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NUMERICAL ANALYSIS OF VOLATILE ORGANIC COMPOUNDS CONCENTRATION IN A C SEGMNET VEHICLE INTERIOR – DIESEL ENGINE EXHOUST POLLUTION

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Abstract

In large cities the number of inhabitants constantly increases. It is caused by economic issues. The ever-growing populations causes more intense traffic and in consequence increase of air pollutions. Topology and roads configuration is conducive to the accumulation of toxic substances.

Harmful substances accumulates inside the vehicles interiors which significantly deteriorate microclimate within the cabin. The study aimed to determine the amount of harmful substances getting into the interior of vehicles and their distribution have been presented in this paper.

Keywords: *Computational Fluid Dynamics (CFD), Volatile Organic Compounds (VOCs), Diesel Engine*

Introduction

The amount of harmful substances in cities increases with the number of inhabitants. The increasing number of inhabitants promotes the formation of congestion on the roads. Standing vehicles produce fumes that accumulate between the buildings [1,2]. Hatful substances accumulate in the interior of vehicles which significantly impairs the microclimate in the cabin [3,4].

During long time spent in traffic the driver and passengers may experience headache, fatigue etc. Basing on the literature knowledge it can be stated that volatile organic compounds are aspirated to a car standing in a traffic. Moreover its concertation increases with time [5,6].

In order to identify the number and types of substances originating from the exhaust of the vehicle with CI engine the exhaust gases collection tests were carried out. The gas composition has been determined by means of (MS) chromatograph. The concentration of the gas within the car cabin of C segment was determined with aid of computational fluid dynamics (CFD).

Methodology

In order to determine the composition of the exhaust gas from a CI engine a gas samples have been collected. Volatile organic compounds was sediment on an active carbon. Sampling took place directly from the exhaust pipe with engine running at idle. The flow through the sample (activated carbon) was forced by aspirator ASP II.

The exhaust gases were additionally directed through a scrubber in order to condensate water vapor. The samples collection last for 30 min. during the process of engine worm up. The volumetric flow of the exhaust gases was set in every case to 30l/h. The whole system of exhaust gas acquisition along the tested drive system is shown in Fig 2.

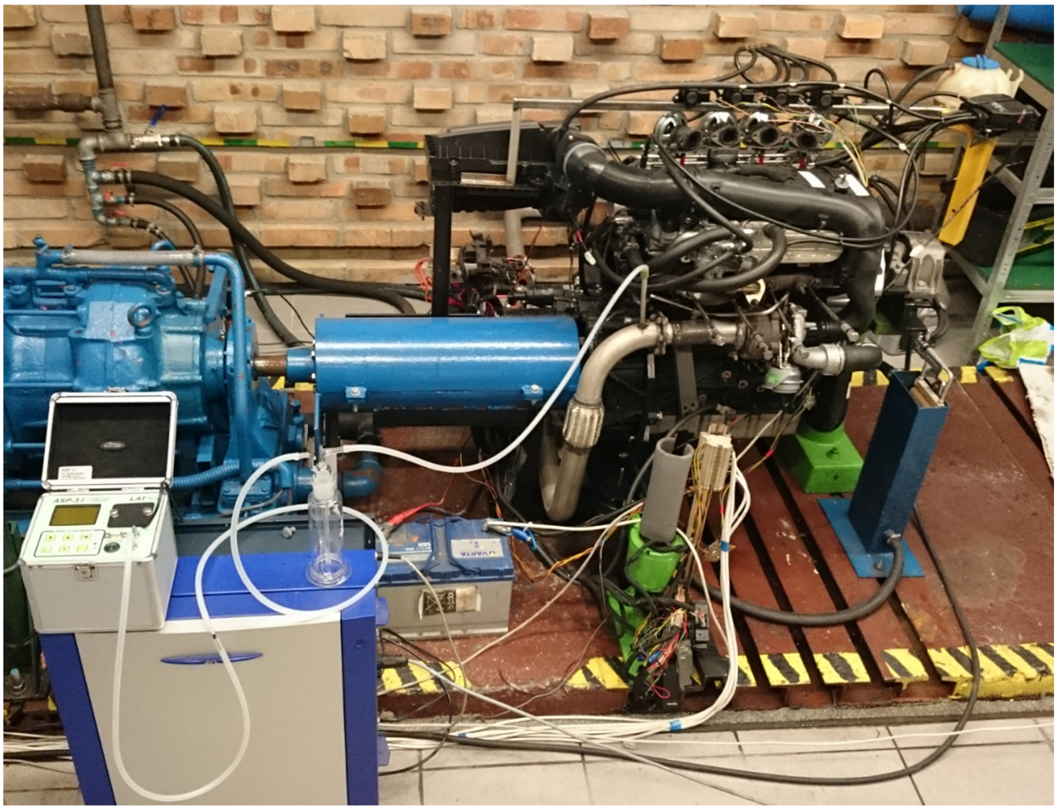

Fig. 1 Measurement system of exhaust compound concentration from Diesel Engine

A chromatograph analysis revealed the ingredients of the exhaust gas mixture. The concentration of particular ingredients is shown in Table 1.

Tabele. 1 Identified VOCs concentration in tested vehicle interior

	%vol.
n-pentan	0,000023
2-propanol	0,000050
benzen	0,000025
toluen	0,000003
1-butanol	0,000004
kumen	0,000001
p-cymen	0,000003

By the simulation was defined microclimate in the cabin. Geometry of tested interior is showed below in the figure 2. Cross-section of vehicle interior is showing in the figure 3.

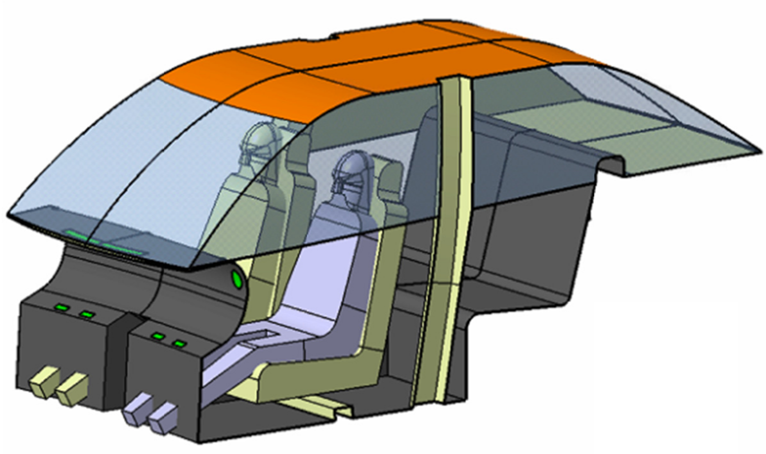

Fig. 2 Vehicle geometry

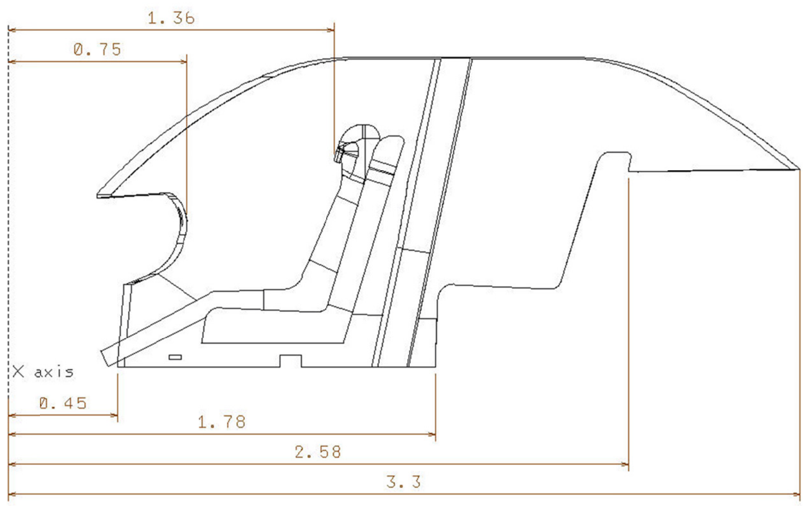

Fig. 3 Dimension of vehicle

Discretization of model was made in Ansys ICEM. Numerical mesh was based on the tetra elements. Simulation was made in Ansys Fluent software. In the simulation k-ε turbulent model was used and Eulerian model for VOCs multi-flow solution. Velocity of air flow from ventilation nozzle in different settings was measured by aerometer in the lowest flow rate. Results are visible in the table 2. In the figure 4 shows position of nozzles and outflow used in the simulation.

Table. 2 Velocity of flow inlet to the cabin

No.	**Inlet velocity**	
1	Front window nozzle (1)	1,85 m/s
	Side window nozzle (2)	2,00 m/s
2	Central middle nozzle (3)	1,60 m/s
	Side middle nozzle (4)	2,40 m/s
3	Front legs nozzle (5)	2,70 m/s
	Front legs side nozzle (6)	1,55 m/s
	Rear legs nozzle (7)	0,50 m/s

Fig. 4 Position of nozzles inlet and outlets

Research and discussion

Results achieved in simulations are presented below. In the figures 5 – 7 are the pic stream lines of velocity influence to the cabin in the other ventilation system sets.

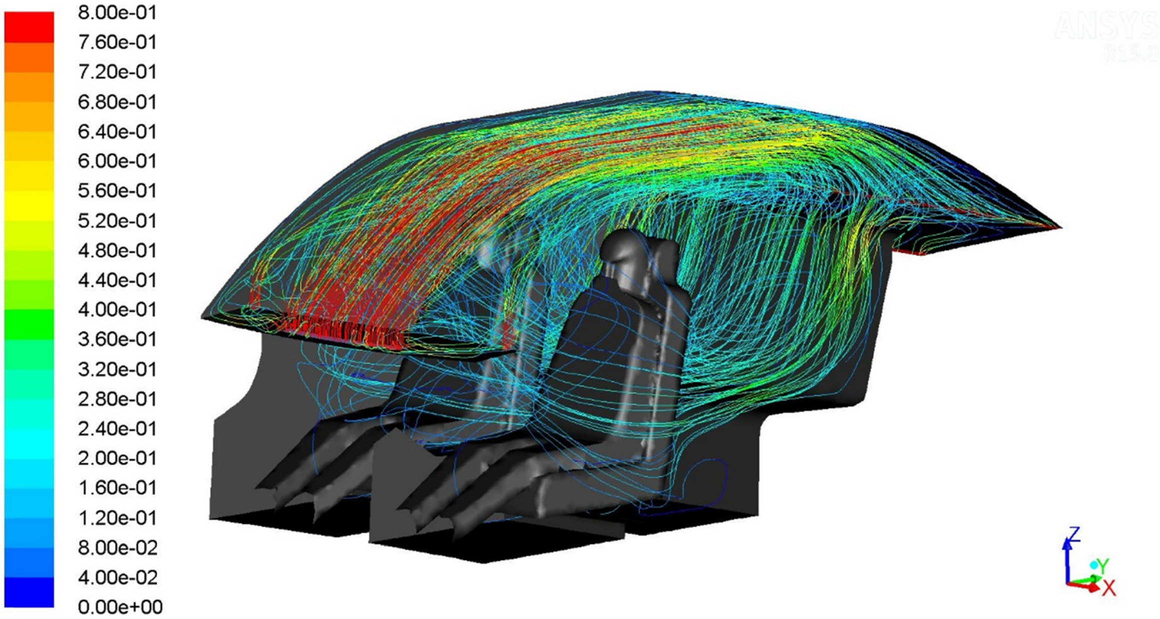

Fig. 5 Stream lines of velocity, m/s, front and side window vent (No. 1 from table 2)

In the figure 5 is presented stream lines of velocity in the ventilation system set in the position no. 1 (front and side windows set). Stream of air flow is directed by front window to the rear part of the cabin where outflows are placed. Small portion of air is directed between front and rear sits.

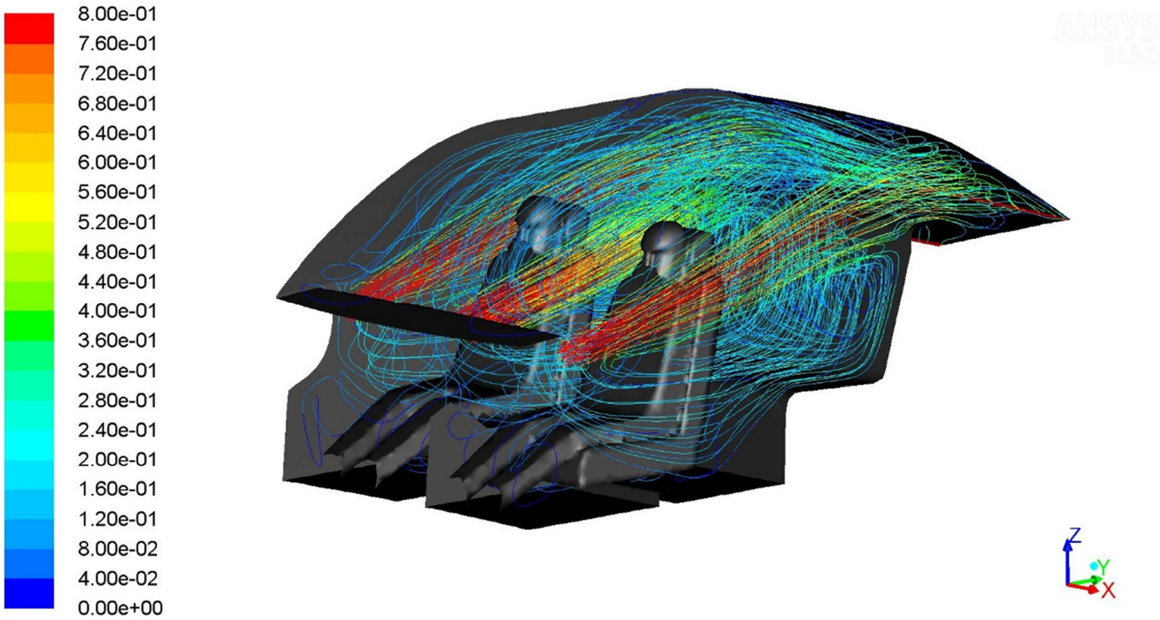

Fig. 6 Stream lines of velocity, m/s, central and side middle vent(No. 2 from table 2)

Figure 6 shows stream lines of velocity in the ventilation system set in the middle position – central and side middle nozzle set (position no. 2). Nozzles are settle down perpendicular to the dashboard surface what is caused that stream of air is directed between front sits – air flow is not directed directly to the driver head space.

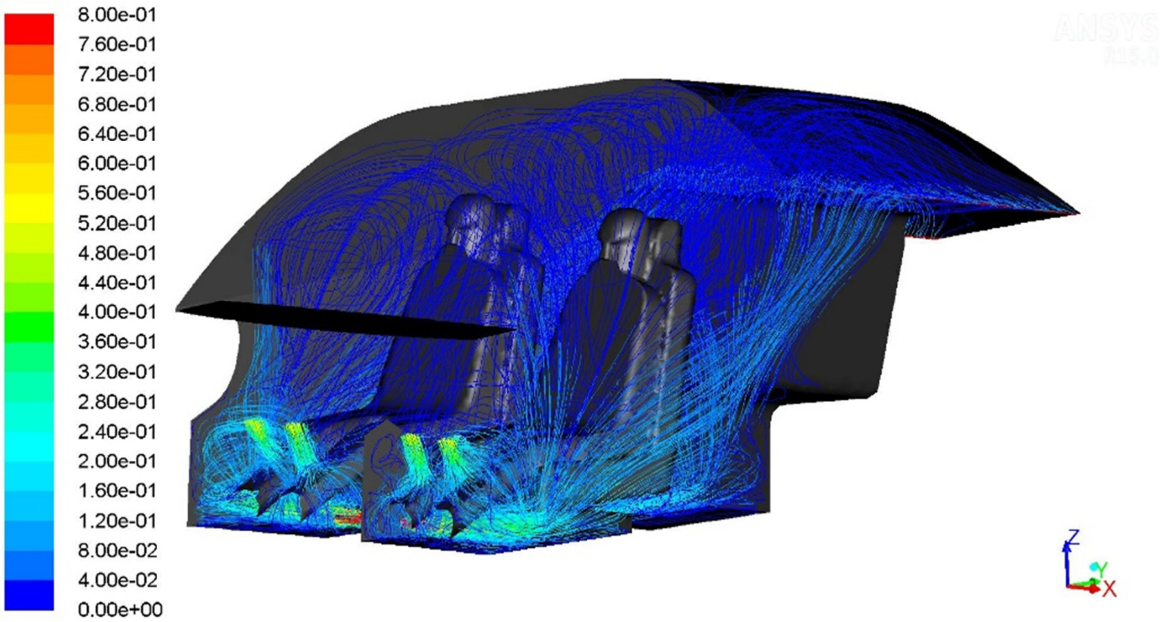

Fig. 7 Stream lines of velocity, m/s, front and rear bottom vent (No. 3 from table 2)

Stream lines of air visible in the figure 7 shows stream lines of velocity in the no. 3 position ventilation system set (Legs nozzle are powered by air). Measured value of velocity in the outflow of leg nozzles is lower than in the other cases. It is caused that in the leg nozzle set area of outflow nozzle is bigger what is related to the summary velocity.

Air flow which is contained pollutions is directed by cabin flour to the top of cabin what is caused that indoor is visible much more circulation of air. Air is circulated in side much more longer than in the previous cases. It is possible that in that ventilation set will be copulation effect appeared.

In the figures 8 to 10 was TVOC concentration (%vol) in driver seats cross - section of cabin showed. (cross- section showed in the figure rys.3).

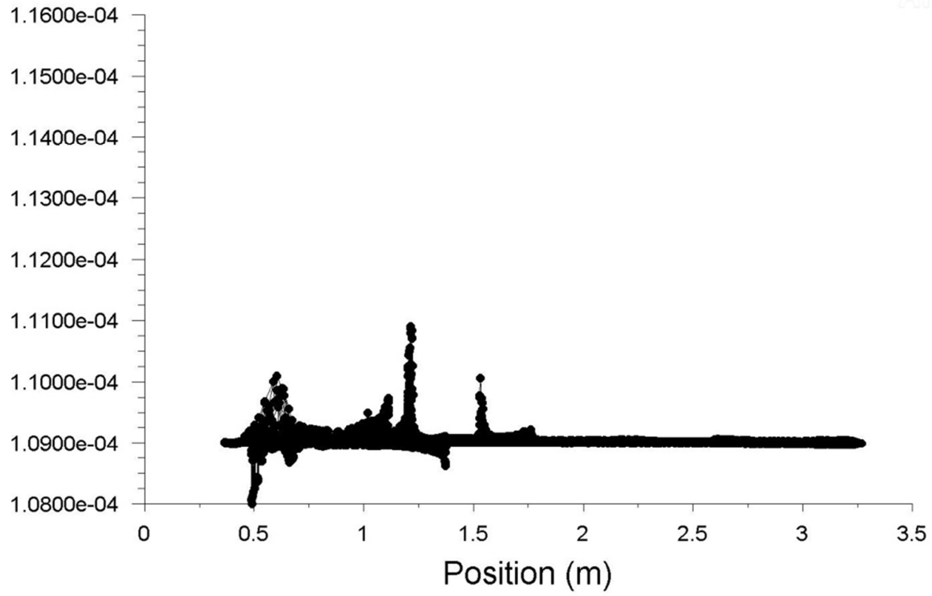

Fig. 8 TVOCs concentration, % on driver position cross-section (No. 1 from table 2)

In the figure 8 TVOCs concentration of TVOCs in the ventilation system set in position no. 1 was showed. Maximum concentration is appeared directly in the driver head position and is equal about 0.000111%vol.

Behind front seat concentration of TVOC is lower and in the stabled level – it is oscillating within about 0.000109 %vol.

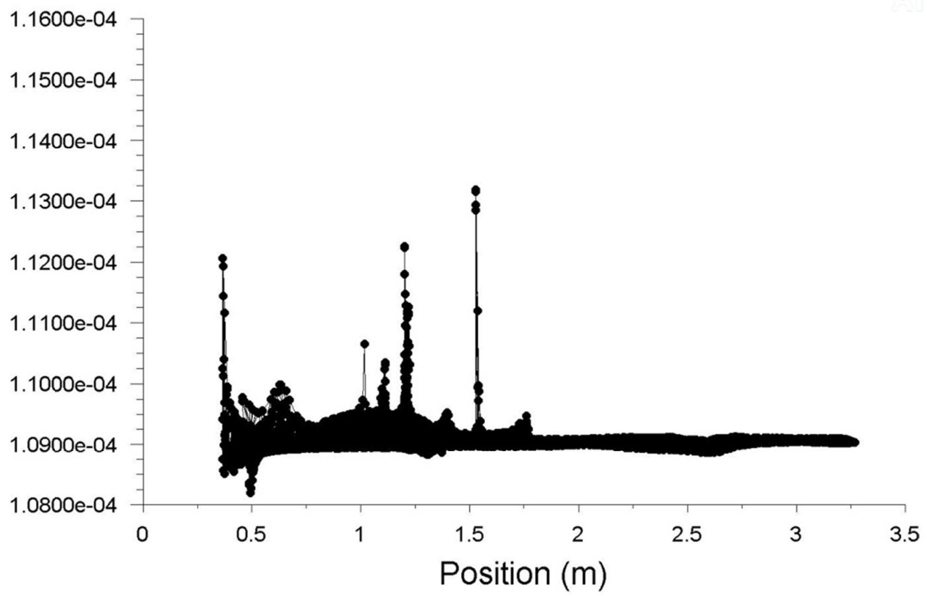

Fig. 9 TVOCs concentration, % on driver position cross-section (No. 2 from table 2)

In the ventilation system set in the no. 2 position, maximum concentration of TVOC in the vehicle indoor is bigger than in the previous case (front and side window nozzles powered) and it is equal round 0.000114 %vol in the driver head space and behind his seat what is presented in the figure 9. In the rear seat area concentration of TVOC such as in the previous ventilation seat is constant about 0.000109 %vol.

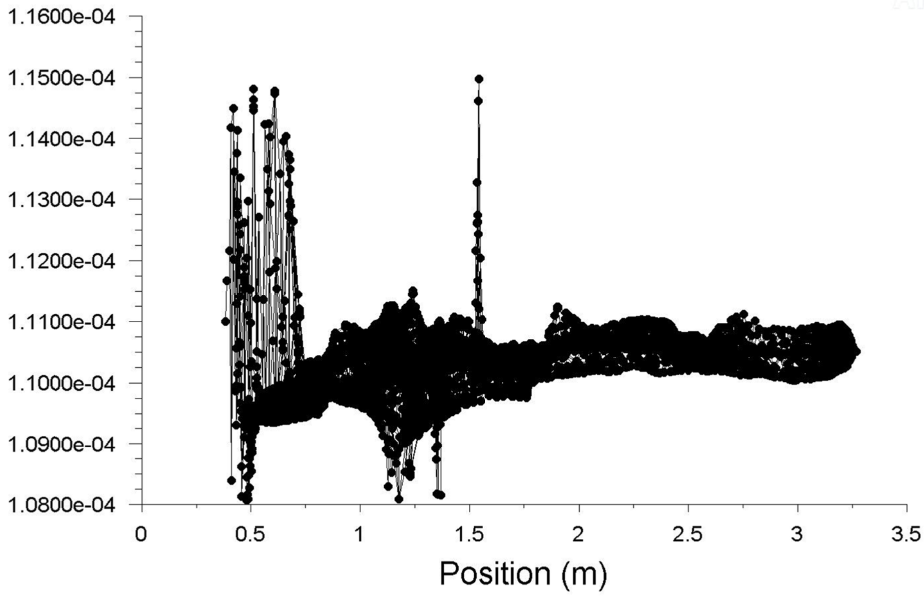

Fig. 10 TVOCs concentration, % on driver position cross-section (No. 3 from table 2)

In the figure 10 is presented concentration of TVOCs in the ventilation system seat in position no. 3 (legs nozzle powered). In that setup concentration of pollutions is the biggest around 0.00015 %vol. The biggest concentration in the space between dashboard and front window is visible and in the driver heads space. In the whale cross-section of vehicle concentration is bigger than in previous ventilation system sets.

4. Summary and conclusions

It is enable to simulate indoor concentration of TVOCs in the vehicle cabin by using Computational Fluid Dynamics in the different ventilation system sets.

After simulation is possible to indicate convenient settings of vehicle ventilation system for human health. When ventilation system will be set in front and side window position then in the cabin of vehicle concentration will be the lowest and the most benefit for humane health.

The worst ventilation system set is when legs nozzles are powered. Air flow from nozzle is reflected from flor surface and then is circulating around the vehicle indoor in small velocity. Circulation in that case is difficult.

Modern trends in automotive should focused on the systems which are able to improve quality of indoor air.

5. Acknowledgment

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