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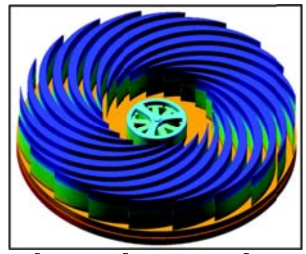
The Sandia Cooler
From LDRD to Tech Transfer



While many at Sandia are likely aware of LDRD support for the development of Jeff Koplow's air-bearing technology—perhaps even for its applicability to cooling electronics—many are also likely unaware of its deeper LDRD roots.

In reality, the roots of this notion date back to Sandia's R&D100-winning fiber laser technology, a revolutionary leap in laser efficiency, a project in which Koplow participated as team member and principal investigator in its last year. Because of their efficiency, fiber lasers converted much more of their input electrical energy to coherent light and less into waste heat. This meant that the elaborate and bulky water-based cooling systems required for traditional lasers might not be necessary for fiber lasers, thereby rendering them far more portable, particularly if they could be air-cooled.

However as Sandia follow-on projects succeeded in increasing the power of fiber lasers, it became apparent to Koplow that existing air-cooling systems would probably be unable to cope with the quantity of heat transfer that would likely be necessary, thereby defeating one of the great advantages of fiber laser technology. The wheels of his creative ideation began to turn.

Reviewing the literature, he realized that there had been no new advances in air-cooling technologies for 40 years, and he set about a theoretical engineering design study, with that end in mind. An LDRD proposal submission won him a year of support in 2009, and the outcome of that project another subsequent three years to continue development of this fundamentally new approach to air cooling.

This approach entailed solving three problems that limited the rate at which traditional fan-driven exchangers could move heat away from the source of a heat-generating device (such as a computer microcircuit board) to the external environment. First, a boundary layer of "dead" (motionless) air enveloping all surfaces of extant heat exchangers created a bottleneck. Instead of an active forcing of heat away from the heat source, some heat transfer occurred passively via diffusion—based on the intrinsic random motion of atoms and molecules that tends to transfer heat or other parameters down a gradient (in this case, from higher to lower temperature), *albeit rather slowly*. Supervening this bottleneck was a major challenge because it sets a limit on the efficiency of an air-cooler. And when one considers that such cooling (heat transfer) devices account for nearly 20% of total electricity consumption in the US, increasing that efficiency becomes a matter that transcends simply the issue of fiber laser cooling.

Second, as heat-exchanger fans move heat, they inevitably become fouled by particulates and other contaminants in the air that they are transferring. And third is the issue of fan noise as the fans necessary to exchange heat increase in size and rate of rotation, Exemplary is a window-located box fan set to move heat from the interior of one's home and out a window to the outside. In general, the larger the fan and the higher its speed, the more noise.

The solution to these challenges is Koplow's ingenious finned heat exchanger. It rotates at about 5000 rpm upon a thin (0.0001-inch) layer of air above a base-plate in contact with the device to be cooled (a computer CPU, for example); this means that the bearing for the cooler is air, rather than some mechanical structure, hence its name, "Air Bearing Heat Exchanger." The rapid rotation of this finned "impeller" pumps air centrifugally from that thin layer, transferring heat to the structure's fins, which then dissipate that heat to the external surroundings. This rapid rotation and its pumping effect eliminates 90% of the dead air bottleneck. The high-speed rotation virtually eliminates particulate fouling of the fins, and their highly aerodynamic structure reduces noise significantly.

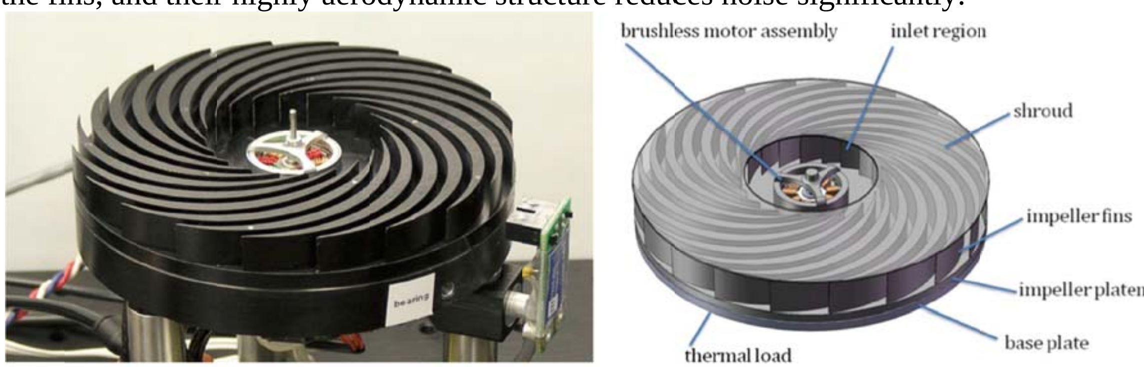


Photo (left) and diagram (right) of the heat impeller

Remarkably, the unit is only 10 cm (about 4.5 inches) in diameter and 3 cm (about 1.4 inches) in height and consumes a mere 5 Watts. Even more incredibly, the manufacturing cost is estimated at $10 per unit. It is hardly surprising, then, that Sandia has recently signed a first option on the cooler manufacture and is actively negotiating other options and full licenses. There are, of course, many technologies that can benefit dramatically from this efficient air-cooling, but foremost among them is the microelectronics industry, where, quite simply, as miniaturization of components continues in smart phones and the like, heat removal is becoming a very daunting challenge.

If Air Bearing Heat Exchanger technology proves amenable to size scaling, it has the potential to decrease overall electrical power consumption in the US by more than 7 percent. Credit LDRD, Sandia management and the inventiveness of its staff members for bringing this technology to the fore; quite appropriately, Jeff Koplow was selected by the National Academy of Engineering (NAE) to take part in NAE's 17th annual US Frontiers of Engineering symposium.

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