Dynamic Behavior of the Direct Solar Steam Generation in Parabolic Trough Collectors: A Simulation Study

Markus Eck

Institute of Technical Thermodynamics, German Aerospace Center (DLR), Pfaffenwaldring 38-40. 70569 Stuttgart, Germany,
Tel.: ++49 (0)711/6862-429, Fax: ++49 (0)711/6862-747, markus.eck@dlr.de

Parabolic trough solar power plants can play an important role in the future energy market. Parabolic trough collectors are employed to heat a synthetic oil which transfers the energy via heat exchangers to a conventional steam turbine cycle for conversion into electricity. The direct steam generation in the parabolic trough collectors is a feasible improvement of this reliable technology.

In the european project DISS (DIrect Solar Steam) three different operation modes will be investigated to identify the specific advantages and disadvantages of each mode. For that purpose a collector loop with a length of 500 m was erected in 1998.

In the *once through concept* (s. Fig 1) the total amount of water that can be evaporated and superheated in the collector loop is fed into the inlet. This concept is the most simple one but its controllability has to be investigated.

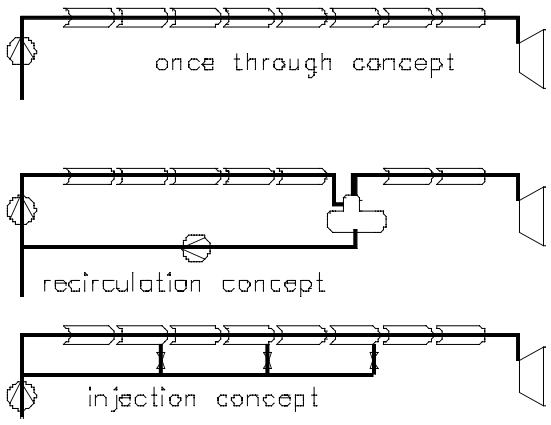

Fig. 1 Basic concepts for the direct solar steam generation in parabolic trough collectors.

In the *recirculation concept* (s. Fig. 1) the collector loop is divided into the evaporator and the superheater section by a steam separator. The amount of water fed at the inlet of the evaporator is greater than the amount that can be evaporated. In the separator the excess water is recirculated to the tube inlet where it is mixed with the preheated water. The steam is fed into the inlet of the superheater section. This is the most secure concept but it is more expensive due to the additional separator and recirculation pump.

An *injection-mode* collector loop (s. Fig. 1) is subdivided into different collector units connected in series. Each subgroup consists of a collector, an injection unit (injection nozzle, control valve and flow meter), and the gauging equipment (to determine the thermal state of the fluid at the end of the collector). The advantage of this concept is that the controllability of the process is expected to be better than that of the other modes. The major disadvantage is the complex design of the loop.

Within the project DISS these different operation modes are investigated, compared and assessed. One criterion for the assessment is the dynamic behavior of the different concepts. To compare their dynamic behavior, a simulation program was written [2], and validated with experimental studies [1].

In this paper, the system performance of the three different operation modes will be compared for the first time, using the dimensions of the DISS test loop for the collector loop.

The pure once-through concept shows the worst system performance for different disturbances, whereas the injection concept and a modified recirculation concept lead to a satisfactory behavior.

In a next step, the number of injection coolers is reduced step by step for the injection concept. Under idealistic assumptions the control performance is not significantly reduced when only two injection coolers are employed.

Under realistic assumptions concerning the quality of the measured data the best control performance is achieved, when at least one injection cooler is located in the evaporator section.

[1] Eck M., Steinmann W.D., Stryk A., Yildirim F., Zunft S.: *Untersuchungen zur Regelungstechnik bei der solaren Direktverdampfung (PRODISS)*, Abschlußbericht zum BMBF Forschungsvorhaben Nr. 0329711 (1999)

[2] Steinmann W.D., Goebel O.: *Investigation of the Stationary and Transient Characteristics of Parabolic Trough Collectors for Direct Steam Generation* In Proceedings of the International Solar Energy Conference, Albuquerque (1998) p. 409-416