International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue III, March 2018- Available at www.ijraset.com

Design and Fabrications of Dust Collector for City Buses

Dr. Nagaraju[1], Jatadhara G.S[2]
[1, 2] *(Department of Mechanical Engineering, Siddaganga Institute of Technology, Tumkur-572103*

Abstract: In modern times with increasing population, there has been tremendous need for urbanization which leads to expedited construction. The materials used in this consist of particulate matter which gets suspended in the atmosphere and depletes the quality of air. Buses being the major mode of transportation in cities, particulate matter is agitated due to the flow of vehicular traffic and thus pollutes the air and disturbs the drive of the person behind. We present a device which reduces this agitation of dust due to suction created by the pressure differential between the flat front and the rear of the bus. The use of a cyclonic filter further separates the dust and clean air. The dust separated is then stored in a storage device and disposed, giving clean and healthy air that reduces the pollution in the atmosphere. Also this system increases the efficiency of the vehicle by minimizing the drag forces and does not use any additional energy sources.
Keywords: Dust collector, Particulate matter, Venture.

I. INTRODUCTION

The dusty roads of the cities are daily cleaned by the government sweepers and the dust is collected and put on the sides of the roads, near the median or the footpath, but these are never taken out of the roads and due to the vehicular traffic, the aerosol particles get air borne and come back to the road. This depletes the quality of air and degrade the environment, to tackle this problem the RSPM (Residual Suspended Particulate Matter) needs to be eliminated from the system i.e., it has to be removed from the roads and appropriately disposed. Fig. 2 shows the graphical description of the declining air quality in Bangalore between year 2001 and year 2010. From Fig.1, it is evident that the concentration of particulate matter has shown an increasing trend. In order to control this increasing concentration, it is necessary to incorporate dust collection systems in the public transports as they ply around the city in excess and have a lot of storage space in them.

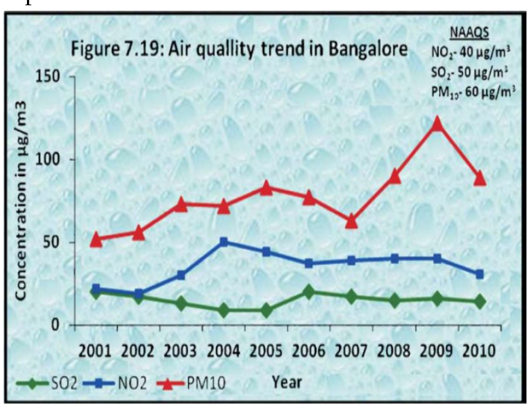

Fig. 1 Air quality trend in Bangalore (source: National ambient air quality monitoring NAAQMS/ 35 /2011-2012 www.cpcb.nic.in)

The dust which is agitated by the wheels of the vehicles also constitutes a major part of the air pollution. The dust particle along with other suspended particulate matter is alone responsible for the formation of smog. Due to formation of smog, the visibility decreases below the prescribed level which causes a lot of problems while driving and hence, leading to accidents. Also, the dust particles get collected on the leaves of the plants and trees which hamper the process of photosynthesis. Literature survey indicates that cleaning devices are effectively utilized in the industries to remove the contaminations from the air for providing safe working environment, but to our knowledge no devices are present to clean the particulate matter which gets agitated due to the flow of vehicular traffic. This designing of this dust collector system is first of its kind and it is hoped to be applied in real life. The present work aims to develop a dust collector system to collect the dust which is agitated by the rear wheels of the bus, thereby reducing the concentration of residual suspended particulate matter in the air.

II. METHODOLOGY

The first step undertaken in this present work is designing of the bus dust collector and also to select the factor of reduction, keeping in mind the actual dimensions of the bus. The dimensions of Bangalore Metropolitan Transport Corporation (BMTC) was obtained and reduced by a scale reduction factor of 20. Accordingly, the dust collector system was designed and modified (approximate dimensions). After the designing, the theoretical calculation of the dust collector was done based upon the Continuity equation and Bernoulli's equation. The 3-D model of the bus and the dust collector system was developed using the software CREO PARAMETRIC 2.0. Now, the Computational Fluid Dynamic (CFD) analysis of the developed bus model was done to obtain the pressure at various points along the body and the rear wheels of the bus. After this, the CFD analysis of the dust collector system was done and the pressure drop at the venture was monitored. It was found that the pressure at the rear wheels of the bus was lower than that at the venture which was the required condition for suction to take place. Finally, a prototype model was developed by 3-D prototyping.

III. CONSTRUCTION AND WORKING OF DUST COLLECTOR

The dust collector system will be designed as shown in Fig. 2. A venture is provided at the centre of the component. Due to the presence of the venture, the pressure will decrease and the velocity will increase. This is in accordance to the Bernoulli's Theorem. It states that an increase in the speed of the fluid occurs, simultaneously with a decrease in pressure or a decrease in the fluid's potential energy. Therefore, the pressure decreases at that region. From the center of the piping, a pipe will be connected near the rear wheels. Due to the pressure difference, suction will take place at the rear wheel area and the dust agitated by the rear wheels will be sucked through and particulates are removed from air using cyclonic filters. The Fig. 3 shows that the dust collector is to be installed at the back of the bus. The inlet of the dust collector is at the roof of the bus while the pipe from where the dust is sucked is near the rear wheel of the bus.

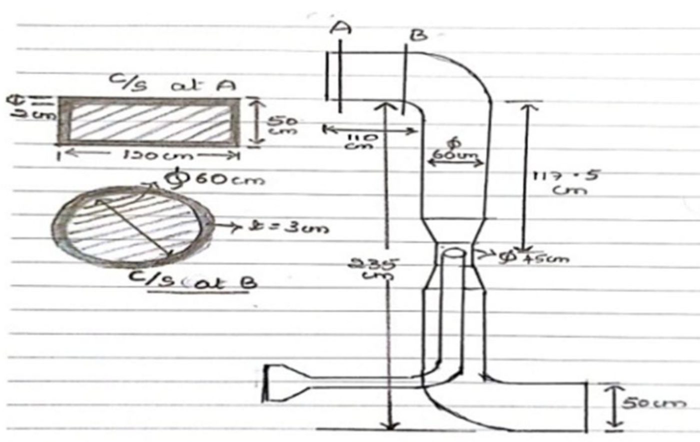

Fig 2: Schematic Diagram of Dust Collector

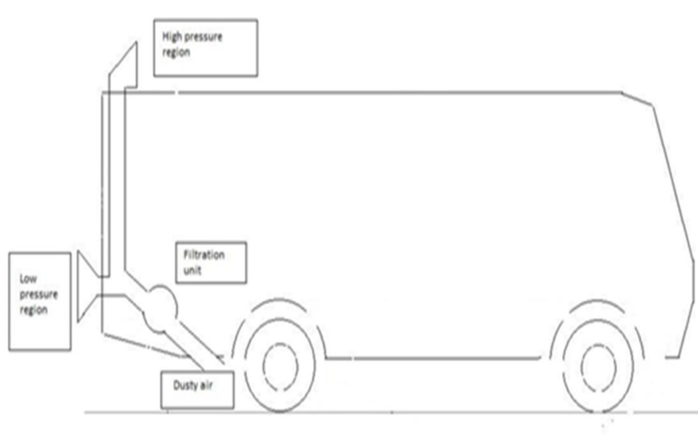

Fig 3: Installation diagram of Bus Dust Collector

A. Components of Dust Collector

1) *Piping System:* The piping system is designed to connect the high pressure region at the inlet to the low pressure region at the rear end. This is done with the help of snorkel like openings and in order to increase the low pressure effect a venture or a throat is added in between the two openings. As the throat (venture) decreases the pressure and increases the velocity of the fluid that passes through it the pressure decreases and this enhances the suction, at the opening provided as shown in the figure.
2) *Cyclonic Filter:* One of the filtration methods is cyclonic separation. Cyclonic separation is a method of removing particulates from an air, gas or liquid stream, without the use of filters, through vortex separation. Rotational effects and gravity are used to separate mixtures of solids and fluids[3].
3) *Storage System:* The basic purpose of a storage tank is to collect the dust particles and settle it in a chamber. It will be provided with a mechanism which allows it to dispose the dust when required without spreading them in the atmosphere. It does not require much space and can be accommodated at the rear end beneath the last row of passenger seat where ample space is present.

IV. DESIGN SPECIFICATIONS AND DESIGN CONSIDERATIONS OF BUS AND DUST COLLECTOR

In this present work, a piping of the dust collector is designed and developed. The inlet of the piping system will be mounted on the roof of the bus. Through the inlet of this pipe, high pressure air will enter. At the center of the piping a venture is provided. Due to this venture the air pressure will decrease in accordance to Bernoulli's Theorem. At the centre of the venture, two holes are provided which two pies will originate and go to the two rear wheels of the bus. The pressure is least near the venture. Due to the pressure difference, i.e. high pressure at the venture and low pressure at the real wheels, the dust particles will be sucked through and filtered.

A. Specifications of Bus

The buses have long coach bodies with huge flat faces facing the front and back, this results in differential pressure around the body and hence this difference can be exploited by the piping system which connects the different pressure regions to create a suction at the any desired spot. Specification of BMTC (Bangalore Metropolitan Transport Corporation) bus was collected. Using this specification a model of bus reduced to the scale of 20 is made and used of the analysis. The dimensions of the bus model are Length of bus is 9900 mm. When reduced to a factor of 20, it approximately comes to 50.08mm. Width and height of bus = 2680 mm. when reduced to a scale factor of 20 comes around 12.7mm. Fig. 2 shows, the design specifications of the dust collector when a real life model is built whereas for the CFD analysis, the dust collector specifications are reduced by a factor of 20 and important dimensions of the dust collector are listed here: Inlet: Rectangle with specifications of 50 mm X 28 mm. Circular cross section makes the construction bulky and hence, for the same cross section, rectangle will provide low height for inlet suction. Fillet Inner radius: 7.05 mm. Fillet Outer radius: 31.05 mm. Length from front till radius: 20 mm. Hole diameter: 16mm The above dimensions are approximate dimensions keeping in mind the actual bus dimensions. It might not be accurate when enlarged by a factor of 20. If not, then it will be adjusted accordingly. Bend angle of outlet: 20º. The angle is taken so that the air coming out will not flow in front of the vehicles behind.

B. Design Considerations

1) The air which is sucked moves through the piping system and exits at the rear of bus hitting the vehicles coming from behind. Therefore, the exit passage should be diverted such as to hit the ground or blow up, else it would cause disturbance to the two wheeler riders and may lead to accidents
2) Another important consideration is that the ground clearance should not be disturbed due to the suction funnel near the rear wheels of bus. Moreover it should not hit the ground while crossing bumps.
3) Large circular cross section of piping makes the construction bulky. For the same cross section area rectangular cross sections will provide low height for inlet suction. Piping System experiences large forces due to vehicle speed and requires heavy fixtures
4) Agitated dust is collected from the rear wheels. If collected individually from both wheels, maximum amount of dust particles can be collected.

V. COMPUTATIONAL FLUID ANALYSIS (CFD) OF BUS AND DUST COLLECTOR

Through CFD analysis, the pressure at various points on the body of the bus and the dust collector system are monitored and analyzed.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue III, March 2018- Available at www.ijraset.com

A. CFD Analysis of Bus At 30 Km/h

X min	-0.120 m
X max	0.120 m
Y min	-0.400 m
Y max	0.400 m
Z min	-0.120 m
Z max	0.120 m

Table 1: Boundary Conditions of bus model

Thermodynamic parameters	Static Pressure: 101325.00 Pa Temperature: 303.00 K
Velocity parameters	Velocity vector Velocity in X direction: 0 km/h Velocity in Y direction: 30.000 km/h Velocity in Z direction: 0 km/h
Turbulence parameters	Turbulence intensity and length Intensity: 0.10 % Length: 0.001 m

Table 2: Ambient Conditions of bus model

Coordinate system	Global coordinate system
Reference axis	X
Heat transfer coefficient	237.000 W/m^2/K
Fluid temperature	293.20 K
Wall temperature	293.20 K

Table 3: Initial Condition of bus model

Number of cells in X	20
Number of cells in Y	62
Number of cells in Z	20

Table 4: Basic Mesh Dimensions of bus model

Total cells	25248
Fluid cells	18734
Solid cells	4180
Partial cells	2334
Irregular cells	0
Trimmed cells	0

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue III, March 2018- Available at www.ijraset.com

Table 5: Number of Cells of bus model

Name	Minimum	Maximum
Pressure [Pa]	101296.82	101375.23
Temperature [K]	302.99	303.04
Density (Fluid) [kg/m^3]	1.16	1.17
Velocity [km/h]	0	34.736
Velocity (X) [km/h]	-22.779	23.470
Velocity (Y) [km/h]	-14.056	32.339
Velocity (Z) [km/h]	-23.355	23.570
Temperature (Fluid) [K]	302.99	303.04
Mach Number [ ]	0	0.03
Vorticity [1/s]	0.167	516.192
Shear Stress [Pa]	0	0.64
Relative Pressure [Pa]	-28.18	50.23
Heat Transfer Coefficient [W/m^2/K]	0	0
Surface Heat Flux [W/m^2]	0	0

Table 6: Min/Max Table of bus model

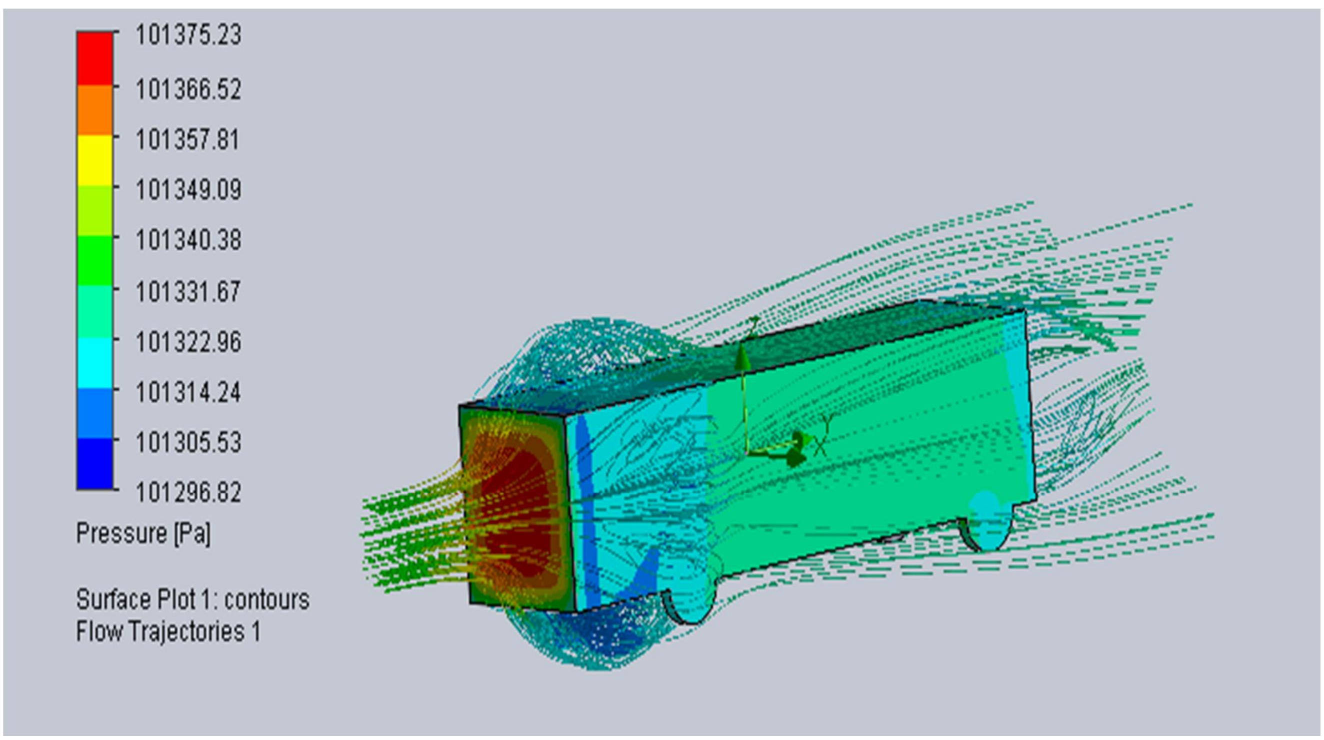

Fig 4: CFD of Bus (at 30km/h)

The Fig. 4 shows the CFD analysis of the bus travelling at 30km/h. From the above analysis it is clear that the pressure at front end of the bus is relatively higher than the rear end which is clear by the color difference on the surface of the bus. The rear wheel of the bus from where the suction is occurred is at lowest pressure. In this region the stream lines are whirling with pressure at a value of 101296.82 Pa

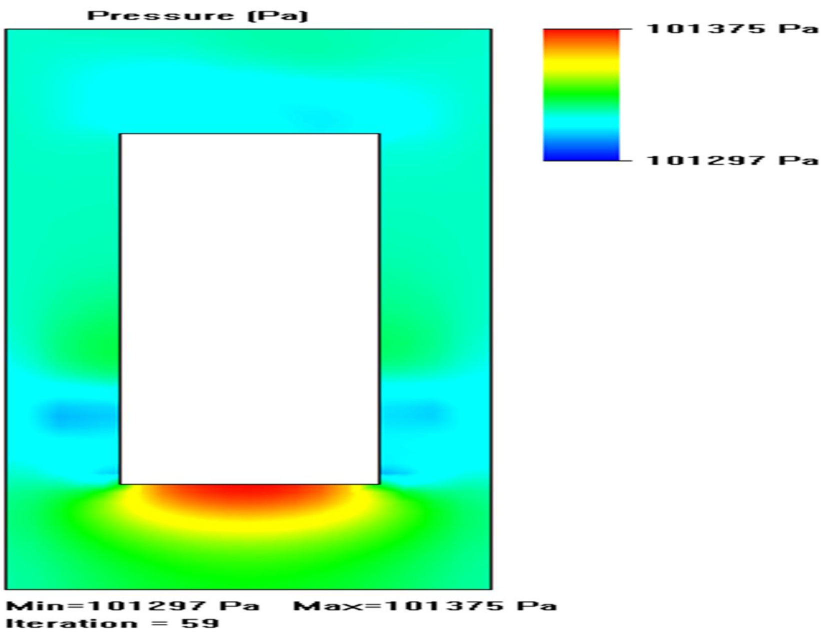

Fig 5: Pressure distribution on Top View of Bu

X min	-0.020 m
X max	0.020 m
Y min	-0.035 m
Y max	0.035 m
Z min	-0.088 m
Z max	0.088 m

Table 7: Boundary Condition of dust collector

Number of cells in X	10
Number of cells in Y	18
Number of cells in Z	48

Table 8: Basic Mesh Dimensions of dust collector

Thermodynamic parameters	Static Pressure: 101325.00 Pa Temperature: 293.20 K
Velocity parameters	Velocity vector Velocity in X direction: 0 km/h Velocity in Y direction: 30 km/h Velocity in Z direction: 0 km/h
Turbulence parameters	Turbulence intensity and length Intensity: 2.00 % Length: 4.200e-004 m

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue III, March 2018- Available at www.ijraset.com

Table 9: Initial Conditions of dust collector

Name	Minimum	Maximum
Pressure [Pa]	100172.68	103599.37
Temperature [K]	292.39	293.22
Density (Fluid) [kg/m^3]	2.39	2.47
Velocity [km/h]	0	165.477
Velocity (X) [km/h]	-50.570	50.978
Velocity (Y) [km/h]	-67.917	121.662
Velocity (Z) [km/h]	-163.182	49.304
Temperature (Fluid) [K]	292.39	293.22
Mach Number [ ]	0	0.21
Vorticity [1/s]	6.014	19176.139
Dynamic Pressure [Pa]	0	2545.19
Shear Stress [Pa]	0	23.48
Relative Pressure [Pa]	-1152.32	2274.37
Heat Transfer Coefficient [W/m^2/K]	0	0
Surface Heat Flux [W/m^2]	0	0

Table 10: Min/Max Table of dust collector

B. CFD Analysis of Dust Collector At 30 Km/H

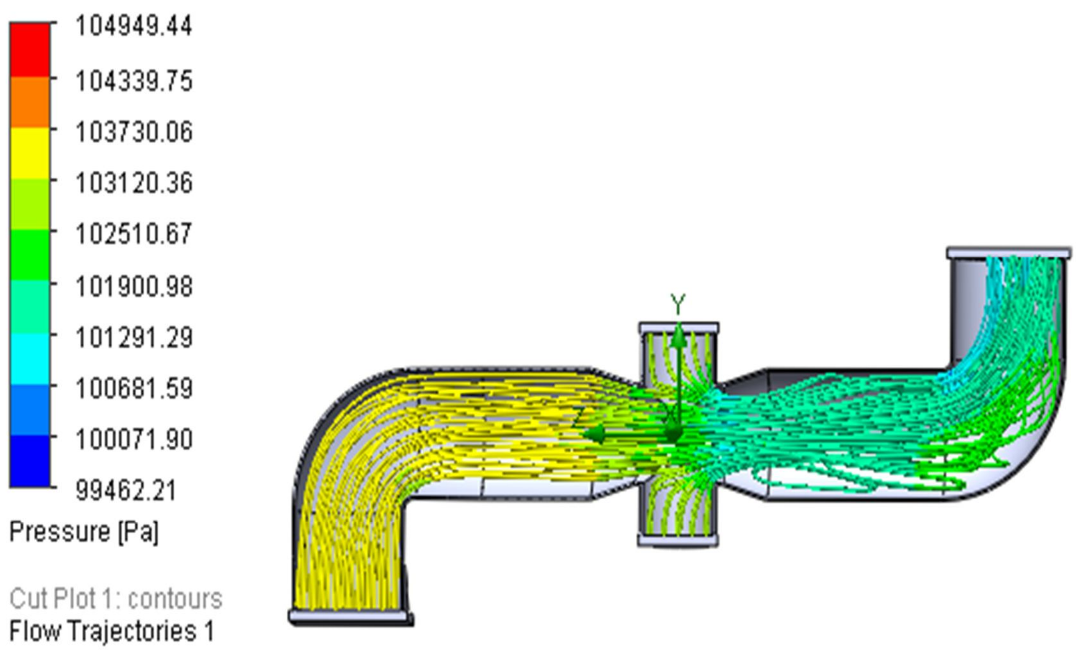

Fig 6: CFD of Dust Collector (at 30km/h)

The Fig 6 shows the CFD analysis of the dust collector system in which the air is travelling at 30 km/h. It is clear from the figure that air enters to the dust collector at high pressure (yellow color stream lines), i.e. 103730.06 Pa, and reduces at the venture where the color change in stream line shows the reduction in pressure to 101291.29 Pa.

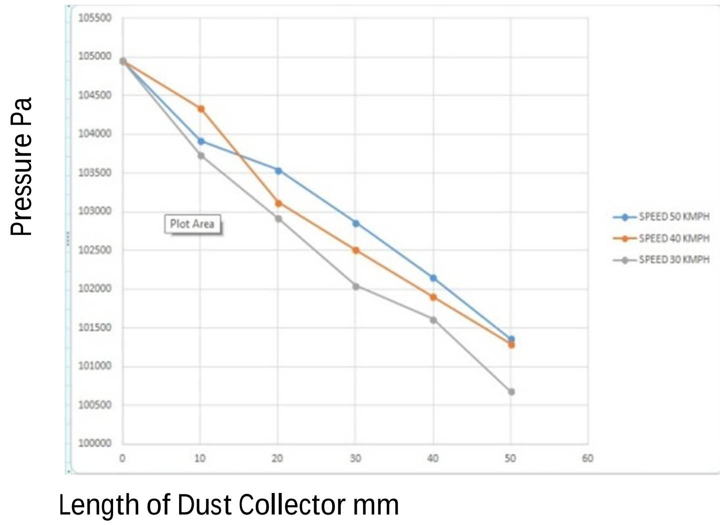

Fig 7: Variation of pressure along the length of Dust Collector

The above figure shows the variation of pressure along the length of dust collection and it signifies that with increase in length of dust collector the pressure decreases takes place.

VI. RESULT AND DISCUSSION

The dust collector consists of a venture at the centre. The purpose of the venture is to drop the pressure at the centre of the dust collector. By theoretical calculations, it is found that there is a decrease in pressure in the venture section of the dust collector which is used to collect the dust from the rear wheel of the bus. Further the CFD analysis of the reduced scale model shows that, the pressure at the inlet of the dust collector is maximum and the pressure near the rear wheels is lower than rear end of the bus but higher than that at venture. The pressure at the venture section of the dust collector is less than the pressure at the rear ends of the wheel.

The pressure at the rear wheels of the bus is analyzed to be 101288.9 Pa and the pressure at the venture is found to be 100681.59 Pa. Therefore, the pressure at the rear wheels of the bus is higher than that at the venture section of the dust collector. This difference in pressure is hence proved, which the required condition for suction is. Therefore this suction is used to collect the dust particle agitated from the rear wheels of the bus. The accuracy of the analysis can further be compared by the wind tunnel test on the prototype model. By the wind tunnel testing, it can be seen that the designing and development of the dust collector model has been done as per the requirement.

The difference in pressure around the body of the bus is exploited by a piping system which connects the different pressure regions to create suction at the rear wheels. This suction pressure is used to suck in the particulate matter which can then be filtered, collected, stored and properly disposed.

VII. CONCLUSION

The overall purpose of the project is to reduce the RSPM level in the atmosphere which causes numerous lung diseases. The dust particles present on the road are very dangerous and harmful. One of the most common problems in developing cities like Bangalore and Delhi are the rising levels of dust particles on the road which exceed the national permissible limit by 283%. In the present work, dust collector for city buses to collect the particulate matter that gets agitated due to running vehicles is designed. The computational fluid dynamic (CFD)

analysis of the bus shows the pressure difference around the body of the bus at different speeds and the computational fluid dynamic (CFD) analysis of the dust collector shows the pressure at the inlet and the venture. The analysis shows that the pressure near the rear wheels is higher than the pressure at the venture and due to this pressure difference, suction takes place. After the result of the analysis, dust collector model to the reduced scale using 3-D prototyping was fabricated and also fabrication of bus model to the reduced scale using wooden planks is done

VIII. ACKNOWLEDGEMENT

This work is supported by Siddaganga Institute of Technology(SIT), Tumkur and authors are grateful to Dr. M N Channabasappa, Director and Dr. Shivakumariah, Principal, SIT, Tumkur for their encouragement

. REFERENCES

[1] National ambient air quality monitoring NAAQMS/ 35 /2011-201
[2] Rosentrater KA. Laboratory analysis of an electrostatic dust collection system. Agricultural Engineering International: CIGR Journal. 2004 Apr 1.
[3] White FM. Fluid mechanics. 5th. Boston: McGraw-Hill Book Company. 2003