North Area 4T Superconducting User Magnet

Michela Neroni
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Summary of activities

1. Support structure for Magnadon (with side supports and tie rods)

2. Snubber portable diagnostic

3. Bending test of End-cap toroid conductor with Weronika
1) Magnadon – support structure

Idea:
- Side support that covers the first two windings (these are the ones that make the greatest contribution to the bursting force)
- Tie rods between side support and inner cylinder, in order to let the inner cylinder handle part of the stress
1) Magnadon – support structure

Von Mises Stress

Without side support

With side support
1) Magnadon – support structure

Regions with Stress > 200 MPa

Without side support

With side support
1) Magnadon – support structure

Improvement also in terms of total deformation

Without side support $d_{\text{max}} = 5.54\ mm$

With side support $d_{\text{max}} = 4.70\ mm$
1) Magnadon – support structure

Space requirements for thermal shield and vacuum vessel outside the structure: actual available thickness 55 mm (split thermal shield → Weronika), at least 70 mm requested to have a single cylinder for the thermal shield.

Considering the reduction of the max radius for the central holder to meet the requirements:

Regions with Stress > 200 MPa
2) **Snubber portable diagnostics**

Portable diagnostics to check the circuit/connections before switching on and during shutdown

Simple charge and discharge cycle up to a small voltage value

**Idea:** to consider the use of Arduino for the acquisition process
- Compact, battery-powered
- Analog acquisition up to max 5 V (a small voltage scaling circuit can also be considered)
- Resolution 4.9 mV/unit
- Frequency of acquisition $f_{\text{max}} \cong 10 \text{ kHz}$
### 3) Bending test

41 mm x 12 mm aluminum conductor from End-cap toroid, 1.25 m long

\[ r = 500 \text{ mm} \]

<table>
<thead>
<tr>
<th>Length along the sample [cm]</th>
<th>Initial thickness [mm]</th>
<th>Thickness after bending [mm]</th>
<th>Deformation [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>12.01</td>
<td>12.13</td>
<td>+0.12</td>
</tr>
<tr>
<td>20</td>
<td>12.00</td>
<td>12.14</td>
<td>+0.14</td>
</tr>
<tr>
<td>30</td>
<td>12.00</td>
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<td>+0.18</td>
</tr>
<tr>
<td>40</td>
<td>12.01</td>
<td>12.17</td>
<td>+0.16</td>
</tr>
<tr>
<td>50</td>
<td>12.00</td>
<td>12.16</td>
<td>+0.16</td>
</tr>
<tr>
<td>60</td>
<td>12.01</td>
<td>12.15</td>
<td>+0.14</td>
</tr>
<tr>
<td>70</td>
<td>12.00</td>
<td>12.16</td>
<td>+0.16</td>
</tr>
</tbody>
</table>

Sensitivity Vernier caliper \( \Delta x = 0.01 \text{ mm} \)

Mean deformation factor \( d = (0.15 \pm 0.03)\text{ mm} \)
3) Spring back considerations

\[ R_i = 500 \text{ mm} \]
\[ t = 41 \text{ mm} \]

For high purity aluminum (from End-cap toroid report):
\[ \sigma_y = 20 - 30 \text{ MPa} \]
\[ E = 70 \text{ GPa} \]

\[ R_f \approx 508 \text{ mm} \]

**Formula for plane stress condition (W>10t):**

\[ \frac{R_i}{R_f} = 4 \left( \frac{R_i \sigma_y}{Et} \right)^3 - 3 \left( \frac{R_i \sigma_y}{Et} \right) + 1 \]
3) Spring back considerations

Measured distance $d=28.30 \text{ mm}$

$R_f = 529.1 \text{ mm}$