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Conversion of Window Air Conditioner into Air Source Heat Pump and Experimentation on Heat Pump Setup

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Abstract: Air source heat pump water heaters are a promising technology and use the same mechanical principles as refrigerators and air conditioners. While refrigerators remove heat from the interior and discharge it to the environment, heat pump water heater take heat from the environment and concentrate it to heat water for service needs. The heat pump water heater, based on the vapour compression cycle, absorbs heat from a renewable energy source. Heat pump is a device that provides heat energy from a source of heat to a destination called a "heat sink". Heat pumps are designed to move thermal energy opposite to the direction of spontaneous heat flow by absorbing heat from a cold space and release it to a warmer one, and vice-versa. A heat pump water heater operates on an electrically driven vapor-compression cycle and pumps energy from the air in its surroundings to water in a storage tank, thus raising the temperature of the water. The hermetically seal compressor compress the refrigerant and send to the condenser. The evaporator absorbed surrounding heat and send to the compressor. The condenser gives heat to the water.

Keywords: Heat pump, Vapour-compression, Heatsink, Condenser, Evaporator

I. INTRODUCTION

A heat pump water heater operates on an electrically driven vapour compression cycle and pumps energy from the air in its surroundings to water in a storage tank, thus raising the temperature of the water. The hermetically seal compressor compress the refrigerant and send to the evaporator. The evaporator absorbed surrounding heat and send to the condenser. The condenser gives heat to the water. Heat pump water heaters collect energy from the ambient air, water, waste heat sources or the ground, and transfer it to water stored in an insulated storage vessel. The electricity is mostly used in the refrigeration compressor. A heat pump is a machine that transfers heat from a source to other by employing a refrigeration cycle. Although heat normally flows from higher to lower temperatures, a heat pump reverses that flow and acts as a pump to move the heat. Therefore, a heat pump can be used both for space heating in the winter and for cooling in the summer. In the refrigeration cycle, a refrigerant is compressed then expanded to absorb and remove heat. The heat pump transfers heat to a space to be heated during the winter period and by reversing the operation, extracts (absorbs) heat from the same space to be cooled during the summer period.

II. NEED AND PROCEDURE OF AIR SOURCE HEAT PUMP

A. Need of conversion

The heating system based on an air source absorption heat pump had been assessed to have great energy saving potential. However, the coal boiler is of low energy efficiency as well as high air pollution, which is regarded as one of the main sources of CO_2, SO_2, NO_x so it will produce hazardous effect on the environment. For instance, electric water heater is convenient for installation and operation, however, the overall efficiency in converting a potential energy of fossil fuels into electric energy, then into thermal energy is quite low. Compared to those water heater, heat pump water heating systems can supply much more heat just with the less amount of electric input used for conventional heaters. Improving heating performance, reliability, and its environmental impact has been a concern. Therefore heat pump water heater is the best solution regarding of above parameters.

B. Procedure of conversion

- We have observed the window air conditioner in our college.
- We studied the principle of the heat pump and its vapour compression cycle thoroughly.
- We studied all the research paper.
- We dismantle all the components and observe all the parts of A/C which work properly or not.
- We will calculate all the design parameters (evaporator length, diameter and condenser length, diameter) related to experimental setup and correlate with a reference set up parameters.

- After accomplishment of all the calculation, we will go for actual construction of experimental setup.
- We will perform experiments to calculate the actual coefficient of performance of our heat pump setup. At the last, experimental reading graphs are plotted and appropriate conclusion are given to each graph

III.EQUIPMENT USED IN HEAT PUMP SETUP

A. Hermetically seal compressor

Reciprocating type compressor is used in air source heat pump setup. Rated power supply: 230V AC, 50Hz 1-Phase, Current: 10-7A, Rate of energy consumption: 2100W, Cooling Capacity: 4500 k.cal/hr

B. Pressure gauge

Two pressure gauges (TIPCO) are incorporated in the system. One of this is used to measure the vacuum pressure and another is used to measure discharge pressure. Vacuum gauge having range 0 to 500 psi and discharge gauge range is -30 to 150 psi.

Fig.1 Discharge pressure gauge

Fig.2 Suction pressure gauge

C. Temperature controller

The temperature controller is an electronic device to control the temperature rise or fall in the system. The temperature controller is made by Robertshaw.

Specification and technical parameter

Dimension: 75×34.5×85mm, Power Supply voltage: 230V/ 50 Hz, Power consumption: less than 3W, Resolution: 1°C, Temperature Range: -50°C to 99°C.

Fig.3 Temperature controller

D. Copper coil

Handles up to 836 PSI of pressure for a strong use.3/8 in. O.D. x 50 ft. Copper Soft Refrigeration Coil Pipe.

E. Energy consumption meter

The energy meter is connected to the system for measuring the quantity of energy consumed by the compressor.

Fig. 4 Energy meter

F. Temperature indicator

The temperature indicator is used for measuring various temperature in heat pump setup during experimentation. Indicators have 6 ports J-type thermocouple and the wire length is 1 meter each. The range of temperature is from -20 to 350°C.

Fig. 5 Air source heat pump setup (Top view)

Fig. 6 Air source heat pump setup

IV. EXPERIMENT RESULTS AND DISCUSSION

Experiment on air source heat pump is carried out between February and March. The experiment is performed in open space (not in the close room). The temperature rise of water is limited to 53°C, after attaining 53°C the heat pump setup is get off by using temperature controller. The lowest temperature of air from evaporator side is in between 19°C to 22°C (during entire running cycle of heat pump). The quantity of water stored in the tank during experimentation is around 36 liter and water in the tank is not circulating.

A. Experiment procedure

- Attached all thermocouple to the temperature measuring places in the setup (compressor inlet, compressor outlet, condenser outlet, expansion outlet etc).
- Filled the water in the storage tank. Deep the temperature indicator probe in water to measure/control water temperature.
- Then switch on the power supply and took a various reading from indicator panel (vacuum pressure, discharge pressure, temperature, energy consumption).

B. Experimental results

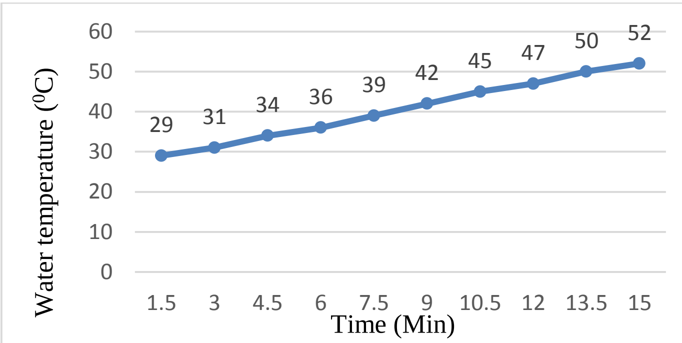

Fig. 7 Water temperature Vs. Time

The temperature of the water is increased continuously because the heat absorbed by the evaporator (from the atmosphere) and compressor heat are given to the water with the help of condenser as shown in fig.7.

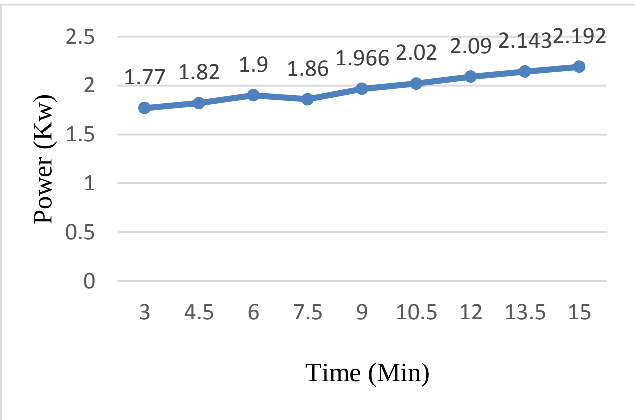

Fig. 8 Power consumption Vs. Time

The power consumption of compressor at the starting is somewhat constant. When the condenser outlet temperature is increased, at that time the evaporator heat absorbing capacity is decreased and it results into increase in evaporator outlet temperature. This high temperature, high-pressure refrigerant enter into the compressor at that time the volume of the refrigerant handle (compress) by the compressor is increased. Therefore the power consumption by the compressor is increased continuously as shown in fig.8. Due to increase pressure in the system; the refrigerant compressing load on the compressor is increased. So, compressor required more power to run the system.

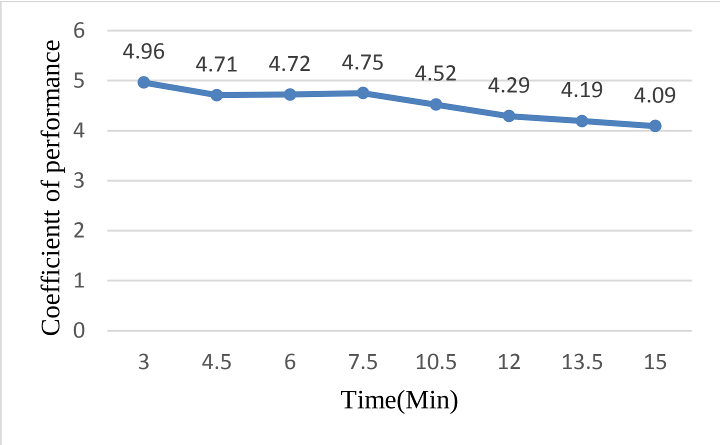

Fig. 9 Coefficient of performance Vs. Time

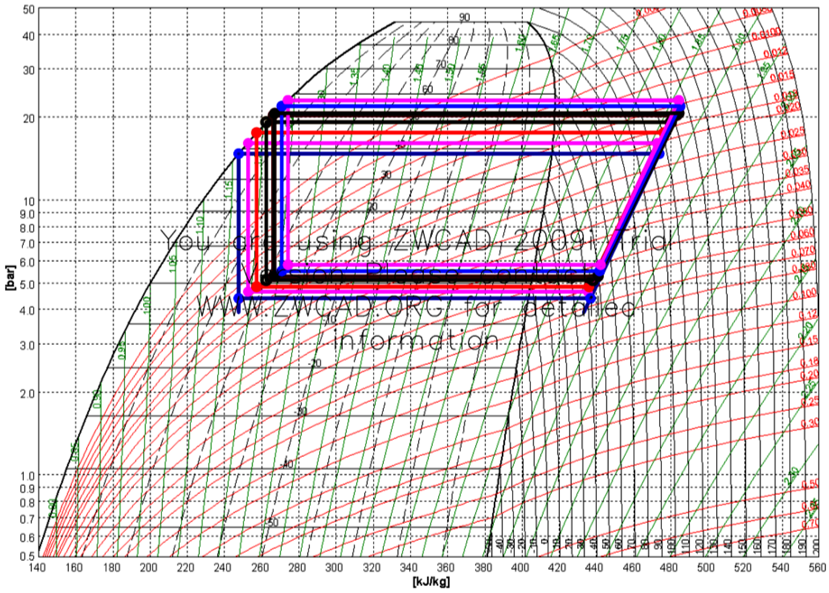

Fig. 10 Actual thermodynamic cycle on P-h chart

Fig.10 show that the thermodynamic P-h cycle is continuously going in upward side. When such condition happens, the COP of the system is decreased continuously as shown in fig.9. COP is decreased due to increase in a vacuum (condenser inlet) and discharge (condenser outlet) pressure. This increased pressure directly reduces the heat rejection to the water and cooling effect in air side according to fig.10.

CONCLUSION

- During running condition of heat pump the temperature of water rises up to 53^0C and pressure in the system is rising up to 22.5 bars. Experimentation reading reveals that at an early stage of running condition the COP is maximum. As the water temperature increases the system COP is decreases.
- The air source heat pump has coefficient of performance 2.04. It consumes 0.4 KW.hr power in 15 min working cycle. According to this, the heat pump setup heated 36-liter water in 3.5 rupees.

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