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RESEARCH INVESTIGATION ON DEVELOPMENT OF PORTABLE EVAPORATIVE COOLER FOR DESERT CLIMATIC ZONE IN OMAN REGION

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Abstract: The main objective of this study is to investigate the practicality of using ice as a cooling agent to improve the air cooling efficiency of a portable cooler by harnessing the latent heat of fusion. A portable air cooler has been fabricated utilising a commercially available polyurethane insulation box. The box has been integrated with a galvanised iron conduit, featuring a square cross section measuring 3 inches by 3 inches, to enable the flow of air. This tunnel efficiently separates the airflow from the ice, while still allowing thermal conduction between the ice and the surrounding air. The system underwent experimental testing at ambient temperatures ranging from 34.6 ℃ to 30 ℃. Based on the test findings, the system has shown the ability to reduce the air temperature by a maximum of 11.4 ℃. The results also suggest that the cooling effectiveness of the system is affected by variations in air temperature, room temperature, and time.

Key Words: Atmospheric temperature, room temperature, outlet temperature

Introduction

On average, the Sultanate of Oman experiences temperatures of around 36 degrees Celsius. Therefore, it is crucial to use various equipment such as air conditioners, coolers, and fans to provide a comfortable thermal environment for those living there. Because of its comparatively high price tag, a large segment of the public cannot afford such equipment. Extreme heat during summer in India is very harmful for students living in various urban locations, people going through tough times economically, and families from lower middle class socioeconomic backgrounds. Traditional air conditioners and coolers are out of reach financially due to the high costs of purchase, upkeep, operation, and installation. Problems with limited installation space due to relatively tiny room sizes are a reality for people living in rental apartments and hostels. People who move about a lot and travel a lot often have to deal with the hassle of moving big and heavy items and the extra money needed to replace non-portable appliances.

Objectives

In order to design a reasonably priced, easily transportable air cooler that may improve cooling performance without drastically lowering surrounding humidity levels, all while maintaining a small footprint and being easy to operate.

We mainly target students living in dorms, students who rent, and tenants from lower middle class families.

The major goal of this initiative is to reduce the severity of heat waves that happen in May and September, which are the warmest months of the summer.

Literature Review

In their study, Sahare et al. (2021) proposed alterations to the current cooler design. The installation of a refrigerated box made of mild steel was carried out inside the cooler tank. Additionally, a rubber cushion was applied to isolate

the cooler tank from external sources of heat, hence minimizing heat loss. With the exception of the front face, which corresponds to the door of a refrigerated box, all other surfaces of the box are in direct touch with the water contained in the tank. To validate the proposed model, a series of experiments were conducted in a controlled environment within a room located in Raipur, Chhattisgarh, India, under certain climate conditions. The box contained an assortment of fruits and vegetables, while an equivalent quantity of fruits and vegetables were housed in the adjacent room, where daily measurements of weight reduction were recorded. A finding was made indicating that apples placed outside experience a greater reduction in weight compared to apples stored within the confines of a refrigerated container. The temperature of the apples decreased when they were placed inside the box, whereas it climbed when they were left outside. The condition of the apples was favorable when compared to apples from external sources. Internally, the gravitational force was exerting a decelerated downward acceleration compared to the external environment.

In their study, Manjunatha Y R et al. [2] put out a novel strategy that serves as a superior substitute for traditional cooling methods, while also incorporating temperature monitoring. The device in question is a thermoelectric cooling system that utilizes the Peltier effect to achieve localized cooling, and is equipped with Bluetooth connectivity. This approach enables the simultaneous detection of both bodily temperature and ambient conditions, while also providing the capability to regulate temperature through manual or automated means. The primary procedure involves utilizing the Bluetooth module to monitor both body temperature and ambient parameters, which are subsequently shown on a visual interface.

The liquid crystal display (LCD) module and mobile screen. Individuals have the option to select between cooling or warming effects from the cooling system and heating device. The researchers reached the determination that cooling systems with temperature control, which integrate Bluetooth technology for monitoring purposes, exhibit greater reliability and efficiency compared to alternative cooling systems. The application of this technology in the medical domain involves the utilization of a portable refrigeration system for the purpose of keeping blood and pharmaceuticals. While the cooling capacity of the device is confined to a certain region, its efficiency can be enhanced by augmenting the quantity of Peltier plates. Portable air conditioners have the capability to expedite the process of increasing or decreasing the temperature. The utilization of Peltier-based air cooling systems presents a viable option for boosting performance in comparison to conventional air conditioning systems.

Passive cooling coupled with renewable energy sources was successfully accomplished by Sujatha Abaranji et al. [3]. The water storage medium utilized in this system is composed of a porous substance, hence obviating the requirement for a pump and sump. The usefulness of the porous material as a cooling medium is examined through experiments conducted at three distinct relative humidity (RH) levels, namely low, medium, and high. The constructed setup is subjected to testing in order to assess its performance. The evaluation of a direct evaporative cooling system involves the assessment of its cooling capacity, efficiency, and rate of water evaporation. Vermicompost is utilized as a substitute for the pump and sump due to its notable capacity for water retention. There is no need to switch materials every time. In contrast, the vermicompost is regenerated through the utilization of a sun dryer once the conclusion of the experiment. The circulation of hot air over the vermicompost additionally serves as a preventive measure against the transmission of any existing mold spores in the surrounding air. The findings indicate that under conditions of low relative humidity (RH), vermicompost exhibits an average reduction in temperature of 9.5°C. In addition, the removal of the pump in the process of vermicomposting results in a notable decrease of 21.7 percent in energy consumption. Consequently, vermicompost presents itself as a potentially more energy-efficient substitute for the conventional pad-pump-sump evaporative cooling system. Moreover, the integration of this direct evaporative cooling system with solar-assisted vermicompost drying can facilitate the establishment of a hygienic and environmentally friendly indoor environment. This approach has the potential to facilitate

the implementation of ecologically sustainable year-round thermal regulation in building cooling systems.

In their study, Sudaporn Sudprasert et al. [4] conducted an investigation to ascertain the extent of thermal comfort achieved through the utilization of evaporative air coolers. Additionally, they sought to identify the various factors that influence thermal comfort while employing an evaporative air cooler inside interior settings, specifically within the tropical climate of Thailand. A comparative analysis was conducted to examine the thermal comfort levels reported by individuals exposed to evaporatively cooled air in contrast to those exposed to natural air, based on the outcomes of a survey. The identification of factors influencing thermal comfort was achieved by the utilization of a multiple regression model. The findings of this study indicate that evaporative air coolers offer a thermal comfort level of 0.6, which corresponds to a somewhat cool sensation on the thermal sensation scale. This level is lower than the 0.0 rating, which represents a neutral feeling, offered by fans. It is advisable to utilize evaporative air conditioners with a high velocity of 1.4 m/s indoors in order to alleviate discomfort resulting from the presence of humid air. The results of the regression analysis indicate that air temperature and velocity are the primary factors influencing thermal experience during the utilization of evaporative air conditioning in Thailand.

The study conducted by M. C. Ndukwu et al. (5) investigated recent advancements in evaporative cooling systems, specifically focusing on enhancing cooling efficiency through the utilization of membrane air treatments, dew point type, and heat pipe type heat exchangers in both indirect and direct evaporative cooling applications. However, the feasibility of implementing these improvements in agricultural storage remains largely unexplored or scarce in existing literature. Several studies have examined the utilization of different materials, including agricultural residues, for air-water contact in evaporative cooling systems across different climates. However, the majority of these analyses have primarily investigated the impact of air flow rate and pad thickness on thermal efficiency. Unfortunately, the evaluation and presentation of energy efficiency and evaporation loss associated with these materials have been largely neglected in most cases. The commercialization of evaporative cooling systems in poor nations is hindered by a lack of awareness and a lack of comprehensive economic and cost analysis, which are necessary to convince farmers of the financial advantages they offer.

Methodology

In order to answer the research topic, this study will use a strict approach. In order to create cool air, this device would use ice instead of refrigerant, which is better for the environment. The steps involved in this process will be detailed in this part.

In order to prolong the time of ice preservation, this study will use a single polystyrene/polyurethane insulation box to offer complete insulation.

As an air passage, a galvanised iron sheet duct in the shape of a zigzag is being built.

This experiment will involve placing a large ice block, around 15 kg in weight, on the duct in order to reduce the temperature of the duct walls. So, the air being pushed through the duct will get cooler as a result.

The dimensions of the duct's cross-section are three inches by three inches. As the air moves through the duct, it comes into contact with the inside surface, which causes the molecules in the air to smash against the walls of the duct. The air's temperature drops because the heat is dissipated in these contacts.

Components

The steps used to choose the various parts used in this undertaking.

A polystyrene or polyurethane installation box.

The organic units of polyurethane are linked together by carbamate (urethane) bonds, making it a type of polymer. Chemical reactions involving di- or triisocyanates and polyols are the mainstay for the traditional synthesis of polyurethane polymers. A number of products make heavy use of polyurethane foam, including rigid foam insulating panels and high-resilience flexible foam seating.

This idea made use of a 50-liter polyurethane insulation box.

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Here we are looking at a DC motor that has a fan attached to it.

This task required the use of a 12-volt DC motor capable of reaching 30,000 RPM. A four-bladed plastic fan with a diameter of four inches was attached to the motor.

An example of a duct material that has been coated with zinc to make it more resistant to corrosion is the galvanised iron duct.

In order to allow air to flow through it without coming into contact with water or ice, a duct is built with a 3x3 inch square cross-section. Air passing through a duct loses heat.

The DC power source.

A single 12-volt, 4-ampere hour battery powers the whole setup.

One tool for keeping tabs on temperature fluctuations is the ubiquitous temperature sensor.

This particular device is the XH-W1209, a display-equipped digital temperature controller module that also includes a waterproof NTC temperature sensor. A cheap 12V device with a 7-segment display and a 3-switch keypad for temperature and other settings, the W1209 Mini Thermostat is a great choice. With its built-in NTC thermistor, this module can detect temperatures to within 0.1 degree Celsius.

The XH-W1209 12V Digital Temperature Controller Module is an efficient and reasonably priced thermostat controller. It comes with a display and an NTC waterproof temperature sensor.

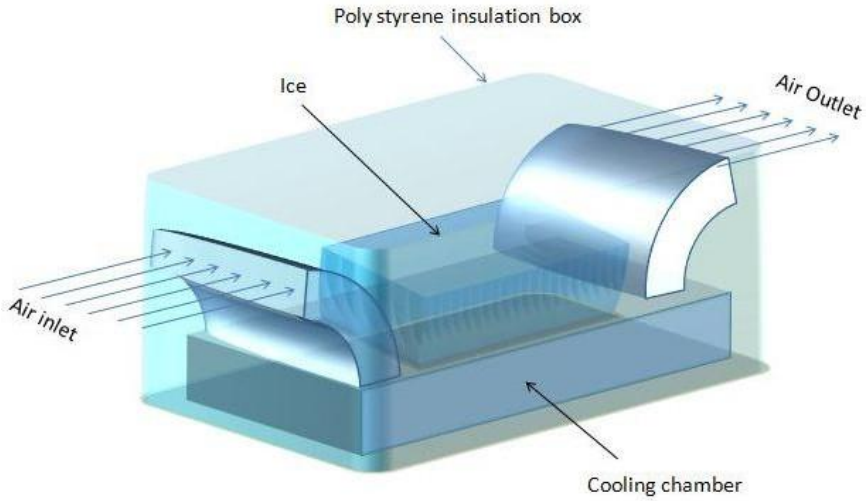

Figure:1 Portable air cooler

Calculations

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

Cooling

We have omitted any calculations for cooling as our project's main objective is to generate cold air from the output, rather than chilling the entire testing area. We are solely utilising ice to generate cool air through the process of latent heat of fusion and conduction. Upon the successful completion of our project's testing phase, we will endeavor to incorporate supplementary features

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aimed at enhancing the cooling process with greater efficiency.

Presented below is the observation table spanning 24 hours, detailing the correlation between time, atmospheric temperature, room temperature, and outlet temperature.

Table:1 Temperature Observation

Time	Atmospherictemperature (in ℃)	Room Temperature (in ℃)	Outlet Temperature (in ℃)
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

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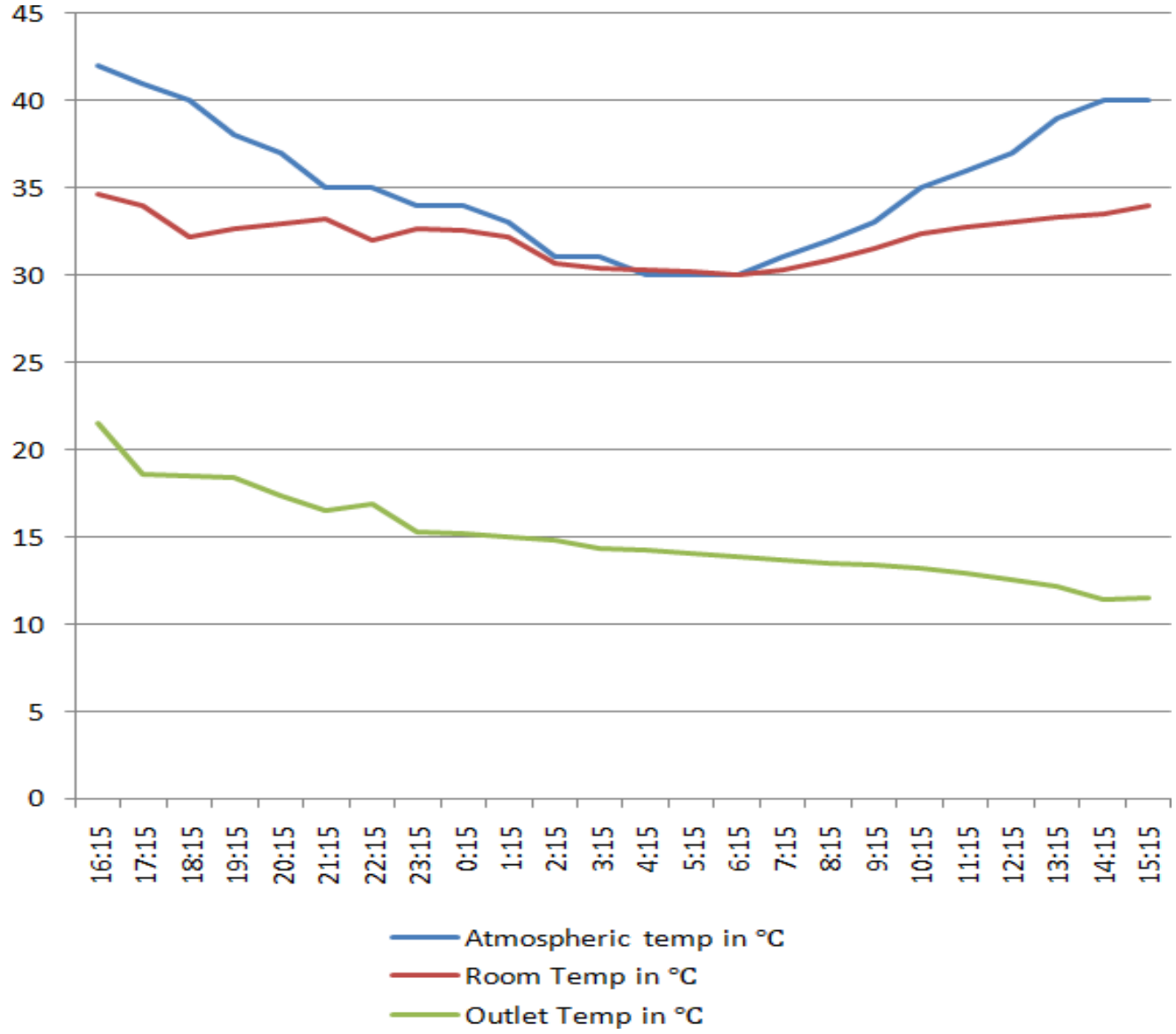

Figure 2: Graph Time Vs Temperature

Conclusion

A portable air cooler has been successfully designed and fabricated. The gadget effectively meets the essential cooling needs of persons in the demanding climatic conditions seen during the summer season in India. The portable air cooler efficiently fulfils the consumer's needs while adhering to a cost-effective approach. The maintenance requirements for the portable air cooler are pretty uncomplicated. An outstanding feature of this equipment is its mobility, which enables effortless transportation between different locations. Given its diminutive size, this item is suitable for placing in a range of contexts, including bedrooms, drawing rooms, and smaller hostel rooms. By using ice as a medium, the

procedure is completely free from contamination. However, the design is still in the prototype stage. Additional investigation is necessary to precisely determine the effectiveness, longevity, and dependability. Below is a collection of suggestions designed to improve the functionality and efficiency of this portable air cooler. Improving the duct design by incorporating rounded corners.

An effective approach to augmenting the cross-sectional area of a duct involves increasing its dimensions by one inch, while ensuring that the inlet and outflow remain their original measurements.

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