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Design and Prototype Development of a Self-Cleaning Portable Air Conditioning Device and System

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Abstract:- This paper details the design and fabrication of a portable air conditioner device with a self-cleaning system which can be set by the user depending on the desired schedule. The self-cleaning system cleans the evaporator and condenser of the air conditioner. The processing unit (a microcontroller) will determine if the cleaning function will commence by extracting data from the water level sensor located on the device's water repository used for cleaning and from the user-defined timer. The self-cleaning system will not initialize if the microcontroller determines that there's no water on the tank. Temperature sensoris used to detect the room temperature and two red-green-blue (RGB) light emitting diodes(LEDs) as indicators. Optimum settings on the water volume and sprinkler's hole diameter were determined in order to satisfactorily clean the evaporator and condenser in 102 seconds. On an ideal room size for a 1⁄2 horsepower AC system, the target temperature of 25°C was reached within 8-14 minutes.

Keywords:- *Self-cleaning device, portable air conditioning system.*

I. INTRODUCTION

Global warming is a long haul ascend in the normal temperature of the Earth's atmosphere system, a part of environmental change appeared by temperature estimations and by various impacts of the warming [1]. Future climate change impacts are relied upon to incorporate rising ocean levels, sea fermentation, provincial changes in precipitation, and development of deserts in the subtropics [2]. Global warming alludes to worldwide midpoints, with the measure of warming changing by area. Since 1979, worldwide normal land temperatures have expanded about twice as fast as worldwide normal sea temperatures. Renewable energy solutions were put in place to help address this problem in various applications to combat global warming and climate change [3-13].

On account of the expanding temperature in nature, individuals utilize a gadget that cools their surroundings, particularly at home [14].In today's modern age where technology is slowly becoming part of our daily lives, there is no question that most people need to use computers and other gadgets to help them in business or work. Some countries easily adapt the high technology right now and more innovations and inventions are still coming for the future of society [15]. We are in the generation which some businesses are based on technology which is still waiting to develop or innovate. Some houses have devices or an appliance inside that lessen their work, help them to ease everyday task and household chores which makes them more comfortable, feel fresh and saves money [16].

When taking a gander at all the diverse models of climate control systems it tends to be very befuddling. On the off chance that somebody is searching for a forced air system for only one room or little region it has two or three options. A client can pick a convenient or window climate control system yet for some, they pick the compact forced air system due to its versatility [17]. Some even have air channels that assistance to refine the air by expelling any allergens. This is gainful for the individuals who have respiratory scatters. With a versatile forced air system, you can do the air conditioner establishment without bringing in an expert [18]. According to Kara Zorn, there are a few advantages could get by an individual utilizing this sort of climate control system. Versatile cooling units are an incredible option as they don't just from the outside of your home. Versatile climate control systems are impeccable in the event that can live in a little space. They are incredible enhancements to focal cooling frameworks, which can be over the top expensive to run when they're striving to cool the whole house. At last, versatile climate control systems cool the air, yet they likewise dehumidify it, leaving the space both cool and dry [19].

There are some air conditioners which have a cleaning system have already been studied and others are on-going research for the innovation. According to George L. Holstein and George R. Tracey, the researchers of the self-washing coil for air conditioners, in their study that air conditioner can be improved in the system efficiency related to the exterior heat exchange coil by cleaning and cooling the coil. Splash head structure on the condenser is orchestrated to shower water from a water supply onto the warmth trade loop. A control gadget intermittently invigorates the water supply whereby water is provided to the shower head and onto the trade curl to perfect and cool the loop. The water supply may include a condensate store and siphon gathering, and conductor for a conveyance of condensate from the channel of an inside evaporator to the repository. On the other hand, the water supply may contain tap water under pressure. At the point when condensate is utilized, faucet water under strain may fill in as a supplemental supply to the reservoir [20,21].

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The main objective of this paper is to design and fabricate a portable air conditioning device with a self-cleaning system which can be set by the user depending on the desired schedule. The self-cleaning system cleans the evaporator and condenser of the air conditioner.

II. MATERIALS AND METHODS

A. *Methodological Framework*

Figure 1 shows a methodological framework of the study which was employed to attain the objectives. It shows the process of achieving the design of the device, major components, construction, specification, operation, performance and evaluation of the study. It also shows the discussion of economic analysis or business model canvas through the valued customer.

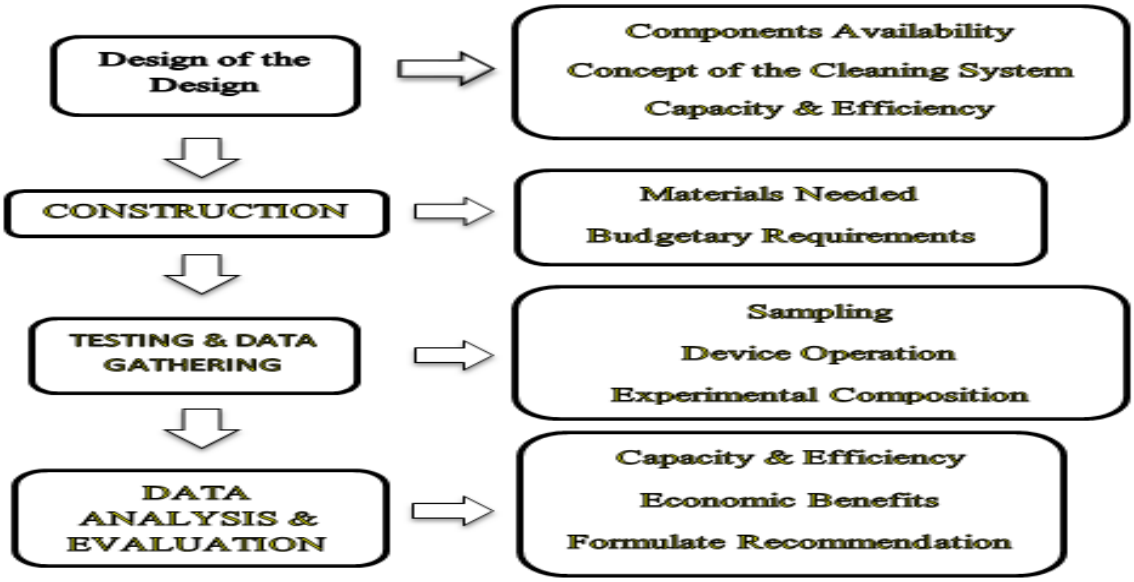

Fig. 1: Methodological Framework

B. *Conceptual Framework*

An AC source is the distribution of energy throughout the system. The one-arrow is unidirectional, two-arrow is bidirectional and a line is a connection from the source. Arduino Mega is the center of the system which controls the triggering of the relays and sensors for the self-cleaning system. The self-cleaning system will work if the button pushes manually and the timers out. The Arduino system is often used to automate any kind of system based on literature review [22-29].

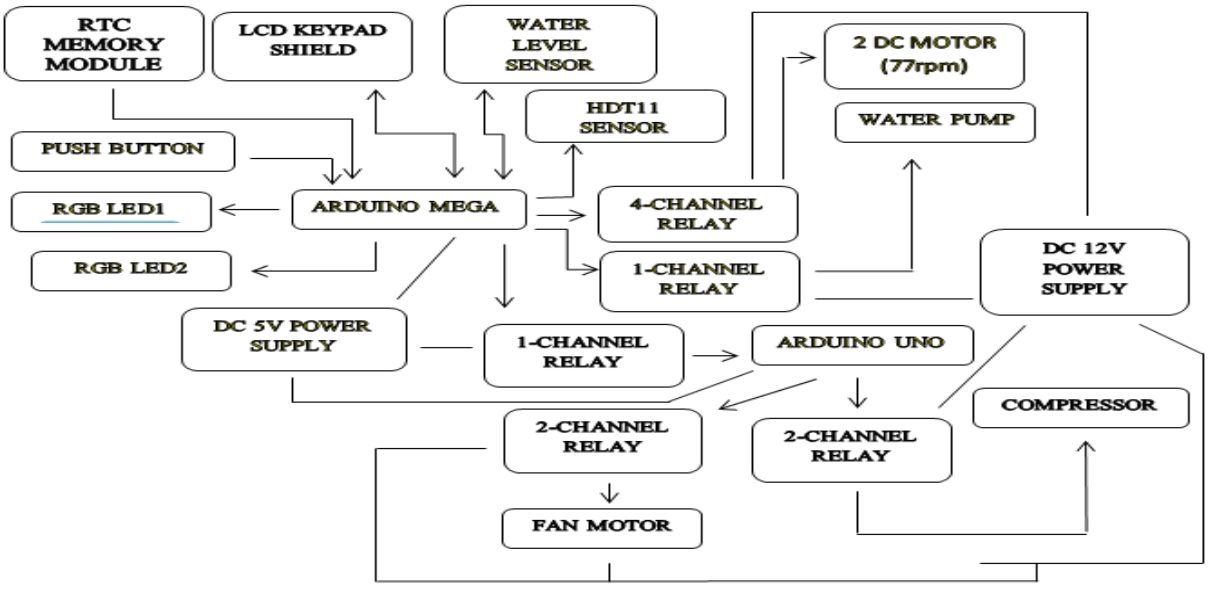

Fig. 2: Conceptual framework

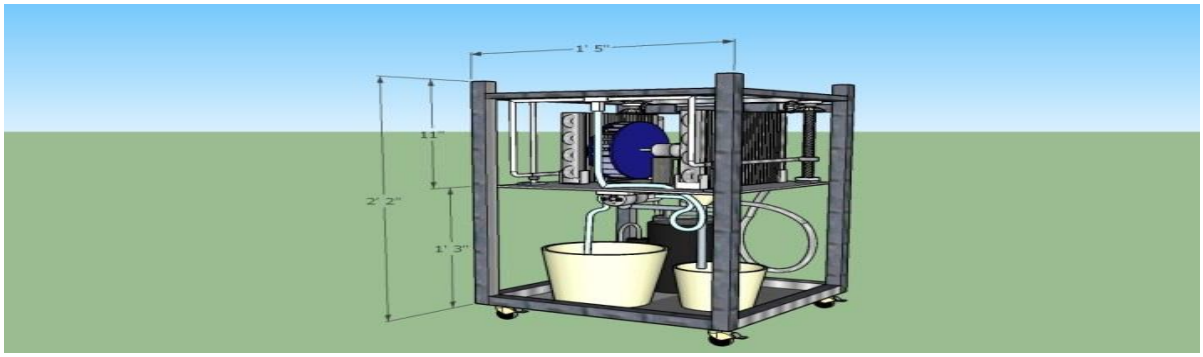

Fig. 3: Side View of the Design

C. System Design

Figure 3 shows the side view of the design whereas Figure 4 shows the logical/conceptual flow of the cleaning system of the device. This is only to focus the concept of different process of cleaning the air conditioner on this study. It also composed of timer, water pump and water sensor as the main components of the system. Cleaning system would not run on that easily. The coolingsystem of the device will simply turn off when cleaning system is activated and working and turn on when cleaning process ends. The product produced from this design is covered with intellectual property (IP) under the IP Policy of the university [30-32].

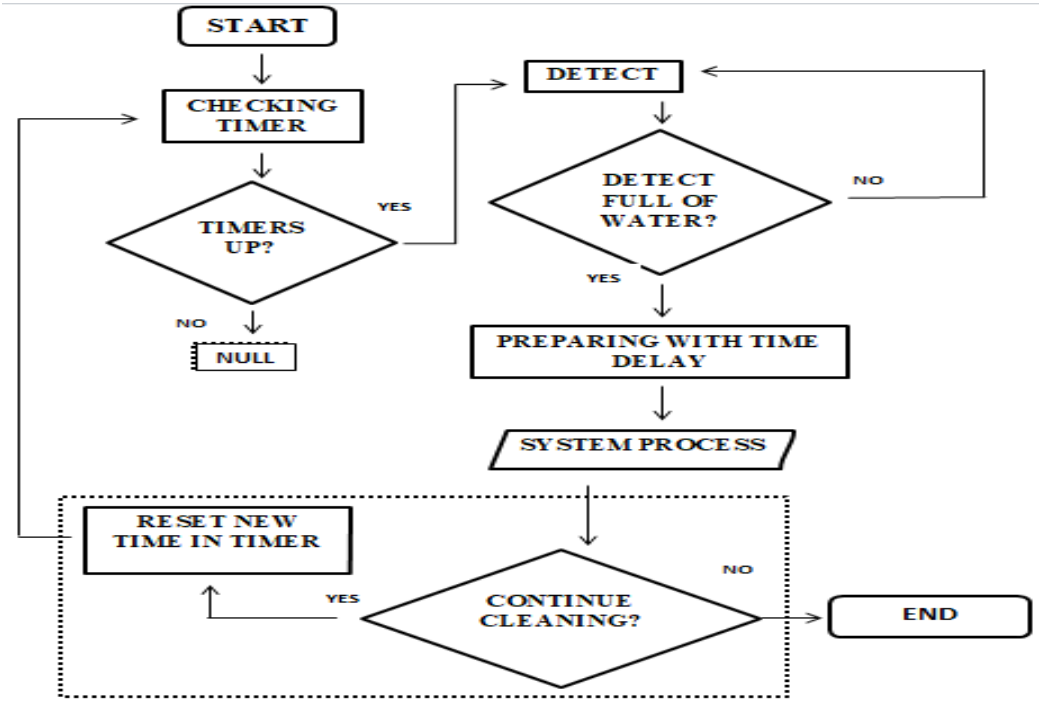

Fig. 4: Conceptual Framework of the Cleaning System

A timer, set by the user for how many hours/days, would check by the microcontroller Arduino mega first before the water level sensor would function to send data for processing the cleaning system. A null word in a box of dashes means no action process. A box of dashes in the flow system means when the cleaning process is over, the user would decide for the continuation of cleaning. The user manually set the timer, by seconds or few minutes as an interval to use the cleaning system again. After setting the timer, it would go back to check the time

III. RESULTS AND DISCUSSIONS

A. Sprinkler

A sprinkler was used to splash water with high pressure for cleaning a dirty material, which is the evaporator and the condenser. A stainless-steel tube was chosen to be a sprinkler of this study where it could be aligned in evaporator and condenser.

The researchers used three (3) stainless steel tubes with different diameter in millimeters: a three-sixteenth (3/16), three-fourths (3/4), and one-fourth (1/4). With a fixed value of Psi of the water pump which is 130, the three steel tubes were tested its efficiency in splashing water. Small holes were made in the steel tubes. The tubes have two-sided

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holes: the one hole was the passageway of water from the pump and the other was locked to let the water pushed by a high pressure runs out through the small holes made by the researchers to produce splashing of water. After the three steel tubes were tested, the researchers confirmed to use the steel tube with 3/16 of its diameter, with 1 cm distance of each holes, in the ability to clean the bristles of the evaporator and condenser without any damage by applying 130 Psi of the water pump. The result shows in Table I.

B. Cleaning System Test

a) Time Duration and Liters Test

The researchers tested and observed the complete cleaning process after fixing its sprinkler, and motion of upward and downward using two DC motor and two gears to each coil, evaporator, and condenser. A water pail must be also being fixed for how much water should be applied to complete the cleaning process up and down. The researchers conducted to try and error of liters of water to use in the experiment, for how many minutes would take it long to clean, and the percentage of a complete cleaning process.

Steel Tube Diameter	Holes Pitch	Remarks
¾ mm	25.4 mm	Not really ok
¾ mm	10 mm	Can't clean enough
¼ mm	12.7 mm	Can't clean the other part of the coils
¼ mm	10 mm	Low pressure of water to splash
3/16 mm	10 mm	Can clean the whole part of the coils

Table 1: Sprinkler Test Results

Liters of Water	Time of Process	Percentage of Complete Cleaning
4L	48 seconds	55%
5L	1 minute & 4 seconds	70%
6L	1 minute & 18 seconds	80%
7L	1 minute & 31 seconds	92%
8L	1 minute & 42 seconds	100%

Table 2: Cleaning Process Results

Table II shows the complete cleaning process tests done by the researchers using different liters of water to determine how many liters must use to complete the cleaning process. Based on the results, 4 liters of water was approximately complete half of the cleaning process, which means could clean upward motion only. 5 liters and 6 liters of water were approximately complete a cleaning process by an upward and half of a downward motion only. 7 liters of water was not enough as it was almost to complete the cleaning process while using 8 liters, a 100% cleaning process was performed. It was confirmed that 8 liters are applicable to use in the device for its cleaning system. The researchers did the cleaning system tests with the complete materials used in the process. The test was performed by putting white ashes, like body powder, to represent as dirt in the experiment, the holes of the sprinklers had an allowance to each other by 1mm, the gears were arranged correctly, eight (8) liters of water and 130 Psi water pump were already arranged too. After that, the test was performed. The time of cleaning stopped when the 8 liters of water in the pail was consumed as it was complete the up and down cleaning process.

b) Cleaning Process Test and Results
Shown in Figure 5 (A-C) the preparation and putting a body powder, cobweb and powder-cobweb combination in the evaporator part of the device.

A B C

Fig. 5: Powder (A), Cobweb (B), Powder-Cobweb (C)

A B C

Fig. 6: Cleaning Process Results Using Powder (A), Cobweb (B) and Powder-Cobweb (C)

In Figure 3.4, in one-time cleaning system process shows that all three kinds of dirt put in the evaporator coil were washed out. Considering 100% of the evaporator and condenser were cleaned after the test and the process was efficient. This process can be continued whatever the decision will the owner or the user of the device to clean more the evaporator and condenser bristles and coils.

C. Operational and Maintenance Cost

For 0.5hp window type air conditioner:

$$\frac{Wattage \times Hours\ per\ Day \times 30\ Days}{1000} \times .75$$

600W x 8 hrs x 30 days = 144000Whr

(144000/1000) x .75 = 108kWh x Php8.6 per kWh = Php928.80 per month

Cleaning Labor Cost: Php350 x 3 = Php1050.00 per year + water consumed

For 0.5hp portable air conditioner:

$$\frac{Wattage \times Hours\ per\ Day \times 30\ Days}{1000} \times .75$$

750W x 8 hrs x 30 days = 180000Whr

(180000/1000) x .75 = 135kWh x Php8.6 per kWh = Php1161.00 per month

Cleaning Labor Cost: Php800 x 3 = Php2400.00 per year + water consumed

The average input current: 19.411A/7 = 2.773 A

Power = VI = (220 V) (2.773 A) = 610.06 W

$$\frac{Wattage \times Hours\ per\ Day \times 30\ Days}{1000} \times .75$$

610.06W x 8 hrs x 30 days = 146414.4Whr

(146414.4/1000) x .75 = 109.81kWh x Php8.6 per kWh = Php944.37288 per month

Fig. 7: Operational and Maintenance Cost

The researchers calculated the operational and maintenance in cleaning cost of the portable air conditioner with a self-cleaning system and compared it to the commercial types, like the window and portable type air conditioner. It was calculated to determine which is more economical, or else it just has a small difference, for one month. In the calculation, it was assumed that the two different air conditioners, window and portable type, are to be clean three times a year, and used eight hours per day. The device was built in Caraga State University, Butuan City, which is under the ANECO to pay the amount of Php8.60 per kilowatt hour.

IV. CONCLUSION

The cleaning system process was designed sufficiently. Two 77 rpm DC motors were used for the up and down movement of the system, with two 8-teeth gears. Two 3/16 diameter stainless tubes were used to be sprinklers each for evaporator and condenser which could handle and splash the water well. After the test, the coil was tried to clean for 8 liters of water in a one-time cleaning system process which results to effective and efficient cleaning in evaporator and condenser. The process was performed by one minute and forty-two seconds with a 130 Psi water pump. Using body powder and cobwebs as dirt for the coils, it cleans the evaporator and condenser efficiently.Based on the operational cost difference between a commercial type and the portable air conditioner with a single temperature setting and a self-cleaning system, the device of this study is more economical than the commercial one. The operation cost is more economical than commercial type portable air conditioner but compare to window type air conditioner which can save Php15.57. In maintenance cost in cleaning, the portable air conditioner with a self-cleaning system is obviously more economical than the window and portable type. In the results, the device's cleaning system is still efficient and better to use without consuming any amount of money for cleaning labor unlike the window and portable type which cost between Php1000 – Php2500 of cleaning labor for three times a year.

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