Progress With Manufacturing the 1st Target Module for ISIS TS1 Project

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Introduction

- Overview of ISIS Target Station 1 - TRaM
- TS1 Project Aims
- Overview of TS1 Project Target design
- ISIS ‘Target Manufacturing Facility’
- Progress With Manufacturing Target Components
  - Target Plates – (10 in total)
  - Target Stack Assembly
  - Target Vessel/Window Assembly
  - Target Spacer
- Summary
ISIS Target Station 1 (TS1)

- Target station in operation for 33 years
- Spallation neutron target serving ~20 neutron instruments
- Original target material – Uranium clad in Zircaloy (Neutrons ✓ Lifetime ✗)
- 23 plate Tantalum target – (decay heat) (Neutrons ✗ Lifetime ✓)
- Current target design – (since 2001) 12 tungsten plates clad in Ta, cooled with D\textsubscript{2}O (Neutrons ✓ Lifetime ✓)
- Typically 160µA of 800MeV protons, 50 Hz pulsed beam
  (note TS1 is run at 40Hz when we run 1 pulse in 5 to the TS2 10 Hz target)
- TS1 Project Target designed for 200µA of 800MeV protons
- Beam sigma of ~17mm (overall beam spot diameter ~70mm)
- Maximum power density ~400MW/m\textsuperscript{3}
- Peak energy ~11MJ/m\textsuperscript{3}/pulse
ISIS Target Station 1 (TS1)

- 12 Tungsten Plates clad in Tantalum
- 3 separate cooling channels
- Thermocouple in each plate
- Secondary cooling circuit (requirement for Uranium target)
Target assembly attached to TRAM door
ISIS Target Station 1 (TS1)

- Reflector – several boxes of Beryllium rods
- Dismantle Reflector and remove target for access to Moderators for maintenance – time consuming

- TS2 solid Be Reflector – splits for easy access to moderators
To enable the reflector to move apart, the target can no longer be attached to the TRAM door – now moves with the reflector.
Target Station 1 Project aims

- Secure the future of TS1 and enable it to operate for many more years
- Provide improved flexibility for future target or moderator changes
- Provide a neutron performance increase, of up to a factor of 2, on some instruments
- Provide confidence in the ongoing operation of TS1 to enable future instrument upgrades
- Improve our knowledge and skills in target station design for future projects
- Make current maintenance operations of the target station easier
Overview of TS1 Project Target design

- Basic elements of the new target design:
  - 10 target plates of varying thicknesses
  - Tungsten Ø98 mm, Ta Cladding 1.5 mm, water channel width 2 mm
  - Target Stack length 368mm
  - 316L Target Vessel

<table>
<thead>
<tr>
<th>Mass of material (kg)</th>
<th>Current TS1</th>
<th>TS1 Project</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>73.8</td>
<td>12.6</td>
<td>82.9%</td>
</tr>
<tr>
<td>Tantalum</td>
<td>32.7</td>
<td>14.5</td>
<td>55.7%</td>
</tr>
<tr>
<td>Tungsten</td>
<td>47.3</td>
<td>46.4</td>
<td>1.9%</td>
</tr>
<tr>
<td>Total</td>
<td>153.8</td>
<td>73.5</td>
<td>52.2%</td>
</tr>
</tbody>
</table>

- Tungsten volume closely matches current design
- Tantalum reduced
- Stainless massively reduced
Overview of TS1 Project Target design
Overview of TS1 Project Target design

Progress With Manufacturing Target Components

- Water Manifold
- Target Spacer
- Target Stack (10 Plates)
- Target Vessel
- Thermocouple Protector
- Window
ISIS ‘Target Manufacturing Facility’

- ISIS committed to bring manufacture of ISIS Targets in-house (2014)
- Investment in workshop space, specialist equipment and people
- Increase our knowledge of working with Tungsten and Tantalum
ISIS ‘Target Manufacturing Facility’

Benefits

• Greater understanding of Hot Isostatic Press process
• Improved quality control and documentation
• Less reliance on outside manufacturing companies
• Reduced time to manufacture targets
• Development of W/Ta target plates for TS1 Project

• Increased service life of TS2 Targets from 1 year to 2 years
Progress With Manufacturing Target Components

- Construction principle of **Target Plates** same as existing TS1 target
- Round profile reduces no of welds from 13 to 3
Meticulous surface preparation and cleaning required before EB welding in vacuum.

Note: Welds are carefully positioned to remain untouched by the post HIP machining operations.
Target Manufacture Facility – R29

• Following EB welding …
• Target Plates are HIP’d to bond tantalum cladding to tungsten core
• 1200°C, 140 Mpa (lower temp inhibits grain growth)
• Ultrasonic NDT to confirm quality of bond
• Machined to finish dimensions
Progress With Manufacturing Target Components

- Target plates interlock to ensure correct positioning of thermocouples
- EB welded together to prevent vibration from cooling water

Machined features fix orientation and provide weld feature
Target Plates 1 to 8 complete, 9 & 10 failed to HIP
Failure to HIP (no. 9) may have been due to insufficient clearance around W core creating trapped volume caused by weld shrinkage. Clearance increased and 1mm chamfer added to W disc edges to aid evacuation.
Progress With Manufacturing Target Components

- **Target Stack** - 10 plates
- Target plates made individually
- Interlocked together and EB welded to form solid stack
Project Progress With Manufacturing Target Components

Dummy Stack

Rotary EB Welding Jig

Stack then machined to finished dimensions
Progress With Manufacturing Target Components

- Stack to be housed in a 316L Target Vessel
- Keep number of welds as low as possible
Progress With Manufacturing Target Components

Test piece to develop machining and EB Welding processes

2 off Target Vessels in production
Progress With Manufacturing Target Components

Rotary EB Welding of Target Vessel/Window just completed
Progress With Manufacturing Target Components

Target Spacer (Flow Transition)

3D Printed Model
Test Piece to develop cutting technique

Order placed with:
Reaction Engines Manufacturing Solutions
Progress With Manufacturing Target Components

- Water Manifold – Out for manufacture
- ‘Corruseal’ Gaskets – Out for manufacture
- Target Module Assembly – Sep 2018
- Flow testing – Oct 2018
- Second Target production – Nov 2018

‘Corruseal’ Gasket - Raised pinch lines crush to form seal
Summary

- Overview of ISIS Target Station 1 - TRaM – operating 33 years
- TS1 Project Aims
  - Secure the future of TS1 and enable it to run for many more years
  - Make current maintenance operations of the target station easier
  - Improve our knowledge and skills in target station design for future projects
- Overview of TS1 Project Target design – integrated into TRaM
- ISIS ‘Target Manufacturing Facility’
- Progress With Manufacturing Target Components
  - Design and development complete
  - All major components well advanced in manufacture
  - Assembly and testing in 4 Qtr 2018
- Manufacture of second target assembly straight after
Thank you for your attention