Polymeric Materials for Solar Thermal Applications
2006 – 2014
Subtask B: Collectors and Components

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Content

- Thermal loads on solar collectors and components
- Overheating protection
- Selected products and concepts
- High lights, conclusion and outlook
Relatively Low Peak Temperatures ($\rightarrow 86 \, ^\circ C$)
Only Short Durations at High Temperatures
Most Low-Cost Polymers Useable

Source: Ch. Reiter, Ingolstadt University of Applied Sciences
Low Peak Temperatures (→ 79 °C)
Temperature Mainly Below 65 °C
Perfectly Suitable for the Use of Low-Cost Polymers

Source: Ch. Reiter, Ingolstadt University of Applied Sciences
Considerable Temperature Loads during Operation (→ 140 °C)

Extreme Temperature Loads in Stagnation (→ 208 °C)

Source: Ch. Reiter, Ingolstadt University of Applied Sciences
Temperatures Solar thermal system

Results at location Graz, Austria

Source: D. Preiß, AEE – Institute for Sustainable Technologies
Consequences and solutions

- High performing (expensive) polymers
- Over heating protection

Source: A.. Thür, University of Innsbruck, Unit for Energy Efficient Buildings
Overheating protection measures

**Basic Function Scheme of the Collector**

- Radiation – Short Wave
- Medium - Cold
- Conversion of Radiation into Heat
- Medium - Hot
- Heat
- Energy Losses
- Controller Signal
- Overheating Protection Measures

**Overheating Protection**

- Reduction of the Optical Efficiency
  - Reduction of Transmission Properties
  - Reduction of the Absorption Properties
- Removal of Thermal Energy
  - Raising of the Thermal Losses
  - Active Cooling of Collector Parts

Source: Ch. Reiter, Ingolstadt University of Applied Sciences
Vents mechanism (MAGEN)

**Active cooling**

**Vents**
Patented unique venting mechanism builds from four ventilation orifices at the collector’s 4 corners that open and close, depending on temperature driven mechanism the casing structure, to eliminate the risk of overheating damage to the plastic absorber.

Source: M. Plaschkes, Magen Eco-Energy
Measured absorber temperatures

A typical graph is shown: collector inclination 30 degrees. Red line: collector with closed slots/green line: collector with slots open.

Source: M. Plaschkes, Magen Eco-Energy
**Goal**

**Fail Safe Temperature Limited Plastic Collector**
Maximum Temperature of ca. 90°C

**Method**
Concept, Material, Simulation, Production and Measurements of Modell-Collectors

**Materials**
Cheap Mass-Produced Plastics (Polyolefine)

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**Problem**

**Principle**

Source: A. Thür, University of Innsbruck, Unit for Energy Efficient Buildings
Back cooler in operation

Source: A.. Thür, University of Innsbruck, Unit for Energy Efficient Buildings
Thermotropic Overheating Protection

Theoretical Potential and Material Requirements


The graph shows the residual transmittance of thermotropic glazing and absorber as a function of absorber temperature. The residual transmittance of the thermotropic glazing is denoted as $T_s=55-60^\circ C$, while the thermotropic absorber is shown with $T_s=75-80^\circ C$. The graph also includes data for different residual transmittances of the thermotropic glazing and absorber, represented by lines of different colors.

Thermotropic Overheating Protection

Application demonstrations in conventional solar thermal collectors

Significant reduction of maximum absorber temperatures (<90° C) with thermotropic layers

To do: optimization of large scale manufacturing

Source: K. Resch, Montanuniversität Leoben
Overheating protection by partial glazing for AventaSolar Thermosiphon system

- Tune the glazing fraction according to the climatic region and the demand in order to avoid overheating (boiling)
- Easy and flexible method
- Additional benefit
  Higher efficiency at low temperatures

- Non-pressurised system
- Heat carrier: water

Source: M. Meir, Aventa
Selected products and concepts
One world solar collector

The design concept:

- functional
- modern
- trendy
- smart
- unique
- intelligent
- handy
- practical

World premiere of One World Solar Collector at Fakuma fair 14th -15th October 2014
(www.fakuma-messe.de/en/fakuma/)

Source: R. Buchinger, Sunlumo
One world solar collector conceptional production line

Fully automated modular factory

Source: R. Buchinger, Sunlumo
One world solar collector production line (prototype)

Source: R. Buchinger, Sunlumo
MAGEN Eco-Flare collector

**Material**
Specially formulated material, all plastic made, tested in authorized labs and proven to be stabilized against the effects of sustained UV radiation, extreme weather conditions, corrosion, limescale, salts and seawater. High resistance for freezing and pressures

**Absorber**
117 + Individual plastic tubes @6.5mm diameter, connected to a unique square manifold header by Over-Molding injection technique

**Back Plate**
UV stabilized Polypropylene back plate

**Casing & frame**
Reinforced plastic and Aluminum components with a very light weight, for easy installation and minimal roof load

**Glazing**
Multiwall Polycarbonate glazing with additional UV blocking tissue. Light weight with extreme impact resistance (200 times more than glass)

**Insulation**
The collector is encased in polyurethane foam and Polyester coated Aluminum foil

Source: M. Plaschkes, Magen Eco-Energy
MAGEN Absorber and header

- Patent Pending
- Bursting Pressure: 50 bar
- Freeze Resistance: -18 °C
- Max. Operating Pressure: 5 bar @ 77 °C

Source: M. Plaschkes, Magen Eco-Energy
AventaSolar collector

- New collector concept based on extruded polymeric sheets (absorber and glazing)
- Collector design adopted to the use of polymers
  - Pure water as heat carrier
  - Non-pressurised collector loop
  - Solar loop with drain-back design
- Light weight with approx. 8 kg/m²: Easy handling, transport, installation

Source: M. Meir, Aventa
AventaSolar collector system

- Collector designed for building integration: Roof and facade integrated collectors replace conventional building materials

- Advantage: Modular collector design with various collector standard lengths

- Simple system design: "Direct system"

- Favorable applications: Low- and midtemperature applications: Combisystems, low temperature heating systems, system with large DHW demand;

Source: M. Meir, Aventa
AventaSolar collector / system - New solutions overcome barriers for Solar Thermal

- Cost reduction by mass production (extrusion, IR welding)
- Replacing conventional building covers
- Modular concept & simple hydraulic design:
  Installation & distribution in collaboration with building industry instead of HVAC installers
- Building modules with well-known installation process: NorDan Solar window concept (NorDan, OSO Hotwater, Uponor)
- Mass-produced housing: AventaSolar in catalogue house programme
Co-operation with building industry
AventaSolar Thermosiphon system

Illustration of the AventaSolar TSS. The flat design with integrated storage (left) consist of polycarbonate glazing, a twin-wall sheet absorber, rear and storage tank insulation and framing for façade or roof mounting (right). Non-pressurised design. Indirect system with immersed tank heat exchanger.

Advantages:

- Light-weight
- Low cost through mass production
- Integrated design (tank and collector)
- Option for easy integration

Source: M. Meir, Aventa
AventaSolar Thermosiphon system

Storage tank behind:
Integrated design with flat-plate look

Storage tank in front:
Easy mounting on flat surfaces

Source: M. Meir, Aventa
Concept Study of a (Co-)Extruded PP Collector

Cost optimized modell

- PP ~70%
- PMMA ~30%
- 10 kg in total

Source: A. Piekarczyk, Fraunhofer ISE
PP-Collector

Extruded profile and injection molded end caps

See: „Simulationsgestützte Qualifizierung neuer Konzepte zur Gestaltung von thermischen Solarkollektoren auf Polymerbasis“
Steffen Jack (2008)

Source: A. Piekarczyk, Fraunhofer ISE
PP-Collector

Extruded profile and injection molded end caps

- End caps
  - Injection molded
  - Insulation due to internal air gap
- Weight ~0.8 kg PP

Source: A. Piekarczyk, Fraunhofer ISE
Collector support and framing

Source: R. Buchinger, Sunlumo
Thermos storage

Injection moulding of two half shells made from glass reinforced engineering materials (Concept Magen)

Thermo-tank QUADROLINE by ROTH WERKE GmbH

Fibre / Plastic composite and EPS blocks
High lights, conclusion and outlook

- Solar thermal has been brought to another level due to the participation and interest of big plastic producing companies (BASF, Chevron Phillips Chemicals, Du Pont, Borealis, Sabic, EMS, Solvay)

- First profil extruded with PPS

- First mass production of polymer collector in sight

- Collectors made from polymers pushed Norvegien solar thermal market

- Promising products for emerging markets
High lights, conclusion and outlook

- World market is and will increase this is why the big companies are interested
- Market development was not supportive (Europe)
- Lacking processing capacity
- Solar thermal industry is not yet interested in plastic production
- Investment for production line is very high compared to conventional production and will only be pay back with mass production
High lights, conclusion and outlook

Plastics are the future for solar thermal

- Real mass production is possible
- Cheaper products can be realised
- Higher freedom in design and building integration is possible
Thank you for the attention!

Thanks to all participants of Subtask B

and their contribution to this presentation!!!