



PATENT



TECHNOLOGY SUMMARY

DEPARTMENT OF THE AIR FORCE TECHNOLOGY TRANSFER & TRANSITION PROGRAM OFFICE

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AFRL Engineers Heat Up with Third Patent to Keep Aircraft Cool

With continued advances in high-performance aircraft comes the need for higher-powered onboard electronics. While these technological gains may be exciting at first blush, the heat from these electronics can lead to mechanical failures within the aircraft. Several methods of dispelling this low-grade heat (20-30°C) have been employed in the past. However, a group of engineers, including two from the Air Force Research Laboratories (AFRL), have patented a process that seeks to improve upon conventional thermal management systems.

In 2013, Soumya Patnaik, PhD., and Nicholas Niedbalski, Ph.D., from the AFRL Aerospace Systems Directorate (RQ), teamed up with Douglas Johnson, and Jamie Ervin, Ph.D., of the University of Dayton Research Institute to combat the issue of high-flux, low-grade waste heat in aircrafts. Heat flux is a thermodynamic term referring to the rate of heat energy transfer through a given surface. The higher the flux, the higher the heat removal rate must be to maintain a device at its operating temperature.

TECHNOLOGY

PATENT NUMBER:

US 11,493,279 B2

TECHNOLOGY NAME:

Thermal Management Using Endothermic Heat Sink

INVENTOR:

Soumya Patnaik
Douglas Johnson
Nicholas Niedbalski
Jamie Ervin

TECHNICAL PROJECT OFFICE:

AFRL Aerospace Systems Directorate

PATENT DATE:

November 2022

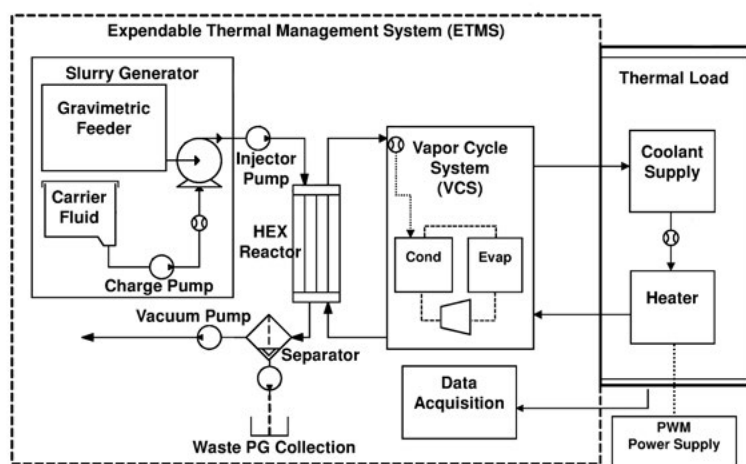
SOURCE:

US Patent and Trademark Office

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CONTACT INFORMATION:

Dr. Soumya Patnaik
soumya.patnaik.1@us.af.mil



A block diagram illustrating an apparatus used for steady-state thermal load.

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“Thermal management systems on aircrafts transport heat away from its source to the heat sink. Two of the most commonly available heat sinks on aircraft are fuel and ram air cooling,” Patnaik explained. The fuel method involves employing a heat exchanger – a system of transferring heat between a source (that is creating heat) and the working fluid (fuel). Ram air cooling is a cooling system which uses the air taken aboard an aircraft during flight.

“The technical objective of this project was to evaluate and demonstrate the feasibility, advantages, and risks of an expendable thermal management system for directed energy weapons from an integrated systems perspective,” Patnaik said. “So, we started to design a feasible thermal management system to address some of the limitations of the state-of-the-art technologies.”

The group, which had earned two previous patents for developing a thermal management system (US #10,578,369 and US #11,150,029), received this most recent patent for designing and demonstrating a heat exchanger reactor as part of a novel thermal management system.

When high-flux, low-grade heat is present in an aircraft, high-capacity cooling systems are often necessary. That can require a bulky system onboard to manage thermal energy in the form of a heat sink.

“(There are) two main advantages in our proposed method compared to these two,” Patnaik said. “First, is that our proposed method is independent of flight condition whereas fuel cooling or ram air cooling is dependent on the flight conditions. The amount of cooling available from fuel depends on the amount of fuel needed by the engine and it decreases with flight time. Similarly, the amount of cooling that can be achieved from ram air depends on its temperature and flow, which in turn depends on the flight condition,” Patnaik said.

The second advantage is that the team’s method creates an endothermic reaction – any chemical reaction that is used to absorb heat -- with Ammonium Carbamate which is converted from a solid to a gas. Then the gas dissipates. Being that chemical reactions can absorb a large amount of heat, the heat sink in this method can manage high energy and dissipate larger amounts of heat. The team found their cooling method showed a significant improvement over the previous methods but believe this is only the beginning.

“Twenty percent more cooling was shown for a specific heat load application as a way to provide a benchmark, but the method can show even higher benefit depending on applications,” Patnaik added.

It was late in 2022 when the team learned they had earned their third patent with this system improvement. “We were glad that we pursued the patent application and are also thankful to our Air Force patent attorney and AFRL Aerospace Systems Directorate (RQ) Business Development Office for all their support. At AFRL we have access to some of the best technology transfer specialists who made this *process manageable for us.*” Patnaik said.

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