Cryogenic technologies for precision tactical and space applications

Honeywell

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Peter Iredale, Engineering Lead at
Honeywell Hymatic

Honeywell Hymatic has been at the forefront of cooling technology for infrared and sensing applications for over 50 years. Operating in some of the most demanding environments, Honeywell technology increases reliability and efficiency, whilst enabling missiles, satellites, fighting vehicles, underwater weapons and submarines to more effectively and accurately complete their missions.

Through our expertise in Joule-Thomson cryogenic coolers, linear Stirling cycle cryocoolers and compressors and extensive knowledge of long life stored energy technologies, Honeywell offers customers an integrated solution for their cooling requirements. From our dedicated cryogenic facility, we provide a bespoke manufacturing service and a responsive aftercare infrastructure to support through the lifecycle of the product.

Joule-Thomson Cryogenic Coolers and Stored Energy Gas Systems

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Joule-Thomson (J-T) coolers remain the simplest, lightest and easiest technology for cryogenic cooling across a wide range of IR sensor applications, employed in numerous global missile programmes such as, Javelin, StormShadow and ASRAAM. They provide rapid, accurate cooling, within tight space envelopes.

We offer a variety of J-T coolers that can optimise gas consumption, resulting in more efficient operation. Complimentary to this are our stored energy products that provide fuel for the J-T coolers and can utilise a variety of gas species, dependant on requirement,

throughout their typically extensive 25 year life cycle. These gas systems can often include various gas management ancillaries that control flow rates under varying ambient pressures (altitudes), temperatures and other complex environmental requirements often akin to tactical/airborne applications.

What this ultimately provides is a complete solution for cooling, gas supply and management of gases for the intended application regardless of the environmental complexities customers are often faced with.

Linear Stirling cycle cryocoolers

Designed for use in high duty applications for continuous use as a replacement for legacy cooling systems, the Linear Cryocooler offers a significantly extended life and enhanced levels of performance.

Honeywell's Linear Cryocoolers incorporate unique, patented technology from the development and industrialisation of an Oxford University design concept. This patented technology, born out of the need for extremely high reliability for space applications, offers superior durability to traditional tactical Linear Cryocoolers.

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Designed to 'fit and forget' standards, the system uses a non-contact dynamic sealing of the internal working gas, coupled with a high reliability linear electric drive, which has been proven to deliver over 120,000 hours of constant, maintenance-free operation.

Due to their durability, reliability and military-grade performance, 85% of US long life flexure

bearing Linear Cryocoolers in orbit on satellites today contain Honeywell Hymatic hardware. Other potential applications include:

- Extended operation cryogenic sensor cooling requirements;
- High efficiency compressors for space applications;
- High reliability/durability sensor cooling – radio isotope detection systems;
- Power generation for forward outposts.

Future developments and forging relationships

Under a General Support Technology Program (GSTP), funding from the European Space Agency (ESA), a consortium of Honeywell Hymatic, Rutherford Appleton Laboratory (RAL) and Thales Alenia Space UK are now working on the next generation of long life Linear Space Cryocoolers for Europe. Cryocoolers such as these are critical to future Earth observation missions where the need for high resolution IR sensing needs to be balanced carefully against the satellite payload size, weight and efficiency. ESA identified the need to push technology of Cryocoolers with respect to size, weight and efficiency after benchmarking US Space Cryocoolers as world leading, including those supplied by Honeywell. The program, currently at its mid-point of a 3 year schedule, promises to deliver engineering qualified units to ESA that will be market leading within Europe, with respect to low mass/size and high efficiency, whilst maintaining the long life heritage required for said applications.

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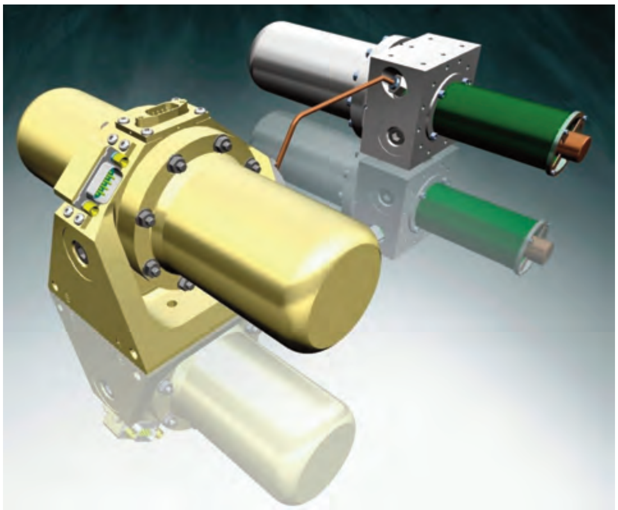
Our relationship with RAL is yielding further development of products for tactical/commercial applications. The Cryogenics team at RAL has a long established heritage in the field of long life Space Cryocoolers, working with ESA and the UK Space Agency. Recently RAL have been developing a Small Scale Cryocooler for use in miniature space satellites, pushing the space envelope ever smaller. Honeywell Hymatic, seeing an opportunity with this design, has taken the technology and is applying our manufacturing techniques to ensure a version can be produced for tactical and commercial IR applications without the high costs traditionally associated with space applications. However this does present an opportunity for space applications in the respect that a Cryocooler may be taken from a standard production run, and with a minimal increase in testing and quality control, supplied to a space customer for a much reduced cost over traditional Space Cryocoolers. The key with this philosophy is sustainability of source product and their manufacturers. The space market represents very low quantities of product per annum, whereas the volumes for tactical/commercial coolers are far greater and often the technology cannot read from one to the other. This is a dichotomy that Honeywell Hymatic is working to break with the Small Scale Cooler.

Honeywell Hymatic employs a dedicated team of specialised engineers and technicians with a combined experience of more than 300 years in cryogenic products. We continue to invest in developing leading-edge technology, working in partnership with our customers, to offer effective solutions based on our mission proven expertise.



For more information on our full product range, please visit our website: https://Aerospace.honeywell.com/cryogenic-cooling

To speak to one of our sales or engineering team, please feel free to contact us on the details below.

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Harnessing new technologies for the defence sector

Professor Neil Stansfield, Quantum Programme Strategic Lead at The Defence Science and Technology Laboratory, explains how new technologies such as cryogenics are making game-changing impacts in the Defence sector…

Traditional cryogenics has long had an important role in defence and security. A wide range of instruments for remote sensing require cryogenic cooling, for instance in forward looking infra-red cameras and sensors. Nuclear Magnetic Resonance spectroscopy, used for the understanding and identification of materials, relies on superconducting magnets cooled by liquid helium. Cryogenic fuels (especially liquid hydrogen and oxygen) are commonly used propellants for space vehicles to launch satellites into orbit and liquid nitrogen is used in the transport of large quantities of food to regions like areas requiring humanitarian aid.

Whilst these interests remain, a new area of harnessing the "super-cold" has opened up, with significant implications for our defence and security capability based on quantum technology: "cold atoms".

Within the Ministry of Defence we put a significant focus on assessing how new technologies are expected to have game-changing impacts for UK defence and security. The potential to use quantum technologies was identified a number of years ago as having the possibility to open up entirely new capabilities for defence and security in a range of areas, including timing, navigation, and sensing. This could be the second 'quantum revolution' – following that from the first half of the 20th century, which eventually produced technologies such as miniature integrated circuits in computers and application specific chips, superconductors, lasers, nuclear energy, thermal imagers and digital cameras.

Many of these new quantum technologies are based around ultra-cold atoms cooled with lasers. By confining a small number of atoms in a magneto-optical or optical dipole trap and scattering laser light off the trapped atoms, detuned from an optical resonance in the atom, we can almost eliminate their momentum in the rest frame of the trap resulting in clouds of atoms at a temperature of tens to hundreds of micro-Kelvin. A new way of super-cooling. The original work on cold atoms resulted in the 1997 Nobel Prize in physics. Once atoms are cooled to these temperatures, interactions of these ultra-cold atoms with their environment can be interpreted using quantum physics to make possible some brand new capabilities.

At their lowest energies the atoms become the coldest known bodies in the universe and move extremely slowly, a few millimetres per second compared to about 1.9 km/sec for H_2 at room temperature. Therefore they are highly sensitive to changes in the local magnetic and gravitational field. Their lack of movement also makes them ideal for atomic clocks, which utilise the ultra-regular absorption and release of radiation by their electrons during energy shifts, as a highly accurate pendulum. Current atomic clocks are limited by the occasional collision of atoms within the clock. Laser cooling the atoms until they are nearly stationary significantly reduces this effect.

Since this early identification of the possibilities of quantum technologies, the Ministry of Defence has built a significant exploitation programme to harness the UK's world leading capability in quantum technologies, with a specific focus on cold atoms.

An investment of £270m in quantum science by the UK government was announced in the 2013 Autumn Statement to support significant UK research activity. The launch of 4 Quantum Technology Hubs at UK universities was announced to explore the properties of quantum mechanics and how they can be harnessed for use in technology. In May 2014, the Defence Science and Technology Laboratory (Dstl) and the National Physical Laboratory showcased some of the new quantum technologies, which are expected to give greater resilience and better performance in positioning, navigation and timing than traditional alternatives such as GPS or conventional inertial navigation systems. Now in 2016 we have a national UK quantum technology programme of around £350m over 5 years, 10% of which is invested from the Ministry of Defence's research programme.

Whilst there are some significant obstacles, it's exciting to see how well placed the UK is on the global stage to address the significant technical and systematic challenges that remain in commercialising quantum technologies and accelerating exploitation.

The potential impact of quantum technology on military activities could be significant – bringing the accuracy of a submarine's navigation under the oceans (denied of GPS signals) from kilometres to hectometres, allowing individual soldiers underground or in buildings to know where they are to within centimetres or to use electric field or gravitational sensing to look underground or through walls to identify hidden adversaries or subterranean tunnels.

Currently, Dstl is conducting research with university and industry partners focussing on increasing optimal performance, investigating miniaturisation procedures and looking at the potential use of new technologies. With the first prototypes due to be demonstrated over the next few years, this could provide new options for the conduct of defence operations in the future.

The defence industry often acts as a pioneer in the development of new technologies and the UK is bringing about a new technological revolution in timing, navigation and sensing that could revolutionise military, defence and civilian operations.

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