Excellence through innovation

IGD-TP 7th Exchange Forum

Canister Design
Objectives for today

- Give you something to consider
- What do you want your canister to do
- Understand how they are made
- Design to maximise efficiencies
Andrew McClusky – Owner & MD of BEP Surface Technologies Ltd

- BEP has been an electro plating company since 1970
- Specialise in plating Nickel, Copper & Chrome
- Approx 40 employees, based in Manchester UK
- World leaders in Cu electroplating of large components/cylinders
- **Research / Knowledge Transfer Activity:**
  - optimisation & control of Cu layer composition
  - surface finish / morphology
Canister Design - Factors to consider?

• Size and shape of your fuel bundles
• Shielding required
• Corrosion resistance required
• Mechanical strength of canister
• Materials to be used
• Retrievability
• Geological conditions
• Method of manufacture
Pierce & Draw Copper Forging

Finishes with 7 tonne rough cast copper tube
Pierce & Draw Copper Forging

Machined in the bore to successfully insert the cast iron insert – 1 mm gap

Machined outside diameter, mainly cosmetic, however needs to fit in the emplacement machine

Both ends welded on
BEP’s Electroforming method

- Bath of copper sulphate with additive system and then either
- Make a seamless tube on a mandrel OR
- Plate on to the insert - no “gap”
- Rate approx. 1mm / day
- Remove shell of the mandrel or is finished plated canister
- The hemi end!
How do we manufacture our rolls?

Anode

Deposition of metallic copper

Cathode

= Cu^{2+} transfer
Copper shell on a mandrel
Full size seamless shells

BEP’s standard production shells for packaging industry

900mm dia X 2000mm face x 16mm thick

Note, perfect bore
Minimal machining required of outside diameter
Trials for NWMO
## NWMO Initial Study Results

### Table 1. Results obtained from testing of copper samples produced by electroforming using the five additives under study.

<table>
<thead>
<tr>
<th>ADDITIVE ID</th>
<th>Compositional analysis - AMG</th>
<th>Mechanical analysis – WMT&amp;R</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>O (ppm)</td>
<td>H (ppm)</td>
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<tr>
<td>NWMO_01</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>NWMO_02</td>
<td>&lt; 2</td>
<td>&lt; 0.5</td>
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<tr>
<td>NWMO_03</td>
<td>95</td>
<td>14</td>
</tr>
<tr>
<td>NWMO_04</td>
<td>&lt; 1</td>
<td>&lt; 0.5</td>
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<tr>
<td>NWMO_05</td>
<td>91</td>
<td>15</td>
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## Chemistry Specification

### KBS -3

<table>
<thead>
<tr>
<th>Element</th>
<th>Range</th>
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<tbody>
<tr>
<td>Oxygen</td>
<td>tens of ppm</td>
</tr>
<tr>
<td>Sulphur</td>
<td>&lt;12ppm</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>&lt;0.6ppm</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>30 – 100 ppm</td>
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</tbody>
</table>

### Electro forming spec

<table>
<thead>
<tr>
<th>Element</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>&lt;1 - &lt; 95</td>
</tr>
<tr>
<td>Sulphur</td>
<td>&lt;2 - 40</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>&lt;0.5 - 15</td>
</tr>
<tr>
<td>Carbon</td>
<td>&lt;10 - 142</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>&lt;2 - &lt; 10</td>
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</table>

Source SKB TR-10-14, Dec 10
page 32

Do we need phosphorous?
## Mechanical Specification

### KBS -3

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Gain size</td>
<td>&lt;360 µm</td>
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<tr>
<td>Hardness</td>
<td></td>
</tr>
<tr>
<td>Elongation %</td>
<td>&gt;40</td>
</tr>
<tr>
<td>Creep ductility %</td>
<td>&gt;15</td>
</tr>
</tbody>
</table>

### Electro forming

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain size</td>
<td>10 - 20µm</td>
</tr>
<tr>
<td>Hardness</td>
<td>100 – 200 HV</td>
</tr>
<tr>
<td>Elongation %</td>
<td>26 - 41</td>
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<tr>
<td>Creep ductility %</td>
<td>?</td>
</tr>
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</table>
Forge Pierce & Draw

- Hot working
- Off site
- Large waste to be recycled
- Wasted energy
- “The Gap”
- Very thick, can it be reduced?

Quick - a day

Electroformed Copper

- Cold working
- On site
- Kg’s not tonnes
- Copper plating is 100% efficient
- No gap or a gap
- Any thickness 2mm – 50 mm

1mm per day
Advantages of Electroforming

- Choose your copper thickness
- Eliminate the gap
- If hemi end, only one seal
- Locate in the repository, under your control
- Minimal machining required
- Minimal waste
- Lights out operation
- Consistent small grain size aids ndt
Mock up electroplating plant
Thank you

Any Questions?