

ABSTRACT

Approaching to commercializing of High Temperature Superconducting (HTS) power applications is becoming more active. And cooling system is very important and essential for practical HTS power applications. HTS power applications on commercial scale will require cooling system which has cooling capacity from 2kW to 10kW at 65K, high reliability (long maintenance interval) and compactness. **Taiyo Nippon Sanso Corporation (TNSC)** is developing a turbo-Brayton cycle refrigerator using neon gas as working fluid (Neon-Refrigerator) for HTS power applications. And a 2kW class Neon-Refrigerator has been marketed in May 2013. Some Neon-Refrigerators were supplied for cable projects in Japan. Furthermore, development of 10kW class Neon-Refrigerator is under going. Detail of commercial type 2kW class Neon-Refrigerator and present status of development of 10kW class Neon-refrigerator will be introduced in this presentation.

BACKGROUND

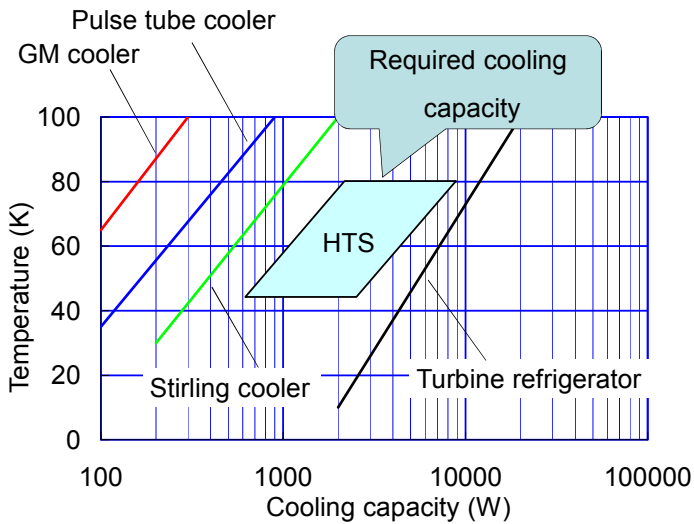


FIGURE 1 Cooling capacity and cooling temperature for HTS applications

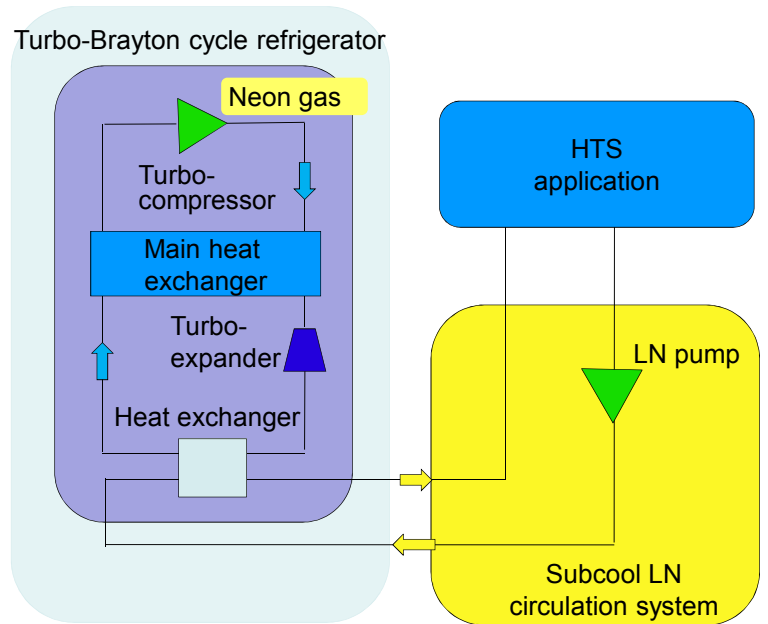


FIGURE 2 Turbo-Brayton cycle cooling system for HTS applications

Key point of HTS cooling system

1. Cooling capacity is required 2 kW to 10 kW at 65 K
2. Continuous operation (Maintenance free)
3. High performance (High Carnot efficiency)
4. Compactness

COMMERCIALIZATION

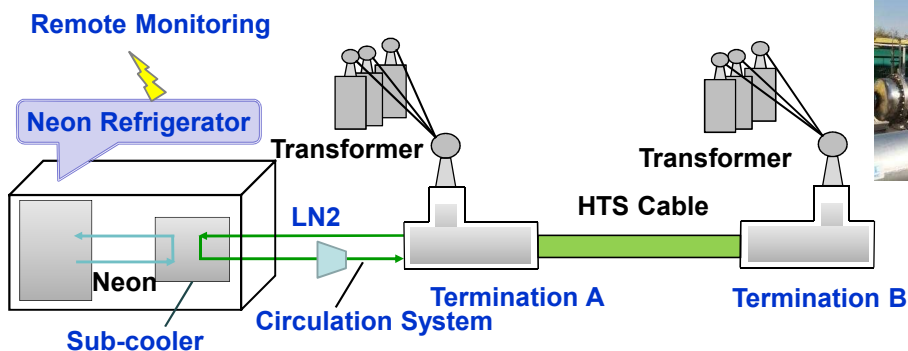


FIGURE 3 TNSC's scope for HTS applications



TNSC supplied Cooling System to Furukawa electric's HTS cable demonstration in China which was supported by NEDO.



TAIYO NIPPON SANSO
The Gas Professionals

NeoKelvin-Turbo 2kW

- Low Maintenance Cost
 - No rubbing parts turbo-expander & turbo-compressor with magnetic bearings.
- Energy Save & Precise Temperature Control
 - No heater power for refrigeration temperature control
 - Cooling power control by turbo-compressor rotational speed
- Easy Installation & Operation
 - Just only connecting Liquid nitrogen, cooling water and power supply
 - Automatically operation at start up, cooling down and temperature control

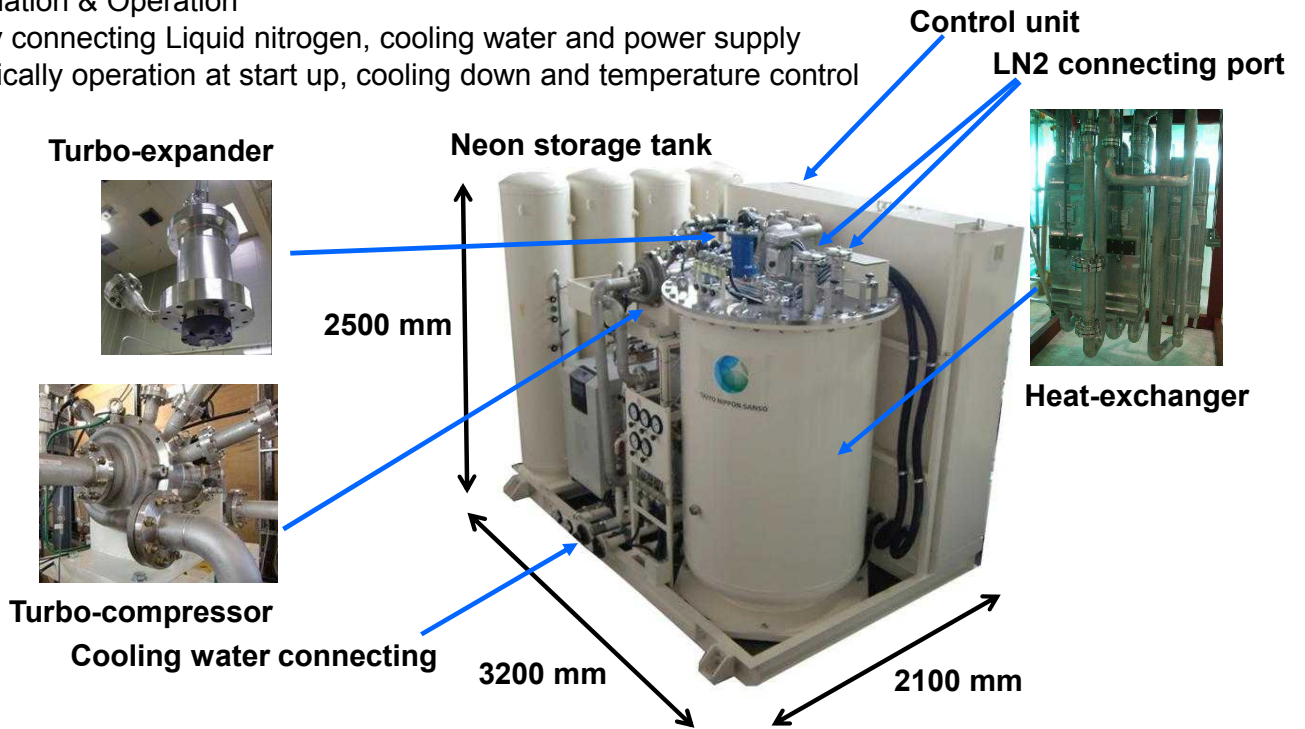


FIGURE 4 Picture of NeoKelvin-Turbo 2kW

Model of NeoKelvin-Turbo 2kW and 10kW will be exhibited at booth No.214 in Cryo Expo.

TABLE 1 Specification of the NeoKelvin-Turbo 2 kW

Cooling Temperature	70 K
Cooling capacity	2 kW
Process pressure	0.5 MPa / 1.0 MPa
Neon gas flow rate	0.3 kg/s
Motor input power	50 kW
Cooling water flow rate	200 L/min

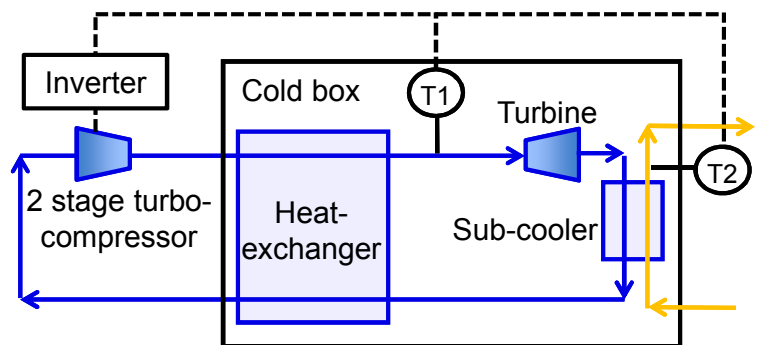


FIGURE 5 Temperature control of NeoKelvin-Turbo

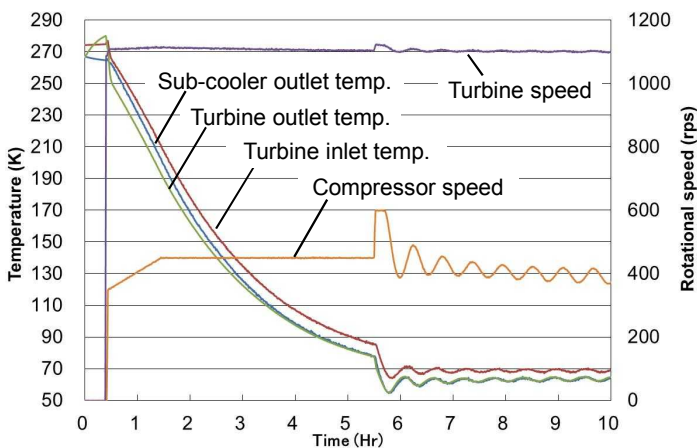


FIGURE 6 Startup and cooling down operation

FIGURE 7 Cooling capacity

Development of NeoKelvin-Turbo 10kW

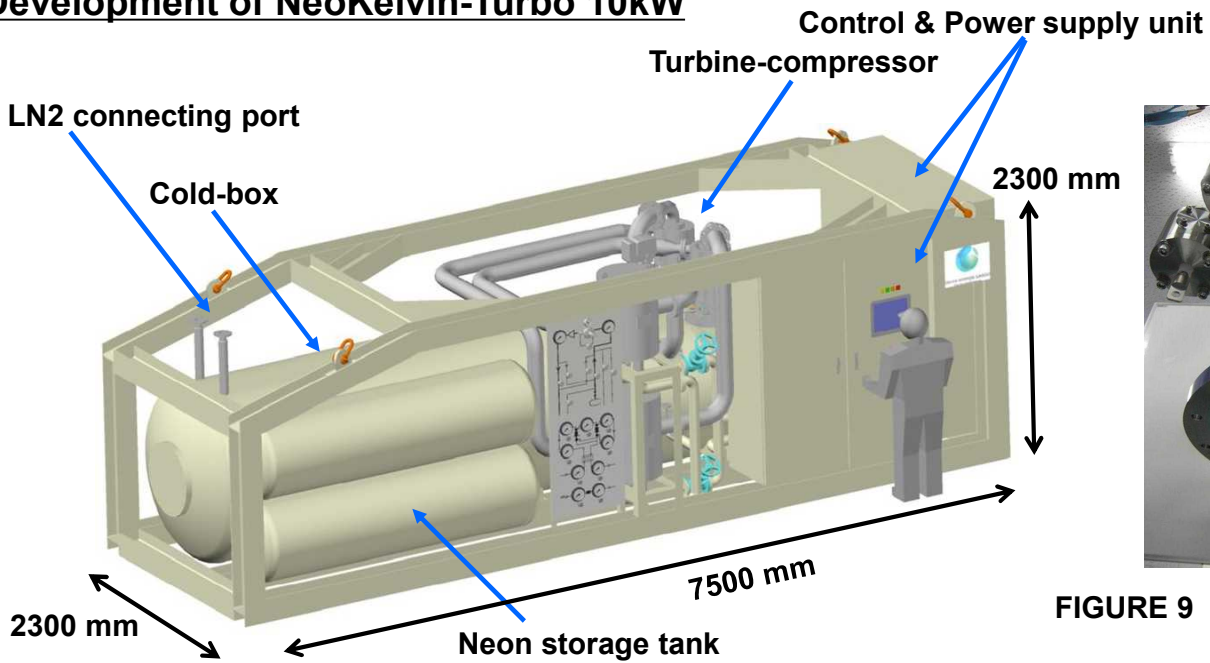


FIGURE 8 Image of NeoKelvin-Turbo 10kW



FIGURE 9 Turbine-compressor

TABLE 2 Prospective Specification of NeoKelvin-Turbo 10 kW

Cooling Temperature	70 K
Cooling capacity	10 kW
Process pressure	0.5 MPa / 1.0 MPa
Neon gas flow rate	0.96 kg/s
Input power	125 kW
COP (Coefficient of performance)	0.08

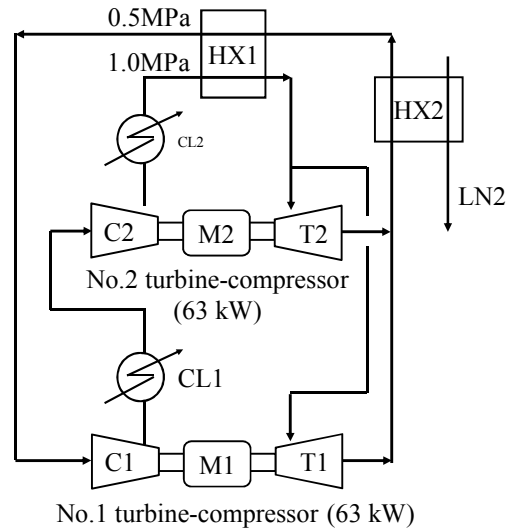


FIGURE 10 Flow diagram of NeoKelvin-Turbo 10kW



FIGURE 11 Prototype NeoKelvin-Turbo 10kW

FIGURE 12 Present status of performance test

Reference

1. "Sub-cooled liquid nitrogen cryogenic system with neon turbo-refrigerator for HTS power equipment", S.Yoshida, et al., in Advances in Cryogenic Engineering 59B (2014) 1246-1253
2. "Development of a turbine-compressor for 10 kW class neon turbo-Brayton refrigerator", H.Hirai, et al., in Advances in Cryogenic Engineering 59B (2014) 1236-1241
3. "Development of neon turbo-compressor with LN sub-cooler for HTS power equipment", H.Hirai, et al., in Proceedings of the Twenty-Fourth International Cryogenic Engineering Conference and International Cryogenic Materials Conference 2012 (2013) 83-86
4. "Neon turbo-Brayton cycle refrigerator for power machines", H.Hirai, et al., in Advances in Cryogenic Engineering 57 (2012) 1672-1679