Benefits Achieved by the Vitrification Test Rig in Support of WVP

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Purpose of VTR

- Full scale non-active support facility
- Aims
  - Improve waste incorporation rate (loading)
  - Increase plant throughput
  - Increase plant availability
  - Broaden WVP process envelope
- WVP does not sample the glass products
- Changes outside process envelope can not be made without demonstrating the impact on PQ
- VTR provides the PQ data
- £27m investment between 2001 and 2004 to design, build and commission
Why Full Scale?

- Lab scale and small scale pilot demonstrator facilities were shown to give pessimistic results with respect to PQ.

- Plant operational personnel sceptical about computer based modelling to support improvements.

- Easier to satisfy customers & regulators when technical arguments demonstrated on an exact replica of the parent plant.

- Client made decision to go to full scale despite the significant capital investment.
• More instrumentation than the active plant

• Same control system as WVP plus AspenTech Process Explorer data analysis software
  - invaluable for data acquisition and analysis to support improvements on WVP

• The project included a small team of product assessment and analysis technologists
Vitrification Test Rig (VTR)

- Vitrification Test Rig (VTR)
- HAL Simulant
- Glass Frit Feed
- Off Gasses
- Recycle
- Sucrose
- Feed System
- Calciner
- Additional Scrubber
- NOx Absorber
- Condenser
- Dust Scrubber
- Discharge
- Liquid Effluent Treatment
- Melter
- To Product Containers
VTR Calciner and Melter
Indicative Operating Costs

- 2004 to 2008 £5m/y = operating team, technical team, lab support, maintenance, analysis, spares, consumables, project management etc (32 weeks of operation) Simulant costs £2m/y

- 2009 onwards VTR operated less frequently, now £3.5m/y and simulant costs £1.5m/y remainder of the time the facility is managed in C&M

- WVP management recognise the value of retaining the faculty beyond the delivery of its original mission. It represents considerable risk mitigation through the life cycle of WVP.
Approach to Product Quality

• Characterise the waste
• Develop representative simulants
• Define the limits of product acceptability
  - wide range of studies at small scale
• Establish the process envelope at full scale
• Develop the case for product quality
• Demonstrate process envelope on active plant during commissioning
• Operate the plant within the defined envelope
Structure of the Development Programmes

- Small scale inactive
- Full scale inactive
- Small scale active
- Forecast product properties
• Establish and confirmed flowsheet
• Determine accuracy & precision of delivery systems
• Develop deeper understanding of the plant
• Define the process envelope within which PQ is guaranteed
• Demonstrate process stability & reproducibility over extended periods of operation
• Demonstrate ability of plant to respond to operating conditions and process disturbances (eg feed delivery problems, temperature and mixing conditions, compositional variation)
• Establish off-gas system DFs and $2^Y$ wastes
• Determine differences between large and small scale processes and/or product properties
• Determine homogeneity by sampling throughout the product
• Determine incorporation by analysis
• Measure chemical and thermal stability of selected samples
• Confirm links with small scale inactive laboratory studies and plant commissioning data
• Long term full scale inactive product assessment
• Provide process knowledge and understanding
Initial Benefits

• Bulk of original “plant capacity” improvements delivered within 2 years

• Incremental approach to waste incorporation and processing rates adopted giving WVP the chance to progressively implement improvements and reap reward on investment – initial improvement to 28 kg/h @ 28 wt%, now 28 kg/h @ 38 wt%

• VTR personnel helped implement changes on WVP (saving of >200 containers so far)
Increased Waste Content of Containers with Time

Date

31.3.06  17.10.06  5.5.07  21.11.07  8.6.08  25.12.08  13.7.09  29.1.10

W.O. Incorporation (%)
Reduced Waste Oxide Content of HAL

1 litre of highly active liquor

Past

Now

Future

180g of waste oxides

130g of waste oxides

90g of waste oxides

Need to ↑ liquor throughput to maintain oxide output
Further Benefits

- High evaporative load to calciner
- High waste oxide throughput
- Optimisation of sugar feed rate (sugar:nitrate)
- Range of blended waste ratios
- High molybdenum wastes trialed
- High platinoid waste trials
- Broadening of Process Specification
  - Low calciner rotational speed
  - Low calciner temperature (& expansion)
  - Low & high melter sparge mixing
  - Container preheat furnace turned off
  - Loss of mixing in feed tank
Yellow Phase

- Forms in presence of reprocessing waste at high MoO$_3$
- ~80 wt% soluble alkali molybdates
- ~20 wt% insoluble alkaline earth and rare earth molybdates

Undesirable due to:
- Water soluble phase
- Partial volatility in melt
- Corrosive to melter
High \([\text{MoO}_3]\) on VTR

- Yellow phase when \(>5.3\ \text{wt}\%\ \text{MoO}_3\) with MW glass

- Excessive at 12 \(\text{wt}\%\ \text{MoO}_3\)
Improved Base Glass Trials

• More crystalline than reprocessing waste in MW
• Colour varies with position in container (cooling rate effect), mottled appearance, but phases not distinguishable on SEM
• Durability as good as standard glass product
Ca/Zn Glass

- Better incorporation of Mo than MW glass
- Presence of Zn and Al for good durability
- Molybdenum trapped as a durable CaMoO$_4$ phase above solubility limit of MoO$_3$ in glass

Laboratory glass  VTR glass slower cooling
Trial with High Mo Waste on VTR

Calcine build up after I13/E27
Dilute POCO + LiNO3
4037g/hHWO (4771g/hTWO)
Additional Learning

• Mal-operation trials
  - Operation without key melter thermocouples
  - Low melter closed circuit cooling water flow rate trials
  - Failed calciner heating elements
  - Delay to water feed when switching from HAL to standby
  - Wash fed to calciner
  - Choking condenser by excessive evaporative load

• VTR demonstrated recovery procedures and satisfactory product quality or limits of operability

• Provided test bench to troubleshoot actual plant problems and provide solutions
• The VTR is an exact replica, this is an invaluable platform for testing recovery procedures and novel maintenance techniques, e.g.

- Test fitting and calibration of replacement constant volume feeders before they were installed on plant

- Testing camera deployment in off-gas system pipework prior to use on WVP
Operator training

• Since the VTR is an exact copy of the WVP it has proven ideal for operator training

• WVP use secondments to the VTR to train operators and technical support staff

• VTR enables a hands-on approach providing an invaluable opportunity to fully observe & understand the process

• A significant proportion of the original operations team took up jobs on WVP, i.e. the VTR acted as a training facility for plant operators
## Increases in Liquor and Waste Oxide Throughput

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Summary of Benefits

• W.O. t’put increased using existing equipment
• VTR demonstrated stable operation of the calciner, melter and off-gas system at significantly higher waste oxide incorporation rate, throughput, and evaporative load
• PQ underpinned for glass produced within much broader Process Specification
• Future feeds qualified
• Mal-operations studied
• Flowsheeting data
• Operator training
• Fewer vit containers, savings exceed all VTR costs