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

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

FIGURE 1 Cooling capacity and cooling temperature for HTS applications

FIGURE 2 Turbo-Brayton cycle cooling system for HTS applications

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.
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

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling Temperature</td>
<td>70 K</td>
</tr>
<tr>
<td>Cooling capacity</td>
<td>2 kW</td>
</tr>
<tr>
<td>Process pressure</td>
<td>0.5 MPa / 1.0 MPa</td>
</tr>
<tr>
<td>Neon gas flow rate</td>
<td>0.3 kg/s</td>
</tr>
<tr>
<td>Motor input power</td>
<td>50 kW</td>
</tr>
<tr>
<td>Cooling water flow rate</td>
<td>200 L/min</td>
</tr>
</tbody>
</table>

FIGURE 4 Picture of NeoKelvin-Turbo 2kW

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

FIGURE 5 Temperature control of NeoKelvin-Turbo

FIGURE 6 Startup and cooling down operation

FIGURE 7 Cooling capacity
Development of NeoKelvin-Turbo 10kW

TABLE 2 Prospective Specification of NeoKelvin-Turbo 10 kW

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling Temperature</td>
<td>70 K</td>
</tr>
<tr>
<td>Cooling capacity</td>
<td>10 kW</td>
</tr>
<tr>
<td>Process pressure</td>
<td>0.5 MPa / 1.0 MPa</td>
</tr>
<tr>
<td>Neon gas flow rate</td>
<td>0.96 kg/s</td>
</tr>
<tr>
<td>Input power</td>
<td>125 kW</td>
</tr>
<tr>
<td>COP (Coefficient of performance)</td>
<td>0.08</td>
</tr>
</tbody>
</table>

FIGURE 8 Image of NeoKelvin-Turbo 10kW

FIGURE 9 Turbine-compressor

FIGURE 10 Flow diagram of NeoKelvin-Turbo 10kW

FIGURE 11 Prototype NeoKelvin-Turbo 10kW

FIGURE 12 Present status of performance test

Reference