Sandvik Group – a global leader

Three business areas

<table>
<thead>
<tr>
<th>Business Area</th>
<th>Invoicing MSEK</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandvik Tooling</td>
<td>19 078</td>
<td>15 296</td>
</tr>
<tr>
<td>Sandvik Mining and Construction</td>
<td>32 621</td>
<td>14 429</td>
</tr>
<tr>
<td>Sandvik Materials Technology</td>
<td>15 328</td>
<td>8 246</td>
</tr>
</tbody>
</table>

31 Dec. 2009
Alumina scale on FeCrAl Alloys

\( \alpha\)-alumina \( \text{Al}_2\text{O}_3 \)

- Thermodynamically stable
- Non-volatile
- Inert
- Dense
- Thin
- Slow growth
- Adherent

Reactive Element (RE) effect!
Conventional vs RSP FeCrAl

Ø9.5 mm wire heaters after 500 h at 1300-1400°C (2372-2552°F)

Conventional FeCrAl alloys
Severe elongation and deformation

RSP FeCrAl (KANTHAL APM)
Form stability and low elongation
Development of Creep Resistant FeCrAl-alloys

Creep Strength & Price

ODS MA FeCrAl Alloys

RSP KANTHAL APMT™ Alloy

RSP FeCrAl Alloys (KANTHAL APM)

Conventional Metallurgy (ex. KANTHAL A-1)
PM based KANTHAL alloys

<table>
<thead>
<tr>
<th>Composition (wt%)</th>
<th>Fe</th>
<th>Cr</th>
<th>Al</th>
<th>Mo</th>
<th>Si</th>
<th>Mn</th>
<th>C</th>
<th>Minor additions</th>
</tr>
</thead>
<tbody>
<tr>
<td>KANTHAL APM</td>
<td>Bal.</td>
<td>22</td>
<td>5.8</td>
<td>&lt;0.7</td>
<td>&lt;0.4</td>
<td>&lt;0.05</td>
<td>Present</td>
<td></td>
</tr>
<tr>
<td>KANTHAL APMT</td>
<td>Bal.</td>
<td>22</td>
<td>5.0</td>
<td>3.0</td>
<td>&lt;0.7</td>
<td>&lt;0.4</td>
<td>&lt;0.05</td>
<td>Present</td>
</tr>
</tbody>
</table>

10 000 h Creep Rupture Strength

- Fe35Ni25Cr
- Alloy 800HT
- Alloy 601
- Kanthal APM
- Kanthal APMT
Production of PM HIP:ed materials
Process Route for Tubes

1. Powder by gas atomisation
2. Filling of Capsule
3. HIP
4. Machining of Billet
5. Hot Extrusion
6. Pickling (Preoxidation)
Grain Structure Kanthal APMT tubes

Delivery State

Creep tested at 1200°C, 2000h

Cross Section
Dispersion in Kanthal APMT tube

Average Particle Size: 75 nm
Average Particle Density: 12 µm⁻³
Overheating

APMT can withstand temperature trips of 24h at 2282°F with Creep Properties maintained!

Creep Strength 2012°F / 1.16 ksi - Impact of Overheating 24 hours

Remained Creep Life [%]

Temperature [°F]

2192 2282 2372 2462 2552
KANTHAL APMT™ material presentation

KANTHAL APMT Sec. Creep Rate

- 6 times higher load
- >1000 times slower creep

Creep rate [s⁻¹] vs. Stress (MPa) for temperatures 800°C, 900°C, 1100°C, and 1200°C.
Gravitational deflection of horizontal tubes

Distance from centre [mm]

Deflection [mm]

-1000  -500  0   500  1000

0,00  0,20  0,40  0,60  0,80  1,00  1,20  1,40  1,60  1,80  2,00

APMT

APM

KANTHAL APMT

Fe35Ni25Cr
Oxide spallation.

KANTHAL APMT

Fe35Ni25Cr

Alumina

Chromia
Joining techniques

- KANTHAL APMT is weldable if WPS is followed.
- Recommended methods TIG (GTAW), laser welding
- Preheating and PWHT is necessary.
- APMT filler is recommended.

- However a loss of creep strength is unavoidable due to remelting of RSP structure.

- Solid state welding techniques are being evaluated.
- Vacuum brazing also possible.
Applications for KANTHAL APMT

Wire mesh belts

Furnace rollers

Furnace furniture

Radiant tubes

Ethylene tubes
KANTHAL APMT applications

Loading cage rings for HIP presses.
KANTHAL APMT™ product forms

Wire and strip
- Hot rolled
  - Billets,
  - Bars,
  - Rod,
  - Profiles
  - Rings

Extruded tubes
- Radiant tubes,
- Muffle tubes,
- Ethylene tubes.

Fabricated components/products

NNS HIP components
For more information

www.kanthal.com

THANK YOU FOR LISTENING!