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Fabrication of Air Conditioner Integrated with Water Cooler and Water Heater

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ABSTRACT

The air conditioning system is designed to provide a comfortable living or working environment within a specific area by controlling the surrounding at a suitable range of temperature, relative humidity, air circulation and purity of the air. The air conditioners are generally used in residential and commercial buildings. Along with air conditioners the electric water heaters and water coolers have also been used in residential buildings. The usage of these electric appliances has been increasing day by day in most part of the world. Due to this, the consumption of energy has increased. Energy saving is one of the key issues not only from the view of energy conservation but also for the support for the global environment. Therefore, more efficient devices have to be designed which reduces the energy consumption and the cost. The cost can be minimised if different devices working in same principle are integrated into single device. The air conditioner can be integrated with the water heater and water cooler. These devices work on the similar principle. The water cooler and air conditioner work in vapour compression cycle and the water can be heated in the condenser. Thus, by integrating these three devices the purchase cost is reduced since these devices will work on single common compressor. The advantage of this system is that the water is heated from the heat released by condenser. The condenser of conventional water cooler are air cooled, due to which the heat energy gets wasted. This energy is utilised to heat the water and energy is conserved. This system is multifunctional used to perform three operations reducing the cost and energy consumption.

Key Words: *Air conditioner, Water Heater, Water cooler.*

1. INTRODUCTION

Energy saving is one of the key issues not only from the view of energy conservation but also for the support of global environment. This report presents the principle of integrating air conditioner with water heater and water cooling system. This system provides conditioned air with hot and cold water, thus making the system multifunctional. Nowadays, besides the air conditioning unit, another comfort providing equipment that can be found in many homes is the instant water heating system which is often used in the morning when both the weather and water temperature are low. However, the instant water heater consumes a considerable amount of electricity and users have to pay for it. There is still a possibility to obtain hot water without using any extra electric power by utilizing the waste heat from the condenser of water cooler.The system uses single compressor to operate both water cooler and air conditioner. The refrigerant used in this system is R-22. From the performance test conducted, it is observed that water gets heated to 65^0C. The temperature of cold water achieved is 18^0C. The air conditioner provides good results with optimum efficiency. The power consumption of the system on an average is 1.1kw.The system uses only one compressor to operate both air conditioner and water cooler, therefore the cost is reduced considerably. The water gets heated by utilizing the waste heat liberated by condenser of water cooler, thus the system provides better way to heat water without using extra electric power. The power consumption of the system is similar to conventional air conditioners. From earlier times, the art of artificial cooling is employed in the preservation of the perishables such as milk, food, drinks, medicines, etc. Indoor air cooling has also been employed in order to provide humanitarian comfort and cool environment in industry applications. The application of cooling is employed in various fields. The two methods employed for artificial cooling are refrigeration and air conditioning. Since refrigerators and air conditioners are widely used, these systems have to be manufactured economically and ensure that they are energy efficient.Air conditioning is the process of altering the properties of air (primarily temperature and humidity) to more comfortable conditions, typically with the aim of distributing the conditioned air to an occupied space to improve thermal comfort and indoor air quality. A heat pump is an air conditioner in which the refrigeration cycle can be reversed, producing heating instead of cooling in the indoor environment. They are also commonly referred to as a "reverse cycle air conditioner".The heat pump is significantly more energy efficient than electric resistance heating. Some homeowners elect to have a heat pump system installed as a feature of a central air

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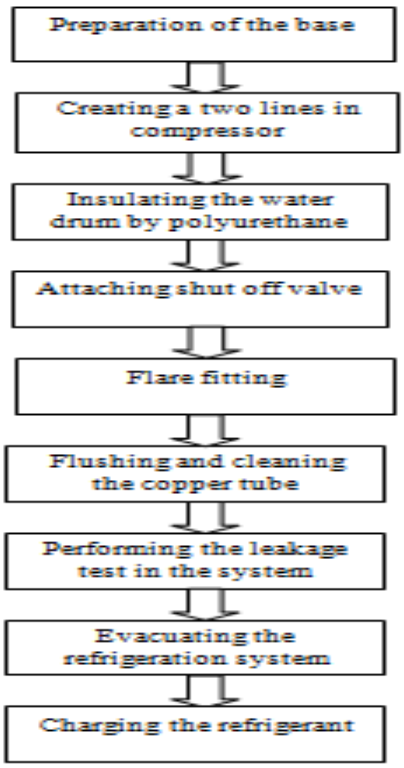
conditioner. When the heat pump is in heating mode, the indoor evaporator coil switches roles and becomes the condenser coil, producing heat.Primary refrigerants are those which can be directly used for the purpose of refrigeration. If the refrigerant is allowed to flow freely into the space to be refrigerated and there is no danger of possible harm to human beings, then primary refrigerants are used. The refrigerants used in home refrigerators like Freon-12 are primary refrigerants. On the other hand, there may be certain situations in which we cannot allow the refrigerant to come in direct contact with the items being refrigerated, and then the refrigerant used is termed as a secondary refrigerant. As for example, we cannot allow a toxic refrigerant to be used for air conditioning in residential buildings. There are some refrigerants which are highly inflammable and so their direct use is forbidden for safety reasons. Again, it may so happen that if direct refrigeration, such as in cooling a big cold storage, is allowed, then the amount of refrigerant required may be so large that its cost becomes prohibitively high. These are some typical situations for which we favour the use of secondary refrigerants. Water and brine solutions are common examples of secondary The vast number of refrigerants available in the market today allows us to choose a refrigerant depending upon the operating conditions of the refrigeration system. As such, there is no refrigerant that can be advantageously used under all operating conditions and in all types of refrigeration systems.

2. METHDOLOGY

Following are the steps involved in our present work



A. Preparation of the base

The frame structure is used to support the entire system. It acts as base for the system. Frame makes the system portable by using heavy duty wheels. The material used for frame work is galvanised iron pipe of size 1inch×1 inch.The dimension of the frame is Length - 4 ft, Width- 2.5 ft, Height- 2.5 ft, Number of wheels used -4.A plywood of dimension 4×2.5 ft is used to mount the system on the frame.

B. Creating a two lines in compressor

The suction and discharge pipes of compressor are joined with the tee fitting to obtain two flow lines. The two lines of suction are joined with evaporator coils of both air conditioner and water cooler. Similarly, the discharge lines are attached to the condenser coils. The condenser coils in water cycle serves to heat the water, while in air conditioner it heats the air. The evaporator coil and condenser coil in water cycle are placed surrounding the drums. The meeting point of two copper pipes is joined by brazing process.

C. Insulating the water drums by Polyurethane foam (PUF)

Polyurethane is a polymer composed of a chain of organic units joined by carbamate (urethane) links. Polyurethanes are thermosetting polymers that do not melt when heated. Hence this material is best suited for insulation purpose.The polyurethane foam (PUF) is applied around the drums covering the coils. This provides thermal insulation and rigid support to the drums. The insulation reduces the heat loss.

Fig 1 : Polyurethane foam (PUF)

D. Attaching shut off valve

The shut off valves are used to control the direction of flow of refrigerant. Four such valves are attached in two discharge and suction flow lines. The valves are joined by flare fitting. In this process the end of the pipe is enlarged using flaring tool.

E. Flare fitting

Fig 2: Flaring tool **Fig 3: Flaring fit**

Flare fittings are a type of compression fitting used with metal tubing, usually soft steel and ductile (soft) copper, though other materials are also used. Tube flaring is considered to be a type of forging operation, and is usually a cold working procedure. During assembly,a flare nut is used to secure the flared tubing's tapered and also the tapered fitting, producing a pressure-resistant, leak-tight seal. Flared connections offer a high degree of long-term reliability and for this reason are often used in mission-critical and inaccessible locations

F. Flushing and cleaning of the system

Flushing is performed in order to remove all contamination (dirt) from the system. The smallest particle of contamination causes restriction and problems for a good functioning of the compressor. The compressor must be lubricated at all times. The compressor is the only moving part in the entire system and the only reason for oil in the system. The oil is being circulated throughout the system, which means that all the components (condenser, hoses, tubes, evaporator, drier and accumulator) have some coating of oil internally. Removing the oil (and oil film inside the components) will eliminate all of the contamination from the AC system. It's the oil that attracts and holds contaminants within the system.Therefore the condenser and evaporator coils have to be flushed before its use. Depending on the method you are using, start by getting some of the flush agent intothe component. Use pressurized gases (dry air or nitrogen) to push the flush agent through the component. Hold a clean wiper on the opposite end of the component you are flushing. This will allow you to apply some back pressure (holding and releasing the wiper to act as a plug). This help to dislodge and remove debris that may be caught in 'hard to get' places. Be sure to perform the same flush procedure in both directions, several times on each component. For the best results, once the system is assembled, but before it is completely sealed, purge the system with nitrogen. By holding the other end of the coil, blow nitrogen through the system so that it will eliminate any moisture that may be left in the system after flushing. This procedure makes the coils free from contaminants.

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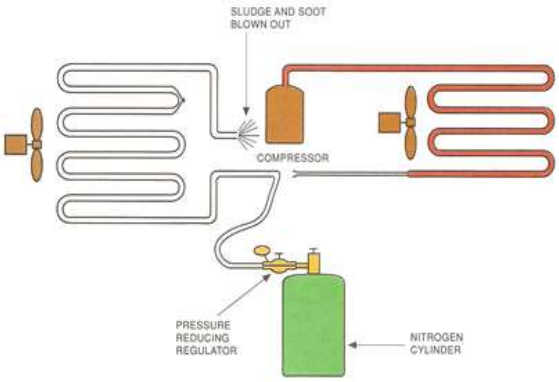

Fig 4: Flushing process

G. Performing leak test in the system

Once all the connections are made the system has to be undergone through leakage test. This test is carried out to ensure leak proof connections and joints. The nitrogen gas is used for the testing. The nitrogen gas is charged to the system until certain pressure. The supply of the gas is stopped. A soap solution is applied on all the brazing joints and connections made. If any bubble formation occurs leakage is detected. The gas is purged out of the system and the leakage defect is repaired. The procedure is repeated and tested for leakage until air tight joints are obtained.

H. Evacuating the refrigeration system

Evacuating is the process of creating vacuum inside the refrigeration line. The main objective of evacuation is to remove the air and moisture content from the refrigeration line. The presence of air makes the system to operate at higher pressure than the desired pressure. The water may freeze up at the expansion device which causes loss of refrigeration effect. Thus evacuating is very much necessary before charging the refrigerant. A vacuum pump is used for the evacuation. The pump is fixed to the charging tube and the air and moisture content is sucked out to the atmosphere. This process is carried out for certain period of time to ensure perfect evacuation.

I. Charging the refrigerant

After the evacuation process, the charging of refrigerant is performed. The refrigerant used in this system is R-22. The refrigerant cylinder is connected with charging hose and gauges. Before charging, gauges and hose are vented with the refrigerant used to avoid introduction of air into the system. Then the hose is connected to the charging tube in the compressor. After attaining the required pressure the charging is stopped andthe system is operated to ensure the proper performance of system

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3. RESULTS AND DISCUSSIONS

A. Water cooler

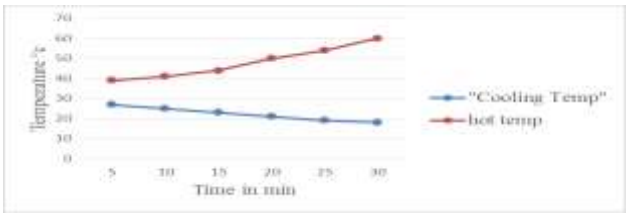

Fig 5:Temperature v/s time at 32ºc ambient temperature

The cold water temperature reduces from the 32ºc to 18ºc and the hot water temperature rises from 32ºc to 60ºc in thirty minutes

B. Air conditioner

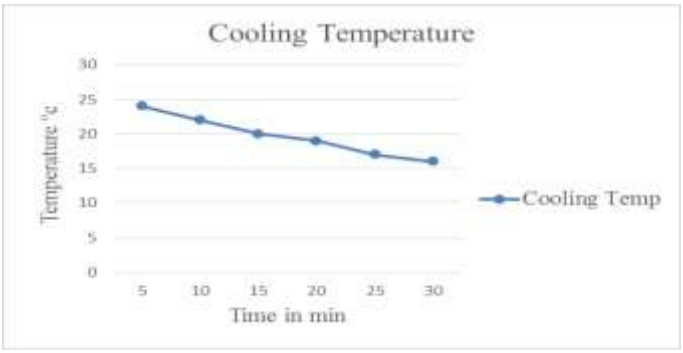

Fig 6: Temperature vs time at 32ºc ambient temperature

While the air conditioner alone is operated the temperature of cooling air achieved at 30minutes is 16ºc

C. Operating air conditioner and water cooler simultaneously

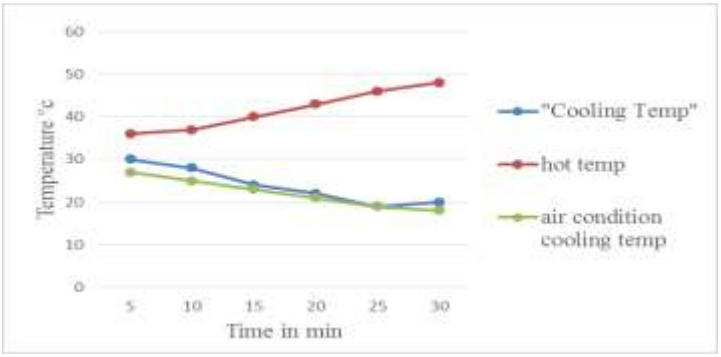

Fig 7: Temperature vs time at 32ºc ambient temperature

When the air conditioner and water cooler are operated simultaneously the temperature attained by cold water is 20ºc and hot water is 48ºc. The air cooling temperature attained at 30 minutes is 18ºc.

D. COP of water cooler

Pressure at exit of evaporator, P1= 0.34 bar

Pressure at exit of compressor, P2= 12.4 bar

Temperature at cold region = 20ºc

Temperature at hot region = 48ºc

From p-h diagram of refrigeration cycle for R-22

h1 = 220kj/kg

h2 = 260kj/kg

h3 = h4 = 90kj/kg

Therefore, COP = $\frac{h1-h4}{h2-h1}$

= 220-90/260-220 = 3.25

The COP of system when water cooler is operated is found to be 3.25

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E. COP of air conditioner

Pressure at exit of evaporator, p1=0.34bar

Pressure at exit of compressor, p2=9.6 bar

Temperature at cold region =22ºc

Temperature at hot region=49ºc

From p-h diagram of refrigeration cycle for R-22

h1= 220 kj/kg

h2= 265 kj/kg

h3 = h4 = 60 kj/kg

Therefore, COP $=\frac{h1-h4}{h2-h1}$

= 220-60/265-220 = 3.55

COP of system when air conditioner is operated is found to be 3.55.

4. CONCLUSIONS

From the performance test conducted the water temperature can be raised from ambient temperature can be raised from ambient temperature to around 58ºc. The water gets heated from condenser unit of water cycle. Therefore it reduces separate water heating charge. The temperature of cold water can be reduced from room temperature to 18ºc. The air cycle provides good results with optimum efficiency. Thus it is concluded that the modified system performs in similar manner to conventional air conditioners and water coolers.The main advantage of this system is that the hot water is obtained by utilising water heat liberated by condenser of water cooler, without spending extra electric cooler. Therefore this system is economic. The average power consumption and the COP of this system is around 1.1kw and 3.5 respectively, which is similar conventional air conditioner and water cooler. The system uses single compressor to operate different modes of operation. Hence the installation cost is also less. Since this device is multifunctional and works with single compressor, this system is economic compared to conventional air conditions. This principle can be used for household purpose and in automobiles etc.

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