Applied Mechanics and Materials Vols. 465-466 (2014) pp 155-160
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doi:10.4028/www.scientific.net/AMM.465-466.155

Investigation of Evacuated Tube Collector performance at high temperature mode using TRNSYS simulation model

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Keywords: solar energy; evacuated tube; solar concentrator, solar thermal simulation.

Abstract. It has been proved that creation of vacuum between the absorber and the cover of a solar collector is resulting in a substantial improvement in the collector efficiency due to reduction in the heat loss through convection ad conduction. In this work, the performance of evacuated tube collectors is investigated using TRNSYS simulation model. Different levels of concentrations have been considered in the simulation to predict the power generation. The simulation results showed that the thermal performance of evacuated tube collectors with high concentration ratio can provide a good improvement to the receiver output.

Introduction

Sun light is the most important source of sustainable energy in our universe, which doesn't have any negative environmental impact to the human life, this why several studies expecting sun as the main future source of energy to the world. That is also because of the accelerated rise of energy demand and decrease of energy sources. Solar power plant with its strongly advanced techniques in many aspects is ready to replace fossil fuel power plants all over the world in the relatively near future. This can be clearly observed in the future planning of USA and Europe for using solar power plants in electricity generation [1, 2]. Also from the fact that the sun provides the world with a number of 1500 million billion kilowatt-hours per annum [3], which is more than 10,000 times the energy that the human race needs at present. The amount of energy emitted from the sun per unit time and received on unit area of a surface perpendicular to the direction of propagation of radiation at means sun earth distance outside the atmosphere is called solar constant G_{SC}. Its value was estimated by $1367 \mathrm{w/m^2}$ [4]. The part of radiation that reaches the earth's surface directly and is not absorbed, reflected or scattered, is called direct solar radiation and its power on a clear day can be estimated by $1\ \mathrm{kw/m^2}$.

The greatest challenge facing the use of solar energy is how to develop efficient ways to collect, convert, and utilize solar energy at affordable costs. The two mainstream categories of devices utilizing solar energy are, conversion of solar radiation to direct electrical energy using photovoltaic cells and conversion of solar radiation to direct heat energy using solar collectors [5]. The latter employs different procedures of capturing solar thermal energy. The main component of solar thermal system is the solar collector. It is the device which absorbs converts and transfers heat to a working fluid flowing through it. Parts and definitions of solar collector can be found in [6].

Solar collectors according to the range of temperature grade are classified into three types, started from low temperature range collectors which are applied in domestic water heating, cooling and cooking. These collectors employ a process temperature in the range of (45° to 100°C). Then a medium temperature range collectors which are applied in industry, water distillation and saturated steam generation in the range go up to 500°C. Finally a high temperature range collectors that are applied in the power-producing heat processes in the range up to 1500°C [7]. Another classification of solar collectors is according to the collector design. They are two general categories [4]. First non-concentrating and stationary collectors in which the absorbing surface is approximately equal to the gross collector area. Three main types of collectors fall into this category. It is the flat-plate collectors (FPCs), compound parabolic collectors (CPCs) and evacuated tube collectors (ETCs). Second sun-tracking concentrating solar collectors, it uses optical devices to concentrate the radiant solar energy passing through the collector's aperture to the absorber. The absorber area is smaller