Overview on AL-AT cryogenic solutions under 4.5K

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Content

- Helium Refrigeration below 4.5K: why?
- Overview of Past projects below 4.5K with AL Technologies
  - Technical approaches
- Ongoing projects
  - JT60SA
  - TARLA
- Conclusions
Helium refrigeration below 4.5K: Why?

- Need of cold power under 4.5 K for different applications:
  - Cryopumps
  - Superconducting cavities
  - Superconducting magnet
  - Use of He II: superfluid properties
Past Projects below 4.5K with AL technologies 1/3

From 1980 to 1990

<table>
<thead>
<tr>
<th>Project</th>
<th>Tore Supra</th>
<th>CEA SBT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHe Bath temp</td>
<td>1.8 K</td>
<td>1.8 K</td>
</tr>
<tr>
<td>VLP Flow</td>
<td>14 g/s</td>
<td>6 g/s</td>
</tr>
<tr>
<td>Nb of Cold compressors</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>VLP Warm compressor</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
From 1990 to 2010

<table>
<thead>
<tr>
<th>Project</th>
<th>CEBAF</th>
<th>SNS</th>
<th>CERN CCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHe Bath temp</td>
<td>2 K</td>
<td>2.1 K</td>
<td>1.8 K</td>
</tr>
<tr>
<td>VLP Flow</td>
<td>237 g/s</td>
<td>120 g/s</td>
<td>126 g/s</td>
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<tr>
<td>Nb of Cold compressors</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>VLP Warm compressor</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
From 2000 to 2010

- Smaller projects with few cavities:
  - No cold compressors
  - With or without cold recovery
  - The Helium refrigerator works as a pure liquefier → HELIAL L product
  - Warm pumps after electrical or atmospheric heaters

- Project Examples:
  - IPR NBI (India)
  - Neurospin (France)
For JT60SA Project, the Cryopumps need cryogenic cooling at 3.7 K

- The dedicate LHe bath at 3.6K is directly pumped by warm pumps via the Cold box exchangers
- No cold compressor on VLP
On going project : TARLA

- Helium Refrigeration system (2 K) for Turkish Accelerator and Radiation Laboratory (TARLA) located in Ankara

- Cooling supply of 210 W @ 2K for two superconducting RF modules

- Selected technical solution :
  - One cold compressor and corresponding warm pumps for around 10g/s
  - A dedicated distribution box to integrate VLP cold parts and connections to the two cryomodules.
  - A modified HELIAL system to recover cold Helium at ~20K

- Status of the project
  - Equipments delivery in September 2014
  - Start-up : early 2015
On going project : TARLA

- Simplified PFD and models
On going project : TARLA

Key figures

- **Cold compressor (ALaT)**
  - Centrifugal compressor on magnetic bearings
  - Standard cartridge architecture
  - Pressure ratio : 3
  - Flow rate : 10 g/s

- **Warm pump**
  - 3 x vane pumps in parallels
  - Each pump with isolation valves
  - Total installed power : ~60 kW

- **HELIAL ML**
  - Modified liquefier for 20K return
  - No LN2 pre-cooling
  - Total installed power : 2 x 132 kW
On going project : TARLA

- Layout overview
Conclusions

- Air Liquide Advance Technologies has developed various cryogenic solutions (cold machines and cryogenic refrigeration) to support superconducting application below 4.5 K

- The choice of the architecture of the VLP circuit depends on a combination of the following constraints and then shall be anticipated in the early stage of the project development:
  - The required flowrate (~ heat load)
  - The temperature level (~bath pressure)
  - Available space allocation (for warm pump)
  - Efficiency requirements
  - Stability and availability requirements
  - …Budgetary constraints

Mini volumetric flow is required for having a cold compressors.
End of presentation
Thank you for your attention