Upgrading the Helium Liquefaction Centre

The Helium Liquefaction Centre of Grenoble, situated at the Institut NÉEL, is the largest in France. Each year, about 400 000 litres of liquid helium are distributed to CNRS and university laboratories as well as to the large European research facilities in Grenoble – the European Synchrotron Research Facility (ESRF) and the Institut Laue Langevin (ILL) neutron source. The recent strong demand for more liquid helium has incited us to undertake a major upgrade of our installation and, at the same time, to implement new possibilities for improving its energy performance.

Since 1996, the centre's installation has consisted of two helium liquefiers, both of them using the Air Liquide company's "HELIAL" technology, an adaptation of rotary-screw compressor techniques to the case of helium. The compressor is an essential element in a helium liquefaction installation. Helium gas is cooled by a sequence of compression and expansion cycles. In each cycle, the gas is compressed, which heats it; the heat is extracted via a circulation of oil (which is injected into the gas and cooled in a heat exchanger). An adiabatic and isentropic expansion then cools the gas to a lower temperature.

Our principal liquefier, purchased in 1986, can produce 100 litres/hour and, with various improvements, continues to operate satisfactorily. The second, smaller liquefier has a longer, more complex history- it had been used in the early 1980's in a collaboration with Air Liquide as a test vehicle for their rotary-screw compressor technology. In 1996, a new HELIAL cold box was adapted onto the compressor used in those tests and this liquefier could then produce 60 l/h. It has been used principally as a backup during periods when the bigger Helial is stopped for maintenance or repairs.

In the last ten years, demand has been consistently around 400 000 litres of liquid helium per year. The Helial 100 l/h liquefier can meet the demand but the older liquefier (60 l/h) was becoming inadequate when operating alone as a backup for long periods. Moreover, it was becoming increasingly difficult to maintain its outdated compressor stage, and it had a very high electrical power consumption. The liquefaction facility consumes a total of 2000 MWh of electricity per year. The 60 l/h liquefier consumes 3.6 kW/litre, the 100l/h liquefier only 1.8 kW/litre. There is a potential energy gain here of 475 MWh per year.

Consequently, the liquefaction service undertook a study of ways to upgrade its installations, including an objective of improving the overall energy efficiency. The solution chosen was to replace the older screw compressor, on the 60 l/h liquefier, with a new compressor in order to boost this liquefier's output to more than 100 l/h. In addition, the new compressor would have a frequency variator allowing us to adapt its speed, and thus its energy consumption, to liquid helium production rates.

Though modified somewhat for helium liquefaction, these rotary-screw compressors are actually standard apparatus used in the industrial refrigeration sector. Their constructors can propose a heat exchanger that recuperates the calories generated during the compression phase, in order to heat a building for example. This feature had never been tested on a helium compressor, but the heat produced by the adiabatic compression of helium is potentially very large, because of its high Cp/Cv ratio. We calculated, that for our installation, the energy recuperation potential from this source would be 100 MWh thermal per year. So, it was decided to equip the new compressor with a heat recuperation system.

***Fig. 1**: Arrival of the new helium-gas compressor in the helium liquefaction centre's building at the Institut NÉEL.*

Other improvements to the installation have been made or are in course, such as optimising the working sequences, and installing an energy management system. With these improvements, a 33% overall energy economy (electricity and heating) is predicted.

The upgrade work, started in the autumn of 2015 has been combined with replacement of the automatic control systems and the electrical bays for the two liquefiers, and also a renovation of the rooms containing the helium-recuperation compressors. This work was carried out over 5 months without interrupting liquid helium deliveries and helium gas recuperation.

At present, the new installation is in the trial phase. The upgraded liquefactor is close to attaining its design performance, and the building-heating facility will be tested over the 2016-2017 winter.

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FURTHER READING...

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