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Design & Fabrication of Solar Powered Air Filtration and Ventilation System

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ABSTACT: *In some application areas like machine workshops, cement industrial area, food processing plant chemical plant etc. It requires air cleaning for comfort of workers.To do so, we are designing the air filtration unit which keeps inside air clean and comfortable for people working there .Our system has multiple stages which simultaneously throws inside air out and inside air in after filtering it. Air flowing inside is filtered with help of different filter layers.With the help of calculations & experiments we have finalized data required to fabricate this unit.*

Key Words: Solar Power, Air Filtration, Air Ventilation, PM2.5&PM10

LITRATURE REVIEW:-

(1) A Review of Air Filtration Technologies for Sustainable and Healthy Building Ventilation.

Authors:- Xingxing Zhang, Llewellyn Tang(2017)

Methodology:- Theoritical calculation

Reviwe:- This paper presents a comprehensive review on the synergistic effect of different air purification technologies, air filtration theory, materials and standards.

It evaluated different air filtration technologies by considering factors such as air quality improvement, filtering performance, energy and economic behaviour, thermal comfort and acoustic impact. Current research development of air filtration technologies along with their advantages, limitations and challenges are discussed. This paper aims to drive the future of air filtration technology research and development in achieving sustainable and healthy building ventilation.

(2) Design and Fabrication of Solar Powered Roof Ventilators.

Authors:- Ti Wai Chan , Umar Nirmal (2015)

Methodology:- Scale model experiment

Reviwe:- This research intends to design a solar powered roof exhaust fan with a simple installation design.

-The design has a structure such that parts are oriented around the axis of the fan. Two types of fans were tested: a centrifugal fan and an axial fan. In these experiments, parameters such as ambient, room and attic temperature were measured. The results showed that the axial fan is more effective.

(3) Design and Fabrication of Solar Powered Air Purifier.

Authors:- Manjeet Kumar, Satinder Jeet Singh, Prabhat Kumar Shukla, Raj Varun Singha Manash Dey, Ashutosh Singh

Methodology:-scale model experiment

Reviwe:- 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

(4)A Review on Solar Powered Air Conditioning System

Authors:- Mr. Amitkumar Gupta , Mr. Shubham Choudhary ,Mr. Abhinish Thakur, Mr. Kaushik Roy

Methodology:- thoritical & statstical data

Reviwe:-An air conditioning system utilizing solar energy would generally be more efficient cost wise, if it was used to provide cooling requirement in the commercial and domestic as well as industrial buildings. And in twenty first century is rapidly becoming the perfect energy storm and the greatest challenge facing mankind is energy. The demand for energy could double or triple as global population grows and developing countries expand their economies. And so the most abundant energy resource available to human society is solar energy. Among the various renewable energy resources, the least utilized energy is solar energy.

(5) Design and Analysis of An Axial Fan Used in Ventilation system
Authors:- Parasaram Sarath Chandra Dr. K. Sivaji Babu (2016)

Methodology:- MATlab simulation,ANSYS software simulation

Reviwe:- The effectiveness of the design procedure is verified with CFD simulation.

The target of improved static efficiency (higher than 67%) has been achieved and it's been calculated as 71%. Performance of the design fan has been investigated by means of ANSYS CFX, a commercial CFD software. In this paper, theoretical results obtained are compared by performance .

OBJECTIVES:- [1]The main objective of our system is to purify & clean the air for human comfort.

[2]In some application areas like machine workshops, cement industrial area, food processing plant, chemical plant, automobile garage etc., air cleaning is required for comfort of workers. Our system filters unwanted particles like dust, debris, pollens and it also removes fumes, moisture, heat produced inside by ventilating it.

INTRODUCTION:-

As ever noticed by one there are many indoor place where air quality management is required like auto garages,machine workshop, cement industrial area etc.., At these places perticulate matter is very high in Amount thus it makes unhealthy environment for workers & can cause the breathing & lungs problem to them.

In conventional system there is only ventilation is done via pressure difference between outside and inside space. Since this is natural phenomena , it is uncertain in nature hence can have variable ventilation rate throught the day. These all problems are overcome by using drought fans & solar powered PV panels in our system. despite of conventional ventilation system our system has multipurpose solar powered system, which can run throught the day on solar power and even in night with stored battery backup power .it has two system called as ventilation unit & filtration unit

In our system different type of methodology is used for ventilation & filtration purpose. In normal system only one way filtration is done by simply taking air from contaminated space and after filtering again throwing back to the same place. While in our system two way path is introduced for faster and easy removal of unwanted particles.

Although there are many systems are available in market but our system in cost effective & it is the only one of its all kind of system available in market.

WORKING COCEPT:-

- In our system different type of methodology is used for ventilation & filtration purpose.
- In normal system only one way filtration is done by simply taking air from contaminated space and after filtering again throwing back to the same place.
- While in our system two way path is introduced for faster and easy removal of unwanted particles. Electric power is developed in solar plate, and then stored in battery. This power is used then to run the electric fans of filter unit.
- The different filters are used in unit to clean the air coming inside space.

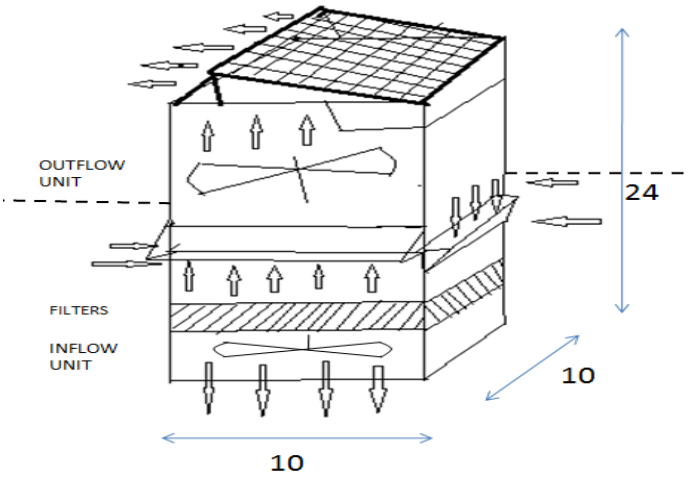

Fig 1. Schematic of system

Ventilation system:- Ventilation system is used for the removal of the heat, suffocation(CO_2), moisture, Odours, Fumes(gases) etc.. suspended inside space by ventilating it to the outside space, with help of blowing fans.

Filtration system:- Filteration system is used for the filteration of the dust, micro particles, contamination, pollens etc..with the help of filterers & blowing fan.

SYSTEM DESCRIPTION:-

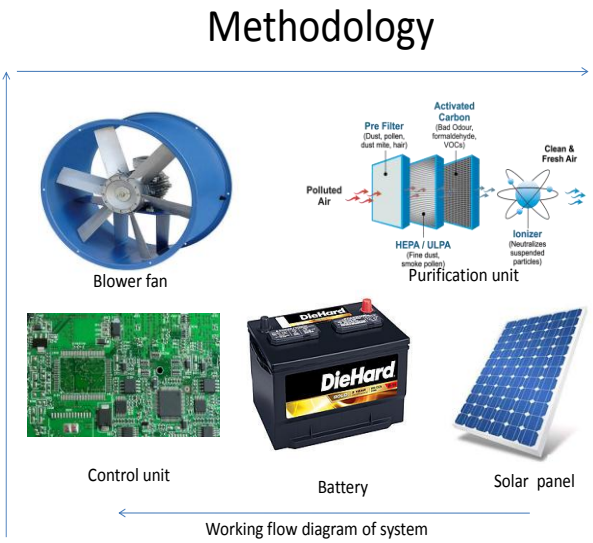

fig 2 .Flow Diagram With Components

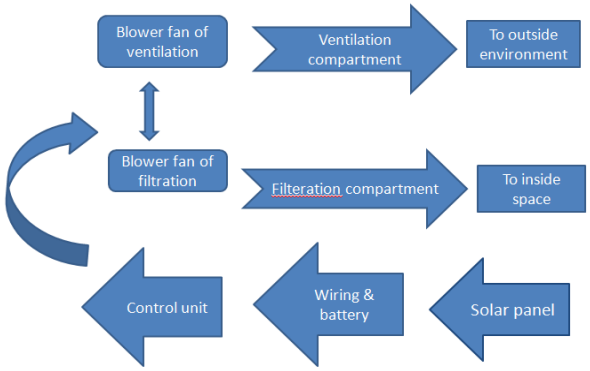

Fig 3 .Block Diagram Representing the Flow of System

Above diagram represents the flow of system with the help of blocks indicating element stage through the system.

INDIVIDUAL COMPONENT DETAIL:-

Components used in our system is listed below:-

- Fans
- Motors
- Battery & Wiring
- Solar Plate
- Outer Body Structure Material
- Filters

(1) Axial fan

Mechanically, a fan can be any revolving vane or vanes used for producing currents of air. Fans produce air flows with high volume and low pressure. Axial fans are used for creating flow parallel to its center axis so it is called as axial fan. We are using this type of fan in our system for generating air flow through filters for filtration process.

Fig 4. Axial Fan

(2) Motors

An electric motor is an electrical machine that converts electrical energy into mechanical energy. Most electric motors operate through the interaction between the motor's magnetic field and winding currents to generate force in the form of rotation. Electric motors can be powered by direct current (DC) source

Fig 5. D.C Motors

Motors are required to run the fans used in system. we are using 8v motors in our system.

Motor runs at 1000rpm which is required for proper volume flow rate through the system according to calculation.

(3) Filters

Type of Filters Listed Below:-

- Mechanical Filters

- Electrostatic (ionizing) Filters

- Coal (adsorption) Filters

-HEPAFilters (filters for better mechanical cleaning)

- Photocatalytic Filters

***Mechanical Filters**

This type of filters is the most common used in air cleaners. Mechanical filters arrest large particles of dust, fabric fibers and animal dander.

They consist of the usual fine grid used as a pre-filter. Such filters are installed in almost all equipment and protect from dust, not only people but also the inside of equipment.

Particles go through this grid and settle on it. That is why filters should be cleaned in time. This process needed removing dust or washing.

We are also using this type of filters for our system.

-Description:-

We are using two type of filter for our project

1. Metal net filter

2. Cotton cloth filter

Both having different filtration capacity according to their mesh size.

First filter is for filtering large size particles, where another is for small particles.

[1] Metal Net Filter

Fig 6. Metal Net Filter

- Specification:-
- Particulate Size:-PM20*(20 micron)
- Thickness:-3mm
- Filter Efficiency:-65%
- Material:-(stainless sleel)
- Dimension:-(10*10)inch

[2] Corrugated Cotton Filter

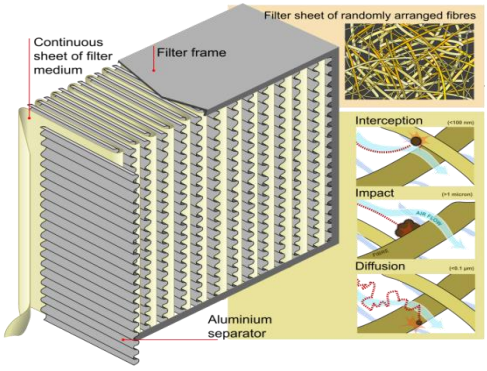

Fig 7 . Corrugated Cotton Cloth Filter

- Specification:-
- Particulate Size:-PM5*(5 micron)

- Thickness:-5mm
- Filtration Efficiency-70%
- Material :- cotton
- Dimension:-(10*10)inch

(4) solar & Electrical System :-

[1]Solar Plate

Photovoltaic solar panels absorb sunlight as a source of energy to generate electricity. A photovoltaic (PV) module is a packaged, connected assembly of typically 6x10 photovoltaic solar cells. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications

A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes an array of photovoltaic modules, an inverter, a battery pack for storage, interconnection wiring, and optionally a solar tracking mechanism.

Fig 8 . Solar PV Panel

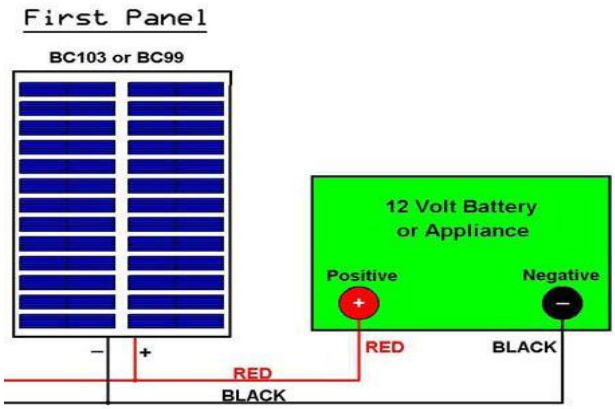

Fig 9 . Solar Circuit Diagram

[2] Battery and Wiring

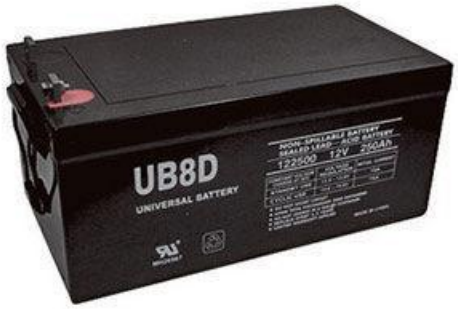

Fig . Battery

Battery is used for storing power developed by solar plate. It stores power and than that power is utilized for running system.

12volt Battery has 3600mAh storing capacity of power which can be utilized for one day.

[3]Electrical Circuit Diagram:-

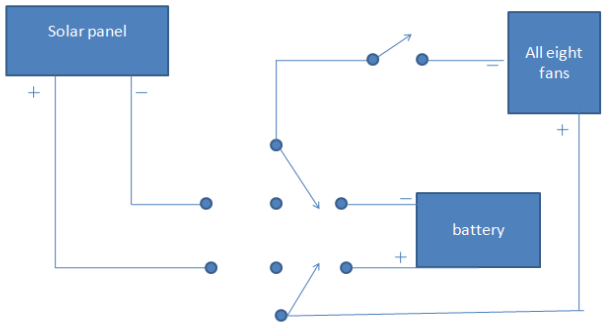

Fig 10. Electrical Circuit Layout

TECHNICAL SPECIFICATION:-

- Dimension - (24*10*10) Inch
- Solar plate - 18v Plate
- Battery - 12v , 3600mAh
- Outer Body - Galvanized Steel Sheet
- Filters - Two Air Filters (Metal Net, Cotton Net)
- Fan - 4 Inch Diameter (Plastic Fan)

(Nos.8)

CALCULATION:-

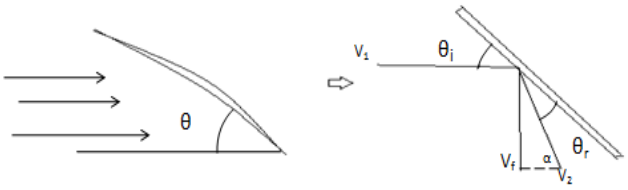

Figure of fan blade:-

- Calculation for fan diameter :-
- Blade angle θ =25
- Incident angle θ_i =25°
- Reflect angle θ_r =25°
- so, α can be calculated as,

$$\alpha = \theta_i + \theta_r$$

$$= 25^o + 25^o$$

$$=50^o$$

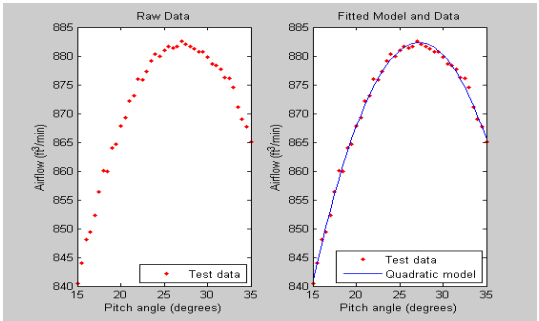

Fig. Graph of Fan Blade Angle v/s Flow rate

Reference: An optimal design for axial-flow fan blade: theoretical and experimental studies

- V_f =Flow velocity
- V_1 = incident velocity
- V_2 = reflected velocity
- N= rpm of motor
- Taking $V_1 = V_2 = \frac{\pi DN}{60}$

$$= \frac{3.14 * D * 1000}{60}$$

$$= 52.3D \text{ m/s}$$

- for finding flow velocity V_f ,

$$V_f = \sin\alpha * V_2$$

$$= \sin 50^o * 52.3D$$

$$= 40.08D \text{ m/s}$$

- Volumetric flow requirement for optimum working of model is 0.22m^3/s
- Taking flow rate = 0.22 m^3/s
- Flow rate = flow velocity * area

$V_m = V_f * A$

$0.22 = 40.08D * D^2$

$0.22 = 31.46 D^3$

D = 0.191 meter

=7.65 inch

Taking Diameter of fan is = 8 inch

Due to unavailability of 8 inch dia. Fan we can take four equivalent fan, having 4 inch dia Each.

STRUCTURE CALCULATION:-

- calculation of dimension of structure:-
- l =fan diameter + 2(gap)

- =8 + 2(1)
- l = 10 inch
- L = 2(l) =2(10) =20 inch
- B = l = 10 inch
- H = 2.4(l) =24 inch

  =2 feet

FILTER CALCULATION:-

- filter calculation :-
- Filter specification:-
- Filter size= 5µm
- Filter efficiency = 70%
- actual filtration rate

  = 0.7*volume flow rate

  = 0.7* 0.22
- Filtration rate= 0.16 m^3/s
- Estimation of Filtration time :-
- Taking standard room size

  = (4.5*4.9*3.0) m^3

  =66.15 m^3

Calculated time for filtration process is,

$$\text{Time} = \frac{volume\ of\ room}{rate\ of\ filtration}$$

$$= \frac{66.15}{0.16}$$

=413.4 second

=6.89 minute

- Taking time = 7 minute + 3 minute of allowance

  = 10 minute

EXPERIMENTAL DATA:-

Considering the points:-

- The experiment has done in close system.
- Air quality index is taken as PM2.5 & PM10

CONDITION	PM2.5(µg/m^3)	PM10(µg/m^3)
Before Experiment	121.5	205
After Experiment	42.6	66.5

Table . Experimental Results

Fig 11. Actual Prototype

- **According to data, calculating the final efficiency of system** :-
- Efficiency by PM2.5= (valueof before – value of after)/(value of before)

  =(121.5-42.6)/(121.5)

  =0.6493*100

  = 64.93%
- Efficiency by PM10= (205-66.5)/(205)
  = 0.6756*100
  = 67.56%

- Thus overall efficiency is the average of both PM2.5 & PM10 ,that is 66.23% according to experinmental analysys. since calculated efficiency was 70%.

-The deviation found in efficiency from calculated one is because of experimental human errors & mistakes.

CONCLUSIONS:-

Our system is very simple & easy to install at any required industry and can be installed on roof at any workshop. System is embedded with solar power. Hence, no external power source required. Even no requirement of pressure difference due to provision of solar powered fans which runs continuously.

We have designed this system for air purification & ventilation purpose with low cost and higher flow rate. Thus this is the efficient product for the future. Also in future, modifications can be made to improve working efficiency without effecting setup.

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