Self-Sustainable Air Purifier with Air Cooling System

Ashwini Rajesh Kamath B , Ashwini MS , and Naresh holla N
Dept. of Electronics and Communication
SDM Institute of Technology
Ujire, India

Prof.Mahesh D S
Dept. Electronics and Communication
SDM Institute of Technology,
Ujire,India

***Abstract*— Air pollution is a major health hazard affecting the developing and developed countries alike. The effect of air pollution on health is complex and their individual impact varies from one to another. It is not only the ambient air quality in the cities but also the indoor air quality in the rural and urban area that are causing concern. In fact, in the developing world the highest air pollution explosion occurs in indoor environment. This paper presents a self-sustainable air purifier with air cooling system for efficient purification and cooling using solar energy as main power. The apparatus mentioned in this paper is capable of purifying the indoor pollutants like dust, small particles, micro particles, smoke and certain bacteria's. After purification, the air it is cooled for certain extent in order to cool the indoor environment. This Apparatus is controlled using a manual remote and an android application called 'E-SHWASA'' for operating it from long distance as well. The apparatus comprises of sensors, cooling unit, filter unit, solar unit and power unit which connected to a LCD display for displaying the temperature, Humidity, Dust density and harmful gases. All the units are interfaced with a single microcontroller for the performance of task. The inlet air is passed through a plurality of filters. In the cooling unit, the water is passed through a water inlet and to the mud pot. The filtered air is passed through the mud pot, thereby cooling the water in the mud pot. The cooled water is pumped via a pump to the Peltier, wherein the hot water is removed, and the cold water is passed onto to the condenser via a hose. The condenser removes humidity from the water and is out let through the outlet pipe. The apparatus is cost effective for regular use owing to its minimal power consumption and eco-friendly since it uses mud pots for cooling instead of compressors.**

Keywords—Self-Sustainable; 'E-SHWASA'; filter unit; Peltier ;

I. INTRODUCTION

Since the onset of industrial revolution, there has been a steady change in the composition of fossil fuels used for the industries, power generation etc. The effect of air pollution on health is complex and their individual impact varies from one to another. It is not only the ambient air quality in the cities but also the indoor air quality in the rural and urban area that are causing concern. Millions of people are prone to indoor air pollution and their health is adversely affected. So it is very necessary to use an air purifier in order to survive against the indoor air pollution. Hence we have come with an air purifier which have many layers of filters and also air cooling system which cools the indoor environment without causing any harmful chemicals as coolant. Since there is no use of harmful coolant this device doesn't cause ozone depletion. Detailed description about the device in given in further sections.

A. Overview

The figure-1 gives brief overview of the whole apparatus through Block diagram as shown

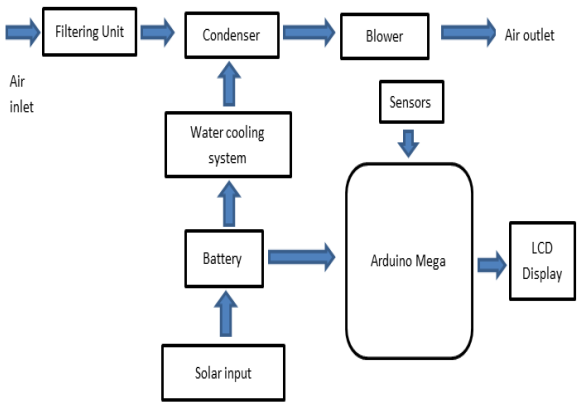

Fig.1 Block diagram

The device consists of different units like filter units, water cooling system and control units.The detail block diagram of the device is given below

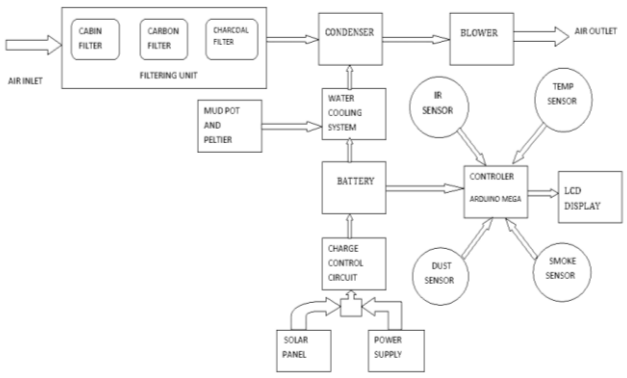

Fig.2 Detailed Block diagram

1.Filtering unit

Filtering unit consists of different layers of filters which are efficient to purify the different particles of different size. The proposed model consists of 3 layers of filter that is cabin filter, charcoal filter and carbon filter which are used to filter out the pollutants, dust particles and other impurities. The roles of the different filters are as below

• Cabin filter: It is first layer of purification here the large sized dust particles are filtered.

• HEPA (high efficiency particulate air filter) plus carbon filter: These filters are the most absorbent filters available. It is used to purify the chemicals present in the air. It is the best filter which is used to purify the small particles present in air. The minimum particle size captured by it is 0.3 micro meter. Ajay N Bhagwat [1], stated that HEPA filter can provide efficiency up to 99.97% in cleaning minute particles and bacteria present in the atmosphere. Subramanian Sundarrajan [2] mentioned in his research paper sHEPA filter and activated carbon filter are sufficient to remove dust particles from the air.

• Active charcoal carbon filters are most effective at removing chlorine, sediment, volatile organic compounds (VOCs), taste and odor. Activated carbon is made up of small particles of carbon in granular form and highly porous in nature. Activated carbon is capable of adsorbing household chemicals, carbon dioxide, smoke etc. Shengbo Ge [3], clearly proved that activated carbon can remove sulphur particles which can be in the form of sulphates and sulphites which does bond formation with sodium and iron. He concluded that Na2SO3, Na2S2O8, Fe2(SO4)3 and S can be adsorbed by the carbon, but adsorption amount will vary time to time. S. B Divate [4], mentioned in his study that activated carbon is having more adsorbing capability than other adsorbents.Nor Adilla Rashidi [5], evaluated activated carbon as adsorbent for CO2. Adsorption of CO2 on activated carbon is physisorption. Adsorption increases with respect to pressure and decreases at elevated temperature.

2. Water cooling system

The cooling unit includes diaphragm pump and a mud pot (Mitti cool system). The cooling unit is configured to receive coolant from a coolant inlet to reduce a temperature of the coolant. The cooling unit also configured to pump the coolant to a peltier unit. The peltier unit is configured to further reduce the temperature of the coolant to obtain a refrigerant vapour. The peltier unit is also configured to pass the refrigerant vapour to a condenser via a hose to remove humidity from the coolant. The apparatus also includes a condenser and operatively coupled to the filtering unit and the cooling unit. The condenser is configured to receive filtered air from the filtering unit. The condenser is also configured to receive the refrigerant vapour from the cooling unit. The condenser is also configured to reduce the temperature of filtered. Figure 3 shows diagram of cooling system.

Peltier module uses the Peltier effect to create a heat flux between the junctions of two different types of materials. A Peltier cooler, heater, or thermoelectric heat pump is a solid-state active heat pump which transfers heat from one side of the device to the other, with consumption of electrical energy, depending on the direction of the current.

Condenser is used to cool down and condense incoming refrigerant.

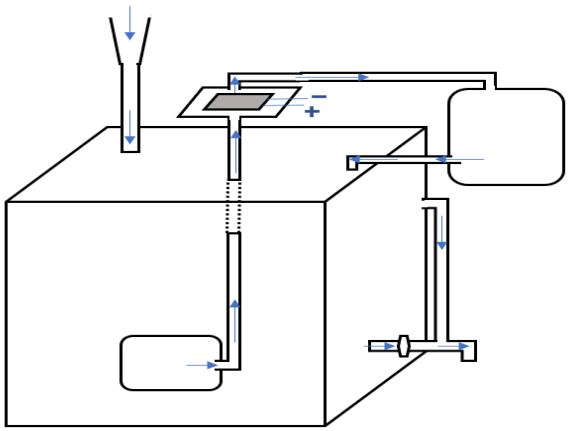

Fig. 3.Air cooling system

3. Control unit

Control unit consists of different sensors like temperature and humidity sensor, dust sensors, IR sensor, smoke sensor, GSM Module, LCD display interfaced with microcontroller. Arduino Mega 2560 is used as microcontroller.

- Arduino Mega 2560

Arduino is an open-source physical computing platform based on a simple i/o board and a development environment that implements the Processing/Wiring language. Arduino Mega 2560 is a Microcontroller board based on Atmega2560. It comes with more memory space and I/O pins as compared to other boards available in the market. There are 54 digital I/O pins and 16 Analog pins incorporated on the board that make this device unique and stand out from others. All the required sensors are interfaced with this controlled like as shown in figure 4

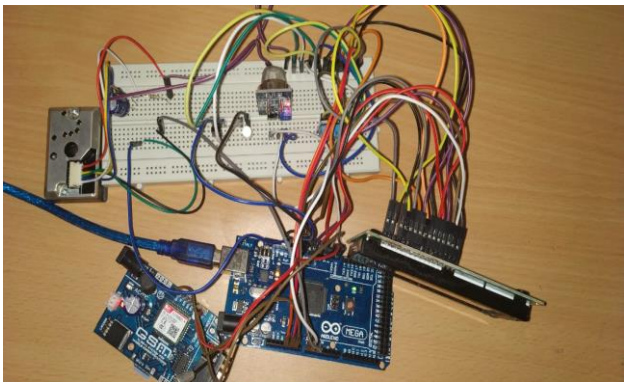

Fig.4 Arduino connected with different parts of the Control unit

- Temperature sensor

The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use, but requires careful timing to grab data. The figure 5 shows DHT11 sensor.

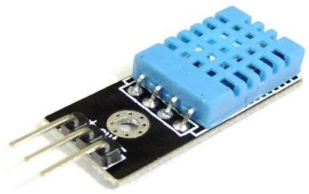

Fig.5. DHT 11 Sensor

- Dust Sensor

GP2Y1010AU0F is an optical air quality sensor, designed to sense dust particles. An infrared emitting diode and a phototransistor are diagonally arranged into this device, to allow it to detect the reflected light of dust in air. It is especially effective in detecting very fine particles like cigarette smoke, and is commonly used in air purifier systems. Figure 6 shows dust sensor.

Fig.6. Dust sensor

- Smoke sensor

The MQ-2 smoke sensor is sensitive to smoke and to the flammable gases like LPG, Butane, Propane, Methane, Alcohol and Hydrogen. The resistance of the sensor is different depending on the type of the gas. The smoke sensor has a built-in potentiometer that allows you to adjust the sensor sensitivity according to how accurate you want to detect gas. Figure.7 shows smoke sensor.

Fig.7.Smoke sensor

- IR Sensor

An infrared sensor is an electronic device that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion.

- GSM

GSM Module plays a very important role. It sends reports to the user about the status of the entire product. SIM900L is used in this apparatus.

- Battery

It is used to store the charge and specification of the battery is 12Volt, 2A to 48A. A lithium-ion battery or Li-ion battery is a type of rechargeable battery in which lithium ions move from the negative electrode to the positive electrode during discharge and back when charging.

- LCD display

A 20 x 4 LCD display means it can display 20 characters per line and there are 4 such lines. In this LCD each character is displayed in 5×7 pixel matrix.

B. Working

The working of the device is based on use of renewable resource like solar energy, (keeping electric power as backup) which makes this device unique from other existing devices in the market. This device makes use of different layers of filter to purify the air present in the surrounding and forcing it to pass through the condenser. Then with the help of the air cooling system, temperature of the air is reduced and pollutants like dust particles or other particles are removed, thus it gives clean and fresh air to the surrounding. Air cooling system consists of diaphragm pump, a Mitti cool system (which consists of mud pot) which is responsible for the modification of the temperature. This is unique method compared to others. We have interfaced different types of sensors with a microcontroller, which helps us to measure the amount of the pollutant content in air after purification. All these operation are controlled using an IR remote and also we have made use of a mobile application 'E-SHWASA' for automation and user friendly operations.

The operation is explained below:

- Air in the atmosphere is sucked and passed to different layers of filters and here the pollutants and dust particles are filtered.
- This filtered air is made to pass through condenser which consists of continuously flowing coolant in it.
- Then the amount of purified content is checked using different sensors present which is interfaced with Microcontroller. Microcontroller is used to control the functioning of battery, display unit, values from the sensors.
- If the extent at which the air cooled is not satisfactory, then the user can control the speed of the motor. Hence user has the direct control over speed.

C. Result Analysis

The below figures show the readings of the different sensor readings in LCD display.

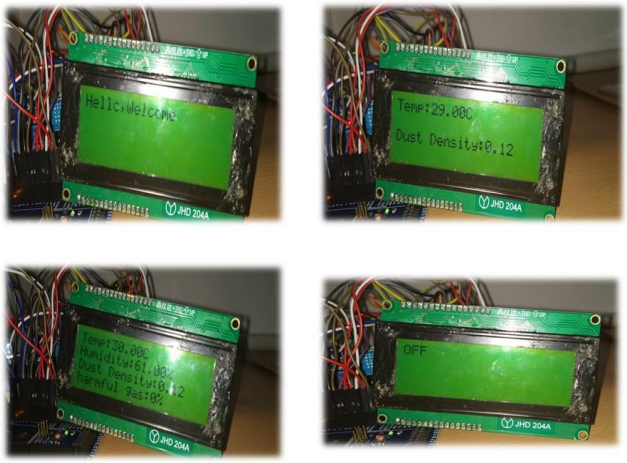

Fig.8. LCD screen showing values of various parameters

Mobile Application 'E-SHWASA' is used to operate the device from long distance. This application is suitable for android mobile phones. Operation of the device like switching the device On and OFF and knowing the current room temperatures can be done through this applications. The below figure shows the screenshots of the applications

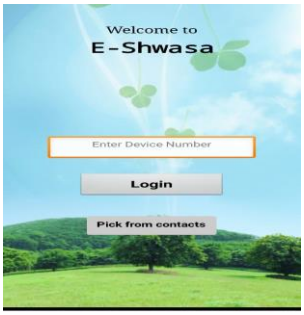

Fig.9. First screen of the application

Figure 9 shows the first screen of the application where the user should enter the number of the device and should login to the next page.

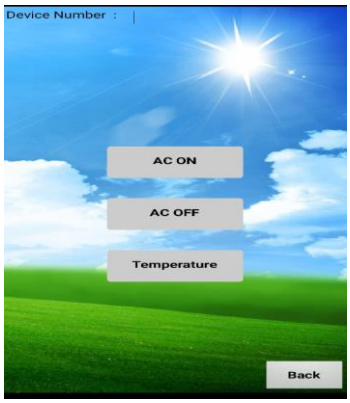

Fig.10 Second screen of the application

Figure 10 shows the second screen of the application where the user will choose the operation he/she want to perform.

D. Conclusion

The device mentioned in this paper is unique device which works as air purifier and air cooler. This device can be used by any individual and can be installed anywhere with less maintenance. This device has no installation difficulties and hence it is a user friendly device using less power for its operation. The future work of the device includes upgrading the cooling for more extent and even improving the lifetime of the filters.

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