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Modeling and dynamic simulation of the collector and receiver system of 1 MWe DAHAN solar thermal power tower plant

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ABSTRACT

DAHAN, the pioneer 1 MWe CRS (Central Receiver System) project, is now under construction at the foot of the Great Wall of Badaling in Beijing. The coupled system-collector and solar central receiver, which plays a dominant role in the radiation-heat conversion, is the most important component in the solar tower plant. Its performance can affect directly the efficiency of the entire solar power generation system. In this paper, the models of the key parts "collector and cavity receiver" were fully developed through the modular modeling method. By adopting the area to flux matching method, the two models were coupled together based on the "STAR-90" simulation platform. The simulation results of static heat flux density distribution at equinox noon and the dynamic response curves under different disturbances were simulated. The result demonstrates it can provide good references for the operation and control system design of the entire solar thermal power tower system.

1. Introduction

"DAHAN", the pilot 1 MWe solar power tower plant in China, which is listed as the key project of the 11th Five-Year Plan of China National Hi-Tech R&D (863 Plan) is now under construction at the foot of the Great Wall of Badaling in Beijing, and the goal is to establish the national research base of solar thermal power technology [1]. In order to ensure the safe operation, it is very necessary to simulate the whole power system before the real operation.

Many previous scholars have done much important work on the system simulation with respect to the several established solar tower plants for the past three decades. Alvarez and Guzmán [2] presented a model of the TSA system with two energy sources using a Mixed Logical Dynamical (MLD) model, which showed that the model was able to integrate both continuous and discrete characteristics in a single hybrid model. Yebra et al. [3] developed the dynamic models using for simulation and control of Spain CESA-I plant, which was based on the thermohydraulic modeling framework thermofluid, and a typical operation cycle with a real perturbation introduced by clouds had been simulated. Ferriere and Bonduelle [4] developed a lumped parameter model for the solar receiver of France Thémis plant, which used molten salt as the working fluid, and the time-dependent parameters involved in the energy balances were simulated. Zhihao et al. [5] and Ershu et al. [6] simulated the DAHAN performance based on the energy balance which mainly focused on the whole system, and the electricity production from this power plant was simulated. Besides, some other researchers [7–9] have also done some relative work about the system modeling of solar tower plants.

In terms of the solar tower plant, the collector and central receiver are the key parts, which play a similar role with the conventional boiler system of coal-fired plants. As mentioned above, although much relative work was studied about the system modeling of solar tower plants, little attention was paid to the coupling modeling for the collector and receiver system. In this paper, the modular model method was adopted to develop the models of the collector and receiver system, and the dynamic and static characteristics for this coupled system were simulated.

2. Description of the collector and receiver systems

DAHAN plant, as shown in Fig. 1, mainly consists of heliostat field, receiver system, thermal storage system, power generation system and auxiliary system. The collector system of DAHAN consists of 100 heliostats, each with an area of 100 m^2. During the operation, the incident solar rays are concentrated and reflected into a cavity receiver, which locates on the 78 m level of a 118 m high tower. The dimension of each heliostat which consists of 64 small square mirror elements is 10×10 m, mounted on a 6.6 m

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