Development of technologies for new cryoplant concepts

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1. Introduction
2. Warm Turbo-compressors
3. Turbo-expanders
4. Cold compressors
5. Conclusions
FCC cooling needs: Towards 1 MW @ 4.5 K with 10 units of 100 kW at 4.5K

>230 MW of electrical consumption with conventional cryoplants

Assessment of the preliminary conceptual design for FCC cryoplants with industry:

- Confirmation of process cycles and performances for large-scale cryoplants

  see for details presentation « Industrial engineering study of FCC-hh refrigerators »

- Lists of required R&D efforts to develop more reliable & energy-efficient cryoplants
Main engineering study results

Industrial engineering studies confirm:

- **Process cycle with:**
  - Advanced precooling stages with MR Turbo-Brayton Fridges
  - Helium Refrigerators for magnets cooling

- **Cryoplant performances with:**
  - Electrical consumption in nominal conditions < 200 MW
  - Turndown factor for transient operations > 3 to 6

- **Identified R&D efforts:**
  - Reliable and efficient warm turbo-compressors (1 to 10 MW)
  - Energy recovery for large turbo-expanders (0.1 to 1 MW)
  - Large-capacity cold compressors (600 to 1000 g/s)
1. Introduction

2. Warm Turbo-compressors

3. Turbo-expanders

4. Cold compressors

5. Conclusions
Technology for compression

Present technology: screw compressors

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Proposed development: turbo-compressors

- Centrifugal warm compressors offer larger flow capacity, better efficiency and limited pressure ratio per stage requiring numbers of stages in series whereas

- Conventional screw compressors offer larger pressure ratio, lower efficiency and limited flow capacity per stage requiring numbers of stages in //,

=> Centrifugal compressors have to be developed for He and Ne-He

Warm Turbo-Compressors

- Reliable and efficient products
  - Oil free
  - Magnetic bearings
  - Compact design

- Already commercially available for natural gas and air separation

- However developments required for light gases (pure Helium or Helium mixture with Neon)
  - Very high circumferential speed

=> Expected gain for FCC: 25% of electrical power consumption and more reliable components (oil free, magnetic bearings)
1. Introduction
2. Warm Turbo-compressors
3. Turbo-expanders
4. Cold compressors
5. Conclusions
Large turbo-expanders for Ne-He and He have to be developed including

**Energy recovery already existing for turbines > ~100 kW**

*With turbine-generators or turbine-compressors*

=> **expected gain for FCC > 1 MW/cryoplant => 7% of Pelec**
1. Introduction
2. Warm Turbo-compressors
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Cold compressors

### FCC-hh cold compressors (200 g/s < Qm < 1 000 g/s – Eff. > 75%)

<table>
<thead>
<tr>
<th>Nominal and Maximal Frequency at Rm [Hz]</th>
<th>0</th>
<th>500</th>
<th>1000</th>
<th>1500</th>
<th>2000</th>
<th>2500</th>
<th>3000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheel diameter [mm]</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>60</td>
</tr>
</tbody>
</table>

- **LHC turbines**
- **Existing cold compressors**
- **FCC needs for 12 kW to 20 kW**

Large cold compressors have to be adapted with larger wheels with special attention to rotor-dynamics with large motors & bearings.

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1. Introduction

2. Warm Turbo-compressors

3. Turbo-expanders

4. Cold compressors

5. Conclusions
Identified R&D efforts for cryoplant design

- Reliable and efficient turbo-compressors (-25% of Pelec)
- Energy recovery for turbo-expanders (-7%)
- Cryoplant with optimized precooling stage

R&D actions identified and started with academic studies (USTT, TUD, CEA, CERN) and product qualification (industries)

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Thank you for your attention