READY FOR TAKEOFF: PUTTING NATURAL REFRIGERANTS INTO SPACE

The Dutch National Aerospace Centre (NLR) is crossing new frontiers by developing a hydrocarbon heat pump to cool down spacecraft. If successful the project may lead to new applications for natural refrigerants back on Earth.

– By Andrew Williams

Spacecraft are designed to take payloads into space, for use on missions or for delivery to the International Space Station (ISS). With electronic equipment becoming ever smaller, spacecraft should theoretically be able to carry larger payloads. But this poses a challenge: disposing of the waste heat given off by all this equipment.

"You have to radiate that waste heat into space. To radiate into space, you need a large surface area," says Dr. Henk Jan Van Gerner, an aerospace engineer at the NLR.

Bigger radiators are not an option, because they already determine the size of the entire spacecraft. "If you make the radiators larger, you make the spacecraft larger," Van Gerner says.

Increasing the temperature of the radiators, then, holds the key to success. The higher their temperature, the more waste heat they can radiate into space – even with their current surface area. "That's where the heat pump comes in," he explains. Heat pumps deliver higher radiator temperatures, radiating more waste heat into space and maintaining the payload at a safe low temperature.

INTO ORBIT: HYDROCARBON HEAT PUMPS

"The whole idea of the heat pump is to help you to either make the spacecraft smaller or fit more electronic equipment in the same sized spacecraft," Van Gerner says.

Operating a heat pump in spaces poses particular challenges. "We couldn't use commercially available compressors for space applications, because they're heavy. Commercial compressors are also huge. They're too large for our application. What we need is a compressor of 2-4kg, which is 10 times lighter than what is currently commercially available," Van Gerner explains.

Another issue with commercial compressors is that they are noisy. They also vibrate. "Vibration is a big problem in a spacecraft, because you have to point a signal to Earth – really accurately! If your spacecraft is vibrating, it's impossible to do that," he says.

The NLR has previous experience of putting natural refrigerant technology into orbit. It built the thermal control system for the AMS02 tracker – a large detector of cosmic particles mounted on the ISS in 2011 – using CO_2 as the refrigerant.

The NLR team's heat pump uses the natural refrigerant isopentane (R601a), a hydrocarbon. "What we needed was a very lightweight, vibration-free compressor," Van Gerner says. He commissioned Swiss firm Celeroton to design a very high-speed compressor (180,000 rpm) with 10 times lower mass than commercial compressors, yet capable of operating at comparable efficiency.

After ruling out refrigerants that are banned or being phased out under the Montreal Protocol, analysis showed that isopentane delivered the best compressor performance.

Van Gerner's team still need to overcome various challenges before sending the system into space – not least the question of its lifetime. The heat pump currently relies on ball bearings – but these only last for 20 hours. But Van Gerner is in no doubt that his team will succeed – their new prototype uses gas bearings.

Potential future applications of the space heat pump back on Earth include cooling aircraft sensors or providing air conditioning in electric cars – or anywhere else that needs lightweight, quiet, vibration-free compressors. AW