ABBAS JASSEM JUBEAR ABBAS . NUMERICAL AND EXPERIMENTAL STUDY OF TURBINE - SOLAR CHIMNEY PERFORMANCE. UNIVERSITY OF TECHNOLOGY Machines And Equipment Engineering Department. PH. D . Supervisors : Prof. Dr. Arkan K. Al-Taie & Prof. Dr. Wahid S. Mohammad. Abbas. 2014. 220*p.*

Abstract

Numerical simulation and performance evaluation for pilot plant solar chimney oriented in Baghdad city have been carried out in this work. A finite volume modeling technique is used to cast the governing equations [i.e.,continuity, Naver-stockes, energy and radiation transfer equations] using commercial computer code Fluent. The flow is assumed to be steady, three dimensions and incompressible. The turbulence is approximated by the standard $k-\varepsilon$ model with Boussiuesq approximation. The main design and operation parameter of solar chimney have been investigated. These are diameter of the solar collector dimension of (6, 8, 10 & 12m), chimney height of (6, 8, 10 & 12 m) and the collector angle of (0^o, 15^o & 30^o). Operation condition at Baghdad city all over the year and day time is approximated by different solar intensity of (300, 600, 700, 800, & 900 W/m^2).

An attempt was made to replace the conventional reaction turbine used in the solar chimney plant by impulse turbine called pinwheel. Special test rig is established to test the performance of this impulse

turbine. Three models of different blades (3, 4 & 5) were manufactured and tested. Five convergent nozzle of different diameter ratio (d_1 / d_2 = 1, 0.8, 0.7, 0.6 & 0.5) were implement as flow guides to impulse turbine. The effects of these guides on the turbine performance were investigated.

The numerical simulation results showed that solar intensity has a stronger effect of the average collector ground temperature, whereas it increased from 35 °C to 75 °C when solar intensity increased from 300 W/m^2 to 900 W/m^2 respectively, while collector diameter and chimney height showed a miner's effect on ground temperature. This was impact on the air temperature difference across the collector since high temperature difference was obtained at high solar intensity. Numerical results show that the solar diameter having a positive effect on air temperature difference while chimney height has miner inverse due to increase of stack effect causing of high air flow rate. The updraft velocity at solar chimney was increased as the solar collector, chimney height and solar intensity increased and maximum updraft velocity of 4.91 m/s was obtained from the model of solar collector 12 m, chimney height 12 m and solar intensity of 900W/m^2. The results showed that the change of collector angle has considerable effects on the plant performance. The velocity increases when the collector angle increases and reaches to a maximum value at a collector angle (30°).

The numerical results indicated that the plant size and solar intensity are important parameters for performance enhancement. It is found that the pressure drop and power output are effectively dependent on the chimney height, collector diameter, and solar intensity. It yields a moderate increase in power output when these parameters are increase. it show that the optimum ratio between the turbine extracting pressure to the available driving pressure and power output are approximately (0.69) and (4.45 W), respectively, when the chimney height is (12m), collector diameter (12 m) and solar intensity (900W/m^2).

The experimental results showed that the proposed pinwheel turbine can be used in the solar chimney plant. The turbine with four blade type gave performance better than other type where high rotation speed was obtained. The nozzle flow guide enhanced the turbine performance when nozzle to turbine diameter is greater than 0.7. This turbine gives better power output compared with other researchers and has ability to work at low air velocity.

The numerical result shows good agreement with other study and good agreement between the present experimental results.The deviation between the experimental and numerical results for the power output of the turbine does not exceed 4%.

Keywords: Solar chimney; Natural ventilation; Numerical simulation