New Pt DPH-materials for the glass industry

Dr. Stefan Vorberg
Requirements from the glass industry

Manufacturing of high quality glasses requires use of equipment with:

- High melting point
- Good mechanical properties
- High corrosion resistance
- Good wetting behavior and no glass coloring effects for optical glasses
- Complex geometry
- Long service life

Suitable materials are:

- Conventional Pt- and Pt-Rh-alloys
- Oxide dispersion hardened Pt- and Pt-Rh-alloys
  - ODS: powder metallurgical manufacturing route
  - DPH: casting metallurgical manufacturing route only from Heraeus
DPH and DPH-A: Casting metallurgical route

- Casting (Pt $T_m=1769°C$) + Forging + Rolling
- Oxy-Annealing of sheets / tubes
  - No powder production necessary
    - No air porosity and no impurities during powder production
  - Internal oxidation of the sheet / tube
    - formation of ZrO$_2$-particles and even distribution inside the grains and at the grain boundaries
  - Platinum hardened by ZrO$_2$-particles at high temperatures

Rolling + Forming of „Platinum components“
“Platinum components” for the glass industry

Materials with different properties are required for different components
Properties of DPH and DPH-A materials

**DPH**

- High elasticity in the heating-up phase
- Robustness to changes in temperature
- High form stability of the components, even in the weld joints
- High ductility
- Good workability
- Excellent weldability

**DPH-A**

- Excellent combination of strength and ductility
- High torsional rigidity for stirrers and plungers
- Very high strength
- High stiffness
- Excellent weldability

Materials for tubes and its components

Materials for active parts like stirrers & plungers
Properties of DPH and DPH-A materials

**DPH**
- Same chemical composition
- Different thermo mechanical treatments for DPH and DPH-A
  - Different microstructure (grains)
  - Different nanostructure (particles)

**DPH-A**

Materials for tubes and its components
- ZrO₂ = 1800 ppm
- ZrO₂-particle size 100–450 nm
- Round shape grains
- Grain size 60 – 90 μm

Materials for active parts like stirrers & plungers
- ZrO₂ = 1800 ppm
- Smaller ZrO₂-particles than in DPH
- Stretched grains
- Grain size 70 – 120 μm
How to measure mechanical properties?

Creep rupture test

- Stress-rupture and creep tests
  - Direct electric current heating
  - IR-pyrometer
  - Temperature controlled by computer Temperature range: 750 - 3000°C
  - Creep curve determination by high resolution camera and the SuperCreep software

Specimen: Strips 120 × 4 × 0.8 mm
4 shoulders laser cut
How to measure mechanical properties?
Creep rupture test
Mechanical properties of DPH and DPH-A

Creep rupture test

High strength and ductile fracture of DPH-materials
Mechanical properties of DPH and DPH-A

Creep rupture test

Different time to rupture for different materials

- Pt-10%Rh: 10 sec.
- Pt DPH: 1 h
- Pt DPH-A: 30 h
- Pt-10%Rh DPH: 100 h
- Pt-10%Rh DPH-A: 4000 h

T = 1400°C
Mechanical properties of DPH and DPH-A

Creep rupture test

Ductile intercristalline fracture

1600°C

creep elongation [%]

8 MPa
6 MPa
5 MPa
4 MPa

Time [h]
Mechanical properties of DPH and DPH-A

Creep rupture test

DPH-materials show high creep elongation

- Pt DPH ≈ Pt-10%Rh DPH > 20%
- Pt DPH-A ≈ Pt-10%Rh DPH-A ≈ 8 - 10%
- DPH > DPH-A materials
Equipment with complex geometry
Welding of DPH and DPH-A materials
Equipment with complex geometry
Welding of DPH and DPH-A materials

- Excellent weldability by all welding processes
  - TIG, Laser, EB, Plasma …

- Fine grained microstructure in welding zone
  - Large amounts of ZrO₂ remain in the material

- High ductility > 20% of welded material

500 µm

Base metal  HAZ  Weld zone
Equipment with complex geometry
Welding of DPH and DPH-A materials

- Mechanical properties of weld's are similar to the base metal
  - > 80% creep rupture strength maintained

- Welded DPH-A has similar strength than DPH base material
Corrosion resistance of DPH and DPH-A materials

- **Pt-10%Rh** show **low corrosion resistance** due to fast grain coarsening.

  ![Image showing grain coarsening](image1)

  Short diffusion paths and easy formation of corrosion cracks along grain boundaries.

- **DPH and DPH-A** show **high corrosion resistance** due to small grain sizes.
  
  - DPH and DPH-A shows no grain coarsening.
  
  - Long diffusion paths lead to high corrosion resistance.
  
  - No material and Pt-part failure.
Long term stability of DPH and DPH-A materials

- High microstructure stability during long term operation at high temperatures

- No noticeable grain coarsening
- Mechanical properties after operation similar to initial state
Wetting behaviour of DPH and DPH-A materials

- DPH and DPH-A grade shows similar wetting behaviour
- No risk to combine DPH and DPH-A in one glass melting system
- No coloring effect for optical glasses
Your benefits

Combine the established DPH and new DPH-A grade in your systems for

- Longer service life
- Less shut-downs of glass production lines
- Heraeus as full service provider
  - Support in precious metals handling
  - Technical support
  - Optimization of your Pt-systems
  - Recycling of used parts
- Best overall cost-benefit-ratio
New Pt DPH-materials for the glass industry

Thank you very much for your attention
Acknowledgement

- Prof. Bernd Fischer
  University of Applied Sciences Jena
  Carl-Zeiss-Promenade 2
  D-07745 Jena, Germany

- Prof. Uwe Glatzel and Dr. Rainer Völkl
  University Bayreuth
  Ludwig-Thoma-Straße 36b
  D-95447 Bayreuth, Germany