Effects of Fuel Type and Fuel Delivery System on Pollutant Emissions of Pride and Samand Vehicles

Akbar Sarhadi[1], Mitra Mohammadi[2], Mandana Mohammadi[3]*

1) Kheradgerayan Motahar Institute of Higher education,Mashhad, Iran
2) Kheradgerayan Motahar Institute of Higher education, Mashhad, Iran
3) Ferdowsi University of Mashhad., Mashhad, Iran

** Author for Correspondence:* mitramohammadi@gmail.com

Received: 06 Oct. 2016, Revised: 08 Jan. 2017, Accepted: 18 Jan. 2017

ABSTRACT

This research was aimed to study the effect of the type of fuel delivery system (petrol, dedicated or bifuel), the type of consumed fuel (petrol or gas), the portion of consumed fuel and also the duration of dual-fuelling in producing carbon monoxide, carbon dioxide and unburned hydrocarbons from Pride and Samand. According to research objectives, data gathering from 2000 vehicles has been done by visiting Hafiz Vehicle Inspection Center every day for 2 months. The results of this survey indicated that although there is no significant difference between various fuel delivery systems in terms of producing the carbon monoxide, carbon dioxide and unburned hydrocarbons by Samand, considering the emission amount of carbon dioxide, the engine performance of Pride in bifuel and dedicated state in GTXI and 132 types is more unsatisfactory than that of petrol state by 0.3 and 0.4%, respectively. On the other hand, consuming natural gas increases the amount of carbon monoxide emission in dual- fuel Pride by 0.18% and decreases that in dual-fuel Samand by 1.2%, which signifies the better design of Samand in terms of fuel pumps, used kit type and other engine parts to use this alternative fuel compared to Pride. Since the portion of consumed fuel and also duration of dual-fuelling does not have a significant effect on the amount of output pollutants from the studied vehicles, it can be claimed that the output substances from the vehicle exhaust are more related to the vehicle's condition than the fuel type.

Key words: Air Pollution, Fuel Delivery System, Consumed Fuel, Dual-Fuel Duration, Pride, Samand

List of abbreviations

Carbon monoxide	CO
Carbon dioxide	CO_2
Hydrocarbon	HC
Oxygen	O_2
Compressed natural gas	CNG
Adsorbed natural gas	ANG
Liquefied natural gas	LNG

INTRODUCTION

The air pollution is one of the most important issues which not only threaten human health, but also have very unpleasant effects on all environmental factors. In human, it affects lungs performance, intensifies Asthma and can cause cardiovascular diseases, bronchitis, etc., and increases death risk caused by respiratory diseases [1,2]. Based on the researches, among the role of vehicles in creating air pollution which is %85-90 [3,4], the utmost effect is by the light vehicles which include more than %72 of metropolitan pollution [5]. This can be the result of indiscriminate increase in number of vehicles, increasing intra-town trips, inappropriate public transportation conditions and the absence of the how-to-use culture, vehicles type and their low quality, wrong way of driving, vehicle burnout, the type of consumed fuel and its low quality and inappropriate traffic management [6,7]. Nowadays, the world is going incredibly fast toward manufacturing the eco-friendly knowledge and technologies, in a way that using the new energies, producing the clean fuels for replacing with the fossil fuels and manufacturing the clean vehicles is one of the most important axes which helps the environmental issues [8]. Among the effective strategies in reduce the environmental pollution caused by the vehicles we can refer to improving the inspection of repairs, fuel adjustments such as regulating petrol and gasoline (the air combination ratio), modern design and the access to

the fuels with low consumption and low pollution, and shifting toward the alternative fuels. Although among the available solutions, using alternative fuels specially the compressed natural gas (CNG) seems to be more practical.

Nowadays, the CNG application is one of the most important solutions for reducing the air pollution in cities, decreasing the greenhouse gases and exhaust pollutants caused by combustion in the vehicle such as suspended particles, SO2 and the Toxins. Iran tries to replace this fuel instead of petrol and gasoline by encouraging policies such as dedicating subsidies as it has the second rank in natural gas resources worldwide [9]. Compressed natural gas is an appropriate fuel for combustion engines because of its high octane number (about 130) which can increase the pressure ratio in engine and cause to the more efficient.

According to the recent studies in USA, the gas buses produce more greenhouse gases than diesel buses. By the way, the suspended particles produce in gas engines are %75 less than the diesel engines. In comparison to the diesel fuel, this kind of fuel can reduce the amount of CO up to %84, NOx up to %48 and suspended particles up to %97 in USA. In order to reduce the air pollution, CNG fuel is used in Mexico's transportation as well. Its average reduction in vehicles and taxis was %88 for CO, %91 for non-methane hydrocarbons and %40 for NOx, while there is % 13 increases in general hydrocarbon emission which includes methane. On the average, the Ozone formation resulting from the emission of vehicle exhaust gases with CNG fuel is 2 or 3 times less than the petrol vehicles [10,11]. According to the researches in Iran, it is concluded that the CO, CO_2 and HC pollutants emission in petrol vehicles is respectively 64.9, 293.5 and 0.78 Km/gr more than dual-fuel vehicles. This is despite the fact that the emission of NOx pollutant in dual-fuel vehicles is 7.42 Km/gr more than petrol vehicles [9]. The Air Quality Monitoring Organization has also reported that the PM10, CO, NOx and SO_2 emission coefficient caused by petrol consuming is 10.11, 311.6, 10.95 and 1.3 g/L and by gas consuming is 2, 0.29, 3, and 0.4 [12].

But what should be considered is whether all the available vehicles in Iran are suitable for using compressed natural gases. Hence, this research has been done for the first time as a field research (in Vehicle Inspection Center) about the vehicles to evaluate the amount of carbon monoxide, carbon dioxide and unburned hydrocarbons production by various fuel delivery systems in Samand and Pride as the most popular cars in Iran and also to study the effect of consumed fuel type and other effective factors such as the duration of being dual-fuel and the portion of consumed fuel on the mentioned vehicles performance in Mashhad during the manufacturing years 2007-2010.

MATERIALS AND METHODS

This research has been done to evaluate the effect of the fuel delivery system type (petrol, dedicated and bifuel), the consumed fuel type (petrol or gasoline), the portion of consumed fuel and also the duration being dual-fuel in producing carbon monoxide, carbon dioxide, and unburned hydrocarbons by Pride equipped by Four Stroke gasoline engine and Samand with XU7JPL3 engine during the manufacturing years 2007-2010.

Petrol fuel delivery system is a vehicle that its engine can only work with petrol, while the vehicles that can use both petrol and natural gas are called dedicated vehicles. There is also another category that is designed to work with petrol, but the owners have done some changes on engine parts such as fuel delivery system and cooling system in workshops and make them able to use the natural gas, these vehicles are called bifuel [13].

Another comparison has also been done to examine the effect of the type of consumed fuel between the amount of exhaust pollutant from a petrol vehicle which can only use petrol and gas based vehicle that uses gas as the fuel.

There has been another comparison between bifuel vehicles which mainly use petrol with the ones that mainly use gas as well. Moreover, a comparison between the dual-fuel vehicles with different dual-fuel duration has been done in order to evaluate the effect of duration of being dual-fuel on the engine performance and its lifetime.

For this purpose and according to the research objectives, collecting data from 2000 vehicles have been done by visiting Hafiz Vehicle Inspection Center (Next to Waste Management Organization, Hafiz Sq., Mashhad, Iran) every day for 2 months from 20/04/2016 to 21/06/2016 (7:30 AM- 4:00 PM). After preparing the requirements to work with Motor Gas Tester device (MGT5) made in Germany, in order to analysis the HC, CO and CO_2 as the air pollutants emission by the mentioned vehicles as well as O_2 gas, a flexible probe was placed inside the exhaust while the vehicle was idle, and the measured amounts was manually written in a table. Furthermore, the evaluation on the pollutant emission amount by dual-fuel vehicles in both petrol and gas state has been done.

Finally, the analysis was done by statistical software SPSS (20^{th} version) after data collection. Independent Sample T Test, Analysis of Variance (ANOVA) and Duncan test ($P<0.05$) was used in order to compare

the average test data. Microsoft Excel was used for drawing the charts.

RESULTS AND DISCUSSION

Comparing the amount of output gases from petrol, dedicated and bifuel fuel delivery systems during 2007-2010

Figures 1 to 4 show the amount of output gas (O2, CO_2, Co and HC) from different Pride types with petrol, dedicated and bifuel fuel delivery systems during 2007-2010. The results of the study indicated that there is no significant difference between the fuel delivery systems in Pride 141 in terms of the amount of exhaust gases (Figs. 1 to 4). While it would not apply for other Pride types and the emission amount of CO_2 among various fuel delivery systems showed significant difference in GTXI and 132 types and the main output was from the petrol fuel delivery system (Fig. 3). Since least oxygen output in GTXI Pride type was from the petrol fuel delivery system and due to oxygen role in vehicle combustion mechanism type (incomplete or complete), we can claim that the fuel combustion in petrol Pride is complete (Fig. 4).

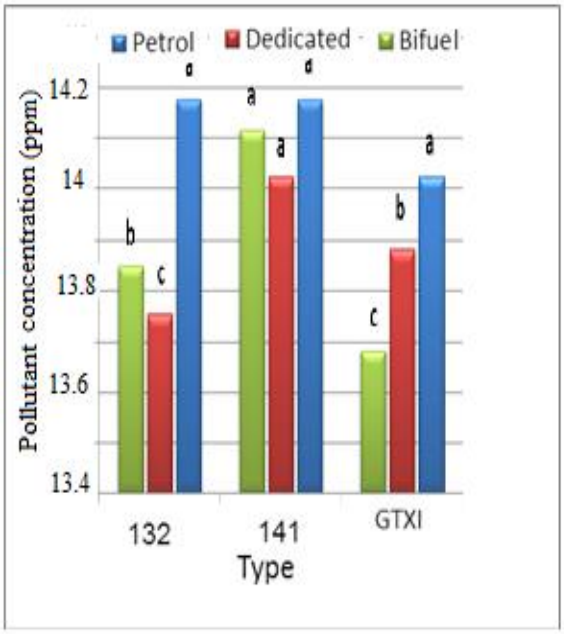

Fig. 1: The amount of hydrocarbon production by different types of Pride with Petrol, dedicated, and bifuel fuel delivery systems (Mean data accompanied by different letters are significantly different according to Duncan's Multiple Range Test, p<0.05) (*i.e.* a and a = not significantly different; a=maximum amount of pollutant production)

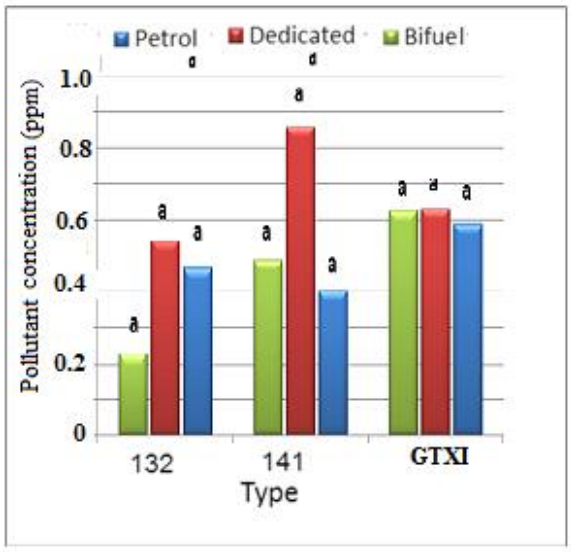

Fig.2: The amount of carbon monoxide production by different types of Pride with Petrol, dedicated, and bifuel fuel delivery systems (Mean data accompanied by different letters are significantly different according to Duncan's Multiple Range Test, p<0.05) (*i.e.* a and a = not significantly different; a=maximum amount of pollutant production)

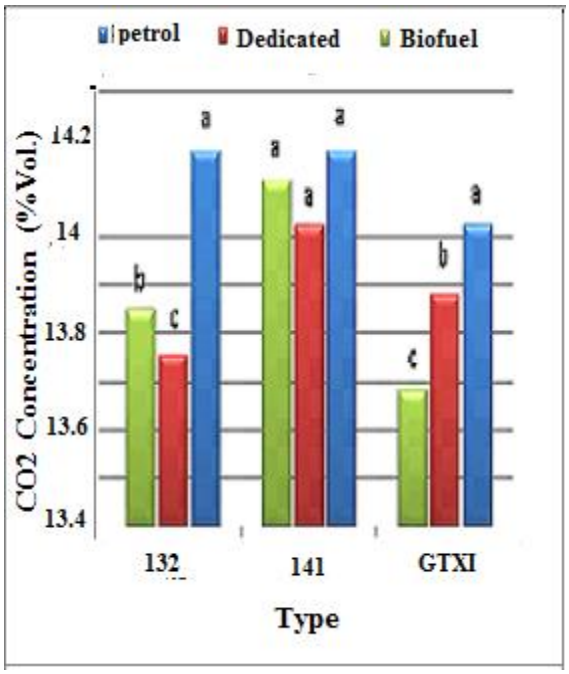

Fig. 3: The amount of carbon dioxide production by different types of Pride with Petrol, dedicated, and bifuel fuel delivery systems (Mean data accompanied by different letters are significantly different according to Duncan's Multiple Range Test, p<0.05) (*i.e.* a and b = significantly different; a and a = not significantly different; a=maximum amount of pollutant production)

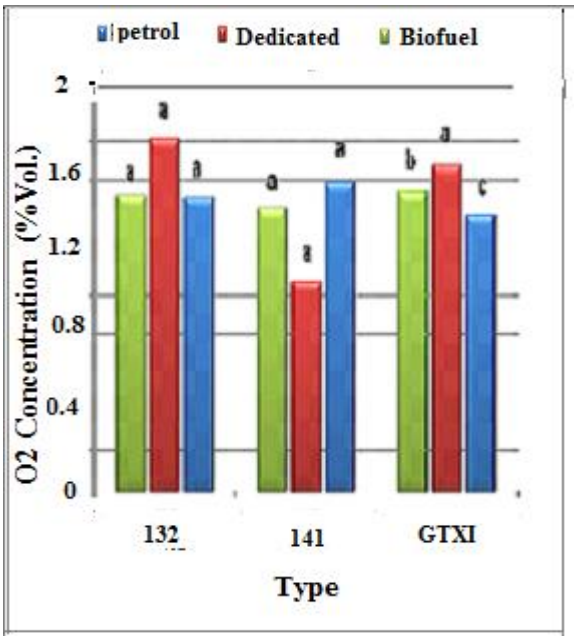

Fig.4: The amount of oxygen production by different types of Pride with Petrol, dedicated, and bifuel fuel delivery systems (Mean data accompanied by different letters are significantly different according to Duncan's Multiple Range Test, $p<0.05$) (*i.e.* a and b = significantly different; a and a = not significantly different; a=maximum amount of gas production)

Despite no significant difference between various fuel delivery systems in terms of HC and CO production, it can be concluded that the engine performance in bifuel Pride and dedicated Pride is worse than petrol Pride in terms of the above pollutant emission which can be the result of stable kit type used while changing the vehicles fuel delivery system into dual-fuel. Since these kits are not designed and adjusted based on vehicle type, they can lead to more fuel consumption and incomplete burning. On the other hand, to increase the engine power, the owners of dual-fuel vehicles omit a part called catalyst converter which can increase the vehicle pollutant emission [13]. This is despite the fact that in most of the researches about dual-fuel engines up to now [14-16], using the natural gas is an appropriate solution for reducing the vehicle pollutants. In a research about evaluating the effectiveness of cost of changing gasoline vehicles to gas system and comparing that to gasoline vehicles, it was determined that the dual-fuel vehicles can reduce the amount of output CO from 5.3 to 16.0 gr while working with CNG, but increase the hydrocarbon output level from 0.14 to 1 gr per mile and NOx gases from 3.5 to 0.16 gr per mile. This shows the reverse relation between the combustion temperature and the amount of CO and NOx production, so that as the combustion process is more completed and the temperature is higher, then the emission of NOx is more and CO is less [17]. However, according to predictions by Najafpour *et al.* [18], the NOx amount will change from 2120 tons in 2010 to 17,000,000 ton in 2060 which needs an intelligent plan to protect the environment and human health.

Moreover, according to the fact that there is no significant difference between the studied fuel delivery systems in different types of Samand in terms of the amount of exhaust gases (the results are not shown), it can be concluded that there is no difference in engine performance from the environmental standard point of view by changing the fuel delivery system into dual-fuel. Ignoring the air pollution reduction, will undermine the economic justification of CNG national plan, Haji nili and Mohammadi [19] said during their studies. Their results showed that if we can reduce the pollution caused by petrol up to 60% by improving petrol quality or increase vehicle engine efficiency, there is no more need to perform CNG national plan. However, the final decision on this issue requires taking into account other parameters such as the engine type, distance traveled, usage of catalyst and service time of vehicles rather than the fuel type, fuel delivery system and manufacturing year of cars. Although, these important factors seem to be neglected in this study due to the high number of studied cars (2000 vehicles) and usage of vehicle's card not questionnaire for data collection. Though, the impacts of the engine type and the distance traveled by car on pollutants emission of Pride and Samand were studied but their results are not shown here.

Assessing the effect of consumed fuel type on the amount of exhaust output gases

Among the available solutions for environmental pollution reduction caused by the vehicles, the option of using alternative fuels specially the compressed natural gas (CNG) seems to be more practical because of some reasons such as great potential in using alternative fuels, lack of access to modern technology in automobile manufacturing and also inability of vulnerable to replace the old vehicles. Hence, in this section a comparison has been done between the amount of output pollutant from petrol vehicle exhaust which only uses petrol and dual-fuel vehicle which uses gas as the fuel. The results indicated a significant difference in CO_2 and O_2 emission from Pride and CO_2 from Samand. So that in petrol Pride the CO_2 emission is more than working in dual-fuel state with CNG gas and this is reversed for O_2 emission (Table 1).

Table 1: Assessing the effect of consumed fuel type on the amount of exhaust output gases from Pride and Samand during 2007-2010

consumed fuel	Exhaust gases							
	HC (ppm)		CO (%Vol)		CO_2 (%Vol)		O_2 (%Vol)	
	Pride	Samand	Pride	Samand	Pride	Samand	Pride	Samand
Petrol[a]	167.804	107.565	0.587	1.546	13.973	11	1.425	1.791
CNG[b]	145.111	61	0.762	0.306	10.4105	13.804	2.226	1.096
Sig	>0.05	>0.05	>0.05	>0.05	<0.05	<0.05	<0.05	>0.05

a= means a petrol vehicle that only uses petrol, b= means dual-fuel vehicle that use gas

Since the low emission of CO_2 and high emission of O_2 is the sign of incomplete combustion and more Co and HC production [17], it can be concluded that using gas as the fuel in Pride can lead to more emission of exhaust pollutants. This can be because of the different gas and petrol density ratio and also different Octane number. It can also be stated that there is no proportion in petrol engine technology with gas and this can be the cause of incomplete combustion in the engine, smell of gas emission, intense reduction in vehicle power and pollution intensification. So we should replace the petrol engines with gas engines first, and then change the fuel type [20].

The results of this study indicate a different procedure in Samand in comparison with Pride, as the amount of CO_2 emission in petrol Samand is less than dual-fuel state with gas as the fuel (Table 1). This indicates the better design of Samand both in terms of fuel pump, kit type and other engine parts in comparison to Pride for switching to dual-fuel delivery system [9,13]. According to the studies on 2.5 years old dual-fuel vehicles, it is determined that when the vehicle is working with gas, the emission of CO reduces from 3.5 to 2.5 gr per mile, while when it's working with natural gas this pollutant increases from 0.16 to 7.2 gr per mile [20]. Moreover, the results of this study indicate that several factors other than consumed fuel type are involved in air pollution resulting from vehicle. As Barkhurdarivan [21] in their study showed that proper functioning of the engine and existence of emission control system regardless of the type of fuel, cause to reduction of emissions from the exhaust.

Assessing the effect of the portion of consumed fuel type on the amount of exhaust output gases from the vehicles equipped with bifuel fuel delivery system

One of the most important problems of dual-fuel system vehicles which are mentioned in several studies is extreme engine depreciation and vehicle lifetime reduction by using natural gas [14-16]. Since, to evaluate the accuracy of this claim, a comparison has been done between petrol based dual-fuel vehicles which mainly use petrol and the ones which mainly use gas. Table 2 shows the effect of the most consumed fuel type (petrol or gas) on the engine performance of Pride and Samand which are equipped with bifuel fuel delivery system during 2007-2010. Since the portion of consumed fuel does not have a significant effect on the amount of output pollutants from the mentioned vehicles that work with the mentioned fuel system, it can be stated that the output substances from vehicle exhaust are more related to vehicle condition than the fuel type (Table 2).

Table 2: Assessing the effect consumed fuel portion on the amount of output exhaust gases from vehicles equipped with bifuel fuel delivery system during 2007-2010

Vehicle	Consumed fuel type	Exhaust gases				Sig
		O_2 (%Vol)	HC (ppm)	CO (%Vol)	CO_2 (%Vol)	
Pride	Petrol	1.56	150.90	0.76	13.72	>0.05
	CNG	1.63	157.91	1.34	13.63	
Samand	Petrol	2.10	92.75	0.95	14.02	>0.05
	CNG	2.09	139.86	0.50	13.45	

In a survey done by Kazemi zadeh and Parsafar [22] from %77 of experts in authorize repair shops it is determined that the engine repair cost will be higher by using more natural gas than petrol in petrol based dual-fuel vehicles. For example, in dual-fuel vehicles should be systems for burning remained petrol in

engine path while switching from petrol to gas, but it is ignored in equipment used to change the vehicle fuel system into dual-fuel one in Iran [13]. Also because using gas in dual-fuel injector vehicles produces more Oxygen, the Oxygen sensor inside the exhaust path sends higher voltage to ECU (Electronic Control Unit) and ECU increases the injector splashing time due to voltage changes which lead to more fuel consumption. Furthermore, when the vehicle is working on petrol state, because the Oxygen sensor data on ECU is not send correctly, some unburned fuel remains and the result is more pollutant production.

Assessing the effect of dual-fuel duration on the amount of exhaust output gases

As mentioned, one of the most important disadvantages of dual-fuel systems is % 20 efficiency downfalls and % 30 dual-fuel engine lifetime drop which leads to more fuel consumption and air pollution [13]. So in this part, a comparison has been done between dual-fuel vehicles with different dual-fuel lifetime duration in order to find out the effect of duration of being dual-fuel on engine performance and lifetime. Since the results of this study indicated no significant difference between various dual-fuel durations in gas based and petrol based vehicles in terms of the amount of CO_2, CO and HC emission, similar to the above part, it can be concluded that the output substances from vehicle exhaust are more related to vehicle condition than fuel type and dual-fuel duration (Table 3) (because of similar results in dual-fuel vehicles, only different durations in 2009 are manually shown). It is generally expected that by passing time the emission amount will increase, a study on the effect of age on pollutant emission by Askarieh and adhami [6] showed.

Table 3: Assessing the effect of dual-fuelling duration on Pride and Samand engine performance during 2007-2010

Vehicle	Fuel delivery system	Dual-fuel duration (year)	Exhaust gases				Sig
			O_2 (%Vol)	HC (ppm)	CO (%Vol)	CO_2 (%Vol)	
Pride	Bifuel	1	1.35	213	1.50	12.45	>0.05
		2	1.86	124.8	0.37	13.60	
		3	1.78	170.75	0.50	14.03	
		4	1.51	162	0.92	12.10	
	Dedicated	6	1.61	162.04	0.48	13.51	>0.05
		7	1.54	142.58	0.64	13.76	
		8	1.53	149.86	0.61	13.94	
		9	1.47	166.96	0.65	13.67	
Samand	Bifuel	2	2.44	167	0.34	11.25	>0.05
		4	2.45	95.50	0.29	13.35	
		5	1.16	117	0.79	13.95	
	Dedicated	6	1.85	130.37	0.44	11.69	>0.05
		7	1.34	131.75	0.55	14.12	
		8	1.55	130.40	0.47	13.81	
		9	1.85	126.71	0.48	12.70	

Although the mentioned increasing procedure was not observed on the results of pollution test on 323 vehicles in mobile model, which can be caused by illogical emission from young vehicles because of their low quality, but according to the results of Copert model, CO, Nox and HC emission increases %90, %120 and %100 respectively because of vehicle aging and vehicle depreciation with engine volume between 1400-2000 cc for average 120,000 Km scrolling [6]. Also according to universal bank report, when the petrol system was replaced with a gas system, the emission amount will be more than petrol engines within 2 years.

CONCLUSION

Currently, the CNG with natural gas origination is chosen as the appropriate alternative instead of other

fuels such as petrol and gasoline for Iran transportation system, which due to its high frequency and low cost can play an essential role in adjustment of energy basket. But the important point is whether all vehicle designs in Iran are suitable to use natural gas. Hence, this research has been done to find out this and the results indicate that using CNG gas in all vehicles is not the best option Moreover, changing Pride fuel delivery system to dual-fuel and using natural gas can increase the pollution in comparison with the petrol-fueling state, but Samand design is in such a way that there is no difference between fuel delivery systems in terms of output exhaust pollutants, and using CNG instead of petrol can reduce pollution. For this reason, the modern countries of the America and the Europe have been investing on other gas fuels like LNG (Liquefied natural gas), ANG (Adsorbed Natural Gas) and derivatives such as dimethyl ether and methanol because of their environmental, economic and technical advantages compared to CNG. It has also been determined in this study that the fuel type portion and dual-fuelling duration does not affect the amount of output pollutant from dual-fuel vehicle exhaust and we can claim that the output exhaust substances are more related to vehicle condition than the fuel type.

ETHICAL ISSUES

Ethical issues such plagiarisms have been observed by the authors.

COMPETING INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTIONS

All authors of this study have a complete and equal contribution for data collection, data analyses and manuscript writing.

FUNDING/SUPPORTING

The authors declare that they have no any financial support or supporting for the culmination of this paper.

ACKNOWLEDGEMENTS

This study has been done with the cooperation of Mashhad Transport and Traffic Organization and Mashhad Municipal Waste Management Organization. The authors of this article hereby express their gratitude and appreciation from the head of Mashhad Vehicle Inspection Center Department, Mr. Siavash Milanian, and the manager of Hafiz Vehicle Inspection Center, Mr. Mojtaba Kelidari.

REFERENCES

[1] Dargahi A, Golestani Far H, Alavi S. The amount of exhaust pollutants emission in Kermanshah's vehicles and its impact on human health. In the 2th National Conference on Health, Safety and Environment (HSE); November 15-November 18; Mahshahr 2012 [Persian].

[2] Dehghani M, Anushiravani A, Hashemi H, Shamsedini N. Survey on air pollution and cardiopulmonary mortality in Shiraz from 2011 to 2012: An analytical-descriptive study. Int J Prev Med. 2014; 5(6): 734–40 [Persian].

[3] Ghobadi F, Hesami Z, Sohrabinia M, Farid A. Survey of citizens about the axis of the fifth comprehensive plan to reduce air pollution in Tehran (vehicle inspection). In the 6th Biennial Conference on Iranian Association of Environmental Professionals; February 25- February 27; Tehran 2007 [Persian].

[4] Hadizadeh B, Zarra Nezhad M, Taee H, Khoda Panah M. The External costs of using private cars in Tehran city. Quarterly J Quantitative Eco. 2011; (29): 51-77 [Persian].

[5] Ghiyasuddin M. Air pollution. Tehran University Press: Tehran; 2006.

[6] Asgarieh M, Ahrami M. The effect of the of fleet and fuel quality on Emissions in light vehicles in Tehran. In the 5th National Conference and Exhibition of Environmental Engineering; November 21- November 22; Tehran 2011 [Persian].

[7] Frey HC, Rouphail M, Zhai H. Regional On-Road Vehicle Running Emission Modeling and Evaluation for Conventional and Alternative Vehicle Technologies. Environmental Science and Technology. 2009; 43: 8449-55.

[8] Hooftman N, Oliveira L, Messagie M, Coosemans T, Van Mierlo J. Environmental Analysis of Petrol, Diesel and Electric Passenger Cars in a Belgian Urban Setting. Energies. 2016; 9(84): 1-24.

[9] Abedi Z, Atadi F, Sufi M. CNG instead of gasoline alternative social sources in Tehran's taxis. J Environ Sci Tech. 2011; 13(3): 39-48 [Persian].

[10] Coelho MC, Frey HC, Rouphail NM, Zhai H, Pelkmans L. Assessing methods for comparing emissions from gasoline and diesel light-duty vehicles based on microscale measurements. Transportation Research – Part D Energy and the Environment. 2009; 14: 91–99.

[11] Haji Tajevardy M. The effects of the use of compressed natural gas in the transportation world's great cities. In the 1'st Conference on Alternative Fuel (CNG) and CNG Vehicles; May 16- May 19; Tehran 2004 [Persian].

[12] Atabi F, Mahootchi S, Abedi Z. The estimated economic savings resulting from the reduction of the

health damage caused by the construction of a CNG stations compared with gasoline in Tehran. J Environ Sci Tech. 2012; 14(2): 51-59 [Persian].
[13] Fartook Zadeh H, Ashraghi H. Dynamic modeling effect of policies changing vehicles to the dual-fuel vehicles on pollution and energy consumption. J Environ Sci Tech. 2015; 17(1): 1-19 [Persian].
[14] Rostami Nejad M, Momeni A, Al Abrahim N. Effect of contaminants and the efficiency of gas engines and its environmental impacts. In the 4th National Conference Research and Development Centers Industry and Mining; December 2- December 4; Tehran 2003 [Persian].
[15] Pirooz Panah V, Musa Zadeh M, Fyruzgan AR, Rostami MR. Review of performance, emissions and fuel consumption in different types of CNG powered vehicles. In the 2th National Conference Combustion Engines; February 17- February 19; Tabriz 2001 [Persian].
[16] Nori Kazaj R, Mohsenian Rad A. The effect on the efficiency of internal combustion engines using compressed natural gas. In the 2th National Conference on CNG; September 20- September 22; Tehran 2009 [Persian].
[17] Reza Zadeh S. The status of air emissions from petrol vehicles in the city of Qazvin. In the 2th National Conference of Environmental Engineering; December 5–December 8; Tehran 2008 [Persian].
[18] Najafpour AA, Allahyari S, Bakhsh Javid A, Ismaili HA. Modeling of air pollution (carbon monoxide and nitrogen oxides) from cars in the city of Mashhad in 2010. North Khorasan Uni Med Sci. 2010; 6(2): 257-47 [Persian].
[19] Haji Nilli A, Mohammadi P. Rising fuel prices and the national plan CNG (economic analysis within the framework of optimal control theory). Conferences optimization fuel; June 17-June 19; Tehran 2010 [Persian].
[20] Islami S. Advantage, problems and priorities, along with an analysis of the emissions of natural gas vehicles, hybrid vehicles. The Magazine Industry Development; 2016 [updated 10 August 2016; cited 20 August 2016]; Available from: http://www.irangreenpen.org.
[21] Barkhurdarivan A. Tests for motor fuels and their role in assessing the quality of gasoline and diesel fuel. J Scientific Promote. 2012; 7(39): 79-67 [Persian].
[22] Kazemizadeh Z, Parsafar N, Mosawi FS. A comparative study of the challenges of using CNG as an alternative fuel in the transport sector with the results of the survey. In the 11th Conference of Transportation Engineering and Traffic; February 21-Febreury 22; Tehran 2014 [Persian]. http://www.civilica.com/Paper-TTC11-TTC11_125 .html.
[23] Gholamzadeh K, Khajeh N, Mohammadi S, Ghafouriyan Frood A, Mohammadi M, Houshmand SH. Air pollution index resulted from Peugeot 405 and Praid Saba. Int J Current Res. 2014; 6(12): 10906-12 [Persian].