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SCHOTT's 4th Generation Receiver – Getting ready for higher operation temperatures

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Abstract

Parabolic Trough Technology needs to push performance to the limits to achieve a solar field system with improved economics. The collector system with the receiver as an energy converter mainly affects the field performance by optical parameters, yet oil-HTF, which is not stable at temperatures beyond 400°C, is limiting overall power plant efficiency improvements. High temperature HTFs are challenging the materials of parabolic trough receivers in terms of efficiency and durability.
The development of the 4th generation SCHOTT solar receiver, ready for shipment in 2014, has been completed and the product just entered the last stage of product validation. The receiver ends have been completely redesigned to provide a receiver that is ready for high temperature operation up to 550°C.
Based on SCHOTT's experience in over 50 power plant projects and one million shipped receivers, distinct features of the design have been introduced, which help to reduce costs in plant construction. The new receiver will have significantly less weight and contains a protection cap at the receiver end, which prevents mechanical impact to sensitive parts during mounting, installation and operation.
An innovative inner heat shield was conceived in order to optimize the temperature distribution and heat flow, resulting in reduced heat losses and improved efficiency of the receiver. As a particular feature a lifetime calculation scheme for the bellow construction was developed, which takes into account the potential location of operation and the target fluid temperature. Based on the results from the calculation, the new flexible bellow was designed as compact as possible while at the same time extending the lifetime expectancy to the case of molten salt operation. In parallel to the new product design an improved and highly durable coating has been developed. Enabling the new product to serve as the technology platform for future high temperature products and operation with molten salt HTFs

SCHOTT; PTR 70; parabolic trough receiver; High operation temperature; Molten Salt

1. Challenges and potentials of high temperature parabolic trough applications

Parabolic Trough Technology needs to push performance to the limits to achieve a solar field system with improved economics. The performance of the CSP plant is mainly driven by the optical and thermal parameters of the collector system - with the receiver as an energy converter - and also by the maximum operation temperature. The commonly used oil-based heat transfer fluids (HTF), however, are restricted to operation temperatures of 400°C and therefore limit the overall plant efficiency. The key-innovation to overcome this limitation is the use of high temperature capable HTF, such as molten salts or direct steam, which enable operation temperatures up to 550°C. Additionally, significant cost potentials in project execution and solar field construction can be levered. In fact, there is a potential of reduced levelized cost of electricity (LCOE) at higher operational temperatures in a molten salt power plant with thermal storage unit of above 20% compared to a non-storage standard HTF plant and 15% to a standard HTF plant with thermal storage [1].

SCHOTT, as the world's leading receiver supplier, will drive the key-innovations by introducing the 4th generation solar receiver that addresses the most significant performance and cost improvement measures, which are summarized in tab. 1. The receivers have been completely redesigned to provide a product platform that is ready for high temperature operation up to 550°C. Moreover distinct product features have been introduced to reduce costs and risks in solar field assembly and installation. The increased material and design challenges incurred with the high temperature operation have been reflected in sophisticated qualification and validation procedures.

The development of the 4th generation SCHOTT solar receiver (fig. 1) has been completed and the product just entered the last stage of product evaluation and will be ready for shipment to commercial CSP projects in spring 2014.

Table 1. Overview of impacts on performance and cost improvements at CSP technologies [2]

Performance can be increased by:	Cost reduction can be achieved by:
• improving output temperature of solar heat cycle • improving the solar field optical efficiency • reducing the solar field thermal losses • reducing parasitic power consumption • developing improved configurations that lead to higher utilization and efficiency • identifying more efficient overall system designs.	• reducing equipment capital cost via lower material content, more efficient design • reducing field assembly and installation costs (via simpler designs and minimization and/or ease of field assembly) • lowering operation and maintenance costs via improved reliability • building larger systems that provide economies of scale, particularly in the power block • deploying more systems to benefit from learning-curve effects.

2. Design features of SCHOTT's 4th Generation receiver

Fig. 1. SCHOTT's 4th Generation receiver.

2.1. Compensator elements

Due to varying requirements of the different operation conditions at various high temperature concepts, a lifetime calculation scheme for the bellow construction was developed (fig. 2), which takes into account the potential location of operation and the target fluid temperature as well as freeze protection scenarios in case of molten salt operation. Based on the results from the calculation, the new flexible bellow was designed as compact as possible. Additionally test criteria for validation purposes have been derived. Specific load profiles, which are transformed by the Palmgreen Miner rule to an equivalent constant stroke model, are tested and validated on the receiver system with additional thermal loads.

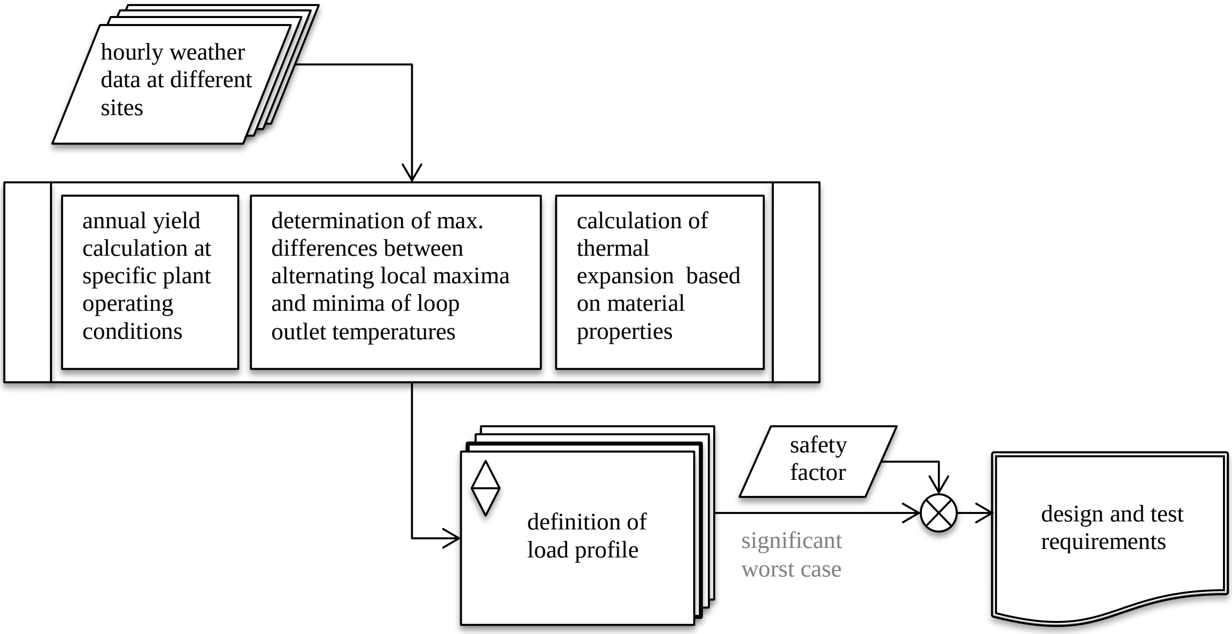

Fig. 2. Process of compensator requirement definition based on specific power plant location and operation conditions

2.2. Radiation protection of compensator elements

Operation at higher temperatures causes additional stresses due to higher temperature gradients at most sensitive parts. An innovative heat shield was integrated into the receiver ends in order to optimize the temperature distribution and heat flow, resulting in reduced thermal loads on sensitive parts of the receiver ends as shown in fig. 3.

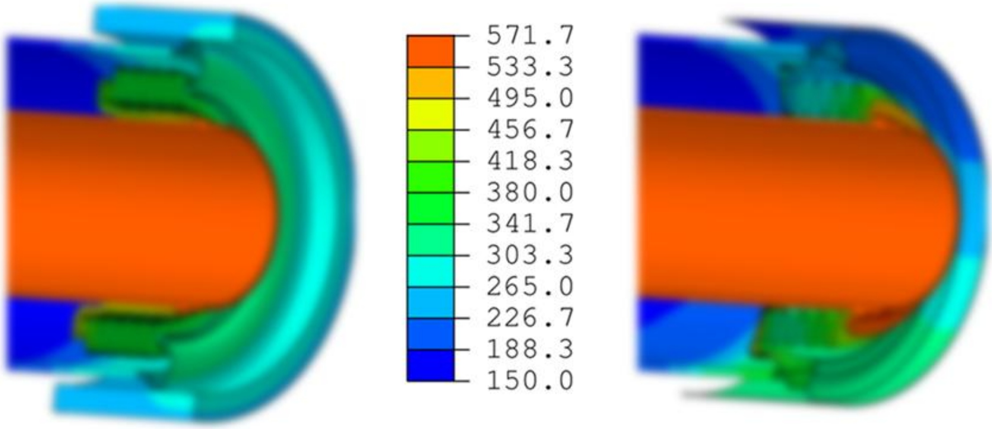

Fig. 3. Temperature distribution on receiver ends at
(a) SCHOTT 3rd Generation receiver; (b) SCHOTT 4th Generation receiver [3].

2.3. Safe and easy at installation

Based on SCHOTT’s experience in over 50 power plant projects and one million shipped receivers, distinct features of the design have been introduced, which help to improve efficiency in plant construction and therefore reduce costs and risks in CSP project execution. The new receiver will have significantly less weight, which simplifies the handling and field installation. Moreover the receiver is equipped with a protection cap at the receiver end, which prevents mechanical impact to sensitive parts like the glass to metal sealing areas already during pre-mounting and installation as well as in operation.

2.4. New solutions for high temperature absorber coating

As a particular feature the new developed absorber coating for high temperature applications with proven and reliable long term stability will support the standard setting product. Performance values are at the same level as known from oil based systems, with the opportunity to serve special needs of high temperature process optimization, such as adapted optical values along the length of a collector system.

Concept evaluations and simulations show, that a product diversification to high temperature receivers with a durable, emittance minimized coating and standard receivers with a tradeoff of absorptance and emittance at the loop inlet will lead to a higher overall plant efficiency with lower LCOE [3].

3. Qualification

The receivers did successfully pass an extensive testing at the KONTAS test facility of DLR. Tests under worst case operation conditions, such as most critical incident angles in combination with possible tracking offsets, have proven a high robustness against impact to sensitive parts of the receiver ends. Currently, the receivers are installed at power plants for field test validation (fig. 4).

Fig. 4. Field installation of SCHOTT's 4th Generation receiver.

4. Market introduction

The 4th Generation of SCHOTT PTR®70 is expected to be commercially available in spring 2014

References

[1] A.T.Kearney, ESTELA, Industry Roadmap Report (2010)
[2] Kutscher C, Mehos M, Turchi C, Glatzmaier G, Moss T, Line-Focus Solar Power Plant Cost Reduction Plan. NREL/Sandia 2010.
[3] Kamp H, Sauerborn A, Schmidt M, Kuckelkorn T, SCHOTT Parabolic Trough Receivers for Operation with Molten Salt. Proceedings of SolarPACES; 2012.