Closed Cycle Refrigerator Systems at ISIS

C. Chapman, R.A Major, J. Keeping, B.E. Evans, R. B. E. Down, O. Kirichek, Z. A. Bowden
ISIS Facility, STFC, Rutherford Appleton Laboratory

Sample Rotation in top loading CCR's

Sample rotation can be offered by using the rotation stage on the right; this is a VCScience rotary platform (ISI) patterned that utilises a Renishaw rotary encoder ring. The platform is controlled by a Mckean motor drive crate and remotely via a Labview VI and can deliver rotational accuracy of 0.01° per step and 0.01° Feedback.

Extending the temperature range of top loading CCR

The top loading CCR can be normally operated between 4K and room temperature; to extend its range two devices are offered currently these are the "Hot Stick" and 1K insert.

The Hot Stick shown above left is produced in house and consists of a copper sample holder that houses 2 Watlow Fire rod 100W 100V heaters and a PT100 sensor; the heating element is thermally insulated by ceramic spacers and 2 thermal shields can be attached to reduce temperature gradient. The device has been successfully used up to 700K; it should be noted that exchange gas needs to be removed from the top loading CCR before any hot work begins.

The 1K insert shown above right is supplied by Ice Oxford, it is a continuous flow device that uses liquid Helium. The 1K insert is installed into the top loading CCR and cooled to 100K by exchange gas, the exchange gas is then removed. A low loss transfer line fed from a 100L liquid helium dewar is then coupled to the insert and cooling begins. Helium liquid is fed to a 4K reservoir which in turn feeds a 1K pot. The 1K pot is then pumped upon to achieve continuous temperatures of 1.25K.

A cryogen free cryostat for neutron scattering sample environment

The design combines a top loading cryogen free system with a helium condensation loop. The Pulse tube refrigerator (PTR) is a Sumitomo RP-82B. High purity helium gas is supplied to the system at 1.1 bar via a liquid nitrogen cold trap. The gas passes through a filter and is pre-cooled on the 1st stage of the PTR. From here it is cooled further on the 2nd stage regenerator heat exchanger; this heat exchanger sits on the regenerator tube of the PTR. After the regenerator heat exchanger the helium gas flows through the 2nd stage heat exchanger; this heat exchanger consists of a copper capillary coiled and hard soldered around a copper former and is thermally connected to PTR's 2nd stage.

After pre-cooling in the 2nd stage heat exchanger the helium gas condenses in a liquid helium chamber which is attached to the PTR 2nd stage. From the chamber the liquid helium is fed into the VTI heat exchanger via an automated cryogenic valve. The liquid helium enters the VTI heat exchanger where it evaporates and is evacuated through the VTI annular pumping space. The system has a temperature range from 1.8K to 300K with cooling power in excess of 200mW at 1.8K; the systems temperature range can be extended to ultra low temperature by using a Felhinova dilution refrigerator insert.

The systems test results are shown below.

Cryogen Free Ultra Low Temperature

Shown here is the pulse tube based E18 cryogen free high powered dilution refrigerator.

The system has a base temperatures of 20mK and has a cooling power measured at 400mW at 120mK.

The system takes on challenging work that current dilution refrigerator systems at ISIS struggle with; examples of the science studied using this fridge are the further exploration of the Helium 4 super solid phenomenon and high pressure studies using clamped cells.

The E18 dilution fridge has been constructed with reinforcing supports from the 1st stage of the pulse tube to the mixing chamber. The fridge itself has been built to take samples of up to 20Kg in mass.

The system has further benefits in that it is completely oil free, its operation is fully automated and computer controlled.