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# Design and Fabrication of Solar Powered Air Purifier

**Manjeet Kumar[1], Satinder Jeet Singh[2], Prabhat Kumar Shukla[3], Raj Varun Singh[4]**

**Manash Dey[5], Ashutosh Singh[6]**

[1,2,3,4] *Students of Bachelor of Technology, Department of Mechanical Engineering*
[5,6] *Assistant Professor, Department of Mechanical Engineering, JIMS Engineering Management Technical Campus, Greater Noida, India.201308, Approved by AICTE*
*Affiliated to Guru Gobind Singh Indraprastha University, New Delhi*

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**ABSTRACT -** *This research paper is about designing and fabricating an air purifier system which is powered by solar energy and testing the effectiveness of the system to curb the air pollution. The focus is on extracting the suspended particulate matter from the air which are the major contributors in the pollution of air in many urban cities. It works on a non-conventional method and intents to achieve best possible air purification results using eco-friendly and economical method. It works on the basic principle of adhesion of the suspended particles in the air with the liquid and settles down due to being heavier than air and gets separated from the air helping us to achieve better air quality index. The fans and the pump in system are operated with the help of solar energy, produced by solar panels, which converts the solar radiations into electricity.*

**Key words**: Air Quality index, particulate matter, Atomization, precipitation, moisture content.

## INTRODUCTION

As we know that air pollution level in cities is very high. Most of pollution comes as by-product from vehicle and construction of buildings, these are in form of particulate matter which are like methane, carbon dioxide, dust particulate etc. These create a lot of health problems like respiratory illness, decreased lung functions, development of diseases like asthma etc. Larger dust particles are major particulate among these and if its air quality value are down to minimum then air has very improved quality in which all type of living things can breathe easily.

Although there are many types of air purifier that are available in market but none of them are sufficient enough to deliver its working efficiency in public places like bus stand, near hospitals, traffic signals etc. Many institutes are also not able to afford these because of high cost and installation cost. Government organizations have very low budget for air purifier like extra expenditure. So, it is advisable to develop such air purifier which can cost less and are highly efficient.

So, we are making solar powered air purifier, which runs on solar energy without use of filters and also works for longer duration than others. It uses component like solar panel, fan, converter, pump, etc.

## LITERATURE REVIEW

### [1] National Air Quality Index

Awareness of daily levels of air pollution is important to the citizens, especially for those who suffer from illnesses caused by exposure to air pollution. Further, success of a nation to improve air quality depends on the support of its citizens who are well-informed about local and national air pollution problems and about the progress of mitigation efforts. Thus, a simple yet effective communication of air quality is important. The concept of an air quality index (AQI) that transforms weighted values of individual air pollution related parameters (e.g. $SO_2$, CO, visibility, etc.) into a single number or set of numbers is widely used for air quality communication and decision making in many countries.

### [2] Identification and Characterization of Particulate Matter Concentrations at Construction Jobsites

The identification and characterization of particulate matter (PM) concentrations from construction site activities pose major challenges due to the diverse characteristics related to different aspects, such as concentration, particle size and particle composition. Moreover, the characterization of particulate matter is influenced by meteorological conditions, including temperature, humidity, rainfall and wind speed. This paper is part of a broader investigation that aims to develop a methodology for assessing the environmental impacts caused by the PM emissions that arise from construction activities. The objective of this paper is to identify and characterize the PM emissions on a construction site with different aerodynamic diameters (PM2.5, PM10, total suspended particulates (TSP)), based on an exploratory study. Initially, a protocol was developed to standardize the construction site selection criteria, laboratory procedures, field sample collection and laboratory analysis.

### [3] Atomization concept and theory

Atomization refers to the process of breaking up bulk liquids into droplets. Common home atomizers you may be familiar with include shower heads, perfume sprays, garden hoses, and deodorant or hair sprays. A spray is a collection of moving

droplets that usually are the result of atomization; they are moving in a controlled fashion. Naturally occurring sprays are rain and ocean sprays. A droplet is a small particle of liquid having a more or less spherical shape. Droplets are also known as particles.

The reason particles are round is due to the liquid's surface tension. Recall that surface tension is the property of a liquid that causes droplets and soap bubbles to pull together in a spherical form and resist spreading out. This property causes sheets or thin ligaments of liquid to be unstable; that is, they break up into droplets, or atomize.

**[4] Understanding drop size**

In order to accurately assess and understand drop size data, all of the key variables such as nozzle type, pressure, capacity, liquid properties and spray angle have to be taken into consideration. The drop size testing method should also be fully understood. The measurement techniques, type of drop size analyser and data analysis and reporting methods all have a strong influence on the results.

**Different components of project:**

**1. CHAMBER**

The chamber is the main part of the air purifier. The polluted air from the environment is sucked into the chamber using a fan. It is designed in rectangular cross-section. In the chamber the rack arrangement is close fitted containing the atomizers and the baffle arrangement. It is designed to provide adequate space for atomization by atomizers and efficient adhering of particles with water droplets. The outlet side of the chamber is elevated from the base to reduce the air flow speed and amount of moisture in the clean air. A clearance is provided at the bottom in the chamber for easy flow of water containing particulate matter.


Figure 1: Solar Panel

**2. ATOMIZER**

The atomizer is used to convert water into very fine droplets. There are two atomizers in the air purification system. The atomizers used in this system are solid cone type. High pressure water is pumped at inlet of the atomizer. In the atomizer, the pressure head of water is converted into kinetic head by the Bernoulli's principle, this result in high velocity and low pressure of water at the outlet. When this high velocity water through the atomizer outlet comes in contact with the air, the air friction acts and the kinetic head of the water is converted into surface energy. Thus, very fine droplets are obtained.

Figure 2: Atomizer

**3. PUMP**

A pump is installed in the device. This water is pumped at high pressure and supplied through the pipes into the atomizers. This is a booster pump which provides reliable inlet pressure. This pump is capable of continuous duty.


Figure 3: Pump

**4. FAN**

A 750 RPM fan is installed at the vent of the device. This fan has two implications that are to suck polluted air from the inlet

environment into the chamber and also to flow away the clean air into the outlet environment.

Figure 4: Fan

## 5. SOLAR POWER SYSTEM

**1)** 5.1 SOLAR PANEL

There is an installation of a 100-watt solar panel. This panel is used to produce electricity from radiation of sunrays. The panel consists of a grid of inter connected photovoltaic cells.

Figure 5: Solar Panel

2) 5.2 ELECTRICAL CONVERTER

There is a 500-watt capacity converter installed in device which is used to convert DC voltage of solar panel power source into AC voltage which is used charge the battery in the system.


Figure 6: Electrical Converter

**3)** 5.3 BATTERY

A battery with a high capacity and a low power rating is installed which delivers a low amount of electricity (enough to run a fan and pump) for a long time.

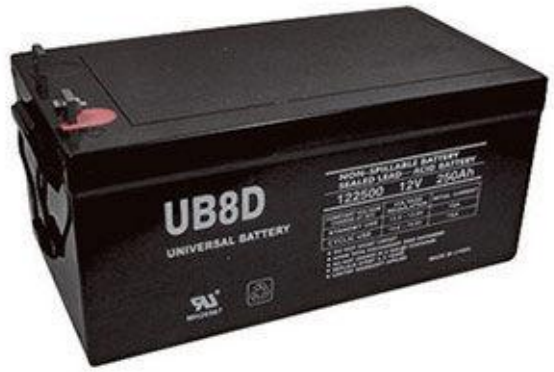


Figure 7: Battery

## 6. ACESSORIES

**4)** 6.1 PIPES

A total of 1.56 metre length pipe is used in the device. These are used to connect and flow water from pump to nozzle.

**5)** 6.2 STRAINER

A strainer is installed in the chamber which prevents residue moisture from entering the fan. It is made of fine fabric.

**6)** 6.3 RACK

Rack is a structure made by bolting the iron angle bar. It installs the baffles and the nozzles. It can be extracted from and inserted into the chamber.


Figure 8: Rack

**7)** 6.4 BAFFLES

Baffles are installed on the rack by nut and bolt. The main purpose of baffles is to increase the air flow path, providing adequate time for efficient absorption of dust particles with water droplets.

**Specifications:**

| Item | Specifications |
|---|---|
| Pump | Open flow: 1.1 L/Min<br>SEIF Suction height: 2m<br>Amps: 1.0 A<br>Max. Inlet pressure: 60psi<br>Max. Outlet pressure: 140psi<br>Voltage: 24V dc |
| Fan | Type: Axial fan<br>Voltage: 230V<br>Frequency: 50Hz<br>Power: 20Watt<br>RPM: 1750 |
| Chamber | Material: 18-gauge GI sheet, MIG welding<br>Size: 18"X20"X3.5' |
| Nozzle | Material: Brass, Chrome plated<br>Outlet dia.: 0.2mm |
| Pipe | Outer dia.:0.6mm<br>Inner Dia.:0.4mm |

**Working**

There is a chamber in which air is sucked in by the fan, while the air is entering it passed through strainer.

Simultaneously water is pumped from reservoir to the atomizer, which converts water into small water droplets and these droplets are suspended into the chamber along with air.

These water droplets have adhesive property due to which the particulate matter and dust particles get absorbed on them.

This way air is cleaned and is flown out from chamber by exhaust fan.

The water with dust and particulate matter is collected in evaporation tank, where water under goes natural evaporation process, leaving behind the dust and particulate matter these are periodically cleaned and water is used again in air cleaning process.

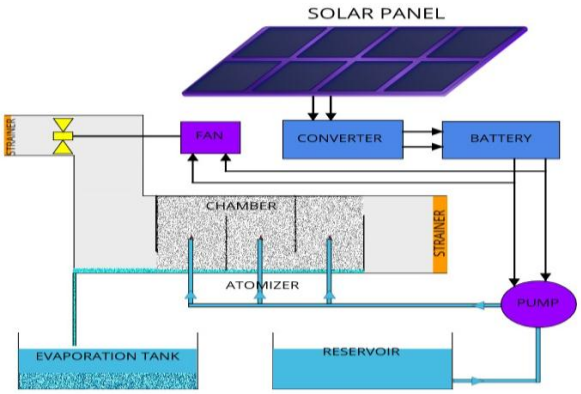


Figure 9: Schematic Diagram

Figure.10 Final project photo

**Calculation:**

There is 1 power generating component as the solar panel and 2 power consuming component as the pump and fan in the system.

Calculating different parameters of each components:

8) 1. Pump

The main work of the pump is to get the low-pressure water flow through the nozzle so that the water gets atomized.

The following given data is considered for the calculation:

Diameter at inlet of nozzle, **d = 0.0002 m**

Area at inlet of nozzle, **a = $3.14*10^{-8}$ $m^2$**

Diameter of pipe, **D = 0.004 m**

Area of pipe, **A = 50.24*10$^{-6}$ m$^2$**

Coefficient of friction of pipe, **f = 0.006**

Length of the pipe, **L = 1.5 m**

Net head of water at inlet of nozzle, **H = 0.26 m**

From the formula,

**v = √[2gH/(1+(4fL/D)*(a/A)2)]**

After calculation,

**v = 3.408ms$^{-1}$**

From the formula, **p = ρ*g*H**

**p = 2548 Ns$^{-1}$**

9) 2. Fan

The air flow rate would determine the power consumption of the fan.

The following data is known to us:

The fan rpm of fan, **N = 1750 rpm**

The diameter of duct, **D = 0.1125 m**

The area of duct, **A = 9.93515625*10$^{-3}$ m$^2$**

The following data is to be calculated:

Velocity of air flowing through fan, **V=?**

Rate of discharge of air through fan, **Q=?**

From the formula,

**V = (2*π*N)/60*(D/2)**

**V = 3.281 ms$^{-1}$**

From the formula,

**Q = A*V**

**Q = 0.0326 m$^3$s$^{-1}$**

**3. Solar Panel**

The total power required = power of fan + power of pump + extra power for storage in battery

Total power = **20 watt + 24 watt+ 56 watts**

Total power = **100 watt**

So, we need to install a **100-watt** solar panel.

**4. Battery**

For making our air purifier any time usable we can install a battery of **500 watts.**

**EXPERIMENTAL READINGS**

**CONSIDERATIONS**

Considering the following points:

- The testing is done in open.
- The AQI of the incense stick is 999+.

**Experiment results :1**

| APPARATUS USED | PARTICULATE MATTER | MAXIMUM VALUE | MINIMUM VALUE | CONSTANT VALUE |
|---|---|---|---|---|
| AMBIENT ENVIRONMENT | PM2.5 | 71 | 55 | 62 |
| | PM10 | 95 | 73 | 83 |
| FAN | PM2.5 | 83 | 62 | 67 |
| | PM10 | 111 | 83 | 89 |
| FAN + PUMP | PM2.5 | 195 | 170 | 177 |
| | PM10 | 260 | 226 | 236 |
| FAN + INCENSE STICK | PM2.5 | 167 | 118 | 132 |
| | PM10 | 222 | 157 | 176 |
| FAN + PUMP + INCENSE STICK | PM2.5 | 257 | 205 | 222 |
| | PM10 | 343 | 273 | 296 |

**Calculation based on PM2.5 reading**

The deviated results of the above table is due to the measuring device limitation of detecting fine droplets as particulate matter and therefore the contribution due to water droplets must be eliminated, which can be done by

Moisture content = (AQI of fan + pump + incense stick) – (AQI of fan + pump)

= 222 - 117 = **105**

Amount of purification = AQI of incense stick – Moisture content

= 999-105 = **894**

Purification percentage = [(reduction of AQI/AQI of incense stick) *100] = **89.4%**