ISSN 2229-5518

Experimental Investigation on the Effect of Adding Di Methyl Carbonate to Gasoline in a SI Engine Performance

D.Gopinath, E.Ganapathy Sundaram

Abstract—Di methyl carbonate (DMC) has a lot of good properties to be used as a blend with gasoline. In order to improve the efficiency, combustion stability and emission performance of a spark ignition engine, oxygenated fuel (DMC) is added to a gasoline. In this experimental work, the effect of using 100% gasoline and gasoline-DMC blends (D5, D10, D15 and D20) on four cylinder engine performance and exhaust emissions were investigated for different engine speeds. The investigation was conducted on a multi cylinder, four stroke spark ignition engine. The emissions were measured using exhaust gas analyzer. The experimental results show that the blending of DMC with gasoline increases the thermal efficiency of engine as compared to 100% gasoline as a fuel. The study also found that decrease of CO and HC with the blending of DMC with gasoline.

KEYWORDS— Oxygenates, Dimethyl Carbonate, SI Engine, HC and CO.

1 INTRODUCTION

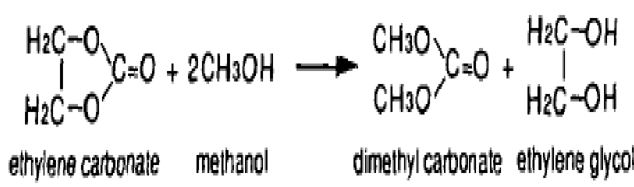
A Variety of fuel additives has been proposed for engine emissions reduction. Fuel additives used in gasoline engines have been classified into four categories- octane number improvers, fuel carburetion deposit cleaning detergents, combustion process promoters and oxygenates.

The addition of oxygenates to gasoline is considered as an effective method in fuel octane enhancement and reduction of engine emissions [1]. The use of esters fuel with high degree of purity and mixtures with gasoline has represented good results in terms of quality. When incorporated into gasoline, these additives alter the physiochemical properties of density, volatility, octane rating and enthalpy of combustion [2]. Depending upon the engine type and operating condition, these properties directly affect fuel consumption and the level of emissions.

By using of oxygenates to gasoline, the combustion of fuel burns clean and free from any deposits, it produces higher compression ratios inside the engines without knocking and increase in horse power due to increase in the octane number[3]. Oxygenates are oxygen-rich compounds which, when they are added to motor vehicle fuels, make them burn more cleanly, thereby significantly reducing toxic tailpipe pollution[4]. Cleaner burning oxygenated fuels are one of the leading tools in fighting automotive air pollution [5]. Oxygenates are produced from a variety of feedstock's. Methanol, derived primarily from natural gas, is one feedstock used in the production of the most commonly used oxygenate, methyl tertiary butyl ether (MTBE) [6].

Another oxygenate, ethanol is derived primarily by fermenting corn and other agricultural products and is used directly as an additive or as a feedstock for the production of ethyl tertiary butyl ether (ETBE) [7]. Isobutylene, which is the other feedstock used in both MTBE and ETBE production, is also derived from natural gas or as a by-product of petroleum refining.

Dimethyl carbonate is very attractive for use as oxygenate for fuel additives. A feasible method of mass production at a low cost is needed for producing di methyl carbonate for fuel additives [8-10]. The transesterification process is one of the di methyl carbonate production processes. In this process, ethylene carbonate with methanol is transesterificated to di methyl carbonate.



In the transesterification process, ethylene glycol is co-generated with di methyl carbonate. The ethylene glycol is considered economically with the conventional product

• D.GOPINATH, Student, Master of Engineering in Internal Combustion Engineering at VELAMMAL ENGINEERING COLLEGE, Chennai, India. PH-09894037569. E-mail: mech.gopinath@mail.com

• Dr.E.GANAPATHY SUNDARAM, Associate Professor in Mechanical Department at VELAMMAL ENGINEERING COLLEGE, Chennai, India. PH-09445254681. E-mail: ganapathy_sundar@yahoo.com

ISSN 2229-5518

from hydration of ethylene oxide, because the quality of the ethylene glycol produced by transesterification is equal to the quality of the conventional product and the demand for ethylene glycol is' growing year by year. Therefore, development of the di methyl carbonate process through the transesterification is indicated. Oxidative carbonization processes in both the liquid14 phase and vapor-phase are known as the other di methyl carbonate processes [9].

This paper aims that to find out the effect of adding Oxygenated fuel (DMC) with gasoline on the thermal efficiency and exhaust gas emissions.

2 Experimental Setup And Procedure

2.1 Experimental Setup

The experiment was conducted on a Water cooled, four cylinders, four stroke, 73 mm bore, 89 mm stroke, 1500 cc displacement, 7.2:1 compression ratio, spark-ignition engine. The specifications of the engine are given in a Table 1. The engine is coupled to a hydraulic dynamometer; the experimental setup is as shown in Fig.1. Hindustan motors; Ambassador (Pre-mark 4) model engine is used for experimental work.

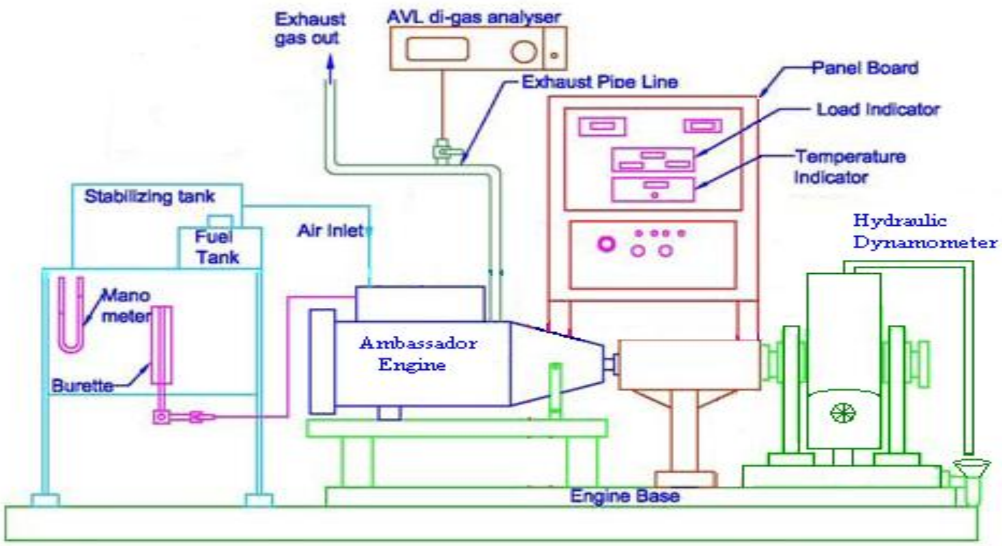


Fig.1 Experimental setup

TABLE 1
TEST ENGINE SPECIFICATION

S.No	Item	Specification
1	Make	Ambassador
2	Type	Four stroke/water cooled
3	Number of cylinder	4
4	Cylinder bore x stroke	73mm x 89mm
5	Maximum torque	76@2500rpm
6	Maximum power	50bhp@4400rpm
7	Compression ratio	7.2:1
8	Fuel system	Carburetion
9	Capacity	1500cc
10	Type of loading	Hydraulic dynamometer
11	Dynamometer constant	2000

2.2 Test fuel

Ester based oxygenated additive (DMC) was experimentally investigated in this experimental work. The base fuel 100% gasoline without any oxygenated additive was used as a reference and base fuel for the preparation for the gasoline-DMC blend fuels. Various blend ratios of DMC-gasoline fuels (D5, D10, D15 & D20) were prepared for the test on the SI engine. The properties of a gasoline and Di Methyl Carbonate are listed in Table 2.

2.3 Emission and fuel measurement

The emissions from the engine are measured using AVL Gas analyzer. The gases HC (ppm), CO (%), CO_2 (%)

TABLE 2
PROPERTIES OF FUEL

S.No	Property	Gasoline	DMC
1	Chemical formula	C8H18	C3H6O3
2	Molecular weight	114	90
3	Density(g/ml)	0.70	1.07
4	Net lower heating value (kj/kg)	44,000	15,780
5	Stoichiometric air-fuel ratio	14.7	4.65
6	Viscosity (mm2/sec)	0.6	0.625
7	Auto Ignition Temperature(^{0}C)	245	220
8	Flash point(^{0}C)	-43	18
9	Oxygen (mass %)	0	53.3
10	Octane number	92-98	101-116

ISSN 2229-5518

2.4 Emission and fuel measurement

The emissions from the engine are measured using AVL Gas analyzer. The gases HC (ppm), CO (%), CO_2 (%) and NOx (ppm) with this analyser.

The fuel flow rate is measured by volume basis using a burette and stopwatch. The fuel from tank is supplied to the engine through a graduated burette using a two-way valve.

2.5 Experimental procedure

The engine was allowed to run with 100% gasoline at various speed ranges of 700, 1000, 1300, 1600 and 1900rpm with a constant load of 10kg respectively. After completing the experiment with 100% gasoline, the experiments were conducted with the blending of DMC with gasoline in the blending ratio of 5%, 10%, 15% and 20% respectively with all the speed ranges mentioned with the gasoline alone.

3 Result And Discussion

The effect of DMC addition to gasoline on SI engines performance and exhaust emissions at variable engine speeds and blending ratios were investigated. The study found the following observations during the experimentation.

3.1 Brake Specific Fuel Consumption

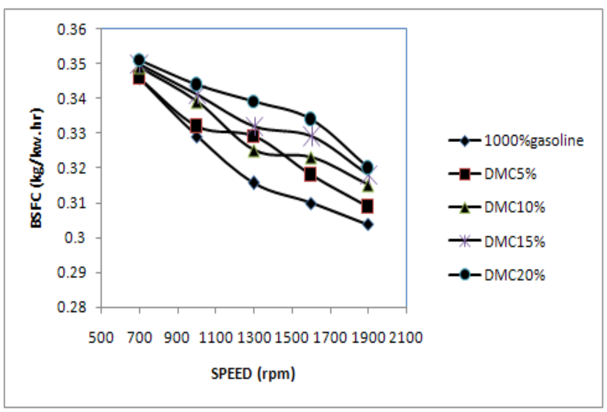


Fig.2 Speed v/s Brake Specific Fuel Consumption

The study found that increase of brake specific fuel consumption with the addition of additive DMC with the gasoline as compared to gasoline without any additive. The primary reason for the increase of oxygenated blended gasoline to have higher brake specific fuel consumption than the gasoline is that the calorific value of the oxygenated fuel (DMC) is less than that of the gasoline. The calorific value of the gasoline and DMC are 44,000 kJ/kg and 15,780 kJ/kg respectively. Also other supplementary factors like low volatility, slightly higher viscosity and high density of DMC which affect mixture formation and thus lead to slow combustion play in increasing the brake specific fuel consumption. The Fig.2 Indicates that, for all the load conditions the brake specific fuel consumption for blending is higher than that the gasoline without any blending.

The specific fuel consumption for 20% blending DMC with gasoline consumes 0.05kg/kw.hr more when compared to 100% gasoline. Significant increase in fuel consumption while using all blends with respect to speed.

3.2 Brake Thermal Efficiency

The effect of the DMC blend with gasoline on thermal efficiency with different load conditions and thermal efficiency without blending is shown in Fig.3.

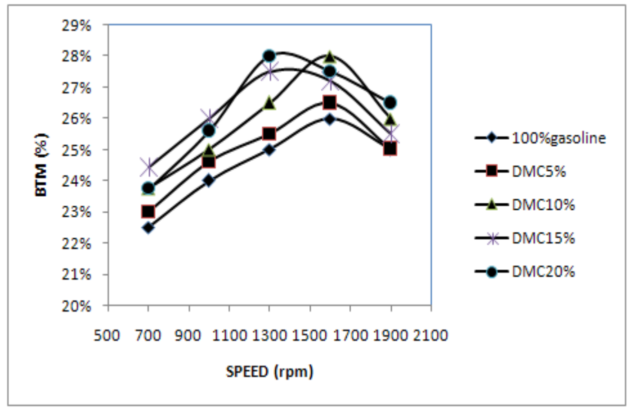


Fig.3 Speed v/s Brake Thermal Efficiency

The Fig.3 indicates that the break thermal efficiency for all the blending ratios with gasoline are higher than that of the without blending. The study also indicates that thermal efficiency increases with the increase of load conditions for all the experiments. The thermal efficiency increased with the increase of blending ratios. The thermal efficiency for the blending of 5%, 10%, 15% and 20% at the 1500 rpm are increased 0.5 to 2.5 % respectively. The reason could be due to increase in the octane number of the samples and perfect combustion due to the addition of additives.

3.3 Hydrocarbon Emission

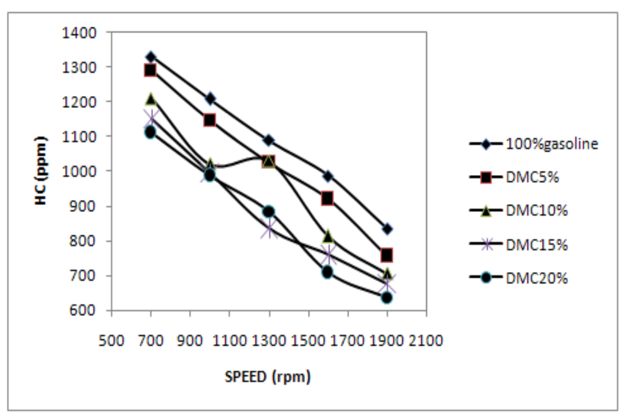


Fig.4 Speed v/s HC Emission

Hydrocarbon emission in petrol engine indicates that the quality of the air-fuel mixture and incomplete combustion during the combustion process. Fig.4 shows that the HC emissions under constant engine load (10kg) at different speeds conditions for blending with different ratios and without blending. The study explored that the decrease of HC emissions with the blending as compared to the gasoline alone as a fuel. There is a notable decrease of HC emission with the 20% blend as compared to the gasoline without any additive. The oxygenated characteristic of the DMC are effective in enhancing the oxidation of hydrocarbons in the air.

The HC emission for the 1900 rpm with the gasoline and gasoline –DMC blends with 5%, 10%, 15% and 20% are reduced 60ppm to 200ppm respectively.

3.4 CO Emission

The Fig.5 shows that the effect of the gasoline - DMC blends on CO emissions and without additive. The CO emission indicates the shortage of oxygen in the combustion process. When there is a shortage in the oxygen the combustion will not take place properly and leads to the more CO formation. This could reduce the overall performance of the system. There is a decrease of CO emission with the increase of DMC bled ratio is observed in this study. The CO emission for all the blends is lower than the gasoline alone as a fuel. This could be due to extra oxygen supplied by the oxygenated fuel during the combustion process of gasoline with DMC as a blend as compared to gasoline itself as a fuel.

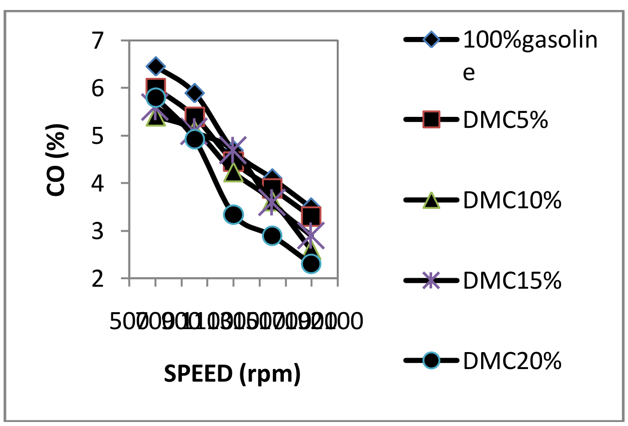


Fig.5 Speed v/s CO Emission

The CO emission for the 1900 rpm with the gasoline and gasoline –DMC blends with 5%, 10%, 15% and 20% are reduced 0.3 to 1.65 respectively.

3.5 CO_2 Emission

The effect of the gasoline - DMC blends on CO_2 is shown in Fig.6. As the speed increases the CO_2 emission increases gradually with all the blends and without blends also. Higher CO_2 emission is observed for gasoline blends with DMC and with the increase of blending ratio the CO_2 emission also increases. Adding oxygen containing additive can increase the CO_2 emissions with increase in speed of the engine. This could be due to, when oxygen blended fuels are used in the engine, the combustion reaction is complete and the concentration of CO_2 emission could get higher.

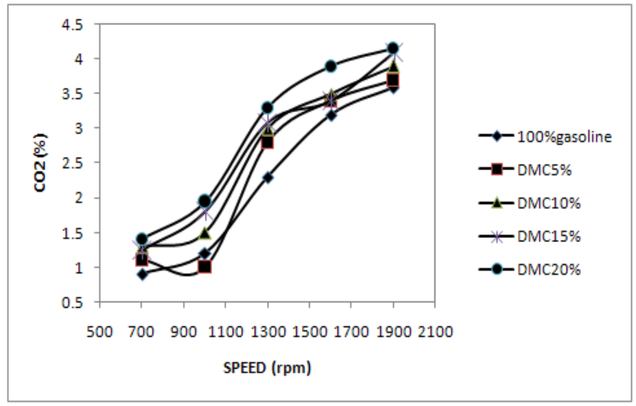


Fig.6 Speed v/s CO_2 Emission

From the graph, the CO_2 concentration is high in D20 blend, and low for without additive, for the speed of 700 rpm the CO_2 values are increased from 0.1 to 0.8% respectively.

3.6 NOx Emission

The effect of the gasoline - DMC blends on NOx emissions is shown in Fig.7.The increase in NOx with DMC addition may be caused by the high temperature promoted by combustion and oxygen enrichment. The maximum NOx is obtained from the D20 fuel blend with respect all the speed conditions. There is a small variation of NOx variation is observed between the D5 and gasoline alone as a fuel but higher variation is observed between D20 and gasoline alone as fuel.

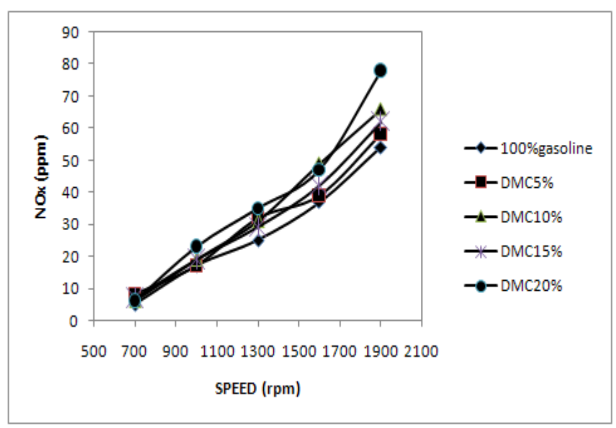


Fig.7 Speed v/s NOx Emission

There is negligible variation of the NOx emission at lower speed for all the fuel conditions, but the variation between different fuels is higher with the increase of speed. At 700 rpm the NOx emission is varied form 2ppm to 4ppm for D5 and D20 respectively. At 1900rpm the NOx created

ISSN 2229-5518

from the different blends varies form 5ppm to 25ppm. A high level of NOx observed when D20 fuel blend is used.

1. 4 CONCLUSION

In this study, the performance and emissions of the single cylinder S.I engine are carried out with gasoline as a fuel without adding blends and blending of oxygenate additive DMC with gasoline in 5%, 10%, 15% and 20% respectively. The specific fuel consumption, thermal efficiency and emissions are experimentally analyzed. The following are the findings from this experiment.

1. For all the additive conditions, the brake specific fuel consumption are 0.01 to 0.05 kg/kw.hr higher than that of the without additive due to lower calorific value of additive (DMC).
2. The thermal efficiency is higher when DMC is mixed with gasoline as compared to 100%gasoline due to proper oxygen supply by additive leads to complete combustion process
3. Complete combustion leads to lower HC emissions in the additive mixed conditions.
4. The oxygen contained additive (DMC) with gasoline reduced a significant amount of CO concentration as compared to without additive
5. Using oxygen contained additive (DMC) increased the CO_2 and NOx emissions with the increase of engine speed. At lower speed conditions the variation of the NOx is lower.

REFERENCES

[1] National Renewable Energy Laboratory USA, "Utilization of Renewable Oxygenates as Gasoline Blending Components," *Technical report*, 2011 NREL/TP-5400-50791.

1. [2] Renato Cataluna, "Acceleration test using gasoline's formulated with di-TAE, TAEE and MTBE ethers," *Fuel, Elsevier*, 2011, vol-90.
2. [3] Farhad Nadim, "United States Experience with gasoline additives," Energy Policy, Elsevier, 2001, vol-29.
3. [4] Rong-Horng, "Cold-start emission of an engine using ethanol-gasoline blended fuel," *Applied Thermal Engineering, Elsevier*, 2011, vol-31.
4. [5] Z Huang, "Combustion characteristics and hydrocarbon emissions of a spark ignition engine fuelled with gasoline-oxygenate blends," *Journal of Automobile Engineering, Sage*, 2001, vol-3.
5. [6] Renato Cataluna, "Acceleration test using gasoline's formulated with di-TAE, TAEE and MTBE ethers," *Fuel, Elsevier*, 2011, vol-90.
6. [7] Eliana weber de menezes, "Addition of an azeotropic ETBE/ethanol mixture in euro super-type gasolines," *Fuel, Elsevier*, 2006, vol-85.
7. [8] Shyue-cheng Yang, "The effect of adding dimethyl carbonate (DMC) and ethanol to unleaded gasoline on exhaust emissions," *Applied Energy, Elsevier*, 2010, vol-.87.
8. [9] Pietro Tundo, "New developments in dimethyl carbonate chemistry," *Applied Chemistry*, 2001, vol-73.
9. [10] Li Xiaolu, "Study of combustion and emission characteristics of a diesel engine operated with dimethy carbonate," *Energy Conversion and Management, Elsevier*, 2006, vol-47.