International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 02 ISSUE 10 Pages: 65-74
SJIF IMPACT FACTOR (2021: 5.478) (2022: 5.636)
METADATA IF – 7.356

Journal Website: http://sciencebring.com/index.php/ijasr

Research Article

IMPROVING THE PERFORMANCE OF A PASSENGER CAR WITH A SPARK IGNITION ENGINE USING LIQUEFIED PETROLEUM GAS WITH THE ADDITION OF DEMETHYL ETHER

Submission Date: October 01, 2022, **Accepted Date:** October 15, 2022,
Published Date: October 25, 2022
Crossref doi: https://doi.org/10.37547/ijasr-02-10-11

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ABSTRACT

The article presents the results of a computational and experimental study of a passenger car with a spark ignition engine running on liquefied petroleum gas (LPG) with dimethyl ether (DME) additives. Recommendations are given on the modernization of gas cylinders for refuelling LPG with DME additives, as well as studies of a passenger car running on composite gas fuels.

KEYWORDS

Passenger car, liquefied petroleum gas, dimethyl ether.

INTRODUCTION

It is known that the use of environmentally friendly alternative motor fuels instead of oil is the most rational solution to modern energy and environmental problems in the field of transport,

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Crossref Google Scholar METADATA INDEXING WorldCat MENDELEY
ISSN-2750-1396

in particular road transport. The use of dimethyl ether (DME) as a motor fuel will expand the use of environmentally friendly alternative motor fuels, reduce fuel supply tensions, reduce oil production and refining, and improve the performance, including the environmental performance of vehicles running on this type of fuel [1-4].

The transfer of cars to DME power supply in whole or in part with minimal design and adjustment changes solves several environmental problems of transport and this connection is a very urgent task [5-9].

MATERIALS AND METHODS

In many countries of the world, scientific and practical work is being actively carried out on the use of DME as the main or additional fuel for internal combustion engines [1, 2, 3].

Most of these scientific works are devoted to the use of DME as a substitute for diesel fuel (DF) and several programs have been carried out for its use as a motor fuel for urban and factory transport [10-17].

In most of these works, it was found that when using DME as the main fuel (complete replacement of DF), the control and design of the fuel supply system become more complicated and a number of problems arise associated with the unstable operation of a diesel engine. All structural and technological changes in the diesel fuel supply system are carried out in order to compensate for the low calorific value and viscosity of DME compared to DF. Several scientific works have also been carried out related to the use of DME as an additive to liquefied petroleum gas (LPG) in order to improve the performance of an internal combustion engine (ICE) with spark ignition [17-22].

In these works, using DME as an additive to LPG, some reductions in power and torque values were obtained for ICE running on base fuels - gasoline and LPG. At the same time, there is some decrease in emissions of harmful substances - carbon monoxide (CO) and hydrocarbon (CH) compared to base fuels [23-37].

However, at the same time, there are no results of scientific works related to studies of the performance of cars running on LPG with DME additives.

Table 1. Comparative indicators of various motor fuels

Indicators	*Fuel*					
	Petrol	Diesel fuel	CNG	LPG		DME
Chemical formula	C_8H_{18}	$C_{15}H_{32}$	CH_4	C_3H_8	C_4H_8	C_2H_6O
Molecular mass	114,5	190	16	44	58	46,07

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Elemental Composition:						
C	85.5	86	74.6	82	82	52.2
H	14.4	13	25.4	18	18	13
O	0.1	one	—	—	—	34.8
C/H ratio	5.3	6.62	2.93	4.55	4.55	4.02
Density, g/cm^3 (kg/m^3)						
liquid phase	0.72	0.85	0.5	0.509	0.582	0.68
gas phase	1.07	1.23	0.68	2.018	2.703	-2.1
Net calorific value, MJ/kg of fuel	44	42	49.5	46.5	45.5	28.4
combustible mixture d=Nmax	3.1	2.09	2.63	3.02	3.02	1.06
Ignition temperature (self-ignition), °C	470…530	290…310	680…700	475…580	475…580	235
	-220	-430	-570	-520	-520	-350
Flammability limit in air, %						
lower	1.4	0.6	5.3	1.8	1.8	3.4
upper	7.4	6.5	fifteen	9.5	9.5	eighteen
Flammability limit in air, %						
lower	1.4	0.6	5.3	1.8	1.8	3.4
upper	7.4	6.5	fifteen	9.5	9.5	eighteen
Excess air coefficient corresponding to:						
flammable limit	0.7…1.1	0.9…5.0	0.7…1.3	0.7…1.2	0.7…1.2	3.4…34
maximum power	0.85…0.95	1.3…1.5	1.05…1.15	0.3…1.05	0.3…1.05	3.0…4.5
Theoretically required amount of air for complete combustion of	14.85	14.35	17.1	15.2	15.2	9

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fuel, kg/kg						

Based on the foregoing, the purpose of this work was to study the performance of a passenger car with a spark ignition engine with the addition of DME.

Description of DME, fuel supply system and experimental vehicle.

In order to use for comparative analysis, indicators of various fuels are given (Table 1).

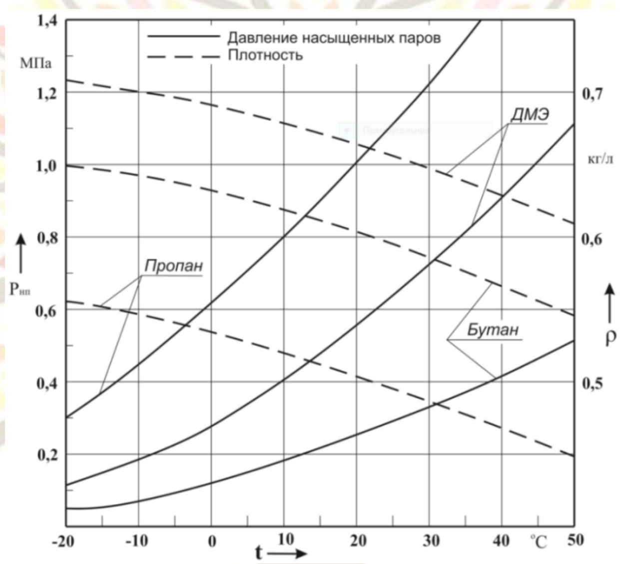

Figure 1. Changes in saturated vapour pressure and density of composite gas fuel depend on temperature.

From the above data it follows that at certain concentrations of DME in the composition of LPG, the combustibility (density, heat of combustion, flammability limits, ignition temperature) of the composite gas fuel can improve. It should be noted that the saturation vapour pressure (SVP) and the density of the composite gas fuel (LPG + DME) have a significant effect on the efficiency of supplying gas fuel to the engine (Fig. 1) and on the performance of a car running on this type of fuel. At the same time, the main element - gas cylinders of the fuel supply system, occupies a special place in order to fulfil the requirements for the safe operation of the car [38-44].

The used LPG gas cylinders when using DME must be modernized, i.e. elements (float, seals, etc.) of the multi-valve device made of plastic, and rubber must be replaced with metal ones (Fig. 2).

The Nexia 3 car prepared for testing (Fig. 3) was equipped with three systems (gasoline, compressed natural gas (CNG), and liquefied petroleum gas), which allows comparative studies of its performance for gasoline, CNG, LPG, as well as for LPG with additives. Calculated comparative indicators of the investigated motor fuels have been established.

Figure 2. Nexia 3 car prepared for testing

RESULTS AND DISCUSSION

Modernized and tested according to the requirements of LPG gas cylinders in order to use them for composite gas fuels (LPG with DME additives) in the research process.

Figure 3. Upgraded LPG gas cylinders.

For the purpose of comparative research on various fuels (gasoline, CNG, LPG, LPG with various DME additives), a Nexia passenger car with three fuel supply systems was prepared. The

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preliminary test (maximum speed, acceleration time to 100 km/h, CO and CH emissions at idle) showed results close to those of the base car [45-58]. In order to eliminate the effect of the catalyst converter on exhaust emissions, the base unit has been replaced with a simple converter housing. Comparative environmental performance of a passenger car running on various fuels (gasoline, CNG, LPG, LPG with various additives of 5, 10, 15% DME) will be evaluated at speeds of 40, 60, 80, 100 km/h of the vehicle.

Conclusion

Based on the analysis of the work performed on the use of LPG with DME additives as a motor fuel for a spark ignition engine, it was found that the power, torque and CO and CH emissions of an LPG engine with DME additives are slightly reduced.

In all cases, the performance and exhaust emissions of a passenger car running on LPG with various DME additives have not been fully investigated.

In preparation for these studies, LPG gas cylinders were upgraded to fill LPG with various DME additives, and a Nexia vehicle with three fuel supply systems was prepared for these types of studies.

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