NOTIFICATION NO-521/2022 **NOTIFICATION DATE:30-09-2022**

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TOPIC: MODELLING OF SOLAR RADIATION AND ITS UTILIZATION IN SPACE CONDITIONING

DEPARTMENT: MECHANICAL ENGINEERING

KEYWORD: SOLAR RADIATION, SOLAR COLLECTOR, NANOFLUID, PROPOSED MODEL, VOLUMETRIC CONCENTRATION

FINDING

This study is to find the regression model for estimation of monthly mean hourly global solar radiation on tilted surface at different locations of India. Thereafter, optimization of collector's tilt angle has been done in order to collect maximum solar radiation on the collector surface. Flat plate collector (FPC), Evacuated tube collector (ETC) and Parabolic trough collector (PTC) is used for the utilization of solar energy.

The performance of these collectors has been tested by the use of nanofluids as the working fluid. Thereafter, collected energy by the different collectors is used to drive the vapour compression refrigeration cycle by the help of Rankine cycle for cooling the required space. This study is quite precious due to lack of solar radiation data availability on the tilted surface.

Firstly, some locations have been selected having different climatic conditions such as New Delhi, Mumbai, Kolkata, Lucknow and Jaipur to find the solar radiation on tilted surface using Liu & Jordan model, HDKR model and Perez model. The mean values of these models are plotted along with the day time. On the basis of regression techniques, four empirical models were developed. Now these models are tested to compute the solar radiation on tilted surface for three new stations Ahmadabad, Bangalore and Chennai. The estimated solar radiation by these four developed models is compared with the estimated values using existing models like: Lie & Jordan, HDKR and Perez on the basis of mean bias error (MBE) and root mean square error (RMSE). It has been found that the proposed model has minimum error and the values estimated by this model is comparable to existing models. The maximum values of RMSE in proposed model found in tested stations are 2.01 % with Liu & Jordan, 2.63 % with HDKR and 2.10 % with Perez. Similarly, maximum values of MBE are -1.79 % with Liu & Jordan, -2.27 % with HDKR and -1.89 % with Perez. Finally proposed model selected to determine the solar radiation on Bhopal, Bhubneshwar, Dehradun, Guwahati and Trivendrum (Thiruvananthapuram).

A novel method for maximum utilization of solar energy on solar collectors by optimizing tilt angle (β). The optimization has been done in two steps, in first, the partial differential equation of total radiation on tilted surface (H_T) is differentiated with respect to β and in second, Taylor's series expansion method is applied to find the optimized tilt angle (β_{Taylor}). The results so obtained, are applied on different locations of India and it is found that on anisotropic atmospheric conditions the total monthly radiation falling on collector surface β_{Taylor} is increased significantly at each location. The maximum gain of 3.19% during winters, 2.46%

during spring, no change during summers and 3.14% during autumn is observed in Kolkata. Only 1.42% radiation losses on seasonal and 8.14% radiation loss on annual basis as compared to radiation on monthly basis at New Delhi station are observed.

Solar energy is the most prominent solution for the energy requirement on earth as it is available as the cleanest form of renewable energy. Different types of collectors are available for the collection of solar energy and make it useful. The most knocking challenge for researchers is to enhance the thermal efficiency of collectors and reduce thermal losses. In this research, flat plate collector, parabolic trough collector and evacuated tube collector at given specification are selected and tested by different working fluids at selected working hours. 5 collectors array connected in series and parallel at same working fluid flow rate in each array are used. After that thermal efficiency of each collector is calculated in each case for every season throughout the year. It is found that at given specification, Parabolic trough collector is the most efficient collector.

Use of renewable energy in the present situation of earth ecosystem is becoming important as the use of fossil fuels adversely impact the climatic condition of atmosphere. Solar energy is the most useful energy among other renewable energy sources. A parabolic trough collector with Al_2O_3-water nanofluid of 3.0% volumetric concentration is used to absorb the solar radiations falling on it. Rankine cycle attached with solar cycle by a heat exchanger of 85% efficiency to transfer the heat energy to working fluid of Rankine cycle. Maximum power produced by the turbine is 6.53 kW in the month of April and minimum power produced by the turbine is 5.44 kW in August at New Delhi location. Power produced by the turbine is transferred to the compressor of attached vapour compression cycle. After overcoming all losses, a 6.4 kW capacity compressor is used to run the refrigeration cycle throughout the selected months. Space conditioning system is designed for worst condition of 48 °C and the system is able to take the cooling load of 2.26 TR with COP of 1.72. This designed system with given climatic condition, shows the maximum cooling capacity of 2.88 TR with COP 2.19 in the month of February and minimum cooling capacity of 2.54 TR with COP of 1.93.