Just add boiling water...

Direct Steam Generation using Parabolic Dish Collectors

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Introduction
A large percentage of the world’s electricity is produced by steam turbines. Steam can be generated by a boiler that uses a heat source such as a coal furnace, a nuclear reactor or the Sun. Solar Thermal Power technology concentrates the light of the Sun.

Solar Thermal Power plants are of interest [1], [2] in an effort to reduce overall plant costs and experimental validation of this model and to test its suitability for Solar Thermal Power systems.

Direct Steam Generation at the ANU
A 500 m² parabolic dish concentrator at the Australian National University is fitted with a mono-lube steam cavity receiver. Water is pumped into the cavity receiver and steam is obtained at 500 °C and 4.5 MPa which can be used to power a steam turbine. Although many solar thermal power plants around the world use special heat transfer fluids, direct steam generation is actively under research [1], [2] in an effort to reduce overall plant costs and complexity.

Dynamic Modeling of the Steam Cavity Receiver
Due to the varying nature of the Sun as a heat source, it is important to model and understand the transient behavior of the water boiling process inside the steam cavity receiver. Inputs such as solar irradiance, mass flow, ambient temperature and wind, are used to calculate the heat transfer from the receiver pipes to the water in them.

A mathematical derivation using a technique called ‘moving boundary formulation’ [3] is used to model the behavior of the steam cavity receiver. A switching approach is incorporated [4], [5] to simulate the transition from liquid water to boiling steam. The advantage of this model versus finite element models is its simplicity and the fact it produces a set of ordinary differential equations that are suitable for control theory.

Controlling the Steam Output
In Solar Thermal Power plants, the mass flow of fluid sent to the receiver is the main variable to control the conversion from solar energy to thermal energy. For a fixed amount of solar radiation, a greater mass flow results in a lower output steam temperature. Conditions such as short cloud coverage (a few minutes) and start up in the morning are of great interest. Longer term variations in the system such as mirror soiling are also considered, which requires a degree of robustness of the control algorithm.

Future work includes the selection and design of an appropriate control algorithm, a system simulation of the controlled system and experimental trials on the ANU 500 m² dish.

Find out more at http://solar-thermal.anu.edu.au

References