Design and development of cryogen free cryogenic test set-up

A cryogen free cryogenic test set-up has been designed, developed and tested at VECC, Kolkata. The system composed of two close cycle refrigerators, a removable sample mount, HTS current leads integrated with conductively cooled HTS magnet. This is a unique facility for low temperature experiments where large sample current and space is required for the measurement under different temperatures and magnetic fields like transport critical current of superconductors. The cooling capacity of 1st (45W at 50K) and 2nd (1.5W at 4.2K) stages of cryo-cooler is judiciously distributed to intercept the heat load from different sources. Low temperatures were achieved by considering several factors, including thermal insulation, radiation heat shielding and current lead optimisation. A key feature of the measurement apparatus is its capacity to carry 400A of current to the sample while keeping the sample cold. A detail electro-magnetic and thermal design is carried out to fix different parameters for fabrication. This includes careful design of cooling plates inside the magnet winding and thermal path to the cryo-cooler. The thermal performance of the system was tested and magnet was energised to 2 Tesla of magnetic field in a clear variable temperature bore of 70mm.

**Salient features**

- A unique facility which is designed and developed to tailor our requirements
- A safe, convenient and energy efficient for testing of any superconducting devices/samples without relying on liquid helium
- Large sample space and sample current
- Variable temperature and magnetic field
- Demountable sample stick/holder
- Conduction cooled HTS magnet & HTS current leads

**Major parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Housing cryostat:</td>
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<tr>
<td>Diameter</td>
<td>600mm</td>
</tr>
<tr>
<td>Height</td>
<td>1100mm</td>
</tr>
<tr>
<td>Mounted table (with castors)</td>
<td>1300 mm × 750mm</td>
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<tr>
<td>Sample space (calorimeter)</td>
<td>70mm × 250 mm long</td>
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<tr>
<td>Maximum sample current</td>
<td>400A</td>
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<tr>
<td>Magnet cold mass</td>
<td>46g</td>
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<tr>
<td>Variable temperature operation</td>
<td>~ 4-300K</td>
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<tr>
<td>Sample centre stick weight</td>
<td>~ 12kg</td>
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<tr>
<td>Cryo-cooler (2nos)</td>
<td>Sumitomo SRDK415D</td>
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</table>

**Magnet**

- Type: Double pancake coil
- Molding resin: Stycast/2850FT
- No of double pancake coil: 36 nos
- Coil inner diameter: 90 mm
- Coil outer diameter: 190mm
- Working bore: 70 mm
- Height of the coil: 172mm
- Magnet current: 180A
- Magnetic field: 2T
- Maximum radial field: ~1.1T
- Operating Temperature: ~ 30K

**Different measurements**

- RRR of Niobium (BARC, Mumbai)
- Phase transition of cobalt and Tin of different composition (SN Bose, Kolkata)
- Calibrated several temperature sensors

**Thermal performance test**

- Temperature variations during cool down
- Magnet successfully energised and quenched at 186 A

**Cross-sectional shape of HTS insert showing reduction of radial component of magnetic field at the coil ends by using step-shape coil and iron rings at both ends.**

**Stages of development**

- Sharp rise of temperature due to current overloading in the warm end side of HTS current lead. We maintained temperature below 60K.

**Test set-up assembly**

**Centre stick for sample mounting**