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Multiscale simulation of energy transfer in concentrating solar collectors of solar power system

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Abstract

In this keynote lecture the multiscale simulation of heat transfer and fluid flow problems is presented in detail focusing on the simulation of heat transfer process in concentrating solar collectors (CSCs) of solar power system. First the meaning of multiscale problems is briefly introduced. From numerical point of view the multiscale problems are divided into two categories: multiscale process(different region has different governing eqs.) and multiscale system (whole system have the same governing eq.). The focus of the present lecture is put on the radiative-convective-diffusive process occurred in CSCs, which is a multiscale process. Then the four kinds of solar collector used in CSCs are presented: parabolic trough solar collector (PTC), the linear Fresnel reflector (LFR), the central receiver collector (CRC) and the solar dish collector (SDC). A coupled Monte Carlo ray tracing (MCRT) method with finite volume method (FVM) is adopted to determine the energy received by the collector and the temperature distribution of the system. The four types of collector will all be discussed with the emphasis being put on the parabolic trough receiver. The geometric and other test data of the LS-2 parabolic trough collector module tested at Sandia National Lab is chosen for simulation. And the predicted solar heat flux distribution along the circumference of the trough agrees with the test data very well. An uncertainty analysis is conducted taking a PTC similar with LS-2 as an example. A new method is proposed to unify the solar heat flux on the absorber tube surface. The uniformity of solar flux distribution and the temperature distribution is improved greatly by this method and the circumferential temperature difference is reduced from about 25 of conventional one to 3 K under the conditions studied. Finally some conclusions are made and some further research needs are suggested.