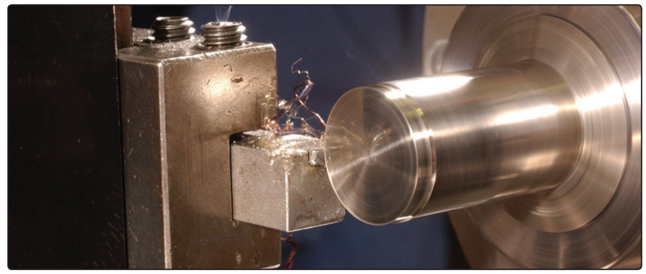
Reducing friction with nanocoatings

Friction is the bane of any machine. When moving parts are subject to friction, it takes more energy to move them. But if you could manufacture parts with tough, "slippery" surfaces, there'd be less friction, requiring less input energy and the parts would also last longer.

"When a hydraulic pump moves fluid, the friction between the turbine vanes and the housing translates into additional torque needed to operate the pump, particularly at start-up," says Bruce Cook, an Ames Laboratory scientist and co-principal investigator on the four-year, $3 million project. "It takes extra energy to get the pump started, and you can't run it at its optimum (higher speed) efficiency because it would wear out more quickly."

Coating the blades to reduce friction and increase wear resistance could have a significant effect in boosting the efficiency of all kinds of industrial and commercial pumps. According to Cook, a modest increase in pump efficiency could reduce U.S. industrial energy usage by 31 trillion BTUs annually by 2030, or a savings of $179 million a year.

Using a technique called pulsed laser deposition, Cook's team is depositing an ultrathin layer of a boron-aluminum-magnesium ceramic alloy, nicknamed BAM, on hydraulic pump vanes as well as tungsten carbide cutting tools. Eaton Corporation, a leading manufacturer of fluid power equipment, and Greenleaf Corporation, a leading industrial cutting-tool maker, are also involved in the project.



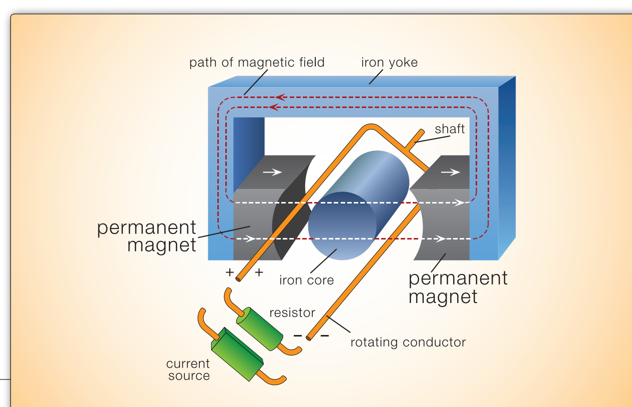
Ames Laboratory researchers Bruce Cook and Alan Russell are studying the use of a ultra-hard, low-friction nanocoating of boron-aluminum-magnesium (BAM) can extend the life of cutting tools and make pumps run more efficiently.

Initial tests at DOE's Oak Ridge National Laboratory, one of the nation's leading friction and wear research facilities, show a decrease in friction relative to an uncoated surface of at least an order of magnitude with the $AlMgB_{14}$-based coating. In preliminary tests, the coating also appears to outperform other coatings such as diamond-like carbon and titanium diboride. The project is funded by the DOE's Office of Energy Efficiency and Renewable Energy.

Boosting electric car's potential

The switch from gas- to electric-powered vehicles will come about thanks to advancements in many fields, among them magnets. Electric motors found in vehicles typically use both permanent and electromagnets. The permanent magnets provide the continuous force that rotates the electro magnets located at the motor's center. Unfortunately, ordinary permanent magnets won't work efficiently in cars. The reason: cars get hot. Common magnets made from neodymium-iron-boron lose half their power when temperatures reach 100 to 125 degrees Celsius. But an Ames Lab team led by Iver Anderson and colleagues, Bill McCallum and Matthew Kramer, created an alloy from neodymium, yttrium and dysprosium that holds most of its strength at 200 degrees Celsius.

Creating vehicle-friendly magnets was only half the battle for Anderson's team. To be commercially viable, large numbers of the magnets need to be produced cheaply and efficiently. And that required a novel production method. The researchers figured out how to process their alloy into a fine, spherical powder using what's called gas atomization. The technique first reduces the magnetic alloy into a stream of liquefied metal, which is then blasted with supersonic jets of gas. The resulting immense force causes the metal to break up into tiny droplets, which are then deposited in a mold. The process is actually a high-tech variation of injection molding, a mainstay manufacturing technique. Someday it may prove key to making zero-emission electric cars affordable to millions.



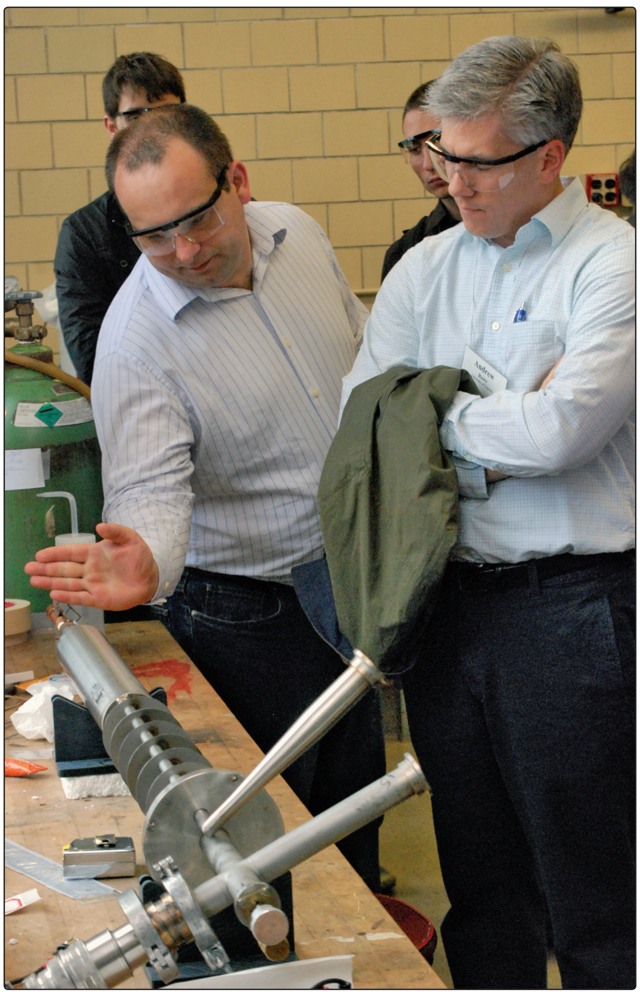
Source: Encyclopaedia Britannica, Inc.

Cooling with magnetic refrigeration

When Ames Laboratory senior metallurgist Karl Gschneidner sees a refrigerator or an air conditioning unit, he thinks of the potential energy savings these essential appliances could offer if magnetic refrigeration, a technology he's helped pioneer, becomes reality.

Magnetic refrigeration isn't a new idea. The technology is centered on the giant magnetocaloric effect exhibited by some rare-earth metals that, when placed in a magnetic field, heat up and, conversely, cool down when removed from the field. Such a system is 20 to 30 percent more energy efficient than traditional gas compression cooling and also uses environmentally benign coolants instead of ozone-depleting refrigerants.

Ames Lab and Astronautics Corporation of America built a proof-of-principle refrigerator in 1997, with Gschneidner's group developing a gadolinium-germanium-silicon alloy and also designing high-strength magnets. Since that time, more than 25 different cooling units have been built and tested throughout the world, though none of the designs has taken off.

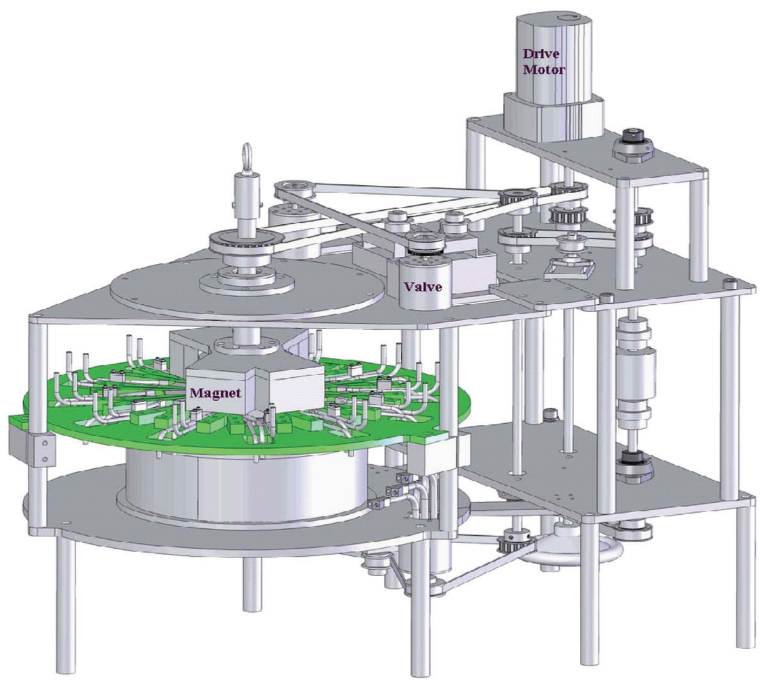


Ames Laboratory scientist Yaroslav Mudryk, left, explains how samples are placed in a calorimeter so the effect of magnetic field can be studied at low temperature during a tour of Ames Laboratory by participants in the Thermag III conference.

"At this point, it's really an engineering issue,"Gschneidner says. "We know the concept works, it's just a matter of working around some of the problems."

One of the problems is that the giant magnetocaloric materials are brittle. And because they also change volume in the magnetic field, there's a tendency for cracks to develop over time. Another problem is increasing or concentrating the strength of the magnetic field while keeping the mechanism reasonably compact and cost effective.

Gschneidner hoped to address those and other issues at Thermag III, the 3rd International Conference of IIR on Magnetic Refrigeration at Room Temperature. Hosted by Ames Laboratory and Iowa State University, 150 of the top researchers from around the world gathered in Des Moines in May to discuss emerging trends and research in the field.



This diagram shows a design by Astronautics Corporation of America for a rotary magnetic refrigerator that's 20 to 30 percent more efficient than today's gas compression designs.