Air Liquide cryogenic solutions for HTS refrigeration

Focus on Turbo-Brayton

Cécile Gondrand – ICEC25 – July 9th 2014
Outline

■ Turbo-Brayton for HTS: Why?
■ Turbo-Brayton description
■ Product line range
■ Recent developments
■ Conclusion
Turbo-Brayton – Why?

- Air Liquide is involved in cryogenics systems dedicated to superconductor since its discovery.
- LIPA : a successful project in operation since 2008
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- LIPA experience
  - Classical Brayton refrigerator
  - Several modules for the overall operation
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- Lessons learnt
  - Simplify the overall system
    - Only one skid => easy and quick installation and commissioning
    - Easier operation and control system
  - Improve the reliability of the refrigerator and its components
  - Improve the efficiency of the refrigerator, with an easy adjustable heat load

⇒ Turbo-Brayton
From conventional Brayton to Turbo-Brayton

- The only rotating part of the system is the Moto-turbo-Compressor shaft

- High efficiency
- No maintenance
- High reliability
- High lifetime

Water

LN2, GHe…
From conventional Brayton to Turbo-Brayton
Turbo-Brayton product line range
Turbo-Brayton Product line – Range

<table>
<thead>
<tr>
<th>Cryogenic power at 77K (kW)</th>
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<td>7.6</td>
<td>20.8</td>
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- Design of the TBF-350

More than 40% Carnot efficiency
Turbo-Brayton recent developments

- Higher refrigeration capacity available
  - Up to 51 kW at 77K
- Lower temperature
  - Down to 35K

Refrigeration capacity vs Temperature of the Turbo-Brayton product line
Turbo-Brayton recent developments

- Goal: maintain a high reliability on global solution
  - Thermal link required to cool HTS devices: need of a pump for circulating fluid
  - Development of a pump on magnetic bearings

→ Overall MTBF not reduced by the use of ball bearings
Conclusions
Conclusions

- Thanks to ALAT long experience in HTS projects, a complete solution has been developed for efficient and maintenance free refrigeration
  - Complete oil-free technology for refrigerator+pump
  - From 35 to 150K
  - Up to 51kW at 77K
  - Carnot efficiency up to 41%
  - Global MTBF 105 000h

- Developments continue
  - Lower cryogenic temperature to address LTS applications
  - Increase efficiency
Thank you for your attention