Abstract

Managing parallel cryogenic flows has become a key challenge in designing efficient and smart cryo-modules for particle accelerators. In analyzing the heating dynamics of the Cornell high-current injector module a power-full computational tool has been set-up allowing time resolved analysis and optimization. We will describe the computational methods and data sets we have used, report the results and compare them to measured data from the module being in good agreement. Mitigation strategies developed on basis of this model have helped pushing the operational limitations.

Comparison to Experimental Findings

The flow to the HOM's and couplers are in parallel, but we discovered the coupler tubing is too small. So the HOM's get more flow, and the couplers less than designed for.

Simulation Parameters

Input parameters for the simulation. The blue table specifies the system properties, the red table specifies the physical properties of the cryomodule.

<table>
<thead>
<tr>
<th>Regime</th>
<th>HOM Heat Load</th>
<th>Coupler Heat Load</th>
<th>Input Pressure</th>
<th>Mass Flow Rate</th>
<th>Initial Fluid Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>No inlet</td>
<td>5 W</td>
<td>50 W</td>
<td>30 bar</td>
<td>9 g/s</td>
<td>80 K</td>
</tr>
<tr>
<td>Inlet</td>
<td>5 W</td>
<td>50 W</td>
<td>30 bar</td>
<td>4.5 g/s</td>
<td>80 K</td>
</tr>
<tr>
<td>High Heat</td>
<td>5 W</td>
<td>120 W</td>
<td>30 bar</td>
<td>6 g/s</td>
<td>80 K</td>
</tr>
</tbody>
</table>

Injector Cryomodule

- HOM beamline absorber at 80K between cavities
- Twin Input Coupler
- Frequency tuner
- 15 feet
- HGRP system with 3 sections
- Number of 2-cell cavities: 5
- Acceleration per cavity: 1 – 3 MeV
- Accelerating gradient: 4.3 – 13.0 MV/m
- R/Q (lmaq definition): 222 Ohm
- Q0: 4.6 x 10^4 – 4.1 x 10^5
- Total 2K / 5K / 80K loads: 30W / 60W / 700W
- Number of HOM loads: 6
- HOM power per cavity: 40 W
- Couplers per cavity: 2
- RF power per cavity: 120 kW
- Amplitude/phase stability: 10^-4 / 0.1° (rms)
- ICM length: 5 m

Effect of the Inlet Pipe

Including the inlet pipe allows more cryogen to flow through the couplers, greatly improving system performance.

It also allows the system to operate with substantially larger heat loads.