NEW CPC BASED HYBRID COLLECTOR FOR SOLAR HEATING PLANTS

Simon Furbo 1, Bengt Perers 1, Weiqiang Kong 1, Zhiyong Tian 1,
Department of Civil Engineering, Technical University of Denmark, Nordvej Building 119, Kgs. Lyngby, 2800, Denmark, 0045-4525857, sf@byg.dtu.dk

Hans-Erik Kiil 2, Anders William Larsen 2, René Bang Madsen 2
POLYCSP ApS. Moellegade 21 9750 Oestervraa Denmark, 0045 9689 2800, hek@polycsp.com

Abstract – A novel low concentrating tracking collector has been developed by POLYCSP ApS in cooperation with the Technical University of Denmark. A row with the new collectors will be installed in the Sæby solar heating plant in 2016. The collector design is of the CPC type, but with a medium concentration ratio. Efforts have been made to improve the collector performance and at the same time lower the cost. The collector is expected to be especially suitable for high temperature levels. During the development it was decided to make the collector tilt-able to allow higher concentration ratio and lower heat losses and at the same time allow overheat protection, as spin off. Comparisons of annual performance for the POLYCSP collector to conventional collector fields in Denmark with Flat Plate and CSP collectors show that they are most competitive from 80°C operating temperature. The collector tilt tracking increases the cost, but more energy can be produced at higher temperatures and the problems during stagnation of a collector field can be mitigated by defocusing the collectors under these conditions.

1. INTRODUCTION

POLYCSP ApS has developed a new hybrid medium concentrating collector with non-imaging CPC reflectors. (CPC = Compound Parabolic Concentrator). The word Hybrid is used as the collector is a mix of Flat Plate and CSP collector designs. POLYCSP ApS is expert in manufacturing of wavelength selective solar absorber coatings for reduction of collector heat losses, in the high temperature range of 100-300°C. To further reduce heat losses from the collector, in this temperature range, medium concentration with CPC reflectors can be applied. In the present collector design also low cost tracking, changing the collector tilt, allows a high concentration factor. This will reduce heat losses more than for a stationary low concentrating CPC collector.

The use of a smaller acceptance angle and larger truncation of the CPC geometry means that the collector box can be made thinner than usual for the concentration ratio chosen. Figure 1 and 2 shows principle drawings of the POLYCSP collector design. Figure 3 and 4 shows photos of the prototypes under assembly.

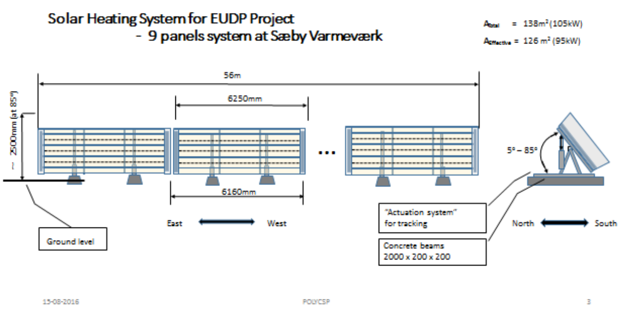

Figure 1. Principal drawing of the POLYCSP collectors mounted in a collector row with low accuracy tracking.

The concentration ratio chosen is four based on the mirror width and the circumference of the absorber tube surface. The absorber tube has an inner tube to create a narrow fluid channel path with, good turbulence/heat transfer.

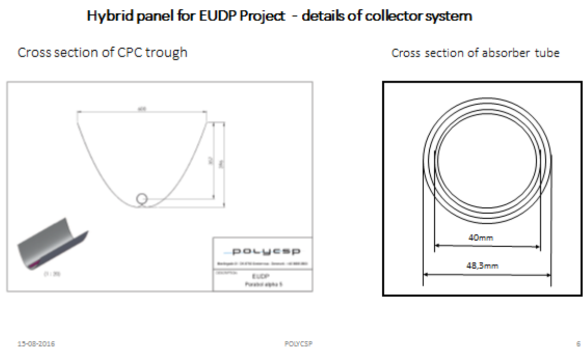

Figure 2. Principal drawing of the CPC reflector and absorber arrangement with cross section of the absorber tube, showing the inner tube creating a thin fluid channel.

Figure 3. Photo of the large area POLYCSP Hybrid collector. Mirror and absorber arrangement.

Figure 4. The POLYCSP collector assembled, but without glass. Note the vertical edge reflectors. They improve the performance at off normal incidence angles.

Figure 5 shows a picture of the POLYCSP collector from far distance, to check the optical precision of the mirrors and also the absorber position. To be OK in this check, the full aperture area should get a dark colour, like the absorber. This is a good basic design and performance indicator.

Figure 5. The PolyCSP collector viewed from a far distance. To be Ok, the full aperture area should get dark like the absorber.

2. METHODS

The design is developed based on experiences of CPC collector design during the last 40 years [1,2]. Modern materials and manufacturing techniques and modern control possibilities are utilized for low cost tracking, where the CPC does not require the high tracking accuracy as CSP collectors do. Two prototypes have been built and will be tested at the Technical University of Denmark during the late summer 2016 and based on the final results a pilot collector row will be built in Sæby solar heating plant to demonstrate the new technology. In this plant side by side comparison to conventional flat plate collectors will be possible at exactly the same operating conditions. The CPC collectors will use the large area principle to reduce edge heat losses and improve the flow distribution inside the absorber. Special attention will be on the absorber design with good heat transfer and flow distribution, but also easy system application in a large collector field with easy air venting and low pressure drop. Also investigations on how to reduce the risk of moisture/condensation inside the collector will be carried out in the development phase.

5. RESULTS

Due to delay of the final manufacturing of the test prototypes, no test results are available at the time for finalizing the paper. We therefore present estimated results in figure 7.
During the design of the tracking equipment, the energy collection at different tilt angle ranges was determined see figure 6. It can be seen that the peak is close to the optimal tilt for fixed collectors and that the tracking range is most important for higher tilt angles above 30 deg. Almost no energy can be collected "behind" the collector (negative tilt values) at 50-70 °C mean operating temperature, even if the sun sometimes is shining from this direction during the long summer days in Denmark.

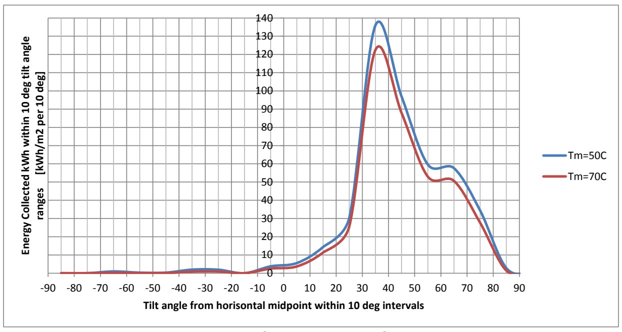

Figure 6. Thermal performance of the POLYCSP collector, distributed in 10 deg tilt angles ranges.

To give an impression of the expected annual performance, estimated collector parameters were used. It can be seen in figure 7, that the tracking gives a significant improvement, especially at higher temperatures and that the best range is above 80°C compared to traditional flat plate collectors.

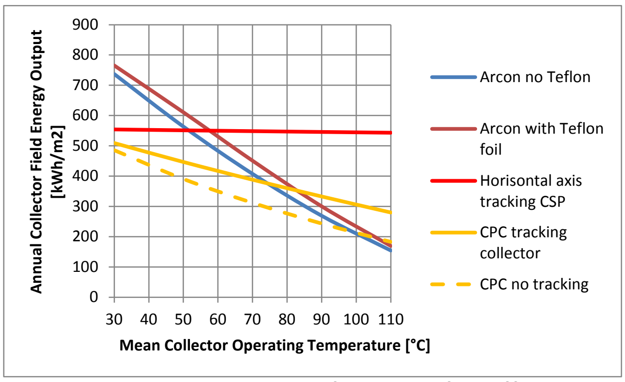

Figure 7. Yearly thermal performance, for different collector designs, as function of the mean solar collector fluid temperature.

6. CONCLUSIONS

The paper describes the prototypes that will be tested at the Technical University of Denmark.

Based on estimated efficiency expressions the yearly thermal performances for the collector have been calculated and compared to calculated yearly thermal performances of marketed solar collectors.

The POLYCSP collector with tilt tracking has the main advantage at high operating temperatures from 80°C.

District heating networks with high temperature demands like seasonal storage systems and industry applications, is probably most suitable for these collectors.

The tilt tracking gives a desirable overheat protection advantage, as well as higher thermal performance over the year.

The collectors also have to be low in cost to compete with traditional flat plate collectors.

The testing at DTU and the demonstration in the Sæby Solar heating plant, will further characterize the collectors.

REFERENCES

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[2] M. Ronnelid, B. Perers and B. Karlsson. Construction and testing of a large-area CPC-collector and comparison with a flat plate collector. Solar Energy Vol. 57, No. 3, pp. 177-184, 1996.