“All of the coatings passed with flying colours”

Aging on the quick: In the Speedcoll research project, the Fraunhofer Institute for Solar Energy Systems and the Research and Testing Centre for Thermal Solar Systems, together with industry partners, have been studying various collector components for their resistance to aging over a three-year period at six climatically different sites. In an interview with SUN & WIND ENERGY, Fraunhofer ISE researcher Thomas Kaltenbach explains how the absorber coatings measured up.

S&WE: Mr. Kaltenbach, how did the absorber coatings in the study hold up against the extremely high desert temperatures and the salty sea air?
Thomas Kaltenbach: We investigated ten absorber coatings from three manufacturers. The happy result is that the differences are quite marginal. All of them passed the durability test with flying colours.

S&WE: They have been tested in various locations, including the Negev desert and the Zugspitze. The coatings held up even under extreme conditions.
Kaltenbach: There were no failures. The optical values of the layers – that is, the degrees of absorption and emission – changed only slightly compared with the original state. So the happy result is that the layers are all very good.

S&WE: How much did the test sites differ?
Kaltenbach: In terms of thermal load, the demands on the Zugspitze were, surprisingly, the highest. That is where we measured the highest absorber temperatures – an initially interesting finding because it was so unexpected. It can be explained by the fact that the air is so pure air at that altitude, which is why the solar radiation is so high. And then there is the Albedo effect, the reflectivity of white surfaces, present on the Zugspitze, with its glacier and snow. That results in higher absorber temperatures.

Speedcoll: where tested

From the temperate climate in Stuttgart and Freiburg to the tropically humid conditions in Kochi in southern India; from the Negev desert in Israel and the Canary Islands with its high sand, salt and UV exposure to the Zugspitze, with both extremely high and extremely low temperatures, the solar collectors in the Speedcoll research project had a lot to cope with. At the same time, the scientists subjected the flat-plate collectors and their components to an accelerated weathering test in the laboratory of the Fraunhofer ISE.

Thomas Kaltenbach works in the service life analysis group at Fraunhofer ISE. PHOTOS (4): FRAUNHOFER ISE

S&WE: In recent years, there has been a recurring discussion over the effects of salty air on absorber coatings. What did you find out?
Kaltenbach: We are testing systems on Gran Canaria, where they are indeed exposed to a high salt load, being set up only 100 m from the coast. If salt spray enters the collector, that is a huge challenge for the absorber layer. And it does get in because the collectors are not sealed. They have ventilation openings. We have found that salt deposits are in fact present in some cases at the point where the header pipe exits the collector housing, where salty air frequently enters the collector. However, the deposits do not have much of an influence on the overall performance of the system since they make up just a small fraction of the surface compared with the non-affected absorber surface. Visually, however, the salt deposits could be a problem

for customers who can see a white precipitate that is not supposed to be there. If collector manufacturers want to avoid these deposits, they will have to find a different solution for how to build their collectors.

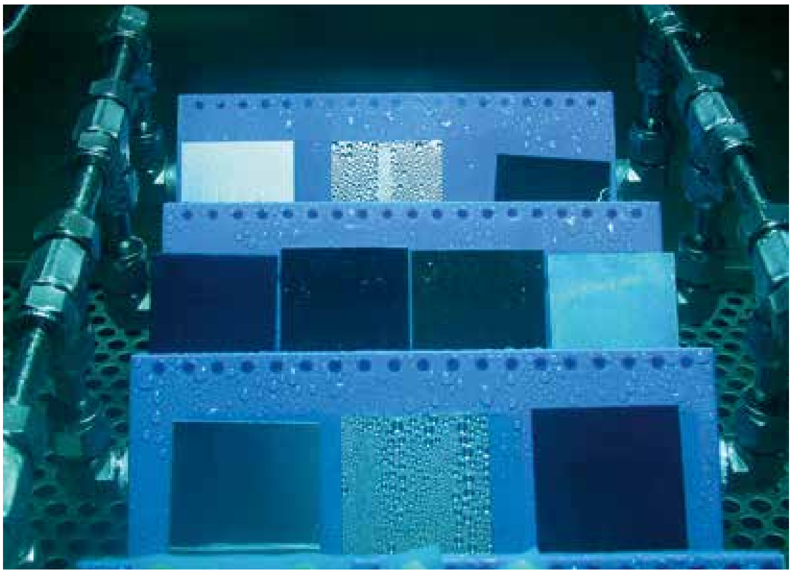
S&WE: For instance?
Kaltenbach: For example, by creating a different way to seal the point where the header pipe passes through the collector frame.

S&WE: But the salt deposits have no great influence on performance?
Kaltenbach: Where there is a salty build-up, the absorption coefficient is very much at rock bottom but the affected spots are such a small fraction of the entire absorber area, which is why the collectors installed on Gran Canaria did only minimally worse on the performance test. That is, the salt deposits have a visual effect that can be seen with the eye, but which has no effect on the performance and yield of the collector over the course of the year.

S&WE: One of the published results is: The surfaces of absorbers on aluminium substrate proved more resistant to temperature aging than those on copper substrates. How do you explain that?
Kaltenbach: That's true, but you have to look very closely. In order to see any differences between the two coatings, we had to perform topography measurements. The effect depends on the material properties of the substrate and has nothing to do with the absorber coating.

S&WE: There has never before been a long-term test of this type for collector components. What is the significance of Speedcoll?

Bracing conditions: At the open-air weather test stand at the Schneefernerhaus on the Zugspitze, the absorber coatings have to withstand extremely high and extremely low temperatures.



In its climatic chambers, Fraunhofer ISE can carry out condensation tests on coating samples.

Kaltenbach: It is a unique project to study different collectors over three years in climatically different locations under extreme conditions. We measure not only the absorber temperature and ambient temperatures, but also ambient humidity and solar radiation. With this treasure-trove of measurements we can move into simulations. We can now estimate the temperature at which, for example, a component has to be tested so that we can simulate a corresponding load duration in the climatic chamber.

S&WE: The Speedcoll project continues. Why keep going if the aging resistance results of the absorber coatings were so clearly positive?

Kaltenbach: Speedcoll2 will run for another three years. We found that the changes in the characteristics of the collectors were too small during the first three years, and that provided the rationale for taking further measurements. This will allow us to investigate whether there are any significant changes in the future.

S&WE: Do you expect changes in the results for absorber coatings?

Kaltenbach: I don't think so. The measurements so far show that the absorber layers we have studied are already very good.

This interview was conducted by Joachim Berner.

Manufacturers of absorber coatings

Manufacturer	Product name	Start of production	Absorptivity [%]	Emissivity [%]	Coating	Coating process
Alanod GmbH & Co. KG, Germany	Mirotherm	2001	95 ± 1	5 ± 2	ceramic-metal-structure	PVD
	Mirosol TS	2010	90 ± 2	20 ± 3	selective nanocomposite	coil coating
	Mirosol TSS	2015	92 ± 1	40 ± 5	selective nanocomposite	coil coating
	Eta plus Al	2005	95 ± 2	5 ± 2	ceramic-metal-structure	PVD
	Eta plus Cu	2005	95 ± 2	5 ± 2	ceramic-metal-structure	PVD
Alanod-Xxentria Technology Materials Co., Taiwan	Sungain Al	2012	95 ± 2	5 ± 2	ceramic-metal-structure	PVD
	Sungain Cu					
	Sungain SS			15 ± 2		
Almeco GmbH, Germany/Italy	TiNOX energy Al	2008	95 ± 2	4 ± 2	ceramic-metal-structure	PVD
	TiNOX energy Cu	2008	95 ± 2	4 ± 2	ceramic-metal-structure	PVD
	TiNOX artline	2011	90 ± 2	5 ± 2	ceramic-metal-structure	PVD
	TiNOX nano	2011	90 ± 2	5 ± 2	ceramic-metal-structure	PVD
Energie Solaire S.A., Switzerland	AS [2]	1980	96	15	black chrome	galvanic
	AS+	1998	95	5		
Savo-Solar Oy, Finland	MEMO	2011	96 ± 2	5 ± 2	TiAlSiN/NO + SiOx	PVD + PECVD
	MEMO 4	2013	97 ± 1	5 ± 2		
Solec-Solar Energy Corp., USA	Solkote HI/Sorb-II	1982	90 ± 2 [5]	25 ± 5 [5]	silicone/calcined oxide	spray-application
Viessmann Werke GmbH & Co., Germany	Therm Protect [6]	2015	95 ± 2	n/a [7]	ceramic-metal-structure	PVD

Footnotes: 1) further thicknesses on request; 2) also used in coverless absorbers and receiver tubes; 3) coating of entire, full-flow absorbers; 4) max. absorber plate length 6,000 mm; 5) dependent on thickness and substrate; 6) Viessmann only coats its own absorbers; 7) depending on temperature

SOURCE: COMPANY DATA

Test stand near the sea: The collectors at Pozo Izquierdo on Gran Canaria have to withstand maritime conditions.

Absorber plate material	Absorber plate thickness [mm]	Absorber plate width [mm]	Internet
aluminium	0.3 to 0.8	max. 1,250	www.alanod-solar.com
aluminium	0.3 to 0.5		
aluminium	0.3 to 0.5		
aluminium	0.3 to 0.5		
copper	0.12 to 0.3 [1]		
aluminium	0.3 to 0.6	max. 1,250	www.alanod-xxentria.com
copper	0.12 to 0.5		
stainless steel	0.3 to 0.5		
aluminium	0.3 to 0.75	max. 1,250	www.almecosolar.com
copper	0.12 to 0.5		
aluminium	0.3 to 0.75		
copper	0.12 to 0.5		
aluminium	0.3 to 0.75		
copper	0.12 to 0.5		
stainless steel	0.4 to 6 [3]	max. 1,000	www.energie-solaire.com
aluminium	0.3 to 65 [3]	max. 3,000 [4]	www.savosolar.com
metals, plastics, masonry	any	any	www.solec.org
aluminium	0.4	max. 1,000	www.viessmann.de

Selective absorber coatings: why they are needed

Absorbers are the engines of solar collectors. They have to absorb solar radiation as efficiently as possible, convert it into heat and pass it on to the heat transfer fluid. The absorber coating (see table) is responsible for the first two tasks, a major challenge for the layers that are just a few nm or even mm thick. They can perform their task particularly well if they have two properties: First, they should be able to absorb a large proportion of the incoming short-wave solar radiation, i.e. They should have a high absorption rate α .

Since the absorber heats up in the process and reaches a higher temperature than its surrounding environment, however, it would release a large portion of the absorbed solar energy again in the form of long-wave radiation, which is why absorber coatings must have a low emission level ε for this wavelength range, i.e. They must give off as little heat as possible. So-called selective layers combine a high degree of absorption for solar radiation with a low emission level for heat radiation.