Study of Liquid Desiccant Air Conditioning Using Flat Plate Solar Collector

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Abstract

The present study deals with a liquid desiccant air conditioning system using a flat-plate solar collector. Initially, there is an investigation for the performance of a flat-plate solar collector using Al_2O_3–water nanofluid and pure water. Using nano fluids as heat transfer fluid instead of conventional fluid (water) improves heat transfer and thermal properties and also there is a remarkable effect on the collector efficiency. The experimental setup comprises of a flat plate collector of the aluminium absorber plate, a closed-loop working fluid system and measurement devices. The effect of various parameters like mass flow rate of fluid, collector inlet and outlet fluid temperature, solar radiation, and ambient temperature on the collector efficiency is investigated. The experimental results show that, each of these parameters can affect the collector efficiency differently by changing the value of the other parameters. The mass flow rate was varied from 1 to 5 L/min and the volume fraction is 0.1 vol. % of nano fluid. By suspending Al_2O_3 nanoparticles (particle size 20 nm) in the base fluid (water) the maximum collector efficiency attained is 83.2% and to the pure water is 59.7%, whereas exergy efficiency maximum is achieved 18.7% and 12.3% for the 20nm Al_2O_3 nanofluid and base water at the mass flow rate of 3 L/min. Hence, efficient solar flat plate collector is achieved.

Finally, liquid desiccant as air conditioning using solar flat plate collector. The main problem of liquid desiccant as air conditioning is the utilization energy for regeneration, corrosiveness and carryover. The dehumidifier is made of stainless steel tubes of 316L and these tubes are stacked in aluminium fins to maintain the desiccant solution temperature using the evaporative cooler. In this experiment, calcium chloride solution is used. The flat plate collector is used for heating water using closed-loop of thermosiphon as regeneration.

The flow rate for air is fixed at 10CFM and the concentration of calcium chloride is 33% by mass. The inlet air is humidified and controlled by a constant temperature bath. The inlet parameters are solution volume flow rate, inlet temperature, inlet relative humidity, regeneration, and solution temperature. The performance parameters are the absolute humidity reduction, outlet temperature and dehumidifier and enthalpy effectiveness of the dehumidifier. The solution volume flow rates of 14 L/min, 16 L/min, 18 L/min and 20 L/min are used for the experiments. The experiments show that for a fixed $T_{a,}$ inlet and RH% as solution volume flow rate increases, there is increase in absolute humidity reduction. The temperature of the dehumidified air is reduced compared to that of inlet air if this air is passed over the pad used for the evaporating cooler. It is seen that the increase in relative humidity from 68.88% to 92.8% for the flow rate of 20 L/min and fixed inlet air temperature, increases absolute humidity reduction from 5.56 to 13.3 g/kg. When the solution temperature changes from 31.5 to 34 ^{0}C, there are reductions in the absolute humidity reduction and dehumidifier effectiveness by 34.4% and 13.04% respectively.

Keywords: *Solar flat plate collector, Al_2O_3-water nanofluid, Efficiency, Heat transfer enhancement, Liquid desiccant, Dehumidifier, Evaporative cooler, Absolute humidity, Effectiveness.*

Short biography

Dr. Geleta Fekadu Daba Ph.D Degree obtained Thermal Engineering, in the Department of Mechanical and Industrial Engineering from Indian Institute of Technology Roorkee (IITR), India. Dr. Geleta obtained his Bsc and M. Sc degrees in Automotive Technology and Automotive Engineering respectively from Adama Science and Technology, Ethiopia, Oromia. After my first degree I hired one of Ethiopian government University Wollega University, College of Engineering and Technology, Department of Mechanical Engineering. After he served wollega University for one year,got scholarship to study Msc. and completed in Automotive Engineering, then he restated to give service for his University. After three years of his service and head of the department he got sponsorship to attend PhD; he wrote one project on solar assisted liquid desiccant air conditioning to department of science and Technology, India and won about 33lac.through his guide and completed his study from in Indian Institute of Technology Roorkee (IITR), Department of Mechanical and Industrial Engineering (Thermal Engineering) since 2020 and he returned back to his home country Ethiopia Wollega University as position of Assistant Professor, College of Engineering and Technology, Department of Mechanical Engineering. He published 4 international reputable journals, 2 book chapters, and 5 international conferences. So, he has keen interest to share his experience on renewable energy resources of solar assisted liquid desiccant air conditioning.

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