J-PARC/MUSEにおけるミュオン回転標的の現状

J-PARC Center, MLF Division, Muon Section (KEK-IMSS)
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The most intense pulsed muon beam all over the world
2014年9月に固定標的方式から回転標的方式に交換を行った。
Muon Fixed Target (Graphite)

Isotropic Graphite
IG-430U (Toyo Tanso)
Diameter; 70mm
Thickness; 20mm

P-Beam diameter; 16 mm (2σ)
4kW heat @ 1MW proton beam

Stainless steel pipe (Water)
Copper frame
Hot Iso-static Press method

Stable proton beam operation without replacements for 5 years
(ISIS/RAL; Beam Power 200kW, 3 ladder-targets ~Lifetime; 1 year)
Lifetime & Replacement of Muon Target

- Radiation damage of graphite; Dimensional change
  Lifetime; < 1 year @1MW beam operation
- Replacement by remote handling

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Beam spot will shrink by proton irradiation.
Learning from Paul Scherrer Institute, Rotating target method is applied to distribute the irradiation damage of graphite to a wider area.

The lifetime of graphite becomes long enough.
The lifetime of bearings is critical. Solid lubricant;
- Silver coating with MoS2 at PSI
- Disulfide tungsten at MUSE

Expected lifetime: 10 years

E target at Paul Scherrer Institute (PSI)
Lifetime; less than 1 year

Collaboration with PSI Target group since 2004
Bearing & Solid lubricants

For our target, the bearing is used under 100 MGy/year, 400 Kelvins, 10^{-5} Pa

<table>
<thead>
<tr>
<th>Type</th>
<th>Temp. (Kelvins)</th>
<th>Pressure (Pa)</th>
<th>Radiation</th>
<th>Speed (rpm)</th>
<th>Storage</th>
<th>Lifetime @15rpm (hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MoS₂</td>
<td>&lt;570</td>
<td>10^5 to 10^{-5}</td>
<td>general</td>
<td>&lt;500</td>
<td>air</td>
<td>1100</td>
</tr>
<tr>
<td>Ag</td>
<td>&lt;600</td>
<td>10^{-3} to 10^{-10}</td>
<td>general</td>
<td>&lt;500</td>
<td>vacuum</td>
<td>5800</td>
</tr>
<tr>
<td>WS₂</td>
<td>&lt;600</td>
<td>10^5 to 10^{-5}</td>
<td>few</td>
<td>&lt;210</td>
<td>air</td>
<td>110000</td>
</tr>
</tbody>
</table>

Retainer, balls, & rings, coated by MoS2 or Silver

Separator made of sintered compact of WS2

Captured from JTEKT(KOYO) Catalog

Evaluation by the formula of the JTEKT Catalog

Great amount of Lubricant

Disulfide Tungsten is used for MUSE target.

Anticipated Lifetime is 20 years!!

Radiation resistance of WS2 should be confirmed.
Radiation Resistance of WS$_2$

Electron beam irradiation
JAEA, Takasaki,
2MV, 1mA, 20hours, 100MGy

Durability tests with load & heat
4.5 million revolutions,
1year@ beam line
No irradiation effect was observed.
Mock-up of Rotating Target

Durability tests of Target & bearings
Heating & Rotating tests

9 days with 300 r.p.m.
(4800h @15 r.p.m.)

It will work at least for 1 year!!

Operation for 4 days
Operation for 5 days

Motor torque (x 10 %)

Heating test

330 mm

Proton beam
Replacement of the used Fixed target

- M2 line
- M1 line
- To neutron source
- Remote-controlled camera

 Radiation dose:
- 750 μSv/h @12 m
- (150 mSv/h @30 cm)

No crack was observed.

7th July, 2014

Dose-meter & Digital camera

400 mSv/h @20 cm

Transportation to tentative storage vessel

10cm gap

30th July, 2014
Installation of Rotating Target

Rotating Target was successfully installed on 16th September of 2014.

- Vacuum pressure; $10^{-5}$ Pa
- Control system; Confirmed
Operation of muon rotating target

300-kW & 400-kW operation for 3 months
600-kW operations for 1 hour on 8th Apr./2015
500-kW operation for 1 week

Motor torque has been remaining constant.

<table>
<thead>
<tr>
<th></th>
<th>300kW</th>
<th>500kW</th>
<th>1MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft (Simulation)</td>
<td>71 degC</td>
<td>84 degC</td>
<td>112 degC</td>
</tr>
<tr>
<td>Shaft (Measurement)</td>
<td>78 degC</td>
<td>95 degC</td>
<td>-</td>
</tr>
<tr>
<td>Graphite (Simulation)</td>
<td>400 degC</td>
<td>475 degC</td>
<td>620 degC</td>
</tr>
<tr>
<td>Th. radiation (Measurement)</td>
<td>45 degC</td>
<td>60 degC</td>
<td>-</td>
</tr>
</tbody>
</table>
Summary

- Since 2008, Stable beam operation by Graphite Fixed target.
- Graphite Rotating Target was installed last September.
- Stable proton beam operation by Graphite Rotating target

ACKNOWLEDGMENT

- 回転標的加熱回転試験機；日立造船
- 回転標的実機；入江工研
- 軸受；JTEKT
- 潤滑材の電子線照射試験；大島氏、花屋氏（原研高崎）

Thank you for your attention