TAIYO NIPPON SANSO
The Gas Professionals

May 8, 2013

News Release

Market launch of the world's first turbo refrigerator used for cooling superconducting power equipment

Taiyo Nippon Sanso Corporation (TNSC; President: Shinji Tanabe) announces the development and market launch of its new turbo refrigerator that uses neon gas as a refrigerant and is capable of cooling superconducting power equipment to -200°C and below.

1. Background of Development

The need for refrigerators suitable for cooling superconducting power equipment is increasing as commercial research commences for this type of equipment, which is anticipated to play a key role in the development of energy-saving power technologies. It is thought that cooling capacity ranging from 2kW to 10kW is necessary to reach temperatures close to -200°C, the operating temperature range of refrigerators used for cooling superconducting power equipment. However, the cooling capacity of commercial cryocoolers is 1kW or less. In addition, such units require regular maintenance due to the inclusion of rubbing parts.

TNSC manufactures and operates cryogenic facility technology, including air separation plants and liquefaction units. Based on its technology, TNSC has developed a 2kW turbo refrigerator that has a long maintenance interval and is suitable for cooling superconducting power equipment.

Furthermore, the New Energy and Industrial Technology Development Organization (NEDO) supported the development of such refrigerators by undertaking the Technological Development of Yttrium-based Superconducting Power Equipment Project (from April2008 to–March 2013). This project enabled TNSC to develop a turbo refrigerator used for cooling the world's first 2MVA superconducting transformers, contributing to the successful supply of electrical current.

2. Overview of the Device

The new turbo refrigerator improves efficiency and reliability thanks to the adoption of neon gas and magnetic bearings. Consequently, this machine is the world's first to use neon gas as a working fluid for cooling superconducting power equipment. This machine also uses the Turbo-Brayton Cycle with a particular eye to reducing refrigerator maintenance.

The new turbo refrigerator enhances turbo machine efficiency and reliability owing to refrigerants that use neon gas, which has a molecular weight heavier than that of helium gas.

In addition, the turbo-compressor and turbo-expander, which are the main components of the new turbo refrigerator, incorporate magnetic bearings. Magnetic bearings use electromagnetic force to levitate the rotating machine shaft. This design eliminates any mechanical contact between the shaft and bearing surface, realizing a maintenance-free rotating machine.

Until now, the cooling capacity of conventional cryocoolers was adjusted using an electric heater installed within the refrigerator. However, the cooling capacity of the new turbo refrigerator can be adjusted by regulating the turbo-compressor's rotational speed, which significantly improves efficiency during partial load operations.

3. Future Development

There is currently a global upswing in projects for developing superconducting power cables and other related power equipment. Against this backdrop, the market release of the world's first turbo refrigerator is a significant step forward in the development of practical applications for superconducting power equipment. TNSC plans to enhance its product lineup by the end of the current fiscal year with the development of a 10kW turbo refrigerator suitable for cooling long-distance power transmission cables.

Note: Turbo-Brayton Cycle

The basic Brayton Cycle generates cooling power through four processes: 1. adiabatic compression; 2. cooled at constant pressure; 3. adiabatic expansion; and 4. heated at constant pressure. The Turbo-Brayton Cycle involves processes 1. and 3. within the turbo machine (turbo-compressor and turbo-expander).

After neon gas compressed by the turbo-compressor expels the heat generated by compression into the atmosphere, adiabatic expansion occurs in the turbo-expander, thus lowering the temperature of the neon gas. Following this, the neon gas absorbs the surrounding heat, which flows back into the turbo-compressor inlet. In an actual refrigerator, a heat exchanger is inserted between the turbo-compressor and turbo-expander, which recovers cold energy to produce extremely low temperatures.

External view of the new turbo refrigerator (prototype)