REVIEW ON DESIGN & DEVELOPMENT OF AIR COOLER WITH INTEGRATED AIR CONDITIONING

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ABSTRACT

Smart device adaptations of traditional products have become necessary in our technological age to improve operational excellence along with user comfort. A typical conventional air cooler receives its smart functionalities through adding regular air conditioning components to create an advanced cooler model [3]. You can boost standard air cooler operation and capability through addition of a compressor and evaporator alongside a condenser component [2]. The basic functioning of an air cooler depends on water to evaporate and generate cold air. The natural cooling method of air coolers proves ineffective in moist environments whereas air conditioners benefit from complex cooling capabilities. The design of an air cooler becomes a hybrid unit when you implement crucial air conditioning system elements such as compressor and condenser alongside the evaporator. The integration of smart features becomes possible along with improved efficiency while the system adds automated temperature control to the range of available energy optimization options.

Keyword: - *Air cooler, Air conditioning, VCC, COP,*

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1. INTRODUCTION

Indoor comfort alongside sustainable practices depends on essential air-cooling technologies because of intensifying global warming alongside rising energy requirements and the need for improved cooling efficiency. Modern living depends heavily on effective energy-efficient cooling systems because of hotter seasons and worsening extreme weather patterns [1]. The market requires cooling systems with combined benefits of air conditioners and air coolers due to their independent advantages and overall performance limitations. The research targets the developing requirement by building an advanced air cooler platform which combines air conditioning components into a versatile hybrid system that performs efficient cooling operations. The integrated system achieves sustainability as the central focus of this project. The proposed design actively works to decrease environmental impacts by using energy-efficient methods that control greenhouse gas emissions which traditional air conditioning methods create. The project supports worldwide initiatives to decrease carbon emissions through its energy-efficient solution which advances sustainable solutions for indoor climate management. The main project objective for “Design and Development of Air Cooler with Integrated Air Conditioning” combines separate cooling technologies to build a multifunctional energy-efficient cooling system. The air cooler component base its cooling operation on evaporative cooling that extracts heat from the environment by evaporating water. Less energy consumption stands as the main advantage over conventional air conditioning systems during this process. The energy efficiency of air conditioning systems stands lower than traditional air conditioners because these systems implement refrigeration principles for precise temperature management while draining substantial power usage. The project aims to combine these two systems because it wishes to leverage their capabilities for delivering efficient and cost-effective adaptable indoor climate control. This integrated system provides the major benefit of high energy efficiency. The amount of electricity needed to operate air coolers remains low since their cooling process requires very little electrical input.

Air conditioners remain effective but they consume substantial energy since they need power to operate refrigeration cycles together with compressors [6]. The hybrid system cuts power usage by using air coolers but will activate air conditioning only during essential conditions which maximize operational efficiency [3]. The purpose of this work is to establish a combined system which operates as a dual-function unit that functions as an air cooler in dry circumstances and functions as an air conditioning system in elevated humidity conditions. Advanced control systems within the combined system will enable automatic selection between cooling functions based on temperature and humidity measurements in the environment. The linked system enables automated sensor monitoring to enhance energy efficiency alongside maintaining thermal comfort within the space [8].

2. KEY OBJECTIVES

The performance enhancement objectives of a domestic air cooler through refrigeration cycle implementation consist of the following points:
A) The construction of an experimental setup demands changing a domestic air cooler with a refrigeration system.
B) The observations of COP changes when a compressor provides cooling conditions will be studied.
C) To fabricate the experimental set up by modifying the domestic air cooler with refrigerator.
D) To reduce size and component as compared to air conditioner.

3. LITERATURE SURVEY

3.1 A. Safaria et.al. (2011) [1], The researchers conducted their study on the widespread super cooling challenge that exists within Phase Change Materials (AIR COOLER). Super cooled AIR COOLERs demonstrate thermos-physical behavior which leads to difficulties when used in thermal storage systems. Supercooled liquid and its solid state are shown in Figure 4. Super cooled liquids offer dependable alternative materials that should be considered in direct application scenarios such as refrigeration systems and air conditioning networks. Industrial implementation of super cooled AIR Coolers depends on adjustments to current energy systems and the outcome of heating and cooling demand evaluations. Operations in remote areas with unreliable energy sources improve the financial prospects of these systems during their functioning.

3.2 Amrit Om Nayak et al. (2011) [2], The team discovered that phase-change materials comprise substances using their latent heat storage capacity to absorb then release big energy quantities throughout the process of melting and solidification at specific temperatures. Engine coolant is cooled through three different arrangements of AIR COOLER with Paraffin wax and sodium acetate tri-hydrate alongside phenolphthalein. Heat absorption rates in AIR COOLER materials slow down in a progressive manner when following the coolant water from its entry point to its exit point.

3.3 Rezaur Rahman et al. (2013) [3], They researched how a phase change material linked to the evaporator of a domestic refrigerator provided better performance results. An increase of 55-60% in conventional refrigerator coefficient of performance resulted from employing water as the AIR COOLER. A performance increase through this method applies to Single evaporator refrigeration system. The compressor operates less frequently because AIR COOLER capsules use energy latent heat as the primary energy source. The food quality improves when the refrigerator turns on and off less frequently during a specific time of operation. The combination of AIR COOLER cuts operating cost over P.C.M. because it raises the C.O.P. ratio in this case. The installation of AIR COOLER results in lengthening the compressor off-time at low thermal conditions but produces shorter off-time with increased thermal loads. When AIR COOLER comes into use it stabilizes the temperature inside the cabinet.

3.4 Gang Tan et al (2015) [4], The thermoelectric cooling system with phase change material (AIR COOLER) functions effectively for space cooling by utilizing night-time storage of cold thermal energy as it reduces thermoelectric module temperatures during daytime cooling operations. The experimental setup of the prototype thermoelectric cooling system appears in Figure 7 which shows its schematic diagram. The cooling power output together with COP and cost serve as crucial elements when selecting thermoelectric modules (TEM) from market products and night-time accumulated heat dissipation leads to AIR COOLER volume determination with nighttime weather evaluation required to guarantee full AIR COOLER discharge.

3.5 Niccolò Aste et al. (2017) [5], The researchers determined that food preservation stands as one of the overlooked fundamental aspects of food security in humanitarian situations. There exist only limited food preservation practices which work for raw and cooked items because of insufficient technologies and limited power supply capabilities as well as financial constraints. Food preservation in power grid inaccessible areas takes either passive or active forms regarding whether grid electricity or fuel is used to operate refrigeration systems. Present off-grid active refrigeration technologies have high potential in commercial solutions but their current applications require additional development. Vapor-compression solar refrigeration operates as one of the best solutions for solar energy areas because it delivers the most effective and affordable performance. The absorption technology with fuel power continues to provide optimal results when performance reliability depends on the availability of non-programmable energy resources including solar and wind power provided consistent fuel supply can be maintained. Given its specifications thermoelectric technology provides an ideal solution to maintain tropical fruits and vegetables which succumb to chilling injury under temperate climates and serves well for mobile applications.

3.6 Diana Enescu et al (2017) [6], Research results indicate that Figure 8 demonstrates thermoelectric cooling works effectively as a cooling technology which offers several advantageous properties including refrigerant and mechanical vibration reduction and mobile operation and flexible application and minimal noise production plus universal position capability and precise temperature management. The research delved into electrical functionality of a TER hooked up to the power grid in micro grid applications that work well for humanitarian situations. The researchers developed a sustainable power solution for the TER which connects to photovoltaic energy generation while integrating an electric storage component. Engineers conducted both sizing and simulation operations in respect to this solution. This study provides applicable solutions for controlling local energy systems used in temporary humanitarian camps.

3.7 Zhongbao Liu et al (2017) [7], Confirmed that, the air-cooled frost-free household refrigerators have been popular in the market for large capacity and frost-free compartment(s)The vast power consumed with defrosting the evaporator prevents the widely application of such refrigerators. In this study, a new method of thermal storage defrosting system integrated with bypass cycle has been proposed. The four types of different AIR COOLERs are tested, the operation modes of the whole system is proposed, and the structure design and optimization of the heat storage exchangers are also carried out. And the experimental study is performed with various defrosting techniques. Experimental results in the highest efficiency rise is roughly half of the speed of the original defrosting mode electric heater. The defrosting system of the thermal storage can also effectively save the defrosting power consumption of 71% compared to the original defrosting mode of the electric heater.

3.8 Wen-long Chenga et al. (2017) [8], They has found that, the heat exchange performance of evaporators and condensers would access to the working efficiency of household fridge. In order to improve the heat transfer of the condensers and evaporators, a new dual energy storage (DES) refrigerator which has the function of heat storage condenser (HSC) and cold storage evaporator (CSE)is proposed. Diagram in Figure 9 is a schematic diagram of cold storage evaporator with AIR COOLER. The performance comparison of three new type of energy storage refrigerators are carried out by establishing the dynamic simulation model of HSC refrigerator, CSE refrigerator and DES refrigerator. From the simulation results obtained, the DES refrigerator gives a higher balanced operational cycle and also have the more higher evaporation pressure and temperature compared to HSC refrigerator and CSE refrigerator. The DES refrigerator. owns the optimal coefficient of heat transfer and operating performance. During the whole cycle time, the DES refrigerator can realize continue heat/cold rejection from condenser or evaporator coil.

4. METHODOLOGY

A) Study of different Research paper.
B) Framing of project setup (line diagram of the model fig-1).
C) Dimensioning of frame, Specification of components fig-2.
D) Selection of components.
E) Assembling Of different components.

F) Results & discussion about the error in the conceptual model.

5. ASSESSMENT AND PLANNING

A) Examine the present air cooler by analyzing its dimensions together with airflow system and water distribution methods. The areas which integrate air conditioning components need identification.
B) Fabricate the structure according to the dimensions of component. The selection process chooses suitable compressor-evaporator-condenser units according to the air cooler dimensions together with defined cooling requirements. You should pick a sensor designed to measure temperatures which will help control cooling operations.
C) Integration of Components: The framework of the air cooler requires modification to fit the new components into place. The design implementation requires either custom-made components or modifications to integrate air conditioning parts into the air cooler structure [3].
D) Compressor Installation: Install the compressor in a suitable location within or near the air cooler unit. Secure all components by linking them to the condenser and evaporator units.
E) The evaporator and condenser must have an efficient placement setup for heat transfer purposes. Follow the guidelines of standard refrigeration circuits to connect the components.
F) The installation of the temperature sensor requires a purposeful placement to achieve accurate indoor temperature measurement. The sensor must have connections to the automated control system for adjusting operations.
G) Connect the all component together with the help of proper connecting wires, also tests the connections
After assembling all components together and connecting the all Electronic components the final test is carried out.[6]

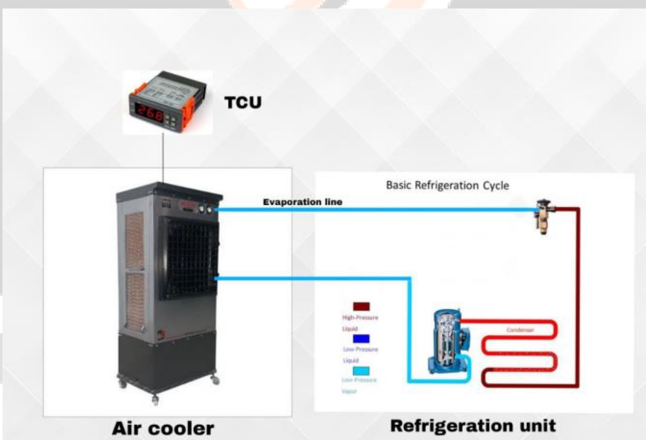

Fig -1: Components integration.

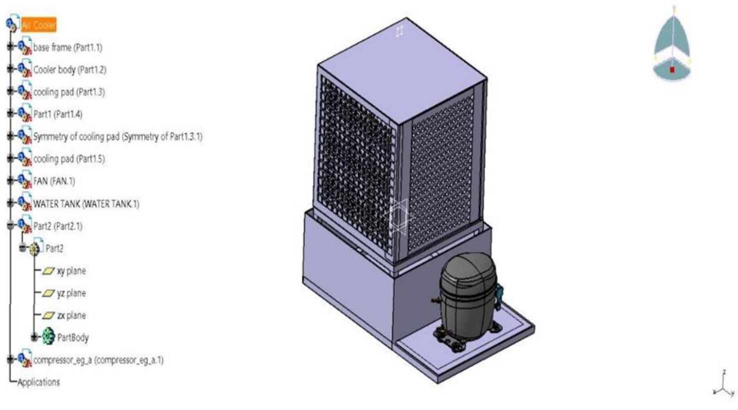

Fig-2: CAD design.

6. SOME DETAILS ABOUT COMPONENTS

6.1 Evaporator Coil

Mode of heat transfer- Free convection and conduction.
Linear length of coil or tube= 14.5 feet= 8.79 meter
Turns= 12 turns
Internal and external diameter of the tube= 5mm and 6mm or 0.00525m and 0.00635m respectively.

6.2 Condenser Coil

Mode of heat transfer= Free convection
inner length of the coil= 9.14m
Internal and external diameter of the tube= 3.23 mm and 4.23 mm or 0.003m and 0.004m respectively.
Material of the tube-copper tube.
Turns: 21 turns.

6.3 Compressor

Compressor: LG MA 42LFJG 1PH 220-240V, 50HZ
Compressor Capacity: 0.5 Ton hermetically sealed
Motion Type: Reciprocating Type
Weight: 1.2Kg.

6.4 Temperature Controller HW-3001

HW-3001 120V Digital Temperature Controller Module W/ Display and NTC Temp Sensor. The HW-3001 Mini thermostat Temperature controller functions as a cost-effective 120V Temperature controller which provides 7-segment display interface together with 2 switch buttons for temperature and parameter control. An NTC thermistor temperature sensing operates within 0.1 C accuracy range of accuracy.

6.5 Expansion valve

Filter fitted with an expansion valve.

6.6 Electric motor

50W power supply
body Material: Mild Steel
Winding Material: Aluminium.
Speed:2800rpm.

7. CONCLUSION & EXPECTED OUTCOME

Use of air cooler with integration of air conditioning are more beneficial as compared to traditional air conditioning or cooler, with the help of this integration we can increase the coefficient of performance (COP) by 18-20% more than traditional approach, also we can improve the efficiency of cooler by using an smart controlling devices like temperature control unit, we can expect more outcome as compared to conventional air coolers.

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9. REFERENCES

[1]. Safaria, R. Saidurb, Sulaimanb, Yan Xua, Joe Donga, "A review on supercooling of phase change materials in thermal energy storage systems", renewable and sustainable energy reviews, Elsevier.

[2]. Amrit om Nayak, M.gowtham, R.Vinod, and G.Ramkumar, "Analysis of air cooler material in thermal energy storage system", international journal of environmental science and development, vol. 2, no. 6, december 2011. Fig 5 Filter fitted with an Expansion valve. technologies for food preservation in humanitarian context" sustainable energy technologies and assessments (2017).

[3]. Rezaur Rahman, md. Arafat Hossain, Shubhrakanti Das, Adnan Hasan, "Performance improvement of a domestic refrigerator by using air cooler (phase change material)", global journal of researches in engineering mechanical and mechanics engineering.

[4]. Gang Tan, Dongliang Zhao, "Study of a thermoelectric space cooling system integrated with phase change material", applied thermal engineering 86 (2015) 187E198.

[5] Porumb B, Unguresan P, Tutunaru L F, Serban A, Balan M. Procedia Engineering, Technical university of cluj-Napoca, Bd Muncii, 103-105, Cluj-Napoca, 400641, Romania.

[6]. Diana Enescu, Alessandro Ciocia, Andrea Mazza, Angela Russo, "Solutions based on thermoelectric refrigerators in humanitarian contexts", sustainable energy technologies and assessments (2017).

[7]. Zhongbao liu, Ao Li, Qinghua Wang, Yuanying chi, Linfei Zhang, "Experimental study on a new type of thermal storage defrosting system for frost free household refrigerator", applied thermal engineering (2017).

[8]. Wen-long chyuan, Miao Dinga, Xu-dong yuana, Bing-chuan han, "Analysis of energy saving performance of household refrigerator with thermal storage of condenser and evaporator", energy conversion and management 132 (2017) 180–188.

[9]. S. Rajendra Siva1, Dr. Senthil Kumar, N. Mathiazhagan, "Experimental investigation on phase change materials", journal of chemical and pharmaceutical science, issn: 0974-2115.

[10]. Khan and hasan m. m. Afroz, "Diminution of temperature fluctuation inside the cabin of a household refrigerator using phase change material", international journal of recent advances in mechanical engineering (ijmech) vol.3, no.1, February 2014.

[11] Malli A, Seyf H R, Layeghi M, Sharifian S, Behravesh H, Investigating the performance of cellulosic evaporative cooling pads, ELSEVIER Energy Conversion and Management, 52 (2011) 2598–2603

[12] Kamble M, Darokar H 1,2Department of Mechanical Engineering, (H.P.), I.C.E.M., Parandawadi, Pune, Maharashtra, India International Journal on Theoretical and Applied Research in Mechanical Engineering

[13] Jain J K, Hindoliya D K Corresponding author-Lecturer in mechanical Engineering Department, Ujjain Polytechnic college, Ujjain (M.P.) –India. International Journal of engineering trend and technology,31 694-697

[14] Anisimov S, Pandelidis D, Jedlikowski A, Polushkin V, Department of Environmental Engineering, Wroclaw University of Technology, 27 Wyspianski St., 50-370 Wroclaw, Republic of Poland, ELSEVIER Energy Conversion and Management
[15] Zhao X, Li J M, and Riffat S B Applied Thermal Engineering, vol, 28, pp, 1942-1951, 2008.