

Flow of Air Inside Indoor Air Purifier Using HEPA, Carbon Activated, Anti-Bacterial, Photo Catalyst Filter

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Abstract- As of now the air quality is decreasing day by day, As the air we inhale daily is consists of smoke, impurities and many harmful gases which is not good for our health. Through this many people got allergy, heart problem and asthma like disease especially when you live in hi-tech cities or even in small towns these types of problem arise. In this particular project we used to make an air purifier which cleans 99.9 percent of air and also cost efficient. In this we use different filters like HEPA(High efficiency particulate air), carbon activated, anti-bacterial, photo-catalyst and pre-filter. In this project design of air purifier is done onCATIA software, in which no direct flow of air so it feels comfortable for users. While the analysis is done in ANSYS with fluid flow fluent workbench for the calculation of flow of air at inlet, flow at outlet, movement of air from inlet to outlet, turbulence contour inside the chamber, turbulence pathline inside the chamber of air purifier.

Keywords- Air Purifier, HEPA filter, Carbon Activated Filter, Anti-bacterial Filter, Photo catalyst Filter, Prefilter ANSYS, CATIA

I. INTRODUCTION

Air purifier and the air cleaner is a device which removes contaminants from the air in the environment. This device are commonly marketed as being beneficial to allergy suffers and asthmatics, and at reducing or eliminating second hand tobacco smoke. The commercially graded air purifiers are manufactured as either small stand- alone unit or larger units that can be affixed to an air handler unit (AHU) or to an HVAC unit found in medical, industrial, and commercial industries. Air purifiers may also be used in industries to remove impurities such as CO₂ from air before processing.

Computation of the AQI(Air quality index) requires an air pollutant concentration over a specified averaging period, obtained from an air monitor or model. Taken together, concentration and time represent the dose of the air pollutant. Health effects corresponding to a given dose are

established by epidemiological research. Air pollutants vary in potency, and the function used to convert from air pollutant concentration to AQI varies by pollutant. Air quality index values are typically grouped into ranges. Each range is assigned a descriptor, a color code, and a standardized public health advisory.

There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. The proposed AQI will consider eight pollutants (PM₁₀, PM_{2.5}, NO₂, SO₂, CO, O₃, NH₃, and Pb) for which short-term (up to 24-hourly averaging period) National Ambient Air Quality Standards are prescribed. Based on the measured ambient concentrations, corresponding standards and likely health impact, a sub-index is calculated for each of these pollutants. The worst sub-index reflects overall AQI. Associated likely health impacts for different AQI categories and pollutants have also been suggested, with primary inputs from the medical expert members of the group.

II. CRITERIA OF AIR POLLUTANTS

1. Ozone (O₃): ozone found on the floor-level, likewise called tropospheric ozone is additionally managed by method for the NAAQS(National Ambient Air Quality Standards)underneath the smooth air act. Ozone transformed into initially observed to be negative to grapes inside the Fifties. America EPS (Environmental Protection Agency) set "oxidants" guidelines in 1971, which covered ozone. Those gauges had been made to reduce rural effects and diverse related harms. Like lead, ozone requires a reconsideration of ongoing discoveries of wellness and blossoms results intermittently. This issue required the formation of a us EPS criteria archive. Likewise examination achieved in 1979 and 1997 made it essential to truly change the toxins prerequisites.^[21]
2. Climatic particulate be tallied: - pm10, coarse flotsam and jetsam: 2.5 micrometers (µm) to ten µm long (albeit current execution comprises of all particles 10 µm or

considerably less inside the prevalent) Pm2.5, top notch particles: 2.5 μm long or less. Particulate matter (pm) changed into ordered in the 1996 models report issued by the EPA. In April 2001, the EPA made a second outside diagram draft of the air top of the line measures for pm, which tended to refreshed examinations finished on particulate matter issue and the altered toxin norms done since the first outside assess draft. In May 2002, a third outside diagram draft wound up made, and the EPA reexamined pm necessities yet again. In the wake of issuing a fourth form of the document, the EPA issued the plain last model in October 2004.^[21]

3. Lead (Pb): in the mid-Nineteen Seventies, lead was recorded as a criteria air poison that required NAAQS law. In 1977, the EPA distributed a document which focused the air attractive measures for lead. This record transformed into principally in view of the clinical evaluations of lead on the time. In view of this record (1977 lead AQCD (Air quality control district)), the EPA introduced a "1.5 $\mu\text{g}/\text{m}^3$ (greatest quarterly date-book normal) PbNAAQS in 1978." the perfect air act calls for intermittent assess of NAAQS, and new restorative certainties distributed after 1977 made it important to overhaul the prerequisites already snared in the 1977 lead AQCD report. An addendum to the record changed into distributed in 1986 and on the other hand as a supplement to the 1986 AQCD/addendum in 1990. In 1990, a lead group of specialists paper end up arranged with the guide of the EPA's Office of Air Quality Planning and Standards (OAQPS) ,which turn out to be basically in view of insights gave in the 1986 lead/AQCD/addendum and 1990 supplement, notwithstanding different OAQPS supported lead attention/chance examinations. In this paper, it move toward becoming recommended that the PbNAAQS be updated likewise and introduced options for modification to the EPA. The EPA chose to not change the PbNAAQS further, anyway resolved to as an elective acknowledgment on the 1991 US. EPA technique for bringing down lead introduction. The EPA focused on administrative and medicinal simple up endeavors to limit Pb presentation from various non-air resources that achieved additional extreme open wellness perils, and attempted activities to diminish air emanations.^[21]
4. Carbon monoxide (co): the EPA set the main NAAQS for carbon monoxide in 1971. The essential well-known transformed into set at 9 ppm arrived at the midpoint of over a 8-hour time frame and 35 ppm over a 1-hour duration. The vast majority of co produced into the surrounding air is from versatile resources. The EPA has explored and surveyed the contemporary logical writing with perceive to co in 1979, 1984, 1991, and 1994. After the assess in 1984 the EPA chose to take out the auxiliary general for co because of absence of generous evidence of the hindering ecological impacts. On January 28, 2011 the EPA chose that the current NAAQS for co had been sufficient and proposed to save the present norms as they stood. The EPA is reinforcing following necessities for co by calling for co video show units to be situated in key places close extensive urban regions. In particular, the EPA has known concerning video show units to be found and operational in CBSA's (center based measurable regions) with populaces more than 2.5 million by means of January 1, 2015; and in CBSA's with populaces of one million or more by methods for January 1, 2017. Also they're requiring the collocation of co video show units with no2 screens in urban locales having a masses of one million for additional. As of may also 2011 there have been around 328 operational co video show units in area across the nation. The EPA has given a couple of expert to the EPA nearby executives to administer case-through-case asked for exemptions and in making sense of the requirement for extra observing frameworks over the base required. The EPA audits the nationwide regular consciousness of co has diminished by utilizing eighty two% in light of the fact that 1980. The last nonattainment assignment transformed into considered in achievement on September 27, 2010. At present all areas inside the US are in fulfillment.^[21]
5. Sulfur oxides (sox): sox allude to the oxides of sulfur, an exceedingly responsive gathering of gases. So2 is of most prominent interest and is utilized in light of the fact that the marker for the whole sox family. The EPA first set essential and optional prerequisites in 1971. Double number one prerequisites had been set at a hundred and forty ppb arrived at the midpoint of over a 24-hour length, and at 30 ppb found the middle value of every year. The optional trendy was set at 500 ppb found the middle value of over a 3-hour term, not to be outperformed additional than a year. The most extreme ongoing outline occurred in 1996 all through which the EPA considered forcing another NAAQS for 5-minute pinnacles of so2 influencing touchy populace's comprehensive of asthmatics. The association did not set up this new NAAQS and put away the predominant measures. In 2010 the EPA resolved to supplant the twin number one measures with another 1-hour trendy set at 75 ppb. On walk 20, 2012 the EPA "took last movement" to safeguard the predominant NAAQS as they stood. Best 3 following locales have passed the contemporary NAAQS for so2, which might all be situated inside the Hawaii volcanoes countrywide stop. The infringement occurred between

2007-2008 and the nation of Hawaii recommended these ought to be absolved from administrative activities due to a 'choice occasion' (volcanic interest). On account that 1980 the nationwide convergence of so₂ inside the surrounding air has diminished by utilizing eighty three%. Yearly regular fixations drift among 1-6 ppb. Right now all ACQR's are in achievement for so₂.^[21]

6. Nitrogen oxides (NO_x): the EPS first set number one and optional gauges for the oxides of nitrogen in 1971. Among those are nitric oxide (no), nitrous oxide (n₂o), and nitrogen dioxide (no₂), the greater part of that is secured inside the NAAQS. No₂ is the oxide estimated and utilized in light of the fact that the marker for the whole NO_x family as it is of the most extreme trouble because of its concise development and commitment to the arrangement of destructive ground degree ozone. In 1971 the essential and auxiliary NAAQS for no₂ had been each set at a yearly normal of 0.053 ppm. The EPS checked on this NAAQS in 1985 and 1996, and for every situation inferred that the predominant general transformed into adequate. The most current diagram by method for the EPS occurred for in 2010, following in a fresh out of the box new 1-hour no₂ essential prominent set at 100 ppb; the yearly normal of 0.053 ppm remained the indistinguishable. Likewise contemplated turn into another 1-hour optional boundless of 100 ppb. This was the first run through the EPS looked into the ecological impacts split away the wellness influences for this gathering of criteria air contamination also, in 2010, the EPS resolved to ensure consistence by method for fortifying following prerequisites, calling for enhanced quantities of observing frameworks close immense urban districts and most critical roadways. On walk 20, 2012 the EPS "made last move" to keep the predominant NAAQS as they stand. The nationwide normal of no_x concentrations has dropped by methods for fifty two% in see that 1980. The yearly mindfulness for no₂ is recommended to normal cycle 10-20 ppb, and is relied upon to bring down comparatively with new cell supply rules. By and by all districts of the assembled states are sorted as in achievement.^[21]

III. MODEL AND FILTERS ARRANGEMENT OF AIR PURIFIER

In this specific air purifier we sketch a 3D diagram in CATIA V5 R20 and the model is designed in such a way that the fan is at the base of purifier and the purified air is coming from the top side for a better comfort and does not create a haziness for a particular individual also doesn't feels that air stuck at his face.

The box is made up of plywood for better lasting and easy to handle. While the air purifier is also made to operate with inverter also as there is only one exhaust fan is used which is of Dimensions: 18×18×10cm;699g, Motor speed: 1750 rpm, Pure copper motor, Blades: three, Power required (in V):230V , 20 Watt power consumption. In which there are arrangements of filters which are basically arranged in a manner for providing a fresh amount of air and removes maximum dirt and smoke particles.

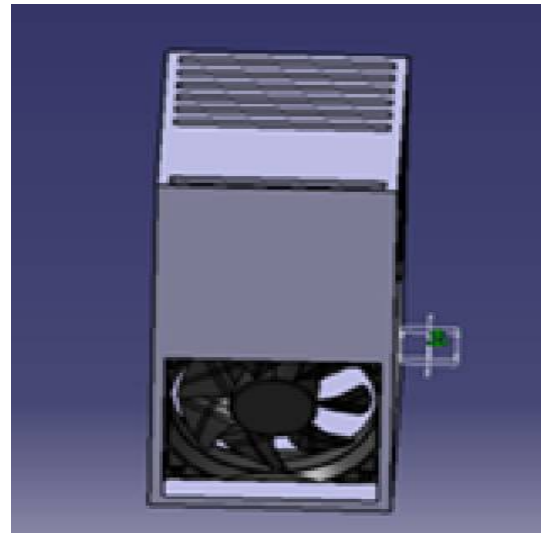


Fig 1: Model of air purifier



Fig 2: Arrangement of filters

In this arrangement we used to make a separation of 2 inch between each filters for the laminar flow and the manufacturing of box is done in such a way that easy to install and removal of filters for cleaning and changing of filters as there is only magnetic lock is in the box which help to easy opening of filter gate. The box is full air tight with the help of thermocol and PVC foam, that when the air enters from the base area there is no other way to move the air without

purification through pre filter, HEPA filter, carbon activated filter, photo catalyst filter, anti bacterial filter.

The flow of air inside the cabin is in such a way that when the air enters with the help of exhaust fan the air get filters through two pre filters and then there is a gap of 2 inch after that air strike to photo catalyst filter on the back of photo catalyst filter there is Carbon activated filter and then there is gap of 2 inch then there is HEPA filter on which the air strikes while on the back side there is anti bacterial filter through which the air completely get purified and then move to upper portion of the chamber for final exit.

IV. USES OF FILTERS IN AIR PURIFIER

1. HEPA filter

HEPA is an acronym for elite particulate air and is an age that has been utilized for quite a long time to sift through trash. HEPA channels need to meet an across the board of catching no less than 99.97% of all particles bigger than 0.three microns. The human eye can best observe particles expansive than 10 microns; so particles got in a HEPA get out which incorporates synthetic substances, microscopic organisms and infections can't be seen. Because of the reality HEPA channels can bait shape and miniaturized scale life form, they make an additional sterile environment. Furthermore, this type of air purifier does never again produce ozone or some other unsafe side-effects.

The HEPA sift through is a totally palatable fiber-like fabric that has been collapsed from side to side to make the type of an accordion. This accordion shape makes a labyrinth of arbitrarily orchestrated strands and exhibits a totally enormous floor for air to be pushed by means of through the air purifier fan. Wind stream ought to have a probability to skip through the get out so concerning it to be wiped clean.

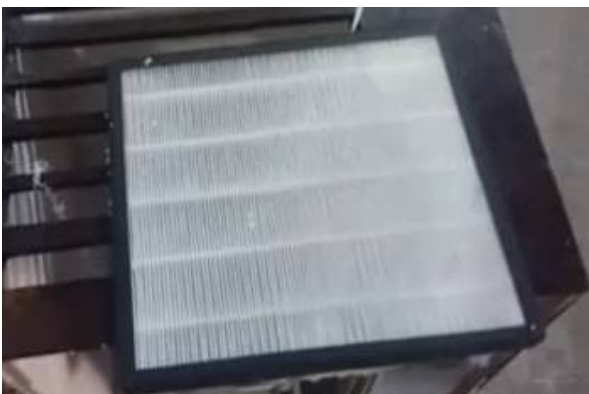


Fig 3: HEPA filter

The more examples wind current goes through the channel in 30 minutes, the chemical the air will move toward becoming. Since the HEPA get out will wind up total, air won't be equipped for skip by means of and a pristine get out might be required; anyway a HEPA channel will ordinarily extreme 2 to 4 years. HEPA air purifiers are the handiest at catching airborne flotsam and jetsam; yet they don't get rid of smells, synthetic mixes or gases. Along these lines, most HEPA air purifiers have a couple of level of actuated carbon principally based texture to drench up scents and substance intensifies never again stuck by method for the HEPA sift through.

2. Activated Carbon filter

Activated carbon is a type of carbon that has been prepared to make it exceptionally permeable and to offer it an extremely gigantic floor territory for retention. The use of actuated cell based dates came back to the mid 1900's the point at which it moved toward becoming purchased financially to clean water and to remove the shading from sugar. Amid wwi, it transformed into observed that it can be used in fuel cover to protect infantrymen, notwithstanding for fighting time water and air purifiers.



Fig 4: Carbon activated filter

For some, people, particulates, for example, tidy, dust or pet dander are the essential aggravations, with smell and synthetic assimilation being less basic. For individuals who require an extreme level of both, it is fine to watch the top notch room air purifiers which give first class particulate, fragrance and synthetic expulsion. Dangerous natural mixes (vocs) brown haze, ozone, exhaust from cooking, pets or tobacco smoke might be awful or irritating for every one of us, not just people who be burdened by touchy responses and sensitivities.

Carbon air channels help an unprecedented arrangement in bringing down the defilement of the air in our rooms; yet they do have a lower execution level in expelling allergens and airborne particles. Moreover they have confinements in

pushing off contaminants which are some separation away and now not constrained through the sift through.

3. Anti bacterial filter

Channels have protracted been utilized as a part of ventilation system structures. Versatile aeration and cooling system structures are no outstanding. An antimicrobial sift through, now not exceedingly, is one of the most extreme celebrated filtration frill on your transportable aeration and cooling system.



Fig 5: Anti bacterial filter

Like any ventilation system sift through, an antimicrobial get out is intended to take away particulates and unsafe aggravations from the air, purging it before it is recycled again into the room. This additionally helps the general proficiency of your cooling framework.

To better perceive how an antimicrobial get out achieves its objectives, it's miles fundamental to acknowledge how it functions. Any antimicrobial instrument is a contraption intended to bait particulates and slaughter microorganisms. The channels attempt this by utilizing the utilization of decidedly charged variables that interest to contrarily accused garbage and of the guide of stressing the particles through minuscule cleft and strands, practically catching the airborne poisons.

4. Photo catalyst Filter

Photo catalysis least complex handles beyond any doubt, compound assortments of air contamination and doesn't cure the inconvenience of particulates (ash and soil). This is the reason photo catalytic air purifiers join uv-initiated, titanium-basically based catalysers with other purifying and sifting innovation to shape a total gadget that can handle a whole scope of earth and contamination.



Fig 6: Photo catalyst filter

An ordinary purifier pulls in approaching air past a chain of different purifying stages, everything about handles an unmistakable type of airborne pollutant: phenomenally coarse pre filter catches colossal particles of family unit earth, hair, and pet hair. This sift through is produced from polypropylene netting fixed with catechin (an intense tasting natural substance, decided in green tea, that fills in as an antibacterial operator and antiperspirant). An incredible HEPA channel disposes of airborne infections, microbes, spores, and shape.

5. Pre-Filters

Pre-channels artistic creations in conjunction with HEPA or distinctive channels as a way to dam gigantic flotsam and jetsam from interacting with sensitive contraptions.



Fig 7:- Pre Filter of air purifier

They're regularly made from nylon or froth and can be washed more than once. Subsequently, these can be an astonishing subsidizing as they may make your essential sift through staying longer.

V. ANALYSIS ON FLOW OF AIR INSIDE PURIFIER

In this present paper analysis is on ANSYS 17.2 on fluid flow fluent workbench. In this we used to observe the movement of air inside air purifier chamber. In which we used to observe flow of air at inlet, flow at outlet, movement of air from inlet to outlet, turbulence contour inside the chamber, turbulence pathline inside the chamber of air purifier.

Fluid flow fluent analysis on flow of air

a) Flow of air at inlet of air purifier

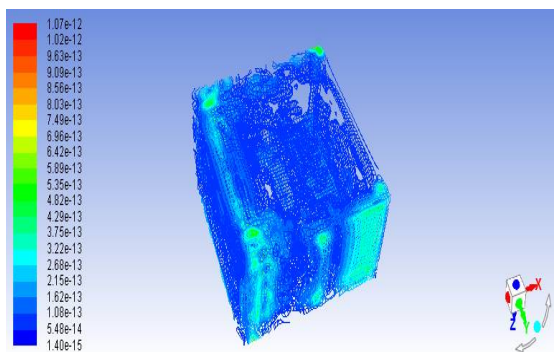


Fig 8: Flow of air at inlet of air purifier

In this flow arrangement when the air is enters inside the chamber flow of air is from 2.68×10^{-13} to 3.22×10^{-13} which is denoted by sky blue colour. After that when the air moves inside there is filters inwhich the flow of air is varying from 2.15×10^{-13} to 1.40×10^{-15} as it is shown in blue colour. In this we observe that the flow of air is decreased as air moves inside because of filters which decrease the flow to purify the air. As there is more amount of air enters and while purification flow decreases.

b) Flow of air at outlet of air purifier

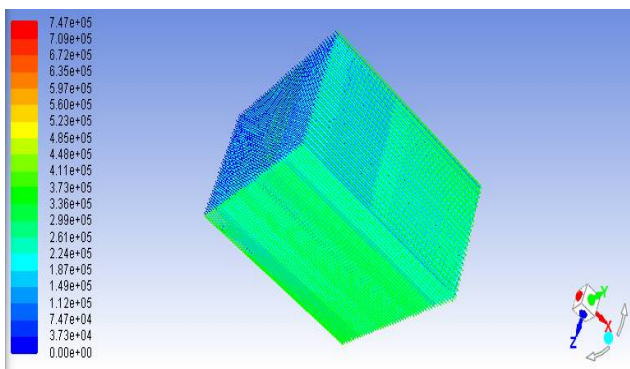


Fig 9: Flow of air at outlet of air purifier

In this flow arrangement there is a flow arrangement at outlet of air purifier in which we use to observe that after purification of air the flow of air is varying from 4.11×10^5 to 2.61×10^5 which is denoted by green colour. and while on exit portion the flow of air is also got some change, while notice after crossing the green region movement of air is suddenly decreased from 2.24×10^5 to 1.12×10^4 due to atmospheric pressure and then finally when it comes outward speed become 3.73×10^4 and then it become negligible that help to does not create any uncomfortable feeling.

c) Movement of air from inlet to outlet inside air purifier

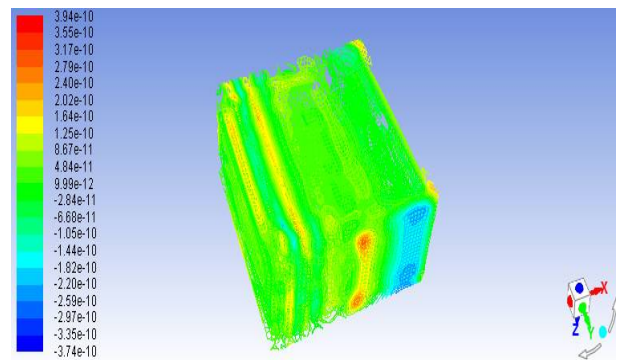


Fig 10: Movement of air from inlet to outlet inside air purifier

In this Fig it shows the movement of air inside the chamber from inlet to outlet. As the entry point the movement of air is varying from -1.05×10^{-10} to -2.20×10^{-10} as represented by blue colour. In purification process movement of air is varying from 4.84×10^{-11} to -6.68×10^{-11} as it represented by green colour. While on outlet movement is from 1.64×10^{-10} to 8.67×10^{-11} which is denoted by yellow colour. It shows that the movement of air is less while entry due to fan rotation and then slightly increased during purification and movement increased after purification but after that it will decreased slightly decreased at the outlet point.

d) Turbulence Contour inside the chamber of air purifier

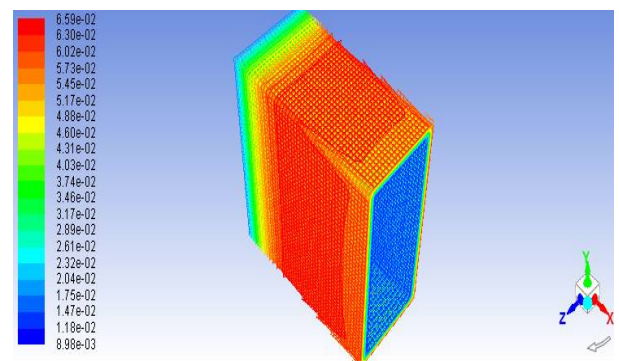


Fig 11: Turbulence contour inside the chamber of air purifier

In this Fig the Turbulence contour inside the chamber as the entry point the turbulence value is from 2.89×10^{-2} to 2.04×10^{-2} as it represented by blue line as while move forward it varies from 3.17×10^{-2} to 4.31×10^{-2} and 4.60×10^{-2} to 5.17×10^{-2} due to purification as represented by green then yellow colour after the there is red colour line which is varying from 5.45×10^{-2} to 6.59×10^{-2} as it shown by red colour. As when the air enters it strike through air fan and then hit to filter while there is not too much turbulence and after purification the turbulence is also constant as it shows there is laminar flow inside the chamber of air purifier.

e) Turbulence pathline inside the chamber of air purifier

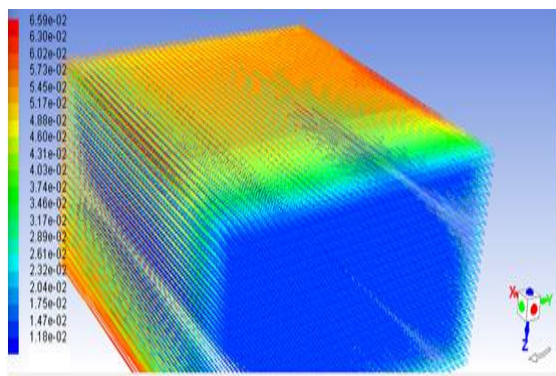


Fig 12: Turbulence pathline inside the chamber of air purifier

In this fig Turbulence pathline is represented inside the chamber, In which when the air enters through chamber the pathline is represented by red colour and the pathline does not show a straight line as range varies from 6.02×10^{-2} to 5.73×10^{-2} . When it passes through all the filters and then it moves towards the exit point the line is straight and it varies from 5.45×10^{-2} to 4.60×10^{-2} as it represented by yellow colour. At the exit portion the turbulence value 1.18×10^{-2} as in blue colour. As there is no such turbulence pathline difference from inlet to outlet, as it shows laminar flow inside the chamber of air purifier.

VI. CALCULATION

Air purifier calculation per 30 minutes

Operational time and the calculation is done for 30 minutes

(1). Mass of air in control volume
 = (mass flow entry) – (mass flow leaving)
 = $P_1 \times a_1 \times V_1 - P_2 \times a_2 \times V_2$
 = $1.225 \times 100 \times 10 - 1.225 \times 96 \times 8$
 = $1225 - 940.8$
 = 1.225 kg/m^3
 = 248.2 kg/sec

(2). Mass during 30 minutes of operations
 = mass flow x time
 = 248.2×1800
 = 446760 kg

(3). Pressure gradient
 Using Bernoulli equation

$$P_1 + \frac{\rho V_1^2}{2} = P_2 + \frac{\rho V_2^2}{2}$$

$\rho = 1.225 \text{ kg/m}^3$
 $V_1 = 10 \text{ m/s}$
 $V_2 = 18 \text{ m/s}$
 $P_1 = 1.013 \times 10^5$
 $P_2 = ?$
 $(1.013 \times 10^5 / 1.225 \times 9.81) + (10^2 / 2 \times 9.81) = (P_2 / 1.225) + (18^2 / 2 \times 9.81)$
 $(1.013 \times 10^5 / 1.225) + (100 / 2) = (P_2 / 1.225) + (324 / 2)$
 $(827 \times 10^3) + (50) = (P_2 / 1.225) + (162)$
 $(827 \times 10^3) + (50 - 162) = (P_2 / 1.225)$
 $(101170.3) = (P_2)$
 $P_2 = (1.011703 \times 10^5) \text{ pascal.}$

(4). Work done
 = $(P_1 - P_2) \times \text{mass} / \text{density}$
 = $(1.013 \times 10^5 - 1.011 \times 10^5) \times 446760 / 1.225$
 = 72940.408 kJ

(5). Power = work done / sec
 = $(72940.408 \text{ kJ} / 1800)$
 = 40522.448 W

(6). Torque
 $T = (60 \times 40522.448) / (2 \times 3.14 \times 1400)$
 = $23245.86 / 8792$
 = 276.540 N-m

VII. RESULT AND DISCUSSION

Corresponding to air best in the "suitable" variety. To convert an air pollutant concentration to an aqi, EPA has advanced a calculator. If more than one pollutants are measured at a tracking web page, then the largest or "dominant" aqi fee is pronounced for the area. The ozone aqi among one hundred and three hundred is computed with the aid of selecting the bigger of the aqi calculated with a 1-hour ozone fee and the aqi computed with the eight-hour ozone value. Eight-hour ozone averages do not define aqi values extra than three hundred; aqi values of 301 or extra are calculated with 1-hour ozone concentrations. 1-hour so2 values do not outline better aqi values extra than 2 hundred. Aqi values of 201 or greater are calculated with 24-hour SO2 concentrations.

Actual time monitoring records from continuous video display units are normally to be had as 1-hour averages. But, computation of the aqi for a few pollution calls for averaging over a couple of hours of statistics. (as an example, calculation of the ozone aqi calls for computation of an eight-hour common and computation of the pm_{2.5} or pm₁₀ aqi requires a 24-hour common.) To accurately mirror the present day air satisfactory, the multi-hour common used for the aqi computation need to be targeted on the modern time, however as concentrations of destiny hours are unknown and are hard to estimate accurately, EPS uses surrogate concentrations to estimate these multi-hour averages. For reporting the pm_{2.5}, pm₁₀ and ozone air first-class indices, this surrogate attention is called the nowcast. The nowcast is a specific kind of weighted common that offers extra weight to the maximum recent air nice facts when air pollution levels are converting.

VIII. CONCLUSION

In the above paper we discussed about different filters of an air purifier. In the ANSYS software of fluent workbench we analyse the flow of air at inlet as well as at the outlet. Here we observe that the velocity of flow at inlet and outlet is varies from 10m/s to 18m/s. Pressure at inlet will be atmospheric i.e. 1.01325×10^5 Pascal and that of outlet will be 1.011703×10^5 Pascal. We will clearly observe that the pressure at the outlet is almost same as that of inlet; hence we didn't feel uncomfortable sitting in front of our air purifier. Moreover the mass flow rate of air at control volume is 248.2 kg/sec. Also with the help of above calculation we will conclude that work done and the power output for the above process is 72940.408 kJ and 40522.448W. Torque required is 276.540 N-m.

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