

Improvement Proposal for Helium Refrigerators Based on Experience of Wolsong Tritium Removal Facility (WTRF) at Nuclear Power Plant

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1. Introduction

Korea Hydro & Nuclear Power (KHNP) has been operating the Wolsong Tritium Removal Facility (WTRF) since its completion in 2007. The main equipment of WTRF, the Helium Refrigeration System (HRS), is experiencing performance degradation issues with heat exchangers. To compensate for the reduced heat exchange efficiency, the output of the helium compressor is increased until reaching final capacity, and then the unit is shut down then helium purification operation before being restarted for use.

Australia's first Cold Neutron Source (CNS) is a major asset to its nuclear research program. The CNS, and associated helium refrigerator, was commissioned in 2006 and is operated at the Open Pool Light Water nuclear reactor (OPAL). The OPAL CNS operates a 20K, 5 kW Brayton cycle helium refrigerator.

The OPAL CNS confirms similar problems related to the use of HRS. They propose methods for gas analysis (Figure 1) and helium compressor usage (Figure 2) as well as mention components that arise when Compressor oil degradation (Figure 3). In the case of WTRF, it was confirmed that the assumption that hydrocarbon gas could occur in the lubricant, which was expected to be difficult to analyze, can indeed happen.

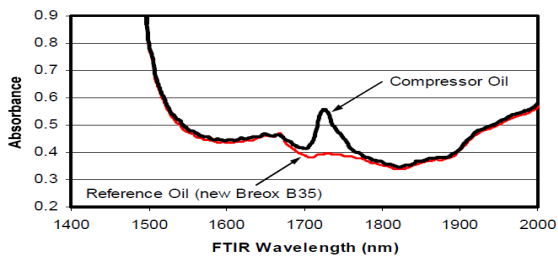


FIGURE 1 FTIR analysis of new and oxidized Breox B35

As a result the following changes have been made:

- A significant lowering of the compressor high temperature warnings and trip to 90 C.
- On-line vibration analysis at strategic points on the gas end.
- On-line trending of gas flow with respect to rotational speed [6].

On top of this the following practices have been adopted:

- A program of periodic helium analysis that looks for hydrogen and carbon monoxide, as indicators of oil degradation.
- The adsorber charcoal inventory is renewed or regenerated after a compressor gas end failure, in order to minimize risk to the turbine during subsequent operation.

FIGURE 2 Lessons Learnt by OPAL CNS

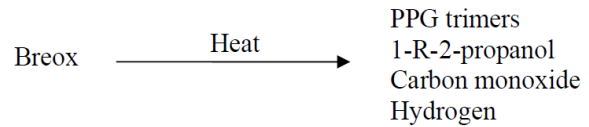


FIGURE 3 Degradation of Compressor Oil

2. Materials and Methods

Gas analysis-based monitoring is accurate but time-consuming and may result in leaks due to additional equipment. Therefore, we sought ways to confirm and remove hydrocarbons by using helium temperature at the outlet of the helium compressor and heat exchanger efficiency that can be verified with existing facilities.

By configuring a cooling system capable of maintaining the temperature of the helium compressor below 90 degrees Celsius and monitoring the heat exchanger efficiency, it is possible to predict real-time generation of carbonaceous gases such as hydrocarbons adsorbed on the heat exchanger. If abnormal gases are generated, a low-temperature helium flow can be formed at the entrance section of the heat exchanger installed with an adsorption device having an inlet above 150 K and an outlet below 150 K to prevent the entry of abnormal gases into the heat exchanger.

In addition, a configuration was added to charge nitrogen to prevent oxygen from coming into contact with compressor oil and oxidizing in the storage tank for compressor oil.

3. Results and Discussion

HRS is expected to have increasing applications in hydrogen liquefaction, isotope separation, nuclear fusion power plants, and quantum computers. Since there is an approximately ten-day period between shutdown and startup of equipment, maintaining continuous operation is crucial. The method presented above can be one way to maintain continuous operation, and we plan to verify its effectiveness through changes in operating methods at Wolsong Tritium Removal Facility (WTRF) and simulations.

REFERENCES

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