Polyamide based integrated storage collector **INFO** Sheet C2

Description	*Glass-fiber reinforced polyamide; injection-moulding and welding of collector parts; performance of pressurized storage collector models*
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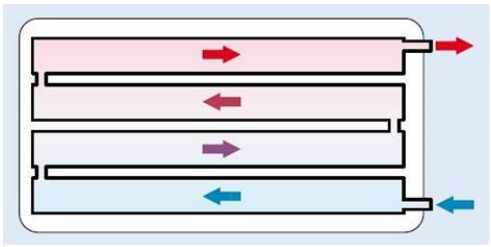
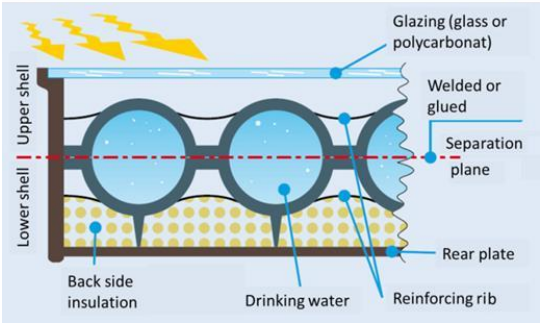
Introduction

Integrated storage collectors (ISC) offer a high potential for domestic hot water preparation in tropical, dry and moderate climate zones. In commercially available pressurized single-loop ISC systems the absorber/storage-tank is made from costly metals such as stainless steel or copper pipes. A specific objective of the European Union collaborative research project SCOOP (Solar Collectors made Of Polymers) is to develop and evaluate plastics based ISC tanks manufactured by well-established, high-throughput injection moulding technologies. This info sheet describes the collector concept, most-promising engineering plastics grades, experimental tools and manufacturing processes and the performance of functional model components.

Design of ISC collectors with injection molded absorber/storage tank and material selection





Integrated storage collectors consist of a pressurized absorber/storage tank with a meander structure, a front-side transparent insulation (incl. glazing), a back-side opaque insulation and a casing. Relevant loading conditions of the pressurized absorber/storage tank in open loop ISC comprise operating temperature limits of 0 and 95°C, a maximum internal pressure of 4 bar at 95°C and a water based heat carrier fluid. To deduce material requirements for the pressurized tank finite element modelling was carried out. At the critical position “fitting/pipe” maximum equivalent stresses of 9 MPa at 95°C were deduced for components with 3 mm wall thickness made from glass-fiber reinforced engineering plastics. Considering thermo-mechanical property requirements along with optical, environmental and processing properties and material costs polyamide grades with a glass-fiber content of at least 30 m% (PA-GF) were selected for manufacturing of functional model

absorber/storage tanks. PA-GF exhibits a high capability for injection moulding and welding or bonding of half-shell parts in order to realize hollow components.

Aging behavior of glass-fiber reinforced polyamides

To assess the aging behavior of glass-fiber reinforced polyamides under service-relevant loading conditions various advanced testing procedures are established. On the one hand, pressure cooker testing is performed using injection molded specimens, which are exposed in water at elevated temperatures (up to 135°C) without additional mechanical loads. On the other hand, a fracture mechanics method is implemented allowing for the characterization of the crack initiation and growth behavior under superimposed environmental and mechanical loads. For selected polyamide grades a good hydrolysis resistance was ascertained without significant embrittlement and a drop of the tensile strength below the critical limit of 20 MPa within an aging time of more than 2000 hours. Hence, the pressure cooker tests at are carried on to generate failure data which are needed for lifetime assessment of polyamide grades for ISC tanks. For the lifetime assessment the Miner`s rule will be applied assuming cumulating damages in the operating temperature range up to 95°C.

Manufacturing and performance of functional model absorber/storage tanks

For injection moulding and joining of functional half-shell parts experimental tools were implemented and used. For different polyamide types with varying glass fiber content a good process ability was obtained. As most appropriate technique for joining of half-shell parts frictional welding was established. Internal pressure testing and pressure rise testing of absorber/storage tank subcomponents with a wall thickness of 3 mm revealed a remarkable pressure resistance. At ambient temperature and 90°C brittle failure of the frictional welding seam was obtained at 20 and 10 bar, respectively. In an ongoing optimization loop the wall thickness of the half-shell parts is further reduced to 2 mm.

Using the injection molded and welded absorber/storage tank subcomponents model collectors were manufactured and examined on an outdoor test facility in Gleisdorf (Austria). To evaluate also meander-type absorber/storage tanks several subcomponents were interconnected with pressure tight tubes. Furthermore, model collectors with state-of-the-art stainless steel absorber/storage tanks and comparable tank volume were realized and investigated. The performance of the novel polyamide based integrated storage collectors was as good as the behavior of the model ISC with stainless steel pipes. Only slight differences were obtained for the heating up cycle during a sunny day and the overnight heat losses.

Summary and conclusions

Within the European Union research project SCOOP a high feasibility for integrated storage collectors based on injection molded absorber/storage tanks was established. The main advantages are the simplicity (e.g., no hot exchangers or extra storage tanks) and high efficiency of this hot water preparation technology. Compared to stainless steel solutions plastics based ICS offer a high potential for cost-efficient, fully automated mass-production and an improved corrosion resistance and long-term performance.

Recommended literature

Meir, M., Ochs, F., Wilhelms, C., Wallner, G.M. (2012) In: Polymeric Materials for Solar Thermal Applications (Köhl, M. et al., eds), pp. 221-242, Wiley-VCH, Weinheim.

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