Solar thermal power plant hybridized with gas turbine and usage of waste heat in chemical industry

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During the last few decades, the demand of energy has increased drastically worldwide. This is attributed particularly to the rapid industrialization of developing countries such as China and India. To meet this demand, new power plants are constructed, giving rise to huge volumes of greenhouse gas emissions as well as rapid depletion of fossil fuels. Because of stress on fossil-fuels, their prices are always on the rise. To account for climatic change due to greenhouse gases as well as stress on limited fossil fuels reserves, a lot of focus is given to energy efficiency and renewable energy technology. Solar and wind energy technology are extremely environment friendly, however because of the intermittent nature of solar radiation and wind these technologies are often hybridized with a conventional power plant technology. This aids in better security of supply and better integration of the fluctuating renewables. In a thermal power plant, the concept of combined heat and power (CHP) is a highly promising concept, where the waste heat of power plant is used up for heating purposes.

The focus of this work is based on these two concepts, involving modelling of a solar thermal power plant hybridized with gas turbine and also usage of the waste heat from the gas turbine in a chemical industry.

The tasks involve selection of an appropriate site, gathering the solar data and demand requirements, designing and modelling the hybrid power plant. A design procedure for the solar field is discussed, taking help from Ebsilon® and MATLAB software. The solar field is designed as such that the costs of the power plant with respect to a single gas turbine plant are reduced. After that, an analysis of the most suitable plant configuration and its behaviour at different load and source profiles is performed. Finally the heat transfer area of the waste heat recovery system and the total costs of the power plant are estimated.

The hybrid solution adopted is the shunt interconnection between the heated air from the solar tower and the air flowing through the combustion chamber. This choice resulted in a better solution for a highly partialised small size gas turbine. The turbine inlet temperature is in this way kept within the limits over the whole profiles, and the cycle thermal and fuel efficiency are higher. A by-pass stack is chosen to guarantee flexibility in the waste heat recovery system. The computations are run for different interest rates, heliostat costs and incentives (only for the solar contribution).

Preliminary computations showed that CO2 emissions can be reduced by at least one fifth in months of high solar radiation. Fuel consumption is reduced consequently up to one fourth. The behaviour of the system is improved by a positive correlation between the heat demand at night, when no sun is shining and the turbine outlet temperature are higher, and the day, where the temperatures are limited by the solar field, leading to reduce flue gas losses and better energy utilization.