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Water Dispenser System using Air Conditioner

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ABSTRACT
The goal of the "Water Dispenser System Using Air Conditioner" project is to research the creation of a water dispenser system that uses a typical air conditioner. The main objective of this gadget's development was to create a multifunctional device that could deliver hot and cold water as well as a regular heating and cooling cycle. Compressor, condenser, evaporator, expansion valve, copper coil, temperature gauges, and gauges for pressure and temperature make up the majority of the design. It includes a common compressor together with the air and water cycles. The researchers developed a prototype of this device, which can distribute hot and cold water for drinking and also blow cool air controlled by a thermostat like an air conditioner. Utilising their fundamental understanding of heat transmission, the researchers created the design. The researchers were able to reach the temperatures that regular water dispensers have after a certain amount of time while using less electrical energy, according to the data gathered during the testing phase. Compressor, condenser, evaporator, expansion valve, copper coil, temperature and pressure gauges, and tumblers make up the majority of the design. The medium used to absorb and remove heat from the area to be cooled and then reject that heat elsewhere called refrigerant. Water that can be used for drinking is cooled using the heat from the refrigerant.

Keywords: *Air Conditioner, Water Dispenser, Heat Transfer Evaporator, Condenser, Compressor, Dispenser, Refrigerant, Valves, Air Cycle, Water Cycle, Temperature, Purity*

INTRODUCTION

Independent of the weather outside, air conditioning is the act of regulating the temperature, humidity, purity, and motion of the air in a closed space. It gives us humans a way to regulate the air in our surroundings.

One of the many appliances that make it easy to adjust the temperature and provide comfort in commercial and industrial buildings, as well as in our own homes, is the air conditioner. Given that the Philippines is a tropical, humid country, air conditioners are in high demand here. Water dispensers are also utilised with air conditioners to give us the convenience of selecting the ideal drinking water temperature for our daily lives. [1]

In order to obtain a cooling and heating effect from a refrigerant, its phase must be changed during refrigeration. As a refrigerant in the past, air was employed. As a result of air's constant phase, or gaseous condition throughout the cycle, it has a very low heat carrying capacity per kilogramme when compared to systems that absorb vapour. Due to their poor performance efficiency and high power requirements, air cycle refrigeration systems as they were originally designed and installed are now essentially obsolete.

We currently have separate water cooler, air conditioner and air refrigeration systems on the market. The same principle underlies how they all three operate. Additionally, the quality of life has increased. They all have these three pieces of equipment placed in their residences, offices, living rooms, and many other places. However, their excessive electricity consumption, which causes people to worry about it, is one of their biggest drawbacks. [2]

Introduction of Refrigerants:

It functions similarly to blood in the human body in a refrigerator. Its choice is influenced by a variety of factors, including the desired temperature, latent heat, potential for ozone depletion and global warming, toxicity, inflammability, inertness, corrosion, erosion, reaction with water and lubricating oil, cost, availability, leak detection, and the required power for the desired cooling level. Halogenated saturated hydrocarbons like R-134 and R-22 as well as inorganic substances like ammonia and air are among the many regularly used refrigerants. The majority of formerly used refrigerants, such as R-12 and R-11, have been outlawed due to their great potential for ozone depletion and global warming. Additionally used are zoetrope and mixed refrigerants. Primary, secondary, and tertiary types of refrigerants are available, depending on the application. In a central

air conditioning plant, the same substance, like air, can also serve as the principal medium in aeroplanes.

A compressor cooling system for a water dispenser or a water cooler is called the water dispenser cooling. It is a compressor refrigeration system with an evaporator coil and a tiny condensing unit for cooling drinking water. On the market, there are three different categories of water dispenser cooler:

- Storage type water cooler
- Instantaneous type water cooler
- Bottle type water cooler

The summertime temperature climbs yearly. India frequently breaks records for July high temperatures at many different locales. Around 45°C is the normal July temperature in India. To keep cool during the heat, a variety of gadgets are used, such as fans, coolers, and air conditioners. Such gadgets are somewhat pricey and out of the ordinary consumer's price range. The summertime temperature climbs yearly. India frequently breaks records for July high temperatures at many different locales. Around 45°C is the normal July temperature in India. To keep cool during the heat, a variety of gadgets are used, such as fans, coolers, and air conditioners. Such gadgets are somewhat pricey and out of the ordinary consumer's price range.

System Design:

Air conditioning prices The water dispenser system incorporates both the air and water cycles into a single component. "Air-conditioning" is the simultaneous control of temperature, humidity, motion, and the cleanliness of the air in a confined space. The three most important elements that affect air conditioning are

- Air circulation and movement;
- Air filtration, cleansing, and purification;
- Temperature management;
- Humidity control

These variables can be controlled simultaneously with complete conditioning. Beyond the comfort benefits of air conditioning, other businesses have found that this approach has made it possible to more thoroughly regulate the manufacturing processes and materials, as well as to improve the quality of the finished product.

The sequential process of controlling the temperature, motion, and purity of water circulating in a closed system is referred to as a "water-dispenser system". Variables regulated by the water dispenser include

- Water motion and circulation;
- Temperature control;
- Water filtration, cleansing, and purification

As a result, air and water are more effectively managed, cleansed, purified, and filtered in a "Air-conditioning cum Water-dispenser system". [4]

Components:

The fundamental components of a cooling system are

- Fans - used to move air
- Filters for purifying fresh, recirculated, or both types of air.
- Condenser: This device produces hot air and exchanges heat with the environment.
- Compressor: used to compress the refrigerant at high temperatures and pressures
- Control system: for automatically adjusting the quantity of heating and cooling. Evaporator: for exchanging heat with the atmosphere and supplying cold air.

Design of Evaporator:

Before entering the cold chamber, which serves as an evaporator, the refrigerant is now routed through a receiver drier. The calculations account for the fact that this chamber also serves as a Shell and tube heat exchanger. Conduction is used to transport heat from the refrigerant, which changes state in the evaporator from liquid to gaseous, to the water.

Energy Consumption Comparison:

Using the energy consumption formula

$E = P \times T$ (Eqn. 1)

The power P in Watts multiplied by the quantity of uses results in the energy used in Kilowatt-Hours per day.

Hours per day T divided by 1000 Watts per Kilowatt.

1 Horsepower = 0.7457 Kilowatts (Eqn. 2)

To calculate Kilowatt-Hours based on eqn. 1, one must convert power ratings, which are often expressed in horsepower, to Kilowatts.

For Air-Cycle

Theoretical C.O.P

This C.O.P. stands for the air cycle's coefficient of performance.

C.O.P = (h1-h4) / (h2-h1)

h1 = Enthalpy at inlet of compressor in KJ/Kg

h2 = Enthalpy at outlet of compressor in KJ/Kg

From Psychometric chart of R-22,

p1= pressure at compressor inlet = 3.2psi

p1= (3.2 x 0.06894) + 1.013= 1.2336 bar

p2 = pressure at compressor outlet = 15.8psi

p2= (15.8 x 0.06894) + 1.013= 2.1 bar

h1 = Enthalpy at p=1.2336 bar and T=27.10

c = 320 KJ/Kg

h2 = Enthalpy at p=2.1 bar and T=79.30

c = 360 KJ/Kg

h4= Enthalpy at outlet of evaporator = 180KJ/Kg

C.O.P = (320-180) / (360-320) [5]

Objectives:

- Researching the creation of an air-conditioning system.
- To comprehend the creation of an air conditioning system with a built-in water dispenser.
- Analysis of the old and hot chambers, pressure, and COP of the water and air.
- To compare energy consumption when designing an air conditioning system with a built-in water dispenser.

Research Methodology:

This chapter provides a full understanding of the study's development as well as the data collection requirements for the researcher. The use of an air conditioner that is also a water cooler and warmer is required by the study methodology. The use of an integrated air conditioner, water cooler, and water heater is required by the research technique. [6]

Review of Literature:

Dr. U. V. Kongre and others. "Testing and Performance Analysis on Air Conditioner cum Water Dispenser" is a 2013 publication. The study provided an introduction to fundamental design concepts and laboratory test analysis. The research also discussed acceptable atmospheric performance coefficients and comfort conditions without compromising air conditioning output. [7]

A two-stage solid desiccant air cooling system coupled with an HVAC system was proposed by Meckler (1989). Without the use of external heat or regeneration, sensible and latent heat were exchanged with return air from conditioned space in order to precool and predehumidify the process air. [8]

In a theoretical study published in 2009, Zhang Jie suggested that low-temperature condensed water from the indoor unit's evaporator drain to the outdoor unit's condenser fins in cooling conditions, lowering the condensing temperature to enhance condenser cooling and raising the refrigeration coefficient of the air conditioner. They were focused on finding a solution to the "Air-conditioning drip water" problem. Condensed water emissions produced by air conditioners while they are in use are uncomfortable, hazardous to the environment, and a waste of water resources. Condensed water management is therefore a very practical concern. [9]

For the purpose of forecasting the performance of a compact split-type air conditioner with an integrated water heater, P. Techarungpaisan (2006) created a steady state simulation model. Submodels of many system elements, including the evaporator, condenser, compressor, capillary tube, receiver, and water heater, are included in the mathematical model. The hot water temperature, condenser exit air temperature, evaporator exit air temperature, heat rejection in the condenser, and system cooling capacity were among the system parameters that the model was used to estimate. The model was coded into a simulation programme. [10]

Result and Discussion:

Design and Working of Air-Conditioning cum Water Dispenser System:

- An air-conditioning cum water dispenser system operates similarly to an air conditioning system, but with an additional water cycle.
- 1.75 kg of R22 refrigerant is initially injected into the compressor pin valve.
- For maximum efficiency, copper coils with 40 turns are formed and installed in the drum that serves as a condenser for the water cycle, while copper coils with 20 turns are created and installed in the evaporator.
- The compressor's outlet and intake are connected to the condenser and evaporator in the water cycle.
- Between the condenser and the capillary tube is placed a filter to stop pollutants from clogging the setup.
- To allow for expansion during the constant enthalpy procedure, capillary tubes are used.
- The air and water cycles are individually regulated and controlled here using valves.
- The air and water cycles receive refrigerant flow when the system is turned on.

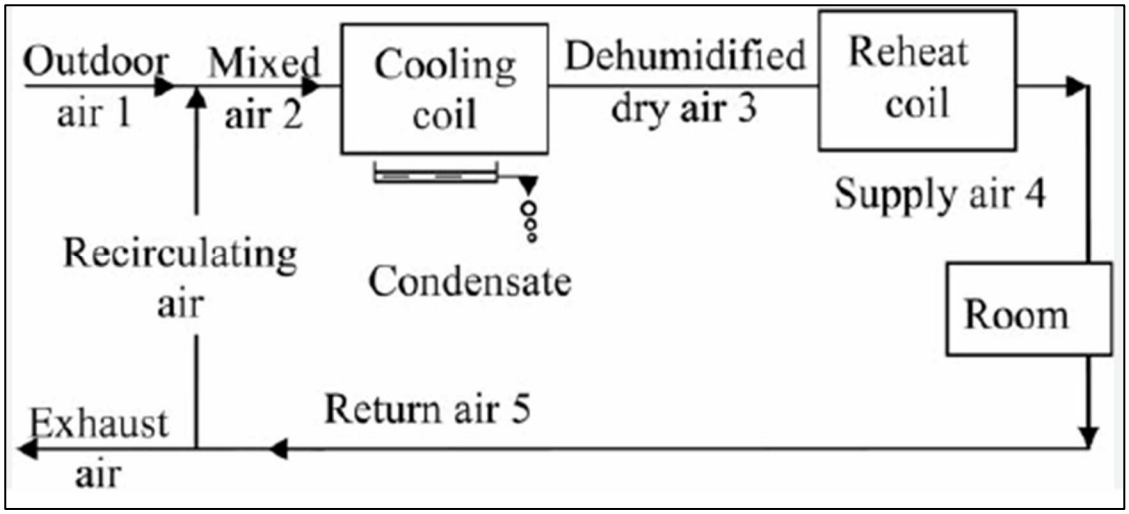

Figure 1: Design of Air-Conditioning cum Water Dispenser System

- The compressed refrigerant is passed through the expansion valve, which causes a drop in refrigerant temperature, and then it is passed to the evaporator in the form of a liquid at a very low temperature, where heat exchange occurs between water at room temperature and the refrigerant, resulting in cooling and heat exchange. The compressed refrigerant flows through the condenser coils, where condensation of the refrigerant occurs, heating the water in the hot water chamber.
- The refrigerant from the evaporator enters the compressor, and the cycle continues.
- Temperatures at the condenser's inlet and outlet, evaporator inlet and outlet temperatures, and compressor inlet and outlet pressures are recorded, and COP, mass-flow rates, and efficiencies are calculated.

Finally, a more efficient combined system of the air cycle and the water cycle is obtained. [11]

Working Principle of Air Conditioning:

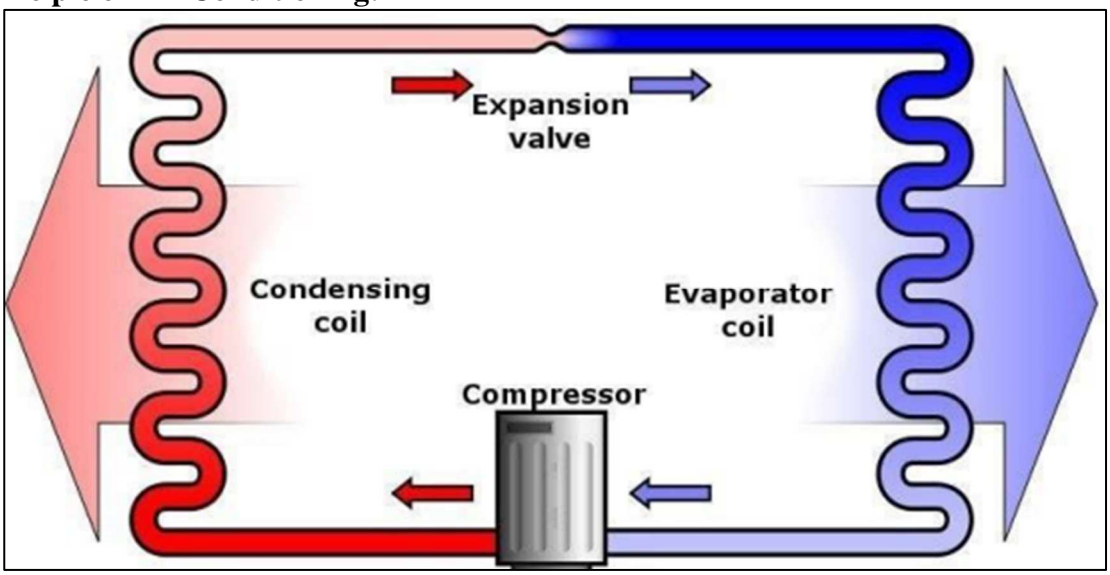

Figure 2: Working Principle of Air Conditioning

Air conditioners function by eliminating heat from the area they serve. An air conditioner is just a large refrigerator that employs the refrigerant process to cool a building. Air conditioners work by removing heat from the air as it passes over direct expansion coils or chilled water coils. Window units, split system air conditioners, package unit air conditioners, packaged terminal air conditioners like those used in hotels, and small split ductless air conditioners are examples of air conditioner systems that use direct expansion coils for cooling.

Commercial air conditioners that use chilled water for cooling are often used in large commercial buildings. Whatever type of air conditioner is used, the coils in the air conditioner system are brought to a temperature colder than the air. These air conditioner coils are designed with materials such as copper or aluminium to absorb heat easily and pass this heat to the refrigerant, which is usually water. Any sort of refrigerant, whether chemical or water-based. Any refrigerant is intended to absorb heat. That is how air conditioning functions. [12]

Description of Vapor Compression Cycle for Air-Conditioner Cum Dispenser:

The following is a list of parameters that must be measured or calculated during the testing phase in order to validate the prototype's operation and the original base design.

The parameters are derived from the system design depicted in Figure 3.

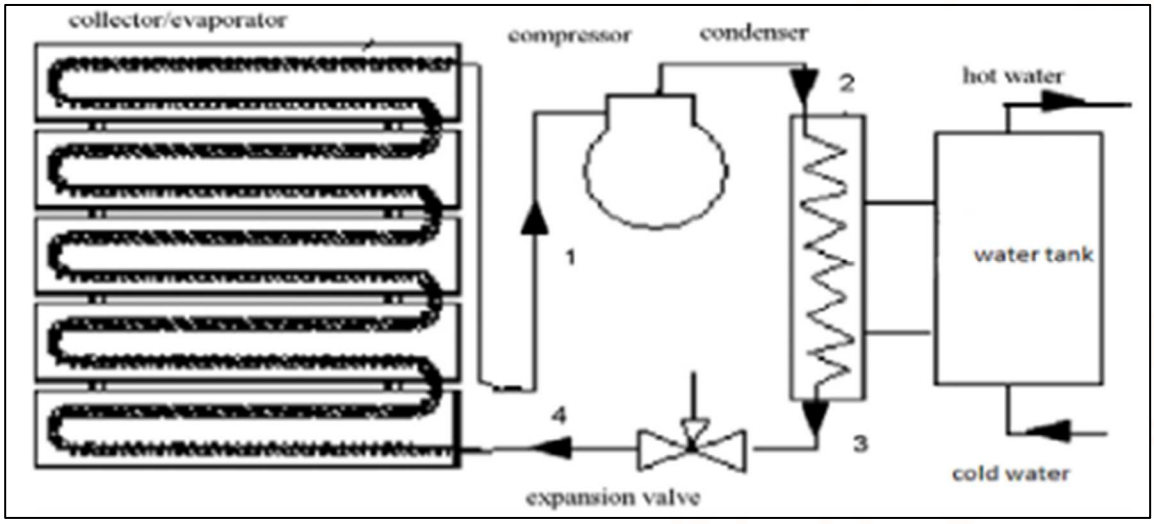

Figure 3: Schematic diagram of vapor compression system

The air conditioner cum dispenser can be operated in a variety of modes. While various parameters were examined prior to the design computations. The temperature of the water entering and exiting the condenser. Another factor is the temperature of the evaporator at the time of refrigerant input and exit.

To determine the need for an air conditioner cum dispenser, the refrigerant condition of the evaporator, condenser, and compressor were calculated.

History of Refrigerants:

Refrigerant is the working fluid used to transfer heat from a low temperature reservoir to a high temperature reservoir. There are various types of refrigerants, which are discussed more below. CFCs are molecules made up of carbon, chlorine, and fluorine. It contributes to the ozone layer's depletion. These are R11, R12, R113, R500, R502, and so on. HCFCs are molecules that are made up of carbon, chlorine, fluorine, and hydrogen. They are less stable than CFCs and, to a lesser extent, damage ozone. These are R22, R123, R124, R401a, and so on. HFCs are molecules made up of carbon, fluorine, and hydrogen.

They do not contain chlorine and hence do not contribute to the depletion of the ozone layer. It does, however, have a high Global Warming Potential (GWP). HC (hydrocarbons): This mostly consists of propane (R290), butane (R600), and isobutene (R600a). These fluids have excellent thermodynamic properties but are hazardous due to their flammability.

Table – 1 Properties of refrigerants: [13]

Refrigerant	*Chemical Composition*	*Critical Temp. [°C]*	*Critical pressure [MPa]*	*ODP*	*GWP*
R134a	*CH2FCF3*	*101.1*	*4.059*	*0*	*1300*
Propane (R6000	*C4 H10*	*152*	*3.79*	*0*	*20*
Butane (R290)	*CH3-CH2CH3*	*96.675*	*4.247*	*0*	*20*

Water dispensers are also referred to as water coolers. The water dispenser cooling system is used to keep water cool for drinking. On the market, there are three primary types of water dispense coolers: storage type water

coolers, instantaneous type water coolers, and bottle type water coolers. Different water coolers and cooling technologies are available.

Storage Type Water Cooler:

A storage-type water cooler is one that stores the water in a tank. In the case of a storage-type water cooler, the storage tank is surrounded by an evaporator coil through which flows a low-temperature liquid refrigerant that removes heat from the water and cools it.

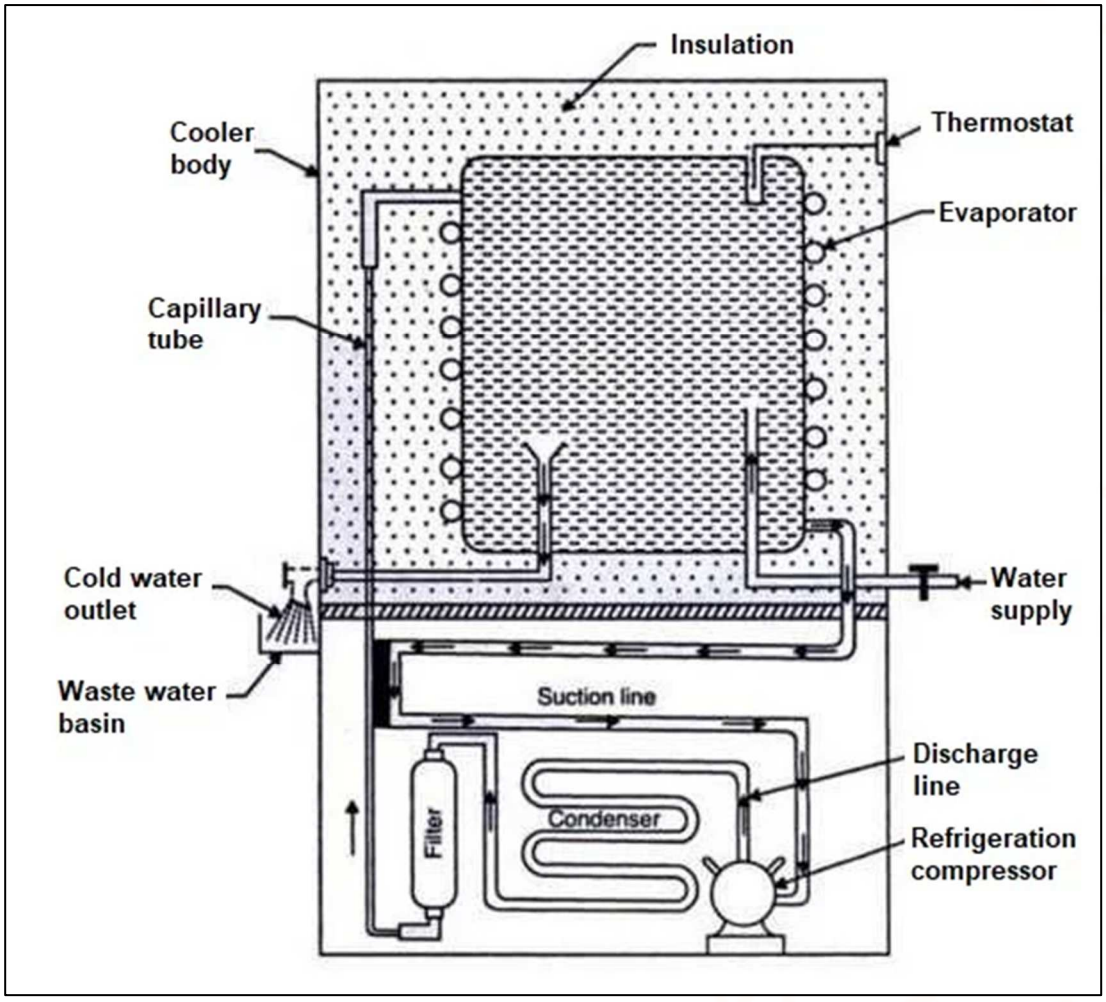

Figure 4: Storage Type Water Cooler

Instantaneous Water Dispenser Cooling System Consist Of:

The refrigerator compressor, air cooled condenser, fan motor, filter, expansion device (usually capillary), and evaporator coil comprise the instantaneous water dispenser cooling system.

Compressor: The compressor is essential in the refrigeration system. It absorbs the vapour low pressure vapour refrigerant and compresses it to high temperature and high pressure vapour refrigerant, much like a pump.

Small refrigerator compressors or small rotational compressors are commonly used in water dispenser compressors.

Condenser: A tiny fin tube coil heat exchanger serves as the water dispenser condenser. It receives high-pressure, high-temperature gas from the compressor and converts it to liquid.

Filter: The filter's primary function is impurity filtration.

Expansion device: Capillary is commonly used as an expansion device in water coolers.

Evaporator coil: The liquid refrigerant from the capillary tube runs through the evaporator coil and absorbs heat from the stainless coil of water, lowering the water temperature through heat conduction. [14]

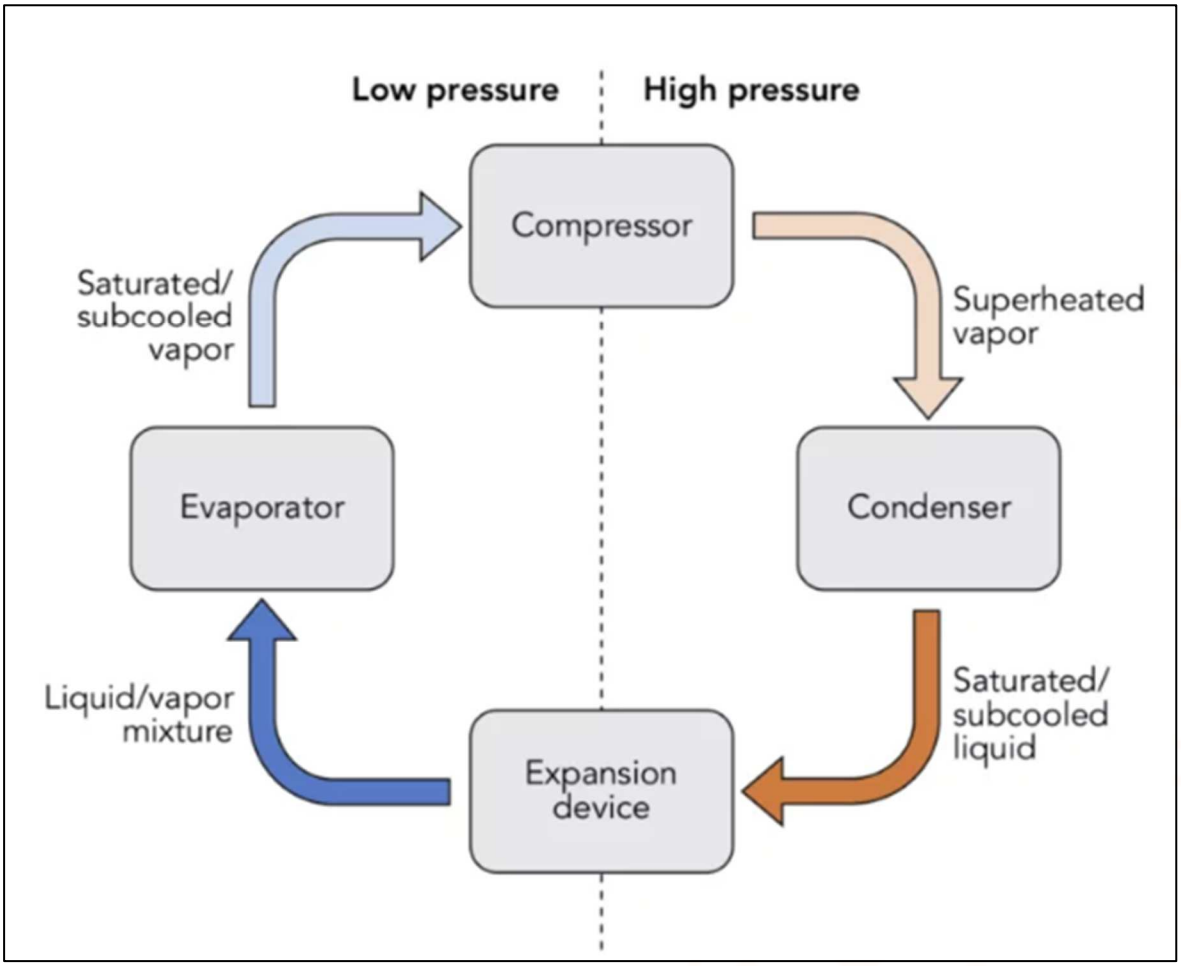

Figure 5: Water Dispenser Cooling System

The air conditioner cum water dispenser system was created to work with the air, water, and air-water cycles. The air cycle delivers good results while remaining efficient. The water cycle predicts better outcomes as well, although it is insufficient on its own.

As a result, conventional air cooling is used by the combined air conditioner cum dispenser. In terms of performance co-efficient, the dispenser delivers the required efficiency. Air conditioning can also be provided using free cooling, which uses pumps to circulate a coolant (often water or a glycol mix) from a cold source, functioning as a heat sink for the energy collected from the cooled room. Common storage media include deep aquifers or a natural subsurface rock mass accessed via a network of small-diameter boreholes outfitted with heat exchangers. Some hybrid systems with limited storage capacity employ free cooling early in the cooling season and then use a heat pump to chill the storage circulation. The heat pump is built because the store's temperature rises regularly during the cooling season, reducing its effectiveness.

The equipment was tested under critical conditions, with values tallied, relevant data tabulated, and graphs based on calculations displayed. The appropriate data is then computed after these numbers are compared to the theoretical values. The graphs are generated using the data from the table for the cold chamber, hot chamber, pressure, and C.O.P comparison of air and water. [15]

Table 2: cold chamber, hot chamber, pressure and comparison of C.O.P of air and water

S. no	Time (t) in min	Evaporator temperature in (^{0}c)		Condenser temperature in (^{0}c)		Compressor pressure in (psi)		Cold water temperature (^{0}c)	Hot water temperature (^{0}c)
		Inlet (T_{ci})	Outlet (T_{co})	Inlet (T_{hi})	Outlet (T_{ho})	Inlet (p1)	Outlet (p2)		
1	0	29	29	32	29	1.7	12	31	31
2	30	31	28	35	31	2.1	13	28	33
3	60	33	27	38	33	2.5	14	24	36
4	90	34	27	50	34	2.7	14	24	42

Conclusion:

The air-conditioner cum water dispenser was designed for the air, water, and air-water cycle. With the advancement of technology, pollution on the planet is steadily increasing. Pollution raises the temperature of the environment. Almost everything in India experiences high temperatures throughout the summer. The need for cool air and cold water increases as the temperature rises. These two items are crucial during the summer season. The water is cooled by the evaporator, which is wrapped around the reservoir. The energy usage of the system is far lower than that of typical air conditioners and water dispensers, making it more cost effective. This method can be applied to residential, commercial, and industrial environments where air conditioning is required. According to the energy comparison, the prototype consumes less energy than the individual energy consumption of the air-conditioning system and the water dispenser, even with the inclusion of a heating coil to hasten the heating process for the hot water.

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