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Design and fabrication of portable air cooler

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Abstract – *The main objective of this work is to experimentally investigate the feasibility of employing ice as a cooling medium to improve air cooling performance of a portable cooler using latent heat of fusion. A portable air cooler has been fabricated with commercially available polyurethane insulation box integrated with galvanized iron conduit of 3*3 inch square cross section for air passage. This passage completely separates the airflow from ice while allowing the thermal conduction between ice and air. This system was experimentally tested under ambient temperature ranging from 34.6 ℃and 30 ℃ The test result show that the system is able to cool air upto 11.4 ℃ The result also signifies that cooling performance of the system is subjected to variations in atmospheric temperature, room temperature and time.*

Key Words: Atmospheric temperature, room temperature, outlet temperature.

1.INTRODUCTION

1.1 Problem Statement

In India, the average temperature is around 26°C (78.8°F), therefore various appliances such as air conditioners, coolers and fans are required to maintain a comfortable temperature for humans. Such equipment is fairly expensive, and not everyone can afford it. Students from other cities, those living in poverty, and lower middle-class families are particularly exposed to the summer heat in India. Traditional coolers and air conditioners are extremely expensive for these people to purchase, maintain, operate, and install. Due to the smaller rooms in hostels and rental apartments, these folks also have a problem with installation space. As these people are likely to travel to other cities and change places they also face problems of transporting bulky and heavy machinery and extra transport charges due to lack of portable appliances.

The major goal of this study is to develop an alternate cooling technology as well as a device that is both economical and portable. This device is suitable for usage in hostels, homes, offices, and other settings. The temperature of the room has no scientific meaning that we can reliably assess. The temperature that is pleasant and appropriate for a person is determined by the individual, meteorological conditions, geographical location and other factors.

As can be seen from the presented study, we have developed an alternative cooling method that may be of great assistance to those who are affected by extreme weather. We have developed a solution to India's heat wave dilemma that is both affordable and portable using mobile technology.

1.2 Objective

a. To develop a portable air cooler that is compact , easy to use, provide better cooling effect without effecting atmospheric humidity content than traditional coolers, all at an affordable price range.

b. Our main focus is on hostel students, students who live as tenants, and tenants from the lower middle class families.

c. Development of this project aims to combat heat waves during the warmest months of the summer season, May and June.

2. LITERATURE REVIEW

Bhupendra Sahare et.al [1], designed modifications to the existing cooler design. A mild steel refrigeration box was installed within the cooler tank, and the cooler tank was insulated from the outside with a rubber cushion to prevent heat loss. Except for the front face, which is a refrigeration box's door, all of the box's surfaces are in contact with tank water. A series of experiments in a controlled atmosphere within a room in the climate conditions of Raipur, Chhattisgarh, India were used to validate the suggested model. The box was stuffed with fruits and vegetables, and the same amount of fruits and vegetables were stored outside in the room, where daily weight loss was monitored. It was discovered that apples stored outside lose more weight than apples stored inside of a refrigerator box. When apples were kept inside the box, their temperature dropped, whereas when they were left outside, their temperature increased. In comparison to outside apples, the apples were in good shape. Inside, the weight was falling at a slower rate than outside.

Manjunatha Y R et.al [2] proposed a solution that is the best alternative to conventional cooling techniques with temperature monitoring Bluetooth-enabled gadget with thermal energy that employs the Peltier effect to chill a specific region. This method allows us to detect both body temperature and environmental circumstances, as well as manage the temperature manually or automatically. The general operation is to use the Bluetooth module to monitor body temperature and ambient factors, which are shown on the LCD module and mobile screen. Users can choose between cooling and warming effects from the cooler and heater. They came to the conclusion that temperature-controlled cooling systems incorporating Bluetooth technology for monitoring are more reliable and efficient than other cooling systems. This can be utilised in the medical field as a portable refrigerator for storing blood and medications. Though it can chill a limited area, its effectiveness can be improved by increasing the number of Peltier plates. The temperature can be boosted or decreased in less time with portable air conditioners. These Peltier-based air cooling systems will be a performance-enhancing alternative to traditional air conditioning systems.

Sujatha Abaranji et.al [3] achieved passive cooling integrated with renewable energy sources. The water storage medium is a porous material, which eliminates the need for a pump and sump. The constructed setup is put to the test, with experiments being conducted for three different RH levels (low, medium, and high) to examine the porous material's efficacy as a cooling medium. The performance of a direct evaporative cooling system is evaluated by determining its cooling capacity, efficacy, and water evaporation rate. Because of its high water retention properties, vermicompost is used to replace the pump and sump. There is no need to switch materials every time. The vermicompost, on the other hand, is regenerated using a solar dryer at the end of the experiment. The passage of heated air over the vermicompost also prevents the transfer of any mould spores present in the air. The results show that During low RH conditions, vermicompost produces an average temperature drop of 9.5°C. Furthermore, by eliminating the pump, vermicompost contributes to a 21.7 percent energy reduction. As a result, vermicompost could be a more energy-efficient alternative to the traditional evaporative cooling system's pad-pump-sump. Furthermore, by combining this direct evaporative cooling system with solar-assisted vermicompost drying, a clean and sustainable interior atmosphere can be created. This method could open the path for environmentally friendly year-round thermal management of building cooling applications.

Sudaporn Sudprasert et.al [4] determined the thermal comfort level achieved by evaporative air coolers and identified variables affecting thermal comfort when using an evaporative air cooler indoors in the tropical climate of Thailand. The results of a survey asking people about their thermal comfort when exposed to evaporatively cooled air were compared to those of participants exposed to natural air. Variables affecting thermal comfort were discovered using a multiple regression model. This study found that evaporative air coolers provide a thermal comfort level of 0.6 (slightly cool) on the thermal sensation scale, which is lower than the level of 0.0 (neutral feeling) provided by fans. Indoors, evaporative air conditioners with a high velocity of 1.4 m/s are recommended to reduce discomfort caused by moist air. The regression analysis shows that air temperature and velocity are the two most important variables in determining thermal experience when using evaporative air conditioning in Thailand.

M. C. Ndukwu et al.[5] examined into new technological improvements in evaporative cooling systems that could boost cooling efficiency, such as membrane air treatments, dew point type, and heat pipe type heat exchanger in indirect/direct evaporative cooling applications, and their feasibility in agricultural storage is either missing or rare. Some materials, particularly agricultural residues, have been used for air water contact in evaporative cooling in various climates, but most analyses focused on the effect of air flow rate and pad thickness on thermal efficiency, and the energy efficiency and evaporation loss of these materials were not evaluated or presented in the majority of cases. Evaporative cooling systems' commercialization in underdeveloped nations is limited by a lack of awareness, as well as a rigorous economic and cost analysis to persuade farmers of their cost benefits.

3. METHODOLOGY

In this proposing system we will going to make an Eco-friendly Portable air cooler that will provide cool air with the help of ice in place of refrigerant.

[1] To begin, we will be using a single polystyrene/ polyurethane insulation box to offer complete insulation that will prevent ice from melting for a longer period of time.

[2] We are fabricating a zigzag-shaped duct out of galvanized iron sheet that will serve as a passage for air.

[3] We will be placing a large slab of ice approximately 15 kg on this duct to chill the duct walls, which will then cool the air flowing inside the duct..

[4] This duct has a cross section area of 3*3 inches. Air passes through this duct and collides with the duct's internal wall, this collisions of air molecule with duct walls causes the air to loose heat and become cold.

[5] We will eventually receive cold air from the outlet after travelling all the way down the duct.

4. ASSEMBLY DESIGN

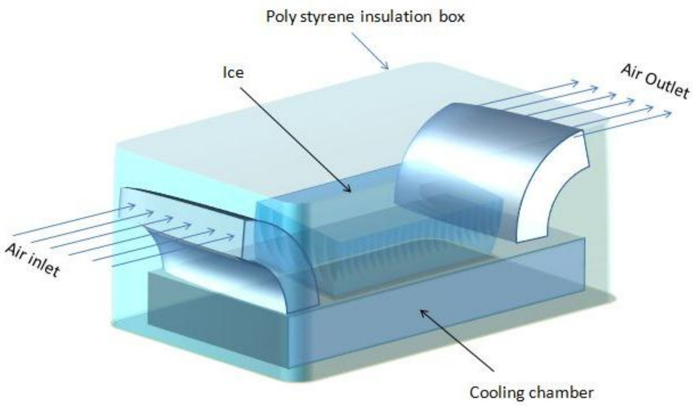

Fig-1: Assembly Design

5. COMPONENTS

a) Polystyrene / polyurethane installation box
b) DC Motor
c) 4 inch plastic fan
d) Galvanized iron duct
e) PVC pipes and fittings
f) Temperature sensor
g) Battery 12 Volt

6. SELECTION OF VARIOUS PARTS USED IN THIS PROJECT

6.1 Polystyrene / polyurethane installation box

Polyurethane refers to a class of polymers composed of organic units joined by carbamate (urethane) links. Polyurethane polymers are traditionally and most commonly formed by reacting a di- or triisocyanate with a polyol. Polyurethane foam is widely used in high resiliency flexible foam seating, rigid foam insulation panels etc.

We have used a 50 litres capacity Polyurethane insulation box for this project.

6.2 DC motor with fan

We have used 12volt dc motor with 30000 maximum rpm with 4 blade plastic fan (4 inch diameter) for this project.

6.3 Galvanized iron duct.

3x3 inch square cross-sectional duct is fabricated to allow air to pass through without coming in contact with water or ice. Air passing through duct also loses its heat during this process.

6.4 DC power source

A 12volt 4 ampere hour battery is used to power this whole setup.

6.5 temperature sensor

This is XH-W1209 12V Digital Temperature Controller Module W/ Display and NTC Waterproof Temperature Sensor. W1209 Mini thermostat Temperature controller is low-cost 12V Temperature controller with 7-segment display and 3 switch keypad for setting temperature and other parameters. The module features an NTC thermistor temperature sensing and has an accuracy of 0.1 C.

The XH-W1209 12V Digital Temperature Controller Module W/ Display and NTC Waterproof Temperature Sensor is an incredibly low cost yet highly functional thermostat controller.

7. Designing Calculation

7.1 working

DC Motor:

Given specifications:

We have used 12 volt, 1.5 Amp and max 30000 rpm DC motor to operate the ducted fan.

P = Voltage* Current

= V * I

= 12 V * 1.5 A

= 18 Watt

7.2 Cooling

We have not calculated anything for cooling because the cold air from the outlet is our primary goal in our project, not cooling the entire testing space. We are only using ice which will provide cool air on the basis of latent heat of fusion and conduction . After the successful testing of our project we will try to add some additional features to do cooling in more efficient manner.

Below here is the 24 hours observation table that we made between time, atmospheric temperature, room temperature and outlet temperature.

Note- all readings were taken on 17/5/2022 in samriddhi boys hostel Near bbd green city, Ganeshpur Rahmanpur, uttar pradesh 226028

Table -1 Observation Table

Time	Atmospheric temperature (in °C)	Room Temperature (in °C)	Outlet Temperature (in °C)
16:15	42	34.6	31.5
17:15	41	33.9	18.6
18:15	40	32.2	18.5
19:15	38	32.6	18.4
20:15	37	32.9	17.3
21:15	35	33.2	16.5
22:15	35	32	16.9
23:15	34	32.6	15.3
00:15	34	32.5	15.2
1:15	33	32.2	15
2:15	31	30.7	14.8
3:15	31	30.4	14.3
4:15	30	30.3	14.2
5:15	30	30.2	14
6:15	30	30	13.9
7:15	31	30.3	13.7
8:15	32	30.8	13.5
9:15	33	31.5	13.4
10:15	35	32.3	13.2
11:15	36	32.7	12.9
12:15	37	33	12.5
13:15	39	33.3	12.2
14:15	40	33.5	11.4
15:15	40	33.9	11.5

8. CONCLUSION

A portable air cooler is successfully designed and assembled. It serves the basic cooling need of human being during harsh weather conditions of Indian summer season. The portable air cooler satisfies the need of the consumer at the most economical cost. The portable air cooler requires relatively minimal maintenance. It has the feature of portability, which allows it to be moved around easily. Because it is smaller, it would be ideal for our bedroom or drawing room even smaller hostel rooms. Because we're using ice as a medium, it's absolutely pollution-free. However, the design is still in prototype stage. More tests need to be conducted before the efficiency, durability and reliability can be demonstrated precisely.

Below are list of suggestion for the improvement of this portable air cooler.

1. Improving the duct design with rounded corners.
2. Increasing the cross section area of duct by 1 inch and using inlet and outlet of same dimension.

Below is the graphical representation of Table-1 observation table.

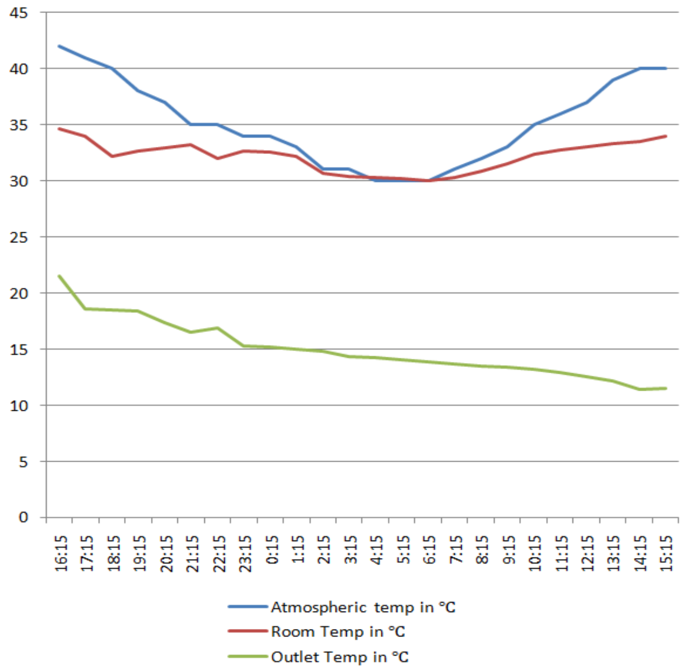

Chart-1 Time-Temperature graph

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BIOGRAPHIES

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