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Collector Coatings Evolve From Black Paint To Selective Surfaces

The growth of solar thermal has also led to the development of absorbers specially customized for particular applications.

Stefan Braendle

Solar thermal capacity is growing worldwide and gaining greater awareness among consumers, utility providers and politicians - even in the U.S., where solar photovoltaic technology has long enjoyed the limelight. The 2009 Solar Study from Switzerland-based Bank Sarasin predicts a global growth rate for solar thermal of 15% to 20% annually to an eventual installed capacity of 340 GW by 2020.

This continued growth and maturation is projected to lead to an increasingly higher quality of products and installations, as well as more industrial manufacturing processes, leading to higher production capacities and more-efficient products. In part, this growth in the market can also be attributed to the development of new applications for the technology.

New advances in solar absorber technology have also enabled solar thermal technology to realize greater levels of system efficiency and durability at lower costs. Even as we are about to witness an important step forward in both the uncovering of new solar thermal applications and the continued growth and expansion of the industry overall, solar thermal technology itself is about to benefit from another significant evolution in design and application.

Most solar thermal systems that utilize flat-plate collectors are built around either a sheet of absorbing material or a series of absorber fins encased in a frame designed to withstand the elements. Tubing is affixed to the back side of this absorber, where the heat from the sun is transferred to fluid traveling through the tube.

Modern solar thermal absorbers have witnessed two significant technology evolutions that led to significant efficiency and durability gains. We are on the cusp of a third technology evolution that will drive the continued expansion and maturation of the industry.

The first evolution was the development of selective surface vacuum coatings (blue coatings) for absorbing surfaces. These coatings are a means of increasing the operating temperature or efficiency of the absorber and the collector. Selective surfaces leverage different wavelengths of radiation to produce various levels of both the absorption and the emission of radiation. The ratio of this absorption to emission is directly linked to the optical efficiency ($\eta 0$) of a flat-plate collector.

Generally, the emissivity of an absorber is determined by the characteristics of the metal substrate. Both copper and aluminum have low emission rates. The applied coating determines the rate of absorption. The key is to apply as thin a layer of coating as possible to allow the emission characteristics of the substrate to perform at their desired level.

The original absorptive surface was black paint. Although black paint has a high level of absorption, its application is too thick, meaning it also has a very high level of emissivity and, therefore, a low total selectivity or efficiency. This led to the development of true selective surfaces with a range of absorption from 80% to 95% and an emissivity from 10% to 30%, depending on the application.

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Surface materials

A wide range of materials can be used in combination for a selective surface, including copper, black chromium, aluminum oxide and titanium nitride oxide. Galvanically applied selective coatings were one of the early methods of application for these surfaces. Although these coatings boasted a high level of absorption, the emissivity rates were too high.

New technology using physical vapor deposition (PVD) vacuum coating lines can provide a higher absorption surface and much lower emissivity rates than earlier coatings. The PVD process is also environmentally friendly.

In one sample study, the efficiency of a collector using a black-paint absorber was compared to the efficiency of a similarly constructed collector using a PVD-coated high-selective surface. Based on an aperture area of 1.826 square meters at a typical collector working point of ΔT/G of 0.05, the PVD-coated collector had a 47.5% higher level of efficiency than the black-paint collector. The price increase for a PVD-coated collector is typically less than 3%.

Black paint will always have a place in low-end consumer markets, but the solar thermal industry has, by and large, adopted the use of PVD selective coatings in high-end applications that call for greater levels of system efficiency.

Specialization

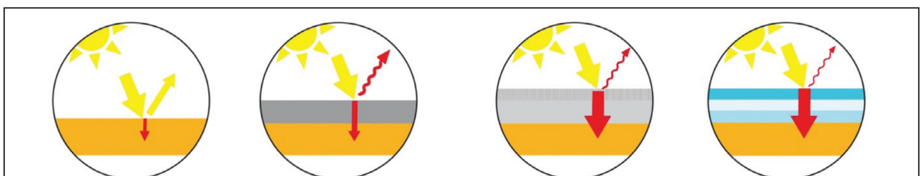
The second major evolution in absorber technology was the development of laser welding to join absorber surfaces to back-side tubing. Previously, this step was accomplished through clamping, soldering or ultrasonic welding methods. The use of laser welding can create a better and more efficient union between the absorber sheet and the pipe. It also enables the joining of two dissimilar materials - the copper pipe and the aluminum absorber sheet.

Traditionally, copper absorbers were welded to copper tubing to avoid problems associated with the joining of dissimilar metals, such as different levels of thermal expansion and known corrosion issues. Joining dissimilar metals also required a much higher level of technical expertise to achieve. However, laser welding eliminates these problems - including the possibility of corrosion - and allows manufacturers to choose the more cost-effective aluminum surfaces and/or tubing in their systems.

By allowing for the use of aluminum in absorbers, laser welding has led to savings and some efficiency gains for solar thermal systems. Specifically, because laser welding does not destroy the selectively coated absorber surface, it leads to a higher efficiency per surface. With laser welding, 2% to 3% more active absorber surface remains in the collector as compared to the active absorber surface that remains with the commonly used ultrasonic welding technique.

The latest advancement in solar thermal absorber technology is the introduction of specialized absorbers. Until now, absorber technology had largely been uniform, aside from the difference in form between absorber sheets and fins. This is no longer the case.

Absorption And Emissivity Values For Flat-Plate Collector Coatings



Source: Alanod Solar

A number of absorber manufacturers have begun to introduce different lines of absorber materials specialized for specific circumstances, collector types or geographies. This trend will lead to a greater diversification of solar thermal systems for specific purposes or markets. In turn, this can lead to adoption in new markets and increased growth in existing ones.

For example, flat-plate collector manufacturer GREENoneTEC recently announced a new project in Riyadh, Saudi Arabia. When completed, this project will be the largest solar thermal project in the world. However, the arid desert environment required GREENoneTEC to design a specially built collector to function in these conditions.

GREENoneTEC designed the GK 3000 series collector using a highly efficient solar thermal absorber, a special solar glass with high light transmission and a modified fixing system that provides for improved space utilization. This collector is also designed to withstand significant wind loads, even those resulting from a sandstorm.

Newly unveiled collectors with even more specialization and levels of performance will be possible and more efficient than before, in part, because of specially designed absorber surfaces.

For example, some absorber surfaces have certain characteristics that make them suited to applications with especially high radiation, such as the southwestern U.S. and Hawaii. These surfaces may reach a high degree of absorption and low emission by using a selective lacquer coating on aluminum to reach a high level of thermal sensitivity. Compared to a standard black lacquer, new specialized coatings may have 30% lower emission, thus helping increase efficiency in the low-end flat-plate collector segment.

These new surfaces are representative of a trend toward specialized or highly diversified absorbers. Similar to the way in which fins have come to dominate the North American absorber and flat-plate collector markets, these materials could grow to take market share away from generic absorbers in their respective markets.

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