Current status of high-pressure gas regulation for SRF cavity fabrication in Japan

LCWS2023,
2023/May/17
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Note

• Today I will show current status of our preparation for HPGR documents, which are under preparation.

• Most of the data shown in this slide is preliminary results. (Please do not consider as final one.)
On-going issues for HPGR

• Prepare documents for KHK (The High Pressure Gas Institute of Japan)
• Mechanical test for all materials (Nb, NbTi, Ti and welding sample)
• Stress analysis of the cavity with He tank

We are now preparing document for
• First cavity which will be fabricated at KEK-CFF
• FG cavity
• 900C heat treatment
• ILC cavity (TESLA shape + short & short beam tubes) design
• Apply for refrigerator safety regulation
Our strategy on HPGR application to KHK

• We prepare following 3 applications separately to KHK
  • Cavity & He jacket
  • Chimney (Ti/SUS clad material) ⇒ clad material might have another difficulty
  • 2-phase pipe (SUS)

• Now we mostly concentrate on the application of “cavity + He jacket”.
  ⇒ Today’s presentation

Later, we will combine these 3 components. And also joint the pipes for CM/cryogenic connection.
Assumed condition for the cavity

- **Surface treatment**
  - 900C heat treatment for better flux expulsion (better Qo)
  - Standard recipe (EP +120C baking) or 2-step baking
  - Ti ring will be welded before surface treatment

- **Tuner**
  - +2mm stroke (from TDR)
  - Stopper against 0.65mm extension at room temperature
900C heat treatment

Flux expulsion for Tokyo Denkai FG Nb cavity (TTC2018)

- Cooldown scheme is not optimized to ILC CM.
- But still high temperature heat treatment have benefit for effective flux expulsion.
- Probably ~50% more flux can be expelled.
- Reducing residual resistance $\rightarrow$ High Q (low He loss) $\rightarrow$ reduce operation cost.
Frequency tuner

- The frequency tuner make the boundary condition for the high-pressure gas issue.
- Actual function of tuner should be fixed/understood before HPGR application.

The basic tuner design and function which currently considering for HPGR application.
- Current design is based on LCLS-II tuner, with slight modification(?)
- Stopper at +0.65mm at RT.
- Tuner stroke 2.0mm (from TDR)

Need to know details mechanism of tuner.
- How the stopper works?
- Is the tuner stroke mechanically limited by 2.0mm?
- Is the tuner used as compression or extension?
## List of mechanical test

<table>
<thead>
<tr>
<th>Material/Type</th>
<th>RT</th>
<th>80K</th>
<th>4.2K</th>
</tr>
</thead>
<tbody>
<tr>
<td>High RRR Nb (RRR &gt; 270)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Low RRR Nb (40 &lt; RRR &lt; 150)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>NbTi (Nb45%, Ti55%)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Ti type-2 (Japanese standard)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H-RRR Nb &amp; H-RRR Nb EBW</td>
<td>△</td>
<td>△</td>
<td>△</td>
</tr>
<tr>
<td>H-RRR Nb &amp; L-RRR Nb EBW</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>L-RRR Nb &amp; NbTi EBW</td>
<td>△</td>
<td>△</td>
<td>△</td>
</tr>
<tr>
<td>NbTi &amp; Ti type-2 EBW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ti type-2 &amp; Ti type-2 TIG</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

○: test was done  
△: sample is under preparation  
(Empty): will be prepared and tested

KEK-CFF group working hard for sample preparation and mechanical test.  
⇒ Allowable stress is estimated from the mechanical test results.  
All test samples were/will be **heat treated at 900 C.**
Mechanical test at KEK

Mechanical test setup under Liquid Helium

[Diagram showing mechanical test setup]

[Graph showing stress vs. stroke]
Stress analysis

- Stress simulation was carried out by using ANSYS.
- Simulation was done for the following 3 cases.

<table>
<thead>
<tr>
<th>CASE</th>
<th>Pressure [MPa]</th>
<th>Temperatur (degree)</th>
<th>Tuner external load or allowable extension</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inside Cavity</td>
<td>Between cavity and jacket</td>
<td>Outside jacket</td>
</tr>
<tr>
<td>CASE-A</td>
<td>0</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>CASE-B</td>
<td>0</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>CASE-C</td>
<td>0</td>
<td>0.2</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 1: SRF cavity assembly shell model.
High stress region for ILC cavity

Some region show relatively higher stress, which might be close to (or bit over?) the allowable stress.

Case A – Critical Region is End Cell- C.F Weld

Case B - Critical Region is End Cell- C.F Weld and C.F and Conical Disc Weld
Schedule (HPGR & cavity fabrication)

<table>
<thead>
<tr>
<th>Activity</th>
<th>FY2023</th>
<th>FY2024</th>
<th>FY2025</th>
<th>FY2026</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepare HPGR document (FG, Japanese)</td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st cavity fabrication at KEK</td>
<td></td>
<td>✔️</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepare HPGR document (Chimney, 2-phase pipe)</td>
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<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Prepare HPGR document (MG, Japanese)</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>FG &amp; MG cavity fabrication in Japan</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Prepare HPGR document (FG&amp;MG, Europe, US)</td>
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<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Cavity fabrication at Europe, US</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

- Above is current rough schedule for ILC-TN
- HPGR document
  FG ⇒ MG ⇒ Europe, US
Summary

- KEK is preparing the documents for HPGR application.
- Currently, we are preparing the document for first ILC-TD FG cavity with helium tank, which will be fabricated at KEK-CFF.
- Many mechanical tests have been performed and currently on-going. Heat treatment of 900C is assumed.
- Allowable stress is to be decided from the results of mechanical tests.
- Stress analysis has been also carried out.
- Checking the consistency between the simulated stress intensity and allowable stress estimated from the mechanical test.