Conceptual Design of a DEMO TF-Coil using High Temperature Superconductor

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**Motivation**
- Pre-conceptual design following EUROfusion EU DEMO
- Main machine parameters by PROCESS system code
- Design concept of a Toroidal Field Coil (TFC) using High Temperature Superconductor (HTS) operating at 4.5 K
- HTS material REBCO as promising candidate:
  - High critical current density at highest magnetic field
  - Possibility for use at temperatures <20 K

**Conductor and Coil Design**
- HTS CrossConductor (CroCo) as basic element for cable

**Electromagnetic Analysis**
- Magnetic field on plasma axis is achieved
- Lorentz forces are calculated for structural analysis

**Quench Analysis**
- Very long QD delay time due to very high $T_c$
- Hot spot Temperature acceptable

**Hydraulic Analysis**
- Due to large T-margin high heat load can be managed
- Helium mass flow rate and pressure drop acceptable

**Structural Analysis**
- Linear Tresca stress in case and conductor jacket ok

**Results**

<table>
<thead>
<tr>
<th>WINDING PACK (WP)</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B_{max}$ [T]</td>
<td>12.124</td>
</tr>
<tr>
<td>Operation current [kA]</td>
<td>49.6</td>
</tr>
<tr>
<td>Current sharing temperature [K]</td>
<td>14.2</td>
</tr>
<tr>
<td>Number of layers</td>
<td>12</td>
</tr>
<tr>
<td>Number of toroidal turns</td>
<td>24</td>
</tr>
<tr>
<td>Radial dimension of WP [mm]</td>
<td>616.6</td>
</tr>
<tr>
<td>Toroidal dimension of WP [mm]</td>
<td>1218.5</td>
</tr>
<tr>
<td>Discharge voltage [kV]</td>
<td>10.3</td>
</tr>
</tbody>
</table>

**Outlook**
- The HTS material can be used for future fusion magnet systems
- Todays HTS material offers enough current density at high field to generate temperature margin above 9 K
- Hot spot temperature is acceptable and structural analysis results are within allowable limits
- Conceptual design will be adopted to baseline 2018