CASE STUDY

Polymer-based Solar Collectors Provide Better Design Options and Lower Costs Thanks to Ryton® PPS

Application: Solar thermal collectors
Parts: Manifolds, connectors and solar absorber sheets
Polymer: Ryton® PPS (polyphenylene sulfide)

Key benefits

- Excellent durability of PPS parts, especially due to good thermal ageing and resistance at 150 – 200°C stagnation temperatures
- Resistant to coolants and water, even at high temperatures
- Stable and lower material price and lower cost-to-produce compared to copper, traditionally used
- Design optimization to compensate the lower thermal conductivity of plastics versus metal

The Challenge

› Starting point: Why is metal used extensively in solar collectors?

Solar converters are used to convert sunlight into energy that can be used to heat water or other exchange fluids. A variety of solar panel components are typically made of metals, such as copper and aluminum, because they deliver a high energy yield due to their outstanding thermal conductivity. Metal components can also withstand the required 6 bars of pressure, stagnation temperatures in excess of 200°C, and exposure to UV radiation for more than 20 years. Plus, they offer excellent dimensional stability and are compatible with water and coolant fluids.

Most engineering polymers cannot withstand these conditions, which is why metals remain the material of choice for these applications. Aventa, a company that specializes in solar heating systems, has challenged the status quo by developing an all-plastic solar collector that offers a number of attractive benefits.

› Why did Aventa develop a 100% polymer-based solar collector?

Aventa wanted to optimize its solar collectors to offer **improved designs, design flexibility and lower costs** to its end-consumers. After investigating several material options, they determined that an all-plastic design was the only way to meet this challenge.

- Plastic components would be **cheaper to manufacture** due to well-established extrusion processes with embedded design, which significantly reduces the number of production steps.
- Plastic components would be **lighter to transport** and easier to assemble and install on buildings.
- Solar panels could be produced in a **variety of attractive colors and optimized designs** to be easily integrated in existing buildings or new constructions.

› What are performance requirements for polymer?

The cost-effective polymer had to meet two essential performance requirements:

1. **Good thermal resistance for good energy yield**

   The polymer must be able to cope with the 160°C stagnation temperature, which is the highest operating temperature produced by the thermal system.

2. **Long-lasting performance to meet 20-year minimum life span**

   The polymer must remain stable when exposed to the harsh end-use environment (e.g., exposure to thermal ageing, heat exchange fluids, UV radiation, etc.) and deliver reliable performance for the lifetime of a commercial system.

What are the components of a solar collector?

Solar collectors are made of a black, glass-covered absorber that harvests solar radiation. Water or some other heat exchange fluid is pumped into a building through the tubes that cover the absorber plate.

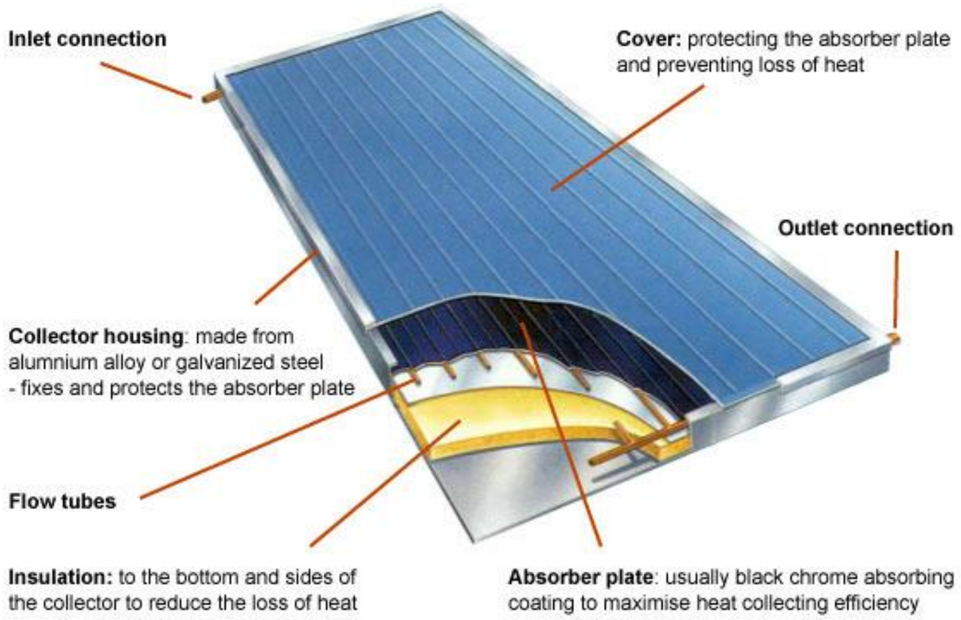

Fig. 1: *Different layers of a solar collector panel*

The Solution

› Advanced polymer technology makes it possible

Due to its excellent chemical resistance and thermal resistance, Ryton® PPS proved to be the best candidate to be used in manifolds, connectors and absorbers with intrinsic channels replacing the metal flow tubes. The glass cover on top of the absorber has been replaced by UV-stabilized polycarbonate sheet.

Solvay Specialty Polymers developed PPS grades for solar thermal collectors in close collaboration with Aventa:

- **Ryton® XE 4500BL is an unfilled PPS** which can be used in twin sheet extrusion for the absorber sheet.
- **Ryton® XE 5030BL is a 30% glass-fiber filled PPS** developed for the injection molded end cups.

Aventa knew that 100% plastic collectors should have lower operating temperatures, and that poor thermal conductivity compared to metal specimens should be compensated by improved design. The operating conditions, the material and the design have to be adapted to the collector.

› Ryton® PPS offers very high and durable thermal resistance

The material choice was critical for Aventa as its maximum stagnation temperature would impact the whole energy yield. After accelerated aging tests, both Ryton® PPS grades gave very successful results. The collector is designed for 160°C stagnation temperature which fully complies with the thermal resistance of Ryton® PPS (150 - 200°C). Although Teflon® was evaluated because it can sustain temperatures of 340°C, it was not selected because, unlike PPS, it cannot be extruded.

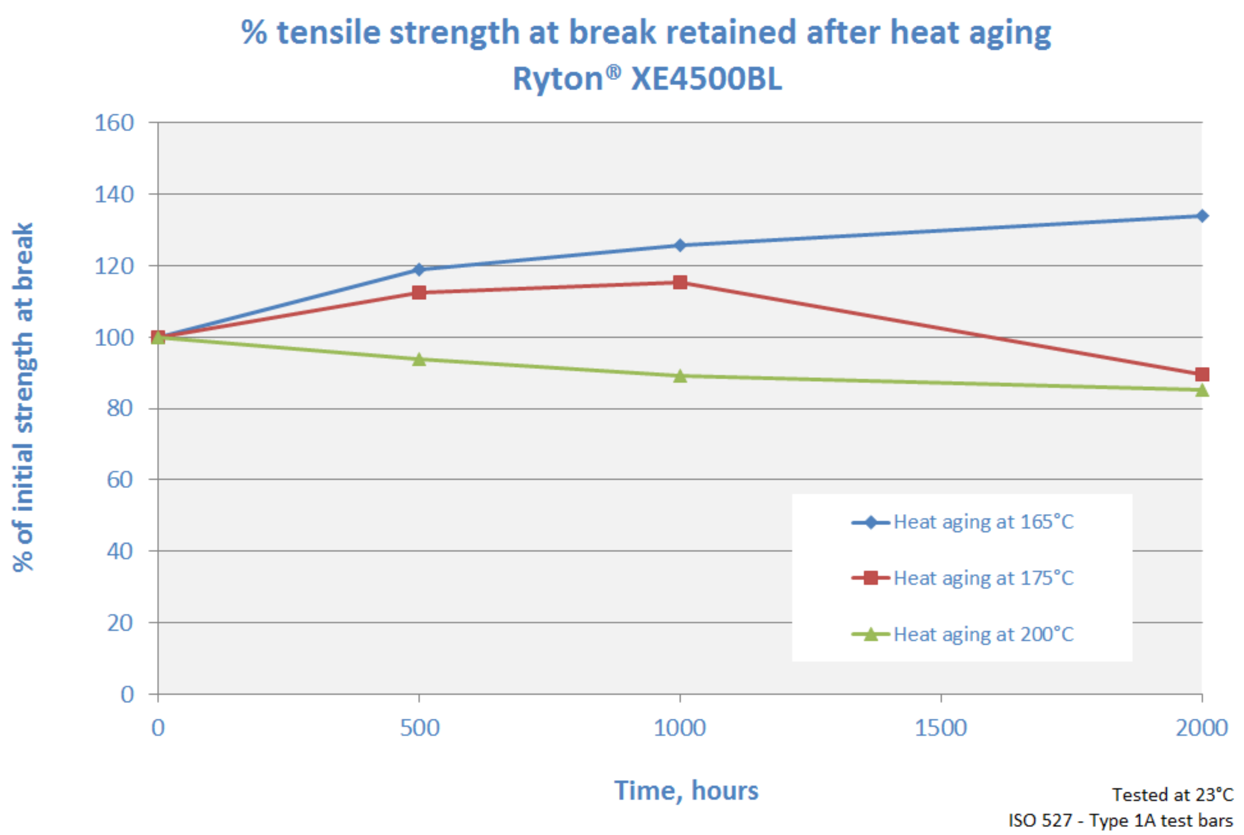

Fig. 2: *Ryton® PPS resists up to 200°C stagnation temperature*

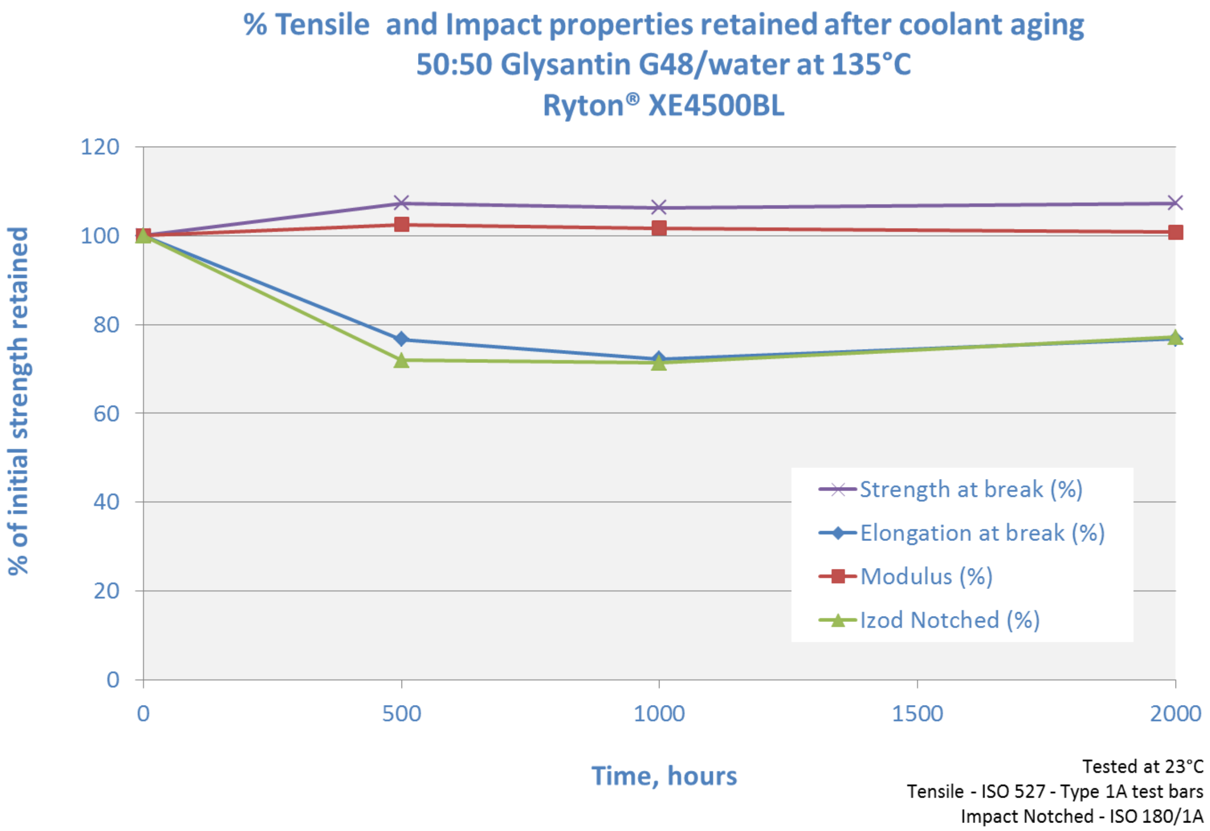

Fig. 3: *Ryton® PPS is not damaged by coolant fluids even at hot temperatures.*

The new Ryton® XE grades have an excellent hydrolytic stability and thermal resistance and maintain their shape, rigidity and dimensional stability over time and temperature variations. Polyamide (PA) could have been evaluated but its dimensional stability is not as good as PPS, especially in contact with chemical agents.

› New collector designs to get maximum energy yield

The design of plastic collectors has to compensate for the material's poor thermal conductivity and lower stagnation temperature by having a large contact area between the heat carrier and the solar absorber sheet. The wall thickness has to be as thin as possible to maximize the heat transfer between the absorber and the heat exchange fluid.

Due to Ryton® PPS, Aventa succeeded in maintaining a very good measured factor F' collector efficiency by reaching 1mm thickness and optimizing the absorber/tubing contact area.

› 50% lower cost to produce than metal collectors

Aventa's goal at the start of this project was to reduce the cost to product collectors by 50% and they achieved their goal. The raw material price of big plastic volumes, the lower transportation cost and the production savings allowed them to reach their objective.

Solvay supported Aventa with processing tips, assisted in die optimization and other value-added technical services and expertise to accelerate the project and make it successful.

› Conclusion

Aventa has developed a 100% polymer-based solar collector, knowing that polymers have inherent limitations compared to metal. Even if metals stand for highly efficient panels, it is not always necessary to reach this level of performance for domestic water and space heating applications. High-performance plastics such as Ryton® PPS made it possible to develop cost-effective solar collectors design for suitable application and in-use conditions.

Aventa has been able to develop plastic solar panels giving similar energy yield as metal collectors. By adjusting the design and the thickness and by selecting the best materials to work in permanent contact with water at medium to high temperatures under moderate pressure, they have been able to produce 50% less expensive and yet durable/performing collectors.