Nano World: Super-insulating frozen smoke

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The world's best thermal insulators, aerogels made of necklaces of nanometer-sized beads, are starting to find their way into flexible, lightweight sheets in everything from attack helicopters to snowboarding jackets.

For instance, aerogel blankets could slash the weight of next-generation naval destroyers by up to 120,000 pounds, experts told UPI's Nano World.

Aerogels are the world's lightest solids. They often are made of as much as 99.8 percent air -- earning the materials the nickname of "frozen smoke" -- but can in theory hold up to 500 to 4,000 times their own weight.

Aerogels are made by drying wet gels under moderate temperatures and high pressures, which replace the liquids in the gels with gas, leaving behind continuous networks of strands made of nanometer-sized beads. The solid tangle of fibers and infinitesimal air pores that comprise aerogels result in excellent thermal, acoustic and electrical insulating qualities. For instance, Aspen Aerogels at Northborough, Mass., noted its silica aerogels outperform conventional thermal insulation materials by two to eight times. Aspen has products that perform in the range of -200 degrees to 650 degrees C, or -328 to 1,200 degrees F, said Aspen Director of Technical Development George Gould.

Aerogels were first invented in 1931 but were notably weak and brittle. Aspen has a patented technique for generating aerogels in a thin,

flexible, easy-to-use blanket form, developed in 1999 for NASA for use as cryogenic insulation in the space shuttle. The researchers essentially infiltrate bedding made of materials such as polyester with a silica-loaded solution and water-repellant additives, and drying at moderate temperatures and high pressures leads to blankets impregnated with aerogel, Gould explained.

Aspen is now selling roughly 5 million square feet of aerogel blankets for use in thermal insulation and expects to see $15 million to $20 million in revenues this year, Aspen Chief Executive Officer Don Young said. For instance, Aspen expects to save hundreds of millions of dollars for its liquid natural gas or LNG clients over the next five years.

"LNG is stored at -165 degrees Celsius. Keeping the product at this temperature is a major thermal management challenge, which requires a product with outstanding insulating properties. This is where we come in. By using our products, our customers have reported a 38 percent reduction in LNG boil off rate versus competitive products. This reduction translates directly into a bottom line savings of millions of dollars," said Marc Lebel, Aspen's vice president of sales and marketing.

Similarly, improved thermal insulation means smaller pipes are needed to deliver oil from subsea wells. "This has resulted in millions of dollars of savings in steel costs for our customers," Lebel said.

Aspen is also collaborating with the U.S. Army and a leading defense contractor on a kit to shield the heat signature of combat helicopters "to make them less vulnerable to heat-seeking missiles," Young said. "We expect in the course of the next six months to have these kits on about 30 helicopters."

Aspen's blankets are finding their way into jackets as well. "You could use two or three millimeters in a jacket and replace a significant volume

of down, to have something much leaner and body-forming," Young said. "There's also interesting work going on to perhaps address firefighter suits. The dream there is instead of 35 pounds of vulcanized rubber, you have something with more freedom and less weight so they can do their jobs."

In September Aspen opened a new 10,000-square-foot lab to develop next-generation aerogel materials, optimize aerogels for specific temperature ranges and improve production efficiencies to reduce costs. In 2006 they plan to begin production on a $30 million manufacturing facility in East Providence, R.I., that could expand Aspen's production capacity by at least five times to roughly 50 million square feet a year.

"The building and construction market is the Holy Grail of the insulation market, and can take up millions of square feet each," Young said.

"They're one of the most impressive nanotechnology startups we've ever met up with," said Matthew Nordan, vice president of research at nanotechnology analyst firm Lux Research in New York. "They've aimed for good, high value, low volume applications where they can charge a very, very large premium, as a way to get manufacturing volumes to a point to attack other opportunities. They've generally taken a very smart and informed approach."