Manufacture of ODS Alloys by Mechanical Alloying ...
Processing and Applications

Huntington Alloys
Special Metals Corporation
a PCC Company
ODS High Temperature Alloys

- Superior strength and creep resistance at highly elevated temperatures
- Improved heat resistance over conventional solid solution Ni-Cr alloys
- Increase in usage range from 200 to 300°F over conventional solid solution alloys
- Fe-Cr-Al alloy offered unique heat resistance, even to sulfidation
## SMC ODS Alloys

### Chemical Composition

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Ni</th>
<th>Cr</th>
<th>Fe</th>
<th>Al</th>
<th>Ti</th>
<th>Y$_2$O$_3$</th>
<th>Others</th>
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<tbody>
<tr>
<td>MA754</td>
<td>Bal.</td>
<td>20</td>
<td>1</td>
<td>0.3</td>
<td>0.5</td>
<td>0.6</td>
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<tr>
<td>MA758</td>
<td>Bal.</td>
<td>30</td>
<td>1</td>
<td>0.3</td>
<td>0.5</td>
<td>0.6</td>
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<tr>
<td>MA6000</td>
<td>Bal.</td>
<td>15</td>
<td>1</td>
<td>4.5</td>
<td>2.5</td>
<td>1.1</td>
<td>W-4; Mo-2</td>
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<tr>
<td>MA956</td>
<td>---</td>
<td>20</td>
<td>Bal.</td>
<td>4.5</td>
<td>0.5</td>
<td>0.5</td>
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</tr>
</tbody>
</table>
INCOLOY MA956 Tubing
Production of INCOLOY MA956 Tubing

- Manufacture powder
- Characterize & blend
- Fill, evacuate & seal cans
- Soak / sinter / homogenize
- Extrude
- Cut, straighten, deglass & pickle
- Cold work - pilger or draw
- Anneal, pickle, straighten & cut
- Test & certify
INCOLOY MA956 Tubing

Sizes Manufactured at SMWL – Hereford, UK

Largest - 114 mm OD X 6 mm AW
(4.5” OD X 0.236” AW)

Smallest - 25 mm OD X 2 mm AW
(1.0” OD X 0.78” AW)

Smaller tubes made by specialist redrawers
INCOLOY alloy MA956
Elongated Grain Structure
INCOLOY MA956 Flow Formed Tube
Longitudinal Microstructure (50X)
INCOLOY MA956 Tubes
INCONEL MA956
Flow Formed Tubes
INCOLOY MA956 Tube Explosively Bonded to an INCOLOY alloy 800H Tube
INCOLOY alloy MA956
Tubes Joined by Friction Welding
Weld Clad Tube
INCOLOY MA956
Rolled & Riveted Tube
Applications for MA ODS Alloys

Aerospace


- **Blades** - Rolls-Royce / Allison Military engines. MA6000 blades forged by Doncasters. Lost out to single crystal casting.
Applications for MA ODS Alloys

Aerospace

– **Combustors and nozzles** - NASA, GE and Rolls-Royce. MA956 and MA754. Numerous projects over 15-yr period. Proposed Title III project to support F22 engine dropped when engine down-rated for stealth capability. Several classified USAF applications.

INCOLOY MA956
Turbine Nozzle for WR24 7 Engine
INCOLOY MA956 Transition Liner
INCONEL MA754
Stator Blade for GE Engine
Applications for MA ODS Alloys

Industrial Gas Turbines


– **Other Components -** GE, Solar, Siemens, Westinghouse, ABB, Mitsubishi, Hitachi, Toshiba. MA956. Never commercialized
INCONEL MA6000
LBGT Turbine Blade
Applications for MA ODS Alloys

Glass Production


- **Drawn Fiberglass** - MA754. Continuing small one-company application.

- **Radioactive Waste Vitrification** - Various components such as stirrers and gas pipes. MA758. USA DOE and France. Continuing application.
Applications for MA ODS Alloys

Industrial Equipment

– Radiant Heaters - MA956
– Reactor vessels - MA956
– Gas fired heat treatment muffles - MA956
– Combustion fans - MA956
– Ethylene production reactor tubes - MA956
– HIP shields and muffles - MA956
– Impellers for floating zone annealing furnaces - MA754
– Steel heating furnace skid rails - MA956, MA758
– Laboratory testing grips & hardware - MA754, MA6000
Heat Treating Baskets
INCOLOY MA956 Furnace Muffle for Manufacture of Ceramics
INCOLOY MA956 Radiant Tubes for Ceramics Manufacture
INCOLOY MA956
Vacuum Furnace Tray
MA ODS Alloy
Heat Treating Furnace Skid Rails
INCONEL MA754
Test Furnace Grips
Applications for MA ODS Alloys

- **Automotive** - Glow plugs for Daimler Benz
  - MA956

- **Nuclear** - Fuel cladding - DOE initiated contact in 1980, intense interest in France and Japan. MA957 (Dourmetal had a slightly different formulation). Inadequate hoop strength is limiting factor.

- **Nuclear** - HTGR heat exchanger - MA956
Diesel Engine Using INCONEL MA758 Valves
INCONEL MA758
Fuel Injection Valve
INCONEL MA758
Radwaste Vitrification

– Molten, aggressive phosphate glass
– High chromium alloys required
– INCONEL alloys 690, 693, MA758
– MA 758 – Strength + Resistance
– Glass Stirring Tubes & Components
– Agitator Blades
Summary

• ODS materials offer a unique combination of properties not attainable from conventional alloys.
• Many applications for the products have been identified.
• Unfortunately, material requirements have not been sufficient to justify continued production.
Questions ???
Thanks !!!