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EXPERIMENTAL AND PERFORMANCE ANALYSIS OF SOLAR REFRIGERATION SYSTEM USING NANO FLUIDS

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[*]Sivakumar M[1], Mahalingam S[2] and Ranjithkumar V[3]

[1]*Department of Mechanical Engineering, Annai Mathammal Sheela Engineering College, Namakkal, Tamil Nadu- 637013, India*
[2]*Department of Mechanical Engineering, Sona College of Technology, Salem, Tamil Nadu- 636005, India*
[3]*Department of Aeronautical Engineering, Mahendra College of Engineering and Technology, Tamil Nadu-637503, India*

ABSTRACT

In today's world refrigeration systems play a vital role to fulfil the human needs. A continuous research is being carried out by many researchers in order to improve the performance of these systems. Presently used, vapour compression refrigeration system does not work efficiently due to shortage of electric power. This study covers a broad overview of solar photovoltaic technology, which uses easily available solar energy for refrigeration purpose. It includes a motor, a compressor, an inverter and battery, a photovoltaic controller and panels. This can be done by converting solar energy in to electricity by means of photovoltaic devices, which can be utilized by the electric motor to drive vapour compression refrigeration system. The main objective of the study is managing the shortage of electric power, in living environments by using a cooling system coupled to a solar installation. In this solar refrigeration system, when conventional refrigerants like (R22, HFCR134a, R600, etc.) are used it leads to low thermal conductivity, heat transfer rate and COP level and some of the other impacts are acid rain, melting of glaciers, sea level raising, health impacts, atmospheric pollution, ozone depletion, which is very hazardous to the environment. To avoid these threats, one of the ways is to use nanofluids which are not harmful to the environment. The usage of nanofluids results in high thermal conductivity, heat transfer rate and give better COP level. The following three nanofluids Al_2o_3, Zro_2, Cu_2o have been already used in the refrigeration system. Some of the properties of given nanofluids will be changed to innovate new nanofluids. The innovated nanofluids will be used in refrigeration system and the same will be compared with other nanofluids like R22, R134a, R290, and R600a. Even though Al_2o_3, Zro_2, Cu_2o gives good results, the new nanofluids have been innovated for better results.

Keywords*: Vapour Compression Refrigeration System, Nano Fluids (Al_2o_3, Zro_2, Cu_2o), Refrigerants (R22, R134a, R290, and R600a), Solar Photovoltaic Collector with battery and Inverter and Coefficient of Performance (COP).*

1. Introduction

Large number of populations in developing countries like India lives in the rural or remote locations where grid electricity is unavailable. So, the storage of drugs and food is not possible because of low temperature requirements. In India, there are innumerable places where the functioning of well-known technology vapour compression refrigeration does not work efficiently due to shortage of electric energy. In this scenario, solar energy is the most copious of all energy forms. Renewable sources of energy from sun are quite non-polluting and considered clean. Solar energy as the green and environmentally friendly energy has produced energy for billions of years. Solar energy that reaches the earth is around 4x1015 MW and it is 200 times as large as the global utilization. Solar power generation grew even more rapidly (+86.3%), but from a smaller base. Renewable forms of energy accounted for 2.1% of global energy consumption, up from 0.7% in 2001. Consequently, the utilization of solar energy and the technology of nanofluids engrossed much more attention. Nanofluids are prepared by suspending Nano sized particles (1-100nm) in conventional fluids which have higher thermal conductivity than the base fluids. Nanofluids have the following characteristics when compared to the normal solid liquid suspensions i) higher heat transfer between the particles and fluids due to the high surface area of the particles ii) better dispersion stability with predominant Brownian motion iii) reduces particle clogging iv) reduced pumping power as compared to base fluid to obtain equivalent heat transfer. Nanoparticles can be used in refrigeration systems because of its incredible improvement in thermo physical and heat transfer capabilities to enhance the performance of refrigeration systems. In a vapour compression refrigeration system, the nanoparticles can be supplemented to the lubricant. When the refrigerant

*Corresponding Author - E- mail: rvssiva@gmail.com

is circulated through the compressor it carries traces of lubricant and nanoparticles mixture (Nano lubricants) so that the other parts of the system will have nanolubricant -refrigerant mixture.

2. Literature Review

Jwo et al. [1] conducted studies on a refrigeration system replacing R-134a refrigerant and polyester lubricant with a hydrocarbon refrigerant and mineral lubricant. The mineral lubricant included added Al_2O_3 nanoparticles to improve the lubrication and heat-transfer performance. Their studies show that the 60% R-134a and 0.1 wt % Al_2O_3 nanoparticles were optimal. Under these conditions, the power consumption was reduced by about 2.4%, and the coefficient of performance was increased by 4.4%.

Henderson et al. [2] conducted an experimental analysis on the flow boiling heat transfer of R134a based nanofluids in a horizontal tube. They found excellent dispersion of CuO nanoparticle with R134a and POE oil and the heat transfer coefficient increases more than 100% over baseline R134a/POE oil results. Fatehmulla et al. (2011) designed and developed low power refrigeration system using PV modules, 2 modules each of 36 solar cells.

Yilanci et al. [3] studied the energy an analysis of a refrigerator, powered by a photovoltaic investigated to obtain efficient operation conditions based on experimental data.

Sobamowo et al. [4] designed and developed photovoltaic-powered dc vapour compression refrigeration system for developing countries such as Nigeria and showed that its applicability to different climatic regions in Africa and could be used for perishable food storage, improvement in the health services and living conditions in remote and rural areas which were unable to access electricity from the grid.

Kumar et al. [5] investigated the effect of aluminum oxide-based Nano-lubricant on the COP of the system and freezing capacity of the system. The experimental set up was built as per Indian standards. Refrigerants like R12, R22, R600, R600a and R134a were used as a refrigerant. The performance of the system depends upon the thermo physical properties of the refrigerant. The addition of nanoparticles to the refrigerant results in improvement in the thermo-physical properties thereby improving the performance of the refrigeration system. The experimental studies indicate that the refrigeration system with nanorefrigerant works normally. There was increase in the COP of the system by 19.6 %. Mineral oil with alumina nanoparticles oil mixture was investigated and it was found that there is an increase in freezing capacity and reduction in power consumption by 11.5 % as compared to polyester. Aluminum oxide-based Nano-lubricant in refrigeration system was found working satisfactorily.

Sendil Kumar and Elansezhian [6] performed analysis on ZnO nanorefrigerant in R152a refrigeration system for energy conservation and green environment, and concluded that the system works safely with replacing of R152a with the conventionally used R134a.No modification in the system was required for the retrofitting process which is a major advantage of the work. The COP increases with the increase in Nano concentration of ZnO. Maximum COP of 3.56 was obtained with 0.5%v of ZnO. The suction temperature decreases with the increase in Nano concentration. The input power decreases with increases in Nano concentration. The pull-down temperature of the evaporator decreases with time. The usage of R152a with very low GWP ensures safe and clean environment with low power consumption. The pressure ratio decreases with the increase in Nano ZnO concentration.

Senthilkumar and Praveen [7] investigated in his paper, Performance analysis of a domestic refrigerator using cuo –r600a Nano – refrigerant as working fluid and concluded that CuO - R600a can work normally and efficiently in refrigerator and the freezing velocity of CuO - R600a was more quickly than the pure R600a system. So, the above works have demonstrated that CuO - R600a can improve the performance of the domestic refrigerator.

3. Experimental Investigations

3.1 Use of Nanofluids in Refrigeration System

There is lot of input and output parameters in the field of refrigeration system. These parameters of refrigerants are related to each other when we use in vapour compression refrigeration system. We can use nanofluids in the vapour compression system to enhance the thermal conductivity. The efficiency of the system depends upon the properties of the refrigerant. Normally R22, R134a, R290, and R600a are used in refrigeration system as a refrigerant. The capacity for heat transfer is not so good and hence it leads to increase in energy consumption. So, the refrigeration system with Nano-refrigerants works competently. It is found that the freezing capacity is higher and decline in power consumption.

3.2 Experimental Setup

The experimental setup consists of a motor, a compressor, an evaporator, a condenser, an expansion valve, a battery, an inverter, a PV controller and photovoltaic panels.

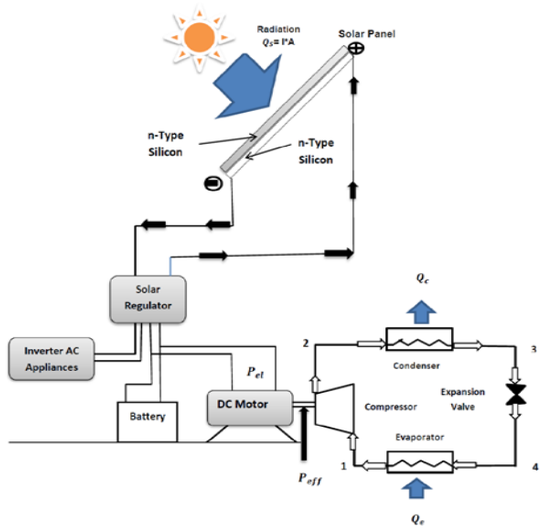

Fig.1 Experimental Setup

4. Experimental Procedure

The solar photovoltaic system utilizes a solar-powered prime mover to drive a refrigeration system. This can be done by converting solar energy into electricity by means of photovoltaic devices, then utilizing an electric motor to work a vapor compressor. A hermetically sealed compressor is used for nanofluids refrigerant, a forced type cool condenser, an expansion valve and an evaporator containing water is included. Five thermocouples, two pressure gauges and one energy meter are provided to measure the inlet & outlet pressure of compressor, temperature and the power consumption at required locations. The refrigeration system performance test includes energy consumption tests and freezing capacity tests. The type of evaporator used in this system is a water tank. To measure the energy consumed during refrigeration system operation, reading is noted from Energy meter. The test is carried out for 20min for each mixture of nanofluids by noting down the average drop in temperature of water from its initial temperature. The freezing capacity is determined by the mass of water stored in the evaporator.

5. Observation and Analysis

For analyzing the performance of Vapour compression refrigeration system the following observations was précised:

i. The refrigerant's heat capacity while using R22, 134a, R290, and R600a is not so good and increases power consumption also.

ii. The refrigeration system with Nano-refrigerant works competently.

iii. It is found that the freezing capacity is higher and the power consumption lessens.

iv. When compared to conventional refrigeration system the COP level is enhanced by the usage of nanofluids.

v. While using the nanofluids various hazardous to the environment are avoided.

Although Al_2o_3, Zro_2, Cu_2o gives good results, the new nanofluids have been innovated for better results.

6. Conclusion

The experimental investigation of Vapour compression refrigeration system was carried out with the following conclusions:

i. The contribution of this work was to improve the thermal comfort in living environments by using a cooling system coupled to a solar installation.

ii. The photovoltaic panel satisfies the power demand of the compressor.

iii. The nanofluid refrigerant works competently in refrigeration system and ensured that the reason will be the thermal property of nanofluids is higher than conventional refrigerant.

iv. The Coefficient of Performance (COP) of the refrigeration system is improved during usage of nanofluids while compared to conventional refrigerant.

v. Nanofluids will be eco-friendly with environment.

vi. Cost of solar power is economical than electric power.

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