**RESEARCH ON MECHANICAL & ALIGNMENT SYSTEM FOR HEPS-TF**
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HEPS is a new generation synchrotron facility with a challenging requirement of very low emittance, and the key technology difficulties are supposed to be overcome during the stage of HEPS-TF. For the mechanical & alignment system, the requirements are very stringent. The alignment error of magnets on a girder should be less than 30μm. Besides, the girder should be capable of doing beam-based alignment remotely to minimize the magnets position error during the runtime. To meet these requirements, studies on vibrating-wire alignment technique and auto-tuning magnet girder were carried out in HEPS-TF. This paper will describe the design and progress of those work.

**Auto-tuning girder**

- **Design Features:**
  - Adjustability: Cam mover + Ball transfer unit
  - Stability: Multi-support + Locking system
- **Two prototypes developed:**
  - Girder I: 3.3m, 6 support points
  - Girder II: 4.3m, 8 support points

- **With the kinematic design, Girder I is a fully constrained structure. Stepping motors are used to perform movement.**
- **Although Girder II is over-constrained, elastic property can make the 8 points loaded simultaneously. Servo motors are used to make sure the force balanced.**
- **Both girders are fully tested and show similar performance.**

**Vibrating-wire alignment**

- **Align the magnets on a girder based on the magnetic center measurement, using a wire carrying AC current.**

  - **Temperature stability: ±0.1°C**
  - **X&Y sensors for Vibration**
  - **Wire supporting**

- **Repeatability:** <±3μm

<table>
<thead>
<tr>
<th>Precision (μm)</th>
<th>Quadrupole</th>
<th>Sextupole</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>± 0.3</td>
<td>± 0.7</td>
</tr>
<tr>
<td>Y</td>
<td>± 1.0</td>
<td>± 1.6</td>
</tr>
</tbody>
</table>

*Ground vibration may be an issue, vibration isolated foundation is essential to avoid unexpected resonance of the wire.*

**Background field correction**
- **Experiment was conducted to verify the main source of background.**
- **Main source:** Remnant field of nearby magnets

<table>
<thead>
<tr>
<th>Magnetic center position</th>
<th>No shield</th>
<th>Shield</th>
<th>Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before correction</td>
<td>X</td>
<td>0.245</td>
<td>-0.019</td>
</tr>
<tr>
<td>After correction</td>
<td>Y</td>
<td>-0.173</td>
<td>-0.184</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Magnetic center/mm</th>
<th>Weight /kg</th>
<th>f1 /Hz</th>
<th>s/mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before correction</td>
<td>After correction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1kg</td>
<td>1.1kg</td>
<td>1.15kg</td>
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</tr>
<tr>
<td>28.95</td>
<td>29.3</td>
<td>30.1</td>
<td>0.247</td>
</tr>
<tr>
<td>0.228</td>
<td>0.228</td>
<td>0.228</td>
<td></td>
</tr>
</tbody>
</table>

- **Magnetic center deviation can be less than 6μm.**

**Sag correction**
- **Based on the measurement of 1st natural frequency of wire.**

\[
sag = \frac{g}{32f_1^2} = \frac{4\text{sag}}{f_1^2} + \frac{4\text{sag}}{f_2^2} + \frac{4\text{sag}}{f_3^2}
\]

- **Magnet adjusting**

  - **Reading of DVRT is much more stable than Laser Tracker. It is very helpful to decrease magnet position errors.**
  - **Magnetic center deviation can be less than 6μm after adjustment of magnet.**