The SNS Liquids Reflectometer

The SNS Liquids Reflectometer is a horizontal-surface unpolarized instrument capable of operating in specular, off specular, and grazing-incident small angle neutron scattering (SANS) geometry.

Operating parameters

- Wavelength range: $2.5 \, \text{Å} < \lambda < 17.5 \, \text{Å}$
- Operating bandwidth: $\Delta \lambda = 3.5 \, \text{Å}$
- 2D Position-sensitive detector resolution: $1.3 \times 1.3 \, \text{mm}^2$
- Solid-sample $Q$ range: $0.003 \, \text{Å}^{-1} < Q < 1.5 \, \text{Å}^{-1}$
- Air/liquid $Q$ range: $0.003 \, \text{Å}^{-1} < Q < 0.4 \, \text{Å}^{-1}$
- Minimum reflectivity (no hydrogen): $5 \times 10^{-8}$
- Robotic sample changer with 18 wafer magazine

Robot Control Network and System Design

The instrument control network provides access to motor controllers, sample environment control and detector data collection computers.

Highlights

- Process variable distribution via NI DataSockets
- Shared memory system on control computer
- Kinematic mount enables sample holders to ‘self-align’
- Fundamental 6-point robot motion for pick and put enables operation with sample magazine

Robot Control

- Mechanical enhancements to ensure repeatability of table reassembly
- Vision system to verify position
- Satellite and control program
- PyDAS integration

Automation

- Initially, instrument operation can become “less efficient” as human-in-the-loop activity is replaced by algorithms
- Detailed timing analysis to identify bottlenecks and resolve them

Vision System

- Consult with vendor FAE during setup
- Protect position-sensitive equipment from bumps

Productivity Metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>2012-A</th>
<th>2013-A</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of neutron runs that could have used the current robotic sample changer</td>
<td>2696</td>
<td>3805</td>
<td>Number of neutron runs that did use the robotic sample changer</td>
</tr>
<tr>
<td>Number of days used to run experiments</td>
<td>30 days</td>
<td>51 days</td>
<td>includes downtime during experiments scheduled and non-scheduled</td>
</tr>
<tr>
<td>Average energy on target/experiment day</td>
<td>16.98 MWh/day</td>
<td>16.20 MWh/day</td>
<td></td>
</tr>
<tr>
<td>Average number of runs/energy on target</td>
<td>5.29 runs/MWh</td>
<td>4.61 runs/MWh</td>
<td></td>
</tr>
<tr>
<td>Estimate average MWh used per sample</td>
<td>1.22 MWh/sample</td>
<td>1.76 MWh/sample</td>
<td>based on 8 runs/sample (typical)</td>
</tr>
<tr>
<td>Typical time of manual alignment scan</td>
<td>14 mins/sample</td>
<td>32 mins/sample</td>
<td>Average time of automatic alignment</td>
</tr>
<tr>
<td>Energy equivalent spent for alignment</td>
<td>165 kWh/sample</td>
<td>360 kWh/sample</td>
<td></td>
</tr>
</tbody>
</table>

Future Projections

<table>
<thead>
<tr>
<th>Benchmarked “markers”-based alignment time</th>
<th>2013-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy equivalent estimate using “markers”-based alignment and accelerator at 875 kW</td>
<td>135 kWh/sample</td>
</tr>
<tr>
<td>Expected number of runs/energy on target using “markers”-based alignments</td>
<td>3.29 runs/MWh</td>
</tr>
</tbody>
</table>

Lessons Learned

Automation

- Initially, instrument operation can become “less efficient” as human-in-the-loop activity is replaced by algorithms
- Detailed timing analysis to identify bottlenecks and resolve them

Vision System

- Consult with vendor FAE during setup
- Protect position-sensitive equipment from bumps

Acknowledgement

The authors wish to acknowledge valuable contributions made by Lloyd G. Clonts, Xiaodong Tao and Rick Reidel for their original work on the DAS control system. Robert Viola and “Cooper” at Square-One Systems for the design and programming of the robot arm. Brad Lokitz, Juan Pablo Hinestrosa, and Mike Kilbey for being the “first” users of the robotic experiment processing system.