn more about NSE please contact
Professor Richard K. Lester, Head
Department of Nuclear Science & Engineering
rklester@mit.edu

Background image:
Dispersion of nanoparticles in water accelerates quenching of a hot rodlet (simulating a nuclear fuel rod), a feature that may be used to improve the thermal performance of nuclear reactors

"I was struck by Prof. Buongiorno's project on nanofluids because it had the potential to have a major and immediate impact on the cost and safety of existing nuclear power plants, requiring only seed funding to take it to completion – and the results exceeded our expectations!"

— *Douglas Spreng*

Cooling processes are central to nuclear power generation, which is widely seen as an important factor in the global reduction of carbon emissions over coming decades. Most reactors today use plain water as a stand-by cooling agent for cases of core overheating, but research led by Buongiorno, the Carl R. Soderberg Professor of Power Engineering, has demonstrated that the addition of nanoparticles to the cooling water provides up to a 100 percent increase in the amount of heat that can be quickly removed from the core. The particles are tiny bits of material such as alumina and diamond, just a few hundred molecules across; researchers are exploring their use in a wide range of materials applications.

"Where this really helps is the broadening of the allowable power range during operation," explains Buongiorno. "The improved cooling capability allows a plant to increase its power output while retaining the same conservative safety margins it's always had." As a result, utility companies can get more electrical output per construction dollar with no safety tradeoffs. "Existing plants may be retrofitted to adopt this new technology if successfully demonstrated and licensed", said Dr. Hu.

Spreng's funding, provided as part of his broader support of the MIT Energy Initiative, enabled Buongiorno's team to build apparatus for research into the use of nanofluids for quenching—the plunging of a very hot object (such as a metallic sphere) into a cool fluid. The research found that the suspended nanoparticles accumulated on the surface of the object being quenched, thus destabilizing the vapor film formed around the object and greatly accelerating the cooling process.

This technology has been patented by AREVA, a nuclear technology company and research co-sponsor, which is conducting R&D for industrialization of nanofluids both in academia and at its own facilities in France, Germany and the US. "AREVA is very interested in industrial application of nanofluids, and we hope our development work will allow their consideration in our basic design. But much remains to be done, and we are approaching the subject very methodically and cautiously," said Dr. Mike Pop, International Expert Level II in Materials at AREVA.

Additional money from Spreng's original gift is now being directed to a new program, which is exploring the use of nanofluids' enhanced heat transfer abilities for in-vessel retention of melted fuel.

Spreng's enthusiastic support of interdisciplinary innovation to address long-term energy problems was an ideal fit for Buongiorno's team—and their accomplishments are providing enabling technology in the worldwide quest to reduce carbon emissions.

Written by Peter Dunn
Photo by Jonathan Sachs