International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

Split air conditioning using Thermoelectric cooler

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Abstract - *Air conditioning is the process of removing heat and moisture from the interior of an occupied space to improve the comfort of the occupants, the system controls the humidity, ventilation, and the temperature of space typically to maintain a cool atmosphere in warm condition. The normal air conditioning system works with the help of a compressor, expansion valve, etc. which are high cost and high-power consumption. This design is conducted for developing an air condition by using the Peltier module and to provide a good alternative to air conditioners which consumes high power and cost*

Key Words: **Split air conditioning, heat load calculations, apparatus dew point temperature, thermoelectric cooling module**

1. INTRODUCTION

The air conditioning is the process of conditioning the occupied space for the comfort of the occupants. Mainly the air conditioning is used for human comfort, which is 75°F and 50% relative humidity. The cooling is typically achieved through a refrigerant cycle like VARS or by free cooling method or by using desiccants. Thus, the requirement is the same. Cooling in the traditional AC system is accomplished by the vapor compression system which uses forced circulation and phase change of a refrigerant between gas and liquid to transfer heat. In this design of air-conditioning, two main parameters are taken into account which is relative humidity and temperature.

Nilesh varkute et al [1] researched and designed the working of air conditioning by using the Peltier module. The design was to make the system more cost-efficient than other commercial systems. The design was to make the system portable and can be used anywhere. The refrigerant used was water. The heat transfer through metal fins has been calculated in the paper. The design was able to bring the temperature to 26°C and better results were achieved with the use of cold water.

Vrushal Deshpande et al [2] In normal AC systems R22 refrigerant is used which causes environmental disaster. This system uses water as a refrigerant and redesigned the vapor absorption system by removing the compressor and expansion valve. Uses desert cooler as a cooling tower to cool down the hot water from the evaporator.

Francis T. Omigbodum et al [3] design of the air conditioning unit of offices was developed to predict the thermal performances and also the energy usage of the system within a specified time. It also facilitates to decide the energy size of the air conditioning system needed by the size of the building, considering the thermal loads and evaluating the maximum cooling power required. Applicable and desirable by institutions and industries at large for the implementation.

Anshu Raj et al [4] paper initiated a review based on an air conditioner study of a particular room. This work offers tremendous significance for developing new technologies pertains to save energy, achieving hot/cool air at an initial cost, no harmful effect, and safer in the environmental aspect. So, more attention is needed in this area and lots of work has to do based in terms of its background, originality, current status, and researches.

Gourav Vivek Kulkarni et al [5] comfort air conditioning can be effectively implemented by designing the air conditioning systems considering various factors like effective temperature, rate of heat transfer of occupants, rate of loss of moisture, air quality, and certain psychological factors like humidity or moisture content in the air and recirculation of the air.

2. CONVENTIONAL AIR CONDITIONING SYSTEM

In the conventional air conditioning system, uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to cooled and subsequently rejects that heat elsewhere. All such systems have four components a compressor, condenser, a thermal expansion valve, and an evaporator.

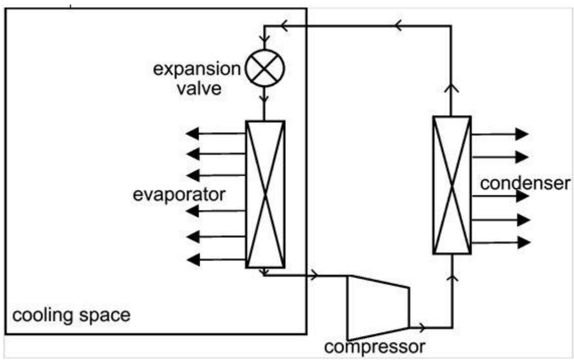

Fig -1: Basic schematic view of a conventional split AC system

In the conventional air conditioning system mostly use a vapor compression system. The evaporator and the throttling device (expansion valve) are kept inside the space and the compressor and the condenser is kept outside, so the heat from inside is rejected outside. The heat inside the room transfers the liquid refrigerant to vapor a form. The vapor refrigerant then goes to the compressor, the compressor then compresses the vapor refrigerant to high pressure and high temperature and gives a push to the vapor refrigerant to the condenser this is why the compressor is called the heart of the refrigeration system it provides the flow of refrigerant. The high-pressure high-temperature vapor then goes to the condenser where the high pressure and high-temperature vapor is converted to liquid. The condenser transfers the heat to the outside. The high-pressure liquid then passes to the expansion valve (throttling device) where the high-pressure, high-temperature liquid is converted to low pressure, low-temperature liquid refrigerant. The low-pressure, low-temperature liquid refrigerant then passes to the evaporator hence the cycle is complete.

3. DESIGN AND CALCULATION

In a conventional air conditioner compressor, condenser, expansion valve, and the evaporator is used but in the proposed system all components except the evaporator are removed. Water is used as the refrigerant. The indoor unit consists of an evaporator which is circulating chilled water and absorbs heat from inside. The water is then cooled by a cooling chamber which is cooled by the thermoelectric module. The cooling chamber and the thermoelectric module is kept outside to improve the performance of the system.

The main purpose of this air conditioning system is for the human comfort that is to keep the space ambient air at 75°F and 50% RH. To keep the space in this condition apparatus dew point must be calculated.

3.1 Heat load and ADP calculation

Consider this room.

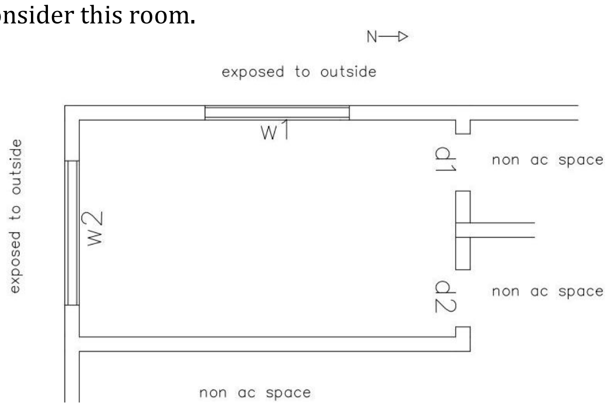

Fig -2: Layout of the room.

Application - Residntial
Windows (w1 and w2)- 3' 10" × 4' 5"
Doors (d1 andd2) - 2' × 6' 4"
Room - 10' 5" × 9' 10" × 9' 5"
Area - 102.42 sqft
Volume - 964.455 cbft
Location - Kerala, India
Latitude - 9.58°N (10°N)
Daily range - 10°F

Outside condition
(Data is taken when maximum values are reached)
DBT - 95°F
WBT - 82°F
RH - 58%
By using the psychrometric chart
DPT - 77°F
Gr/lb- 146Gr/lb

Required condition
DBT - 75°F
RH - 50%
By using the psychrometric chart
WBT - 62°F
DPT - 55°F
Gr/lb – 65Gr/lb

So the process of air conditioning should be cooling with dehumidification

ΔDBT = outDBT – inDBT
= 95-75 = 20°F
ΔGr/lb = out Gr/lb – in Gr/lb
=146 – 65 = 81Gr/lb

Infiltration of the door exposed to outside or a non-ac area
perimeter of door = 16.66ft
total perimeter = 2×16.66 = 33.32ft

Heat gain, $Q = A \times \Delta T \times u$
A - Area
ΔT - Heat gain
U - Transmission coefficient

Solar heat through glass (south)
$Q = A \times \Delta T \times u$
$= 16.926 \times 11 \times 0.56$
$= 104.264$ Btu/hr
Solar heat through glass (west)
$Q = 16.926 \times 158 \times 0.56$
$= 1497.612$ Btu/hr

Transmission heat through the glasses
$Q = 33.852 \times 20 \times 1.13$
$= 765.055$ Btu/hr

Solar and transmission heat through the wall (south)
$Q = A \times \Delta T \times u$
$\Delta T = \Delta t +$ correction factor
correction factor = 10

Q = 75.661 × 36 × 0.39
= 1062.280 Btu/hr

Solar and transmission haet through the wall (west)
Q = A × ΔT × u
Q = 81.150 × 36 × 0.39
= 1139.346 Btu/hr

Solar and transmission through the roof (shaded)
Q = A × ΔT × u
Q = 102.420 × 18 × 0.12
= 221.227 Btu/hr

Transmission heat through the partition
Q = A × ΔT × u
Q = 190.664 × 15 × 0.37
= 1058.185 Btu/hr

Infiltration sensible heat
Q = cfm × ΔT × 1.08
= 33.32 × 20 × 1.08
719.712 Btu/hr

People sensible heat
Q = 1 × 240
= 240 Btu/hr

Light heat
Q = Area × 3.41
= 102.42 × 3.41
= 349.252 Btu/hr

Appliances
Q = 150 × 3.41
= 511.5 Btu/hr

Room sensible heat(total) = 7668.433 Btu/hr

Adding factor of safety (10%) = 8435.276 Btu/hr

Effective room sensible heat = 8435.276 Btu/hr

Infiltration latent heat
Q = cfm × ΔGr/lb × 0.68
= 33.32 × 81 × 0.68
= 1835.265 Btu/hr

People latent heat
Q = no: of people × latent heat/people
= 1 × 160
= 160 Btu/hr
Room latent heat = 1995.265 Btu/hr

Adding factor of safety (10%) = 2194.791 Btu/hr
Effective room latent heat = 2194.791 Btu/hr

Effective room total heat = 8435.276 + 2194.791
= 10630.067 Btu/hr

Effective room sensible heat factor
ESHF = effective room sensible heat/effective room total heat
= 8435.276/10630.067
= 0.79
ADP = 50.33 °F (from databook corresponding to ESHF)
= 10°C
So, the evaporator coil must be kept at 50°F in order to attain the required condition in the room.

3.2 Design of the model

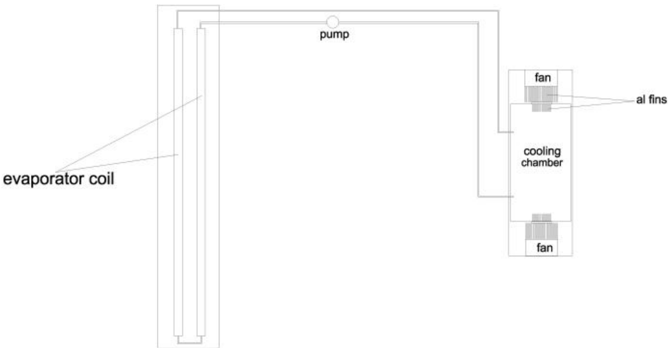

Fig -3: design model

Here the evaporator coil is cooled by the cold water, the cold water is made from the outside unit which consists of a cooling chamber, al fins, fans. The cold side of the thermoelectric module is kept in contact with the cooling chamber and the hot side is kept in contact with the al fins which is attached to a fan. These fans continuously work and the heat is rejected to the atmosphere. The cooling chamber maintains the cold temperature and the cold water is transferred to the evaporator using a pump.

The indoor unit consists of evaporators and blowers. The blowers help to supply more air to the evaporator coil thus more amount of air is cooled.

Fig -3: final setup of air conditioning model

4. TESTING AND RESULT

From the above experimental setup, the water can be cooled up to 5°C but the required temperature is 10°C, so the cooling module is controlled by a microcontroller which cut off the supply of module when it reaches below 10°C hence the cold temperature is maintained. After a few times, the room ambient temperature came to required temperature.

5. CONCLUSION

The ambient temperature of the room becomes below 25°C and humidity is also maintained. The cost and power consumption of this model is less. The major drawback of the system is that it takes more time to cool the water. This drawback can be changed by increasing the cooling modules and by using cold water instead of normal water.

6. REFERENCES

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