Receiver for Solar-Hybrid Gasturbine and CC Systems (REFOS)

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ABSTRACT

Solar hybrid power plants have a significant potential for cost reduction when the solar energy is introduced into a gas turbine system. The thermal efficiency of gas turbine power systems (in combined cycle or recuperated configuration) is about 40 % higher than that of steam cycles at comparable power levels. The absorbed solar power is converted much more efficiently, which results in significantly reduced collector area and thus reduced cost for solar electricity.

The introduction in gas turbine systems could be realized with pressurized volumetric air receivers preheating the compressed air of the gas turbine before it enters the combustor. In 1996 the REFOS project was initiated to demonstrate the receiver technology required for air heating in gas turbines. A receiver module, consisting of a secondary concentrator and a volumetric receiver unit, was designed and tested at the Plataforma Solar de Almería, Spain. Instead of a gas turbine a closed pressurized test loop was used to achieve representative operating conditions.

A secondary concentrator guides the solar radation to the entrance aperture of the receiver unit which is closed by a domed quartz window. The volumetric absorber consists of several layers of metallic wire screens. Due to the hexagonal entrance aperture of the secondary concentrator several modules could be installed in the focal spot to achieve required power level.

The layout conditions for the receiver module are: air exit temperature: 800°C; nominal absorbed thermal power: 350 kW; operating pressure: 15 bar.

The receiver test campaign started in October 1998. In July 1999 the layout conditions were successfully demonstrated. Tests were carried out at air exit temperatures up to 815°C, the maximum power level was 400 kW at pressures up to 15 bar. Total solar test time summed up to 117 h.

Test results are discussed in detail: component efficiency, temperature distributions of absorber and window, flux mapping in the secondary entrance aperture, pressure drop, time constants. Problems occuring during the tests are also discussed. The major power loss occured in the secondary concentrator due to the non-optimized geometry. Test results were compared to results from simulation models and showed good agreement.

Several improvements were developed within the project. A new secondary concentrator was designed leading to a significant increase in efficiency. Simulation results show that the

envisaged module efficiency of 80 % is achievable. Optimized layout and economic perspective of such solar-hybrid power plants is discussed in a related paper.