SCOOP
Novel materials, ideas and designs for solar collectors made of polymers

NEWS

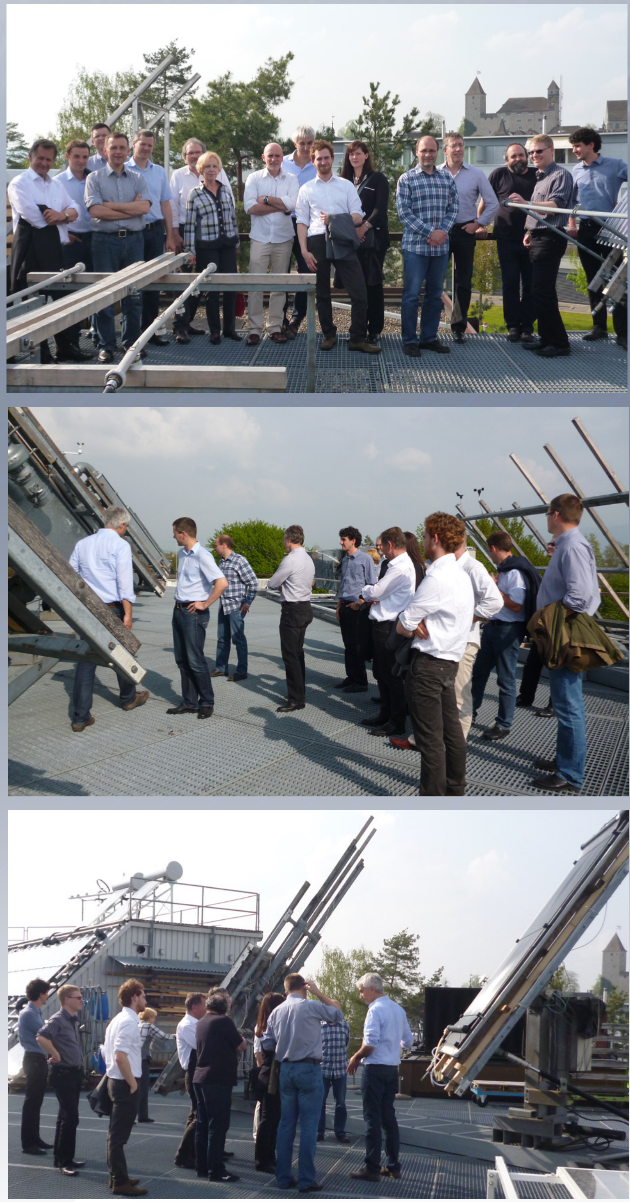
The next steps towards all-polymeric solar collectors

Halfway down the road towards the demonstration of innovative all-polymeric solar thermal collectors – time for some of the most important choices. Which markets will be entered? Which concepts shall be realized? How do the novelties look like? Which polymers are used and how suitable are common standards and test procedures for SCOOP's future developments?

This newsletter depicts the latest developments in SCOOP by placing special emphasis on the design developments (p. 2-3) and allows insights into the progress in material testing and selected plastic manufacturing processes (p. 3-5).

News & Events

The last project meeting was held in Rapperswil, Switzerland on May 2nd + 3rd, 2013. Beneath (and above) the roof of Rapperswil's University of Applied Sciences, partners became acquainted with the facilities of the University's Institute for Solar Energy (SPF) and had the opportunity for intense exchange about the on-going work (figures 1 -3). The mid-term meeting takes place in **October 2013**.



Figures 1 - 3: Impressions of the project meeting in Rapperswil, May 2013.

Read more

SCOOP was presented at the 23rd OTTI Solar Thermal Energy Symposium at Kloster Banz, Bad Staffelstein, on April 24th - 26th, 2013. Abstracts on current developments of thermosiphon systems and storage collectors as well as combined spectroscopic and mechanical investigations of degradation factors can be found on our homepage www.eu-scoop.org .

See more

The IEA SHC Task 39 "Polymeric materials for solar thermal applications" exhibits a selection of polymer based components and collectors during the SHC 2013 in Freiburg, Germany.
Interested parties are invited to have a look at these pioneering polymeric solar thermal systems and get to know SCOOP's experts who also offer the opportunity for an active engagement in the project by volunteering as host for one of SCOOP's demonstration projects. Come and visit us at:

TASK39 EXHIBITION
SHC 2013 23-25/09
Freiburg, Germany

For more information about the exhibition contact:
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Market, costs and scale effects

Very low solar system prices compared to the power purchase parity and the gross domestic product per inhabitant are perfect market conditions for solar thermal systems. Mostly gravity systems (thermosiphon systems and integrated collector storage systems) meet those requirements with their simplicity and are therefore easy to afford for nearly everyone.

In countries like India, Brazil and in regions like South Africa or Southern Europa hot water is in most cases made electrically. The electrical energy capacity is limited during peak demands of domestic hot water use. This bottleneck in electrical supply and the increasing prices for electrical and conventional energy such as gas and oil along with the unpredictability of prices and fossil resources is an opportunity for future developments in solar thermal systems. There are several governmental programs launched or in preparation (South Africa, Brazil, MENA region, India) to overcome this situation. But also cheap and easily affordable pumped systems can activate markets and contribute to energy and resource efficiency worldwide.

Potential markets addressed by SCOOP

Thermosiphon systems and integrated collector systems are dominant in Southern Europe, Asia, South America, Mexico and Africa mostly for domestic hot water preparation (DHW).

Whereas in Asia open loop / non pressurized thermosiphon systems with simple (vacuum tube) collectors are dominating, closed loop / pressurized freeze resistant thermosiphon systems are the mainstream products in other thermosiphon countries (Italy, MENA region). Figure 4 shows a design example of an installed integrated collector storage system (ICS). With the use of polymeric materials this system could be easier to handle and metal-corrosion due to chlorinated water is no topic anymore.

Pumped systems for DHW, room and pool heating are dominant in regions with a bigger distance to the equator where freeze protection is needed, e.g. Central Europe and the USA. The general trend goes towards simple solar systems with high quality standards and a long lifetime. Design is an additional aspect that becomes more and more important. Key market for polymer based solar thermal panels for building integration will be Europe, future potential may be seen in the USA.

Focus for gravity systems will be on markets like Southern Europe, Mexico, South America and Africa. At a later stage, Australia and India could be an option, too.

Design (reference) examples

One problem for building integration of solar collectors, especially the integration into façades, is the variability of collector sizes needed for optimized utilization of the available façade areas. This can be addressed by polymeric collectors quite well because of their design flexibility.

Figure 4: ICS design example (GoT, 2013).

Another example is depicted in figure 5. This is a building integrated solar thermal system for domestic hot water preparation (DHW).

Figure 5: Façade integration of flat plate collectors for domestic hot water preparation in a multi-family building in Paris, France (Photo by G. Kalt).

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From concepts to production design in two development lines

In this newsletter the most promising system design concepts suitable for plastic manufacturing processes like injection moulding or extrusion are presented. The solar thermal system design process focuses on two main development lines: Gravity driven systems that usually work directly with drinking water and pumped systems with a freeze protected heat transfer fluid and an additional heat exchanger.

The gravity driven thermosiphons operate with an external storage while in integrated collector storage systems the absorber works simultaneously as storage. They are mainly used for domestic hot water production. The second development path covers pumped systems for building integrated solar heating systems.

Integrated collector storage (ICS)

This system concept is suitable for injection moulding. The absorber is also used as a hot water storage tank. Two polymeric shells are connected by welding or gluing other connection methods (gluing, mechanical).

The absorber is positioned in the center of a glazed housing with backside insulation. Figure 6 shows a cross section through the whole system concept. The interconnection of the pipes forms a meander to control the hot water flow when water is drawn at the tap.

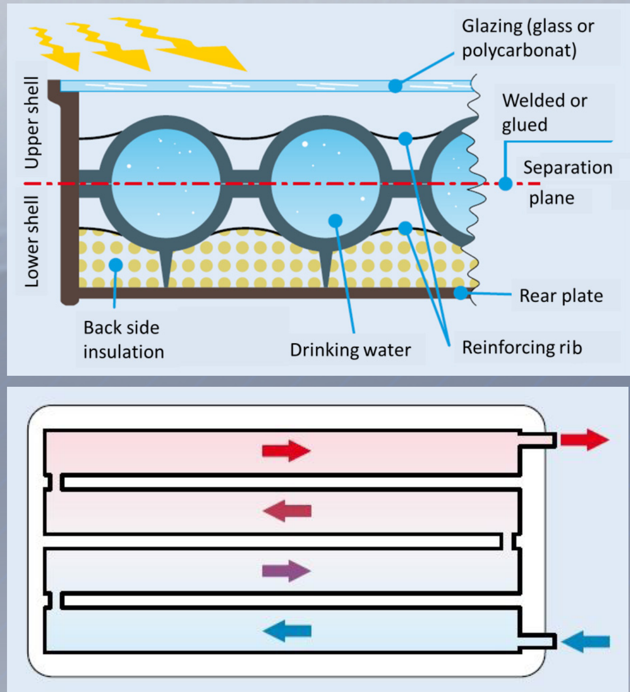

Figure 6: ICS system concept with an injection moulded absorber. Meander connections of the absorber pipes that simultaneously represent the storage pipes (AEE INTEC and GOT, 2013).

The main advantages of this concept are:

- Simplest method for heating water
- High efficiency
- No heat exchanger
- No extra storage tank
- No auxiliary energy is used for warming
- Easy to install
- Corrosion free

Pumped system for building integration (PS)

"In our context, building integration means that the components of a solar thermal system are given additional functional tasks in addition to providing solar heat to domestic hot water and comfort", explains Michaela Meir.

The design of a pumped system with collector absorbers of polymeric material is different to that of most pumped systems in operation. The heat store is not pressurized and contains pure water that also circulates in the collector and in the space heating system. Freezing and boiling protection is provided by a water drain-back system.

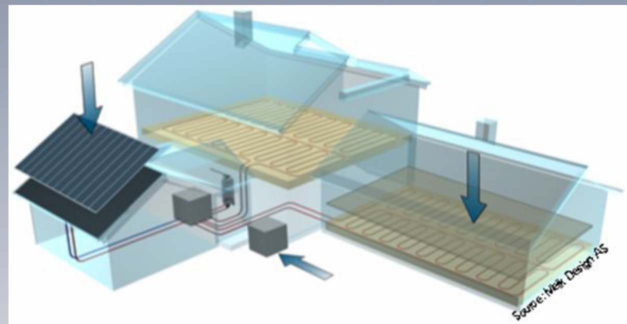

Figure 7: Principle of a solar combi heating system with floor or wall heating elements for comfortable and efficient use of low temperature heat (Aventa, 2013).

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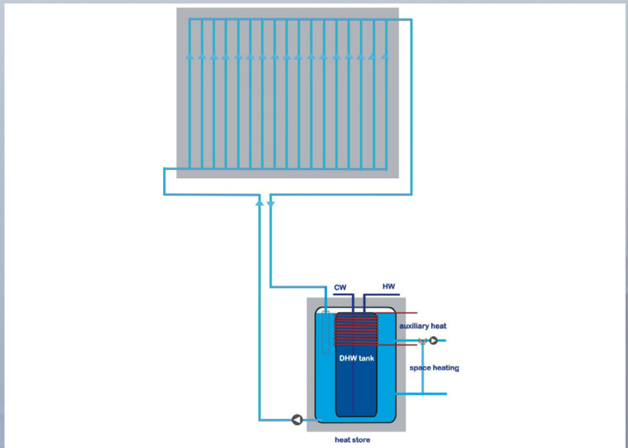

Figure 8: The heat store is not pressurized and contains pure water that also circulates in the collector (and in the space heating system). Freezing and boiling protection is taken care of by drainback (Aventa, 2013).

The system concept is characterized by the following aspects:

- Non-pressurized solar circuit
- Water as heat carrier
- Low module weight (approx. 8 kg/m^2)
- Overheat and freezing protection by drainback and pressure-less system design, high temperature performance polymers as absorber material
- Collector modules can replace existing façade or roof materials
- Flexibility regarding the installation: suitable for roof and façade integration
- Available as combi system or DHW system

Multifunctional polymeric or hybrid materials and injection moulded components

The focus of the material research was placed on multi-functional polymer grades for injection moulding and injection-moulded components for collectors.

Based on the performance defined for the ICS pipe a property profile for the materials was deduced and a systematic material search was carried out. Commercially available glass-fiber reinforced engineering polymer grades were selected and characterized (figure 9).

The characterization on specimen level focused on dynamic mechanical analysis in the operating temperature range. For selected grades also basic time and temperature dependent mechanical properties were determined. Primarily polyamides (aliphatic and aromatic grades with varying fiber content) and modifications with enhanced long-term performance are investigated.

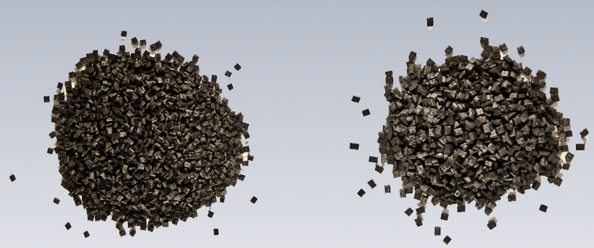

Figure 9: Representative glass-fiber reinforced, black-pigmented granules.

Regarding the design and construction of injection moulded model components a concept based on half-shell parts was established and elaborated. An experimental mould allowing for the processing of model components with varying wall thickness (2, 3 and 4 mm) was machined and implemented. First parts were moulded clearly revealing the principal processability of miniaturized absorber parts with a storage volume of about 6 l (figure 10). Injection moulding experiments will be carried out, focussing on the joining of half-shell parts and connection of absorber parts.

Figure 10: Experimental mould (left: closed, middle: open) and manufactured half-shell absorber part (right).

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Joining polymeric absorber components

The challenge is to interconnect intrinsic absorber components with varying tolerances from different production processes, such as extrusion of structured sheets and injection moulding. For high temperature performance polymers the high melt temperature and a narrow temperature range for welding are demanding factors. Several joining methods were evaluated at an early stage and three have been selected for further investigation: Adhesive bonding, hot-plate welding and infrared (IR) welding.

Together with the expertise of machine builders and material suppliers a fully automated line for IR welding of absorber components could be realised in a pioneer process (figure 11). This line was opened at Aventa's production site in Holmestrand, Norway in February 2013. In the frame of IEA SHC Task 39 a workshop was arranged with invited partners and business contacts in Norway.

The fully automated welding line is an important step for upcoming milestones and deliverables such as the production of modules for component and prototype testing, for demonstration systems and the development of new concepts.

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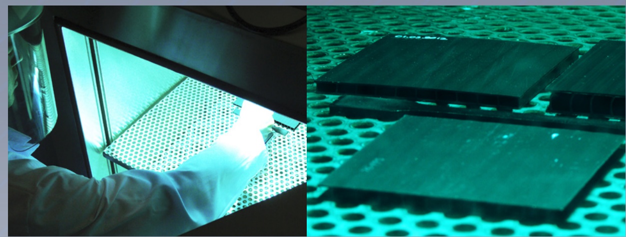
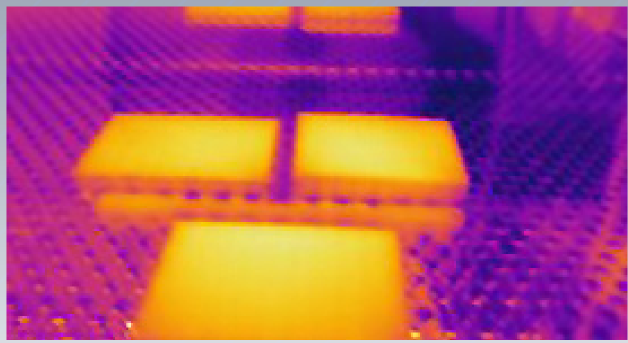
Figure 11: Fully automated welding line at Aventa's production site in Holmestrand, Norway (Aventa, 2013).





Figures 12 - 13: Researcher at ISE detecting increase of sample surface temperature due to additional UV-irradiation (top) in the process of combined UV and temperature ageing using thermographic imaging (bottom).

SCOOP @ 23rd OTTI Solar Thermal Energy Symposium, April 2013

At this year's OTTI conference for solar thermal energy, Fraunhofer ISE presented its first results on the development of new approaches to combine spectroscopic methods, mechanical testing and accelerated aging. The contribution dealing with the use of polymeric materials for solar thermal applications might have been exotic to the audience but SCOOP´s approach with its high potential of cost reduction convinced the interested community.

The results on the detection of UV-influenced changes in the spectroscopic properties of the examined polymeric materials are promising regarding the identification of UV-induced damages in polymers at an early stage and make destructive analytical methods obsolete. The development of non-destructive screening tests in the context of material testing is one of our scientific goals.

SCOOP's materials (figures 12 - 13) are armed with an extra portion of UV-stabilizers like carbon black, a black carbon pigment that absorbs visible and UV-light which not only prevents UV-damage to the polymers but also increases the absorption efficiency.

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Collector and System Testing for Certification

One of the key elements for a successful market penetration of polymeric components is their ability to meet the longevity requirements as much as every other solar thermal component. In Europe this means passing all the tests required to get the Solar Keymark certification.

The collectors and systems that have been developed in the frame of the SCOOP project will be assessed and tested by SPF following the Solar Keymark certification scheme. If possible, the specific additional requirements for other interesting markets such as the US and Australia will be considered as well.

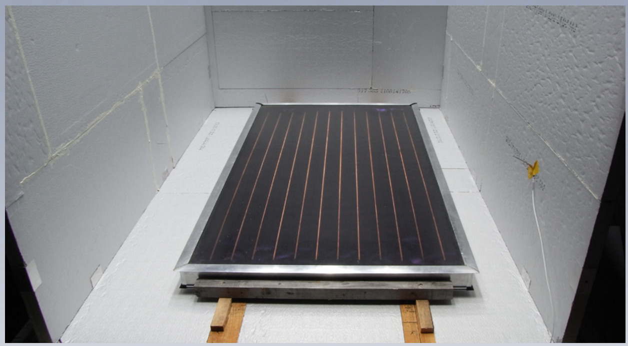

Figure 14: Test room for high temperature resistance also covering the requirements for harshest Australian outback conditions.

Apart from the fundamental performance rating, the collector testing will hence cover a range of different tests such as high temperature tests, thermal shock tests, mechanical load tests, rain penetration tests, pressure resistance tests etc. In the best case there are no problems and the collectors and systems will be certified as they are. In general, however, it must be expected that in a first round of testing some unexpected weak points might surface. Based on these results the collectors and system designs will have to be adapted to meet all requirements.

On the other hand, we also expect that the testing will reveal some weaknesses of the standards themselves as they were elaborated having in mind polymeric collectors mainly as swimming pool heaters. These insights will generate input for the future revisions of the solar thermal standards.

Additional issues related to the resistance against natural hazards such as hail and snow loads are becoming more and more relevant, mainly as a requirement of the building insurances. SPF will also perform some testing in this field using its newly developed and unique test rigs for hail and snow load simulation.

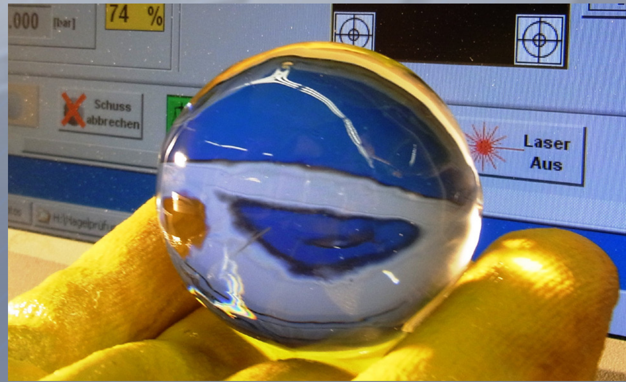

Figure 15: Crystal clear ice balls are used for fully reproducible hail tests on solar thermal collectors and other exposed materials.

Testing polymeric components not only under standard conditions but also under very harsh conditions is important to demonstrate that these materials are competitive. It is furthermore expected that the standards in general are becoming more demanding with respect to various aspects. To cope with these increasing requirements SPF strives to explore the limits of the newly developed products at the end of the project.

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