EVALUATION OF THE PERFORMANCE OF A FOUR STROKE PETROL ENGINE AND IN MIXTURES OF FUEL AND METHANOL THROUGH THE TEST OF MORSE

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ABSTRACT

In the present work, the properties of methanol were analyzed from the viewpoint of their applications for igniting vehicles with ignition engines. The use of mixtures of methanol and gasoline with up to 15 volume percent methanol requires only minor engine modifications. However, the miscibility of methanol and gasoline is poor, and to avoid fuel separation, the mixture of these fuels requires fuel additives. The Morse test was also conducted to evaluate the performance of each cylinder for gasoline as well as gasoline and methanol blends. The specific fuel consumption of the brake and the thermal efficiency of the brake in the short circuit of each cylinder were significantly different due to the distribution of the mixture that reaches the cylinders, due to its positioning with respect to the intake manifold and also due to the gas flow phase separation of gasoline and methanol at higher Loads and Speeds The engine was operated with mixtures of methanol and gasoline. The feasibility of using methanol as fuel for the SI engine is discussed from a technical and economic point of view.

KEYWORDS: Fuel additive; Mixture of gasoline and methanol; methanol; Specific fuel consumption of the brake; Thermal brake efficiency; Ratio of air and fuel.

1. INTRODUCTION

All over the world, the use of petroleum products has increased tremendously. This has resulted in great scarcity of fuel for IC Engines and problem has become acute during the recent years. Petroleum supply of today can not keep up with the demands made upon them due to many factors. Some of these factors may be summarized as follows:

- The increased use of automobile.
- Rapid rate of industrial & technological development throughout the world [6].

These factors are due to population growth and environmental impact such as global warming, acid rains and green house effect etc [10]. The problem of fuel scarcity has become very grave for developing countries like India. About sixty five percent of total fuel oil requirements of India are met through imports.

Gasoline is the fuel of the majority of spark ignition-engines with the transport sector being the most oil dependent on all major energy consumption sectors in the present economy [6]. The recent manifold increase in the price of this commodity in the world market is causing a heavy drain on the country's foreign exchange reserves. This is posing a major threat to the economy of the country. The increase in oil prices has brought an end to the era of cheep gasoline for SI Engines. Even though search of new oil resources in the country's land and sea is being intensified but there do not seem to be any changes of immediate relief. Moreover complete dependence on stored fuels like petroleum with its fast vanishing reserves is likely to cause a very grave energy crisis in time to come. This put heavy stress on the conventional reserve of fossil-based fuels to meet this demand. This problem has initiated the incentive for the search for alternative sources of energy, which are cleaner and more environmentally friendly. These alternatives may be either complete replacement for the present fuels or additives that can be added to the present fuels to improve its properties

[6].

Currently, various alternative fuels have been investigated for spark ignition engines to reduce the consumption of gasoline and NO_X, CO, and unburned hydro- carbon (HC) emissions. In alcohols, methanol and ethanol are used most often as fuels and fuel additives, because their potential to improve air quality when used to replace conventional gasoline in engines because of its good anti-knock characteristics and the reduction of CO and unburned HC emissions in engines. Methanol, known as methyl alcohol, has been used as an alternative fuel for automotive engines in many countries. Recently, its excellent combustion properties have made it the strongest choice of the automotive industry as well. The other most important characteristic of methanol is that it is undoubtedly the cheapest liquid alternative fuel per calorific unit, which can be produced from the widely available fossil raw materials including coal, natural gas, and bio substances [2]. This means that many countries can solve their energy imbalance problems because of the petroleum shortage by using methanol as a source of energy.

Abu-Zaid et al. [6] studied an experimental investigation in to the effect of methanol addition to gasoline on the performance of spark ignition engines & concluded that the calorific value of the blend decreases as the percentage of methanol increases. The addition of methanol to gasoline increases the octane number, thus engine fueled with methanol-gasoline blend can operate at higher compression ratios.

Shenghua et al. [11] made a study on spark ignition engine fueled with gasoline/methanol fuel blends. They concluded that with the increase fraction of methanol engine power and torque decrease, while the brake thermal efficiency is improved. Methanol addition to gasoline improves the SI engine cold start and reduces CO (25 %) and HC (50 % in cold start period and 30 % in warming up period) emissions significantly.

Bilgin and Sezer [15] studied the effects of methanol addition to gasoline on the performance and fuel cost of a spark ignition engine under various engine speeds, spark timings, and compression ratios. They concluded that M5 blend yields the best engine performance in terms of the brake mean effective pressure. M20 blend suggests the best performance in terms of brake thermal efficiency.

Mallikarjun and Mamilla [17] made an experimental study of exhaust emissions & performance analysis of multi cylinder S.I. engine when methanol used as an additive. They drawn following conclusion that mission characteristics are improved for additive methanol compared to petrol except NOx which is slightly higher than gasoline.

Yasar [18] investigated experimentally the effect of methanol addition to gasoline in small scaled generators on exhaust emissions and noise level. They concluded that with increasing engine loads, noise level increases using methanol gasoline blends.

Pandya and Chaudhary et al. [21] performed an experimental study on the effect of methanol-gasoline, ethanol-gasoline and n-butanol-gasoline blends on the performance of 2-stroke petrol engine using unleaded gasoline and alcohol as additives blends on spark ignition engine . They claimed that the addition of 5 % methanol, 5 % ethanol and 5 % n-butanol to gasoline gave the best results for all measured parameters at all engine torque/power values without any problems during engine operation.

Pankhaniya, Chauhan and Ranpara [22] studied about the performance & exhaust analysis of petrol engine using methanol-gasoline blends. They concluded that among the different blends, the blend including M20 is the most suited for SI engine from the engine exhaust emission point of view. It leads to a reduction of CO and HC by about 25 % and 10 % respectively.

1.1 Problem Statement

Petroleum popularly known as “Liquid Gold” is very important for the overall industrialization & development of our economy. It is the major fuel used in spark ignition engines but due to the following basic problems, gasoline needs an additive which can be used with gasoline as an alternative fuel in SI engines. These problems may be summarized as follows:

● Our oil reserves are depleting and we are nearly at the point where we are consuming more petrol than we are finding. Because of the high demand and decreasing supply, the price of petrol is increasing [18].

● The gasoline greatly affects the environment as carbon is produced when petrol is burned. Burning 100 litre of petrol emits about 250 kg of carbon dioxide into the atmosphere [13].

● There are some important differences in the combustion characteristics of methanol and hydrocarbons (As gasoline is petroleum derived liquid mixture consisting primarily of hydrocarbons). Methanol is a high-octane fuel with anti-knock index numbers (octane number) of over 100. Engines using high-octane fuel can run more efficiently by using higher compression ratios. It has higher flame speed [22].

● This is very attractive for developing countries like India because methanol can often be obtained from much cheaper biomass source than Gasoline [22].

To overcome these difficulties the methanol is used as an additive with gasoline to increase the performance of engine and minimize the fuel consumption.

1.2 Objective of the Study

- The main aim of my study is to reduce the consumption of Gasoline by mixing it with Methanol.
- To study the properties of Gasoline and Methanol.
- To compare the performance of the 4 stroke SI engine:

(i) Using Pure Gasoline as a fuel.

(ii) Using Gasoline-Methanol blends (up to M15) as a fuel.

1.3 Scope of the Study

To increase the performance of the four stroke SI engine, the methanol has been used as an additive with gasoline and stretching the limited supply of gasoline for a longer period as well as providing a hopeful source of future energy requirement. The results and graphs obtained from conducted test are discussed and compared.

2. EXPERIMENTAL SET UP AND INSTRUMENTATION

A vertical, water cooled, four stroke, four cylinder, 10 bhp stationary fiat car engine loaded by a hydraulic dynamometer is chosen for experimental work. Table 1 lists some of the important properties of methanol and gasoline and table 2 lists some of the specifications of the engine under test. The photographic view of the experimental set up is shown in figure 1. Fuel consumption was measured by using a calibrated burette and a stopwatch with an accuracy of 0.1 sec.

Table 1

Properties of Methanol and Gasoline

Property		**Gasoline**	**Methanol**
Chemical Formula		mC_nH_2n	CH_3OH
Molecular Weight (kg/kmol)		112	32
Mass Content (%)	Carbon	85	37.5
	Hydrogen	15	12.5
	Oxygen	Nil	50
Density (at 20°C) in kg/m^3		737	791
Latent Heat of Vaporization (KJ/kg)		330	1104
Lower Calorific Value (Kcal/kg)		10500	4802
Vapour Pressure (kg/cm^2)		0.8 at 58°C	0.32 at 38°C
Stoichiometric Air to Fuel Ratio		14.17	8.4
Boiling Temperature (°C)		40-190	64.5
Freezing Temperature (°C)		- 40 to -50	- 97.7
Self Ignition Temperature (°C)		257	460
Octane Number	RON	91	106
	MON	82	92
Cetane Number		10	3
Maximum Flame Velocity (m/s)		40	55
Viscosity (at 20°C) in cP		0.42	0.60
Specific Heat (KJ/kg °C)		2.009	2.60
Water Solubility (mg/L)		100-200	miscible

Table 2

Engine Specifications Name

Specifications Engine	
Four Stroke Fiat Car No. of Cylinders	
Four	
Rated BHP (with gasoline)	10
Compression Ratio	7.8:1
Rated RPM	1500
Bore	68 mm
Stroke	75 mm

2.1 Specifications of other Device and Fluid used in Experiment

(i) Coefficient of discharge for orifice = 0.62
(ii) Diameter of orifice = 20
mm (iii) Density of air = 1.193
kg/m^3 (iv) Density of water =
1000 kg/m^3
(v) Stabilizer air tank capacity = 0.75 m^3

(vi) Fuel tank capacity = 8 litre

Fig. 1 Experimental Set Up for the Effect of Gasoline and Gasoline-Methanol Blends

The engine was started and allowed to warm up for a period of 10 to 15 minutes. Experiment was conducted at constant load and then at constant speed. The speed was measured by tachometer and load was measured by hydraulic dynamometer. Before running the engine to a new fuel blend, it was allowed to run for sufficient time to consume the remaining fuel from the previous experiment. Morse test which is applicable only to multi-cylinder engines; the engine is first run at required speed and the output is measured. Then one cylinder is cut out by short circuiting the spark plug. The procedure is repeated for all four cylinders. The output is measured by keeping speed constant in first case and in the second case, keeping load constant. In first case experiment was performed at constant speed 1600 rpm at various loads 1 kg, 2 kg, 3 kg and 4 kg. In second case experiment was performed at constant load 5 kg at various engine speeds 1300 rpm, 1400 rpm, 1500 rpm and 1600 rpm. Methanol-gasoline blends were prepared by volume measure. Alcohol fuel used was methanol (laboratory grade, CH_3OH, 99.5 %). Methanol-gasoline blends used in the experiment were 5 %, 10 % and 15 % of methanol by volume. The parameters such as brake specific fuel consumption, brake power, brake thermal efficiency were estimated by standard equations.

2.2 Experimental Data

		Sr. No.	Speed (rpm) N	Load (kg) W	Brake Horse Power bhp	Mass of Air Consumption (kg/min) m_a	Mass of Fuel Consumption (kg/hr) m_f	Air to Fuel ratio A/F	Brake Specific Fuel Consumption (kg/bhp hr) bsfc	Brake Thermal Efficiency (%) η_{bth}
100 % Gasoline	**Constant Load**	1.	1300	5.0	6.50	0.2907	1.010	17.30	0.155	38.86
		2.	1400	5.0	7.00	0.2907	1.070	16.33	0.152	39.68
		3.	1500	5.0	7.50	0.2907	1.140	15.30	0.151	39.89
		4.	1600	5.0	8.00	0.2907	1.180	14.68	0.148	40.70
5 % Methanol by		5.	1300	5.0	6.50	0.4520	1.008	21.72	0.169	36.02
		6.	1400	5.0	7.00	0.4350	1.068	19.09	0.170	36.52
		7.	1500	5.0	7.50	0.4250	1.140	17.22	0.171	36.55
		8.	1600	5.0	8.00	0.4220	1.118	15.61	0.172	36.82
10 % Meth		9.	1300	5.0	6.50	0.3415	1.320	15.38	0.205	31.17
		10.	1400	5.0	7.00	0.3372	1.420	14.29	0.202	31.58

anol by 15 %		11.	1500	5.0	7.50	0.3328	1.480	13.52	0.197	32.46
		12.	1600	5.0	8.00	0.3284	1.650	11.94	0.206	32.97
		13.	1300	5.0	6.50	0.4353	1.370	10.29	0.230	22.50
Methanol by		14.	1400	5.0	7.00	0.4286	1.970	13.06	0.280	23.42
		15.	1500	5.0	7.50	0.4217	2.090	12.12	0.270	23.65
		16.	1600	5.0	8.00	0.4147	2.150	11.55	0.260	24.45
100 % Gasoline	Constant Speed	17.	1600	1.0	1.60	0.2753	1.050	15.73	0.656	9.180
		18.	1600	1.9	3.04	0.2753	1.090	15.12	0.359	16.78
		19.	1600	2.9	4.64	0.2753	1.160	14.19	0.250	24.09
		20.	1600	4.5	7.20	0.2753	1.124	13.29	0.172	35.22
5 % Methanol by		21.	1600	1.0	1.60	0.3860	1.080	20.29	0.680	9.080
		22.	1600	2.0	3.20	0.3890	1.140	19.77	0.357	17.46
		23.	1600	3.5	5.60	0.3930	1.220	18.89	0.217	28.50
		24.	1600	4.5	7.20	0.3970	1.240	18.03	0.160	38.93
10 % Methanol by		25.	1600	1.0	1.60	0.3622	1.280	15.61	0.801	7.960
		26.	1600	2.4	3.84	0.3582	1.490	14.39	0.389	16.42
		27.	1600	3.0	4.80	0.3541	1.550	13.72	0.323	19.80
		28.	1600	5.0	8.00	0.3499	1.630	12.91	0.203	31.43
15 % Methanol by		29.	1600	1.0	1.60	0.4350	1.570	16.61	0.982	6.700
		30.	1600	2.0	3.20	0.4280	1.720	14.99	0.538	12.23
		31.	1600	3.1	4.96	0.4220	1.840	13.78	0.370	17.78
		32.	1600	4.6	7.36	0.4150	1.970	12.64	0.267	24.62

3. RESULTS AND DISCUSSIONS

The tests were conducted using gasoline and gasoline-methanol blends containing 5, 10 and 15 percent of methanol by volume as fuel. The brake horse power developed, brake specific fuel consumption and brake thermal efficiency of the engine were analyzed.

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3.1 Effect on Brake Horse Power at Constant Speed

The bhp developed by the engine at various loads 1 kg, 2 kg, 3 kg, 4 kg and 5 kg at constant engine speed of 1600 rpm and at various speeds 1300 rpm, 1400 rpm, 1500 rpm and 1600 rpm at constant load of 5 kg on gasoline and gasoline-methanol blends is shown in fig. 2 and fig. 3 respectively. This figures show that with increase in load the bhp developed increased and the engine developed 8 bhp (maximum) at 5 kg brake load and 1600 rpm on gasoline, 5 %, 10 % and 15 percent gasoline-methanol blends respectively. The straight line representation of bhp developed by the engine on gasoline as well as on gasoline-methanol blends containing 5, 10 and 15 percent methanol by volume as evident from the figure indicates that almost same bhp was available from the engine. The straight line relationship was obtained due to the reason that for every condition on the engine on both, gasoline and gasoline-methanol blends, the engine speed and load remained constant.

3.2 Effect on Brake Specific Fuel Consumption

The brake specific fuel consumption of the engine utilizing gasoline and gasoline-methanol is shown in fig. 4 and fig. 5 respectively. It is clear from the figures that brake specific fuel consumption for all the blends & for pure gasoline decreased as the speed and load increased. The highest bsfc was observed 0.975 kg/bhp hr at 1 kg and 1600 rpm using 15 % gasoline-methanol blend and lowest bsfc was observed 0.145 kg/bhp hr at 5 kg and 1600 rpm using 100 % gasoline. The change in brake specific fuel consumption as evident from figure was due to the reason that any engine when operating at very light load or speed uses more fuel per hp-hour. . Also when the load is increased brake specific fuel consumption decreases up to rated speed and load. Further certain amount of fuel is required to operate the engine itself that is to supply power to overcome friction. This friction and amount of fuel required to overcome it, remains practically constant for a speed regardless of the load on the engine and changes slightly as speed is changed. Therefore, as the load increases this quantity of fuel required to overcome friction becomes less and less in proportion to total amount required.

3.3 Effect on Brake Thermal Efficiency

The thermal efficiency obtained for gasoline and gasoline-methanol blends are plotted in fig. 5 and fig. 7. The figures show that for gasoline as well as gasoline-methanol blends, the thermal efficiency increases as the load and speed are increased. Rate of increase of thermal efficiency after 3 kg load, is more for gasoline than for gasoline-methanol blends. The lower thermal efficiency of the engine on blended fuel at higher loads was due to lower heating value of the blend than the gasoline. The thermal efficiency of the engine was highest (40.7%) on gasoline fuel at 5 kg brake load and 1600 rpm speed. The highest thermal efficiency was 36.5 % for the fuel having 5 percent methanol in the blend at 1600 rpm and 5 kg brake load. The lowest thermal efficiency was observed for blend containing 15 % methanol at all loads and speeds. This is due to the fact that at higher speeds, specific fuel consumption decreases leading to a rise in thermal efficiency for gasoline, whereas for gasoline-methanol blends at higher speeds prevent effective utilization in the cylinder and increase in fuel consumption and thereby decreasing thermal efficiency.

From the analysis of these results it may be concluded that performance parameters such as brake specific fuel consumption and thermal efficiency for 5 percent blend of methanol with gasoline are quite comparable with gasoline. As the percent of methanol is increased, thermal efficiency decreases and bsfc increases. For 15 % methanol blend thermal efficiency is very poor and bsfc is higher almost at all loads and speeds. It was also noticed that fuel separation occurred after some time when 10 and 15 % methanol was added with gasoline. Hence, satisfactory use of methanol in gasoline up to 5 percent level by volume may be recommended

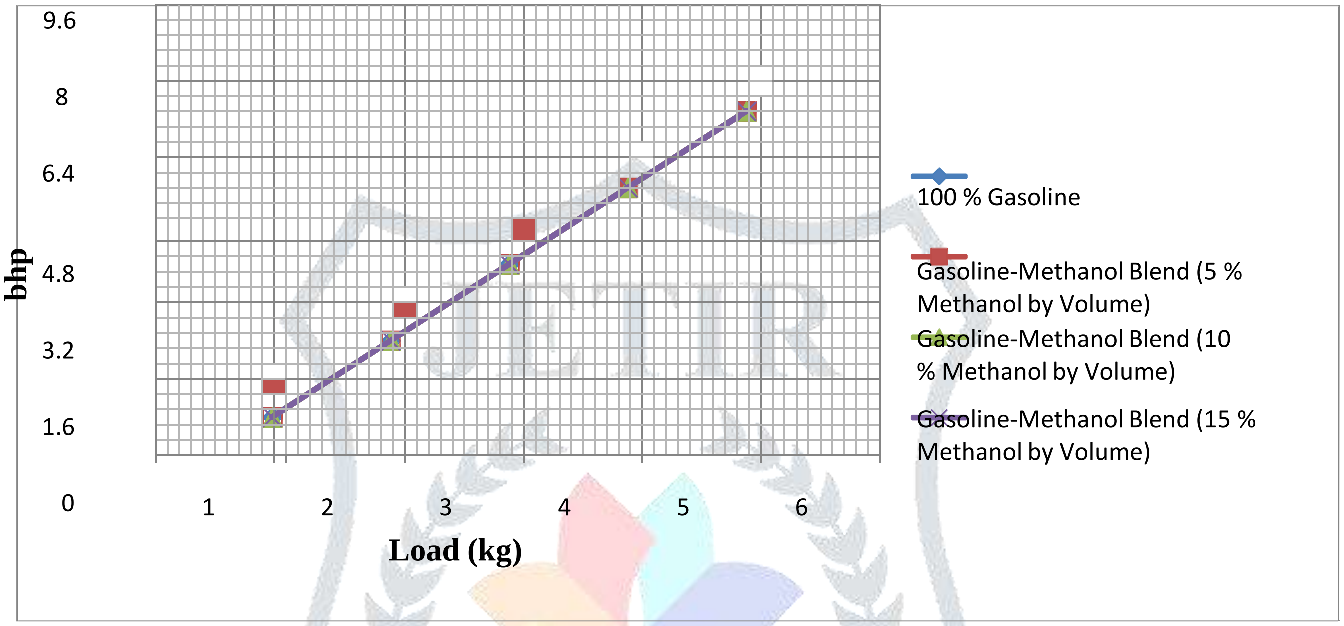

Fig. 2 Variation of Brake Horse Power with Load at Constant Speed (1600 rpm)

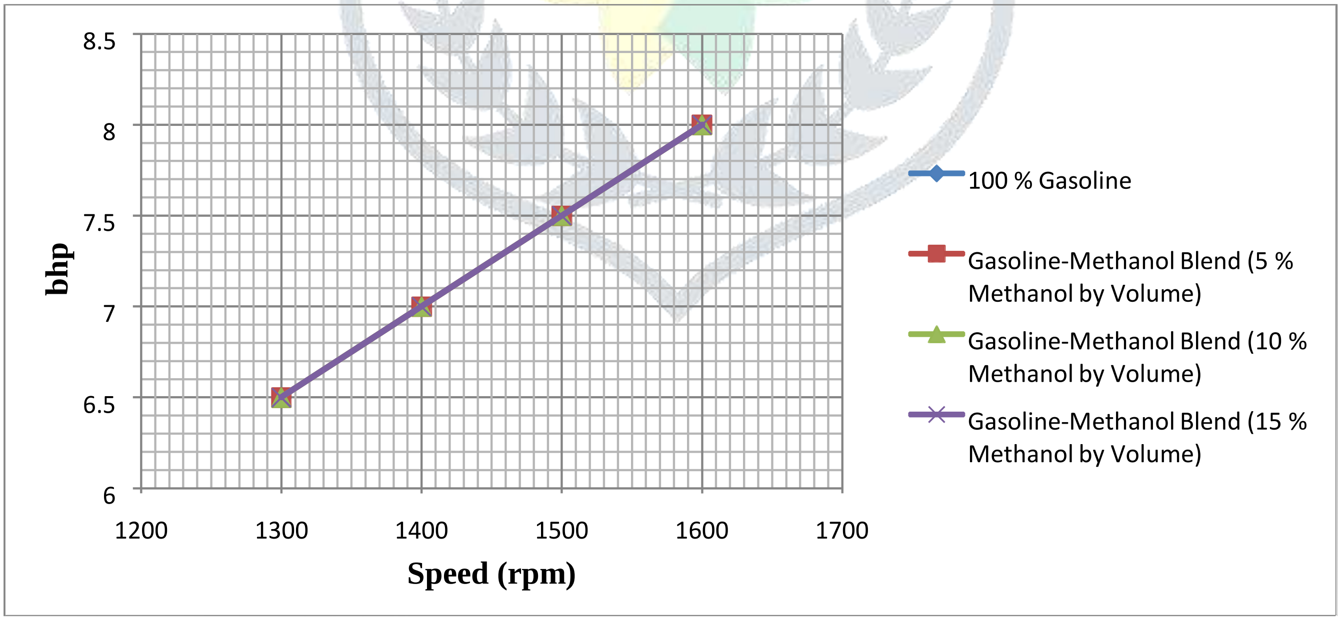

Fig. 3 Variation of Brake Horse Power with Speed at Constant Load (5 kg)

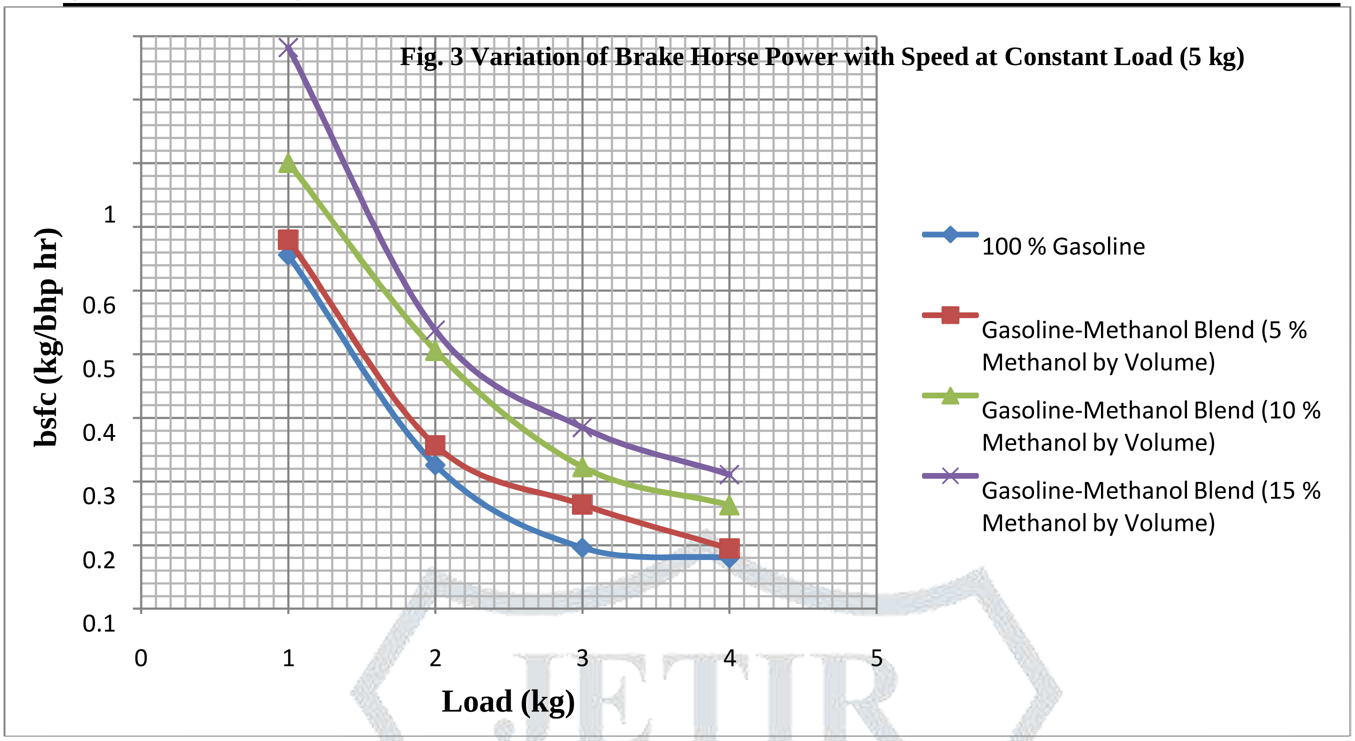

Fig. 4 Variation of Brake Specific Fuel Consumption with Load at Constant Speed (1600 rpm)

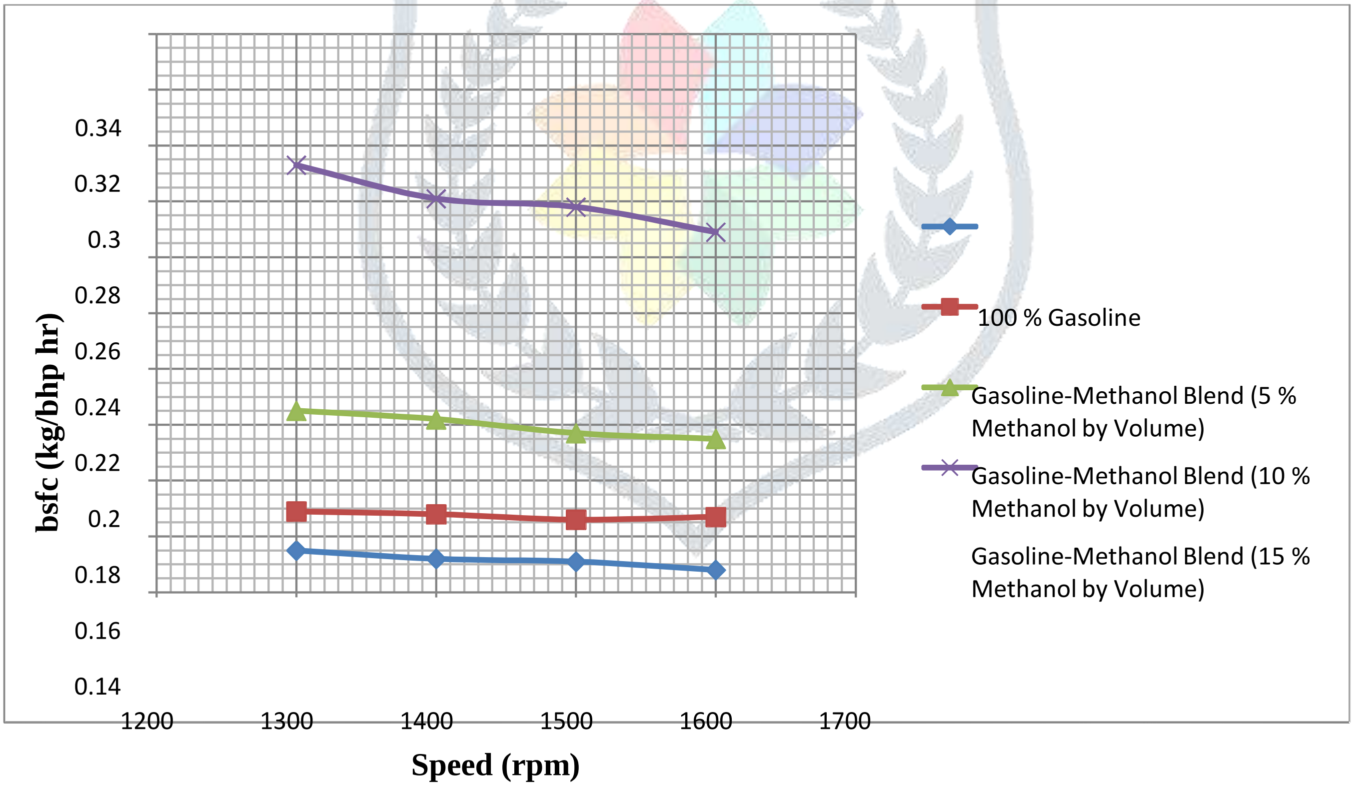

Fig. 5 Variation of Brake Specific Fuel Consumption with Speed at Constant Load (5 kg)

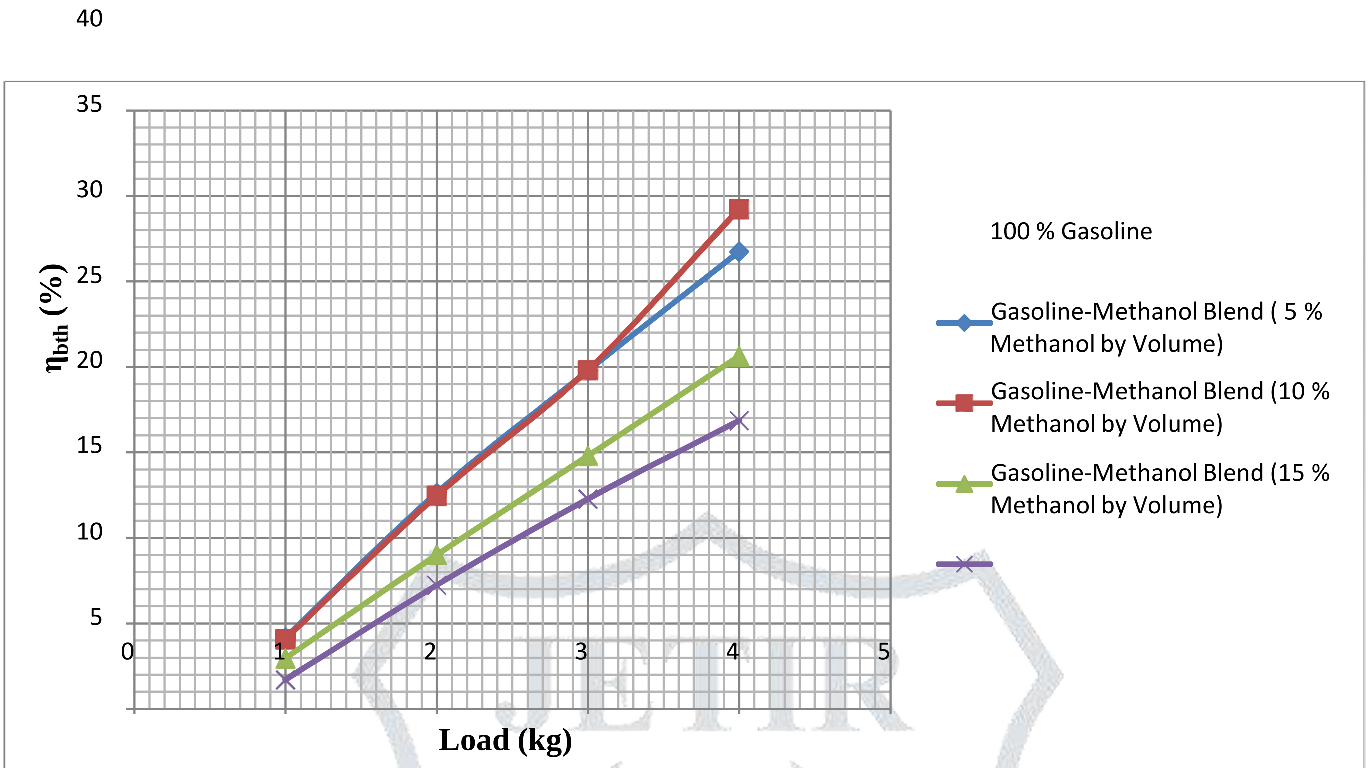

Fig. 6 Variation of Brake Thermal Efficiency with Load at Constant Speed (1600 rpm)

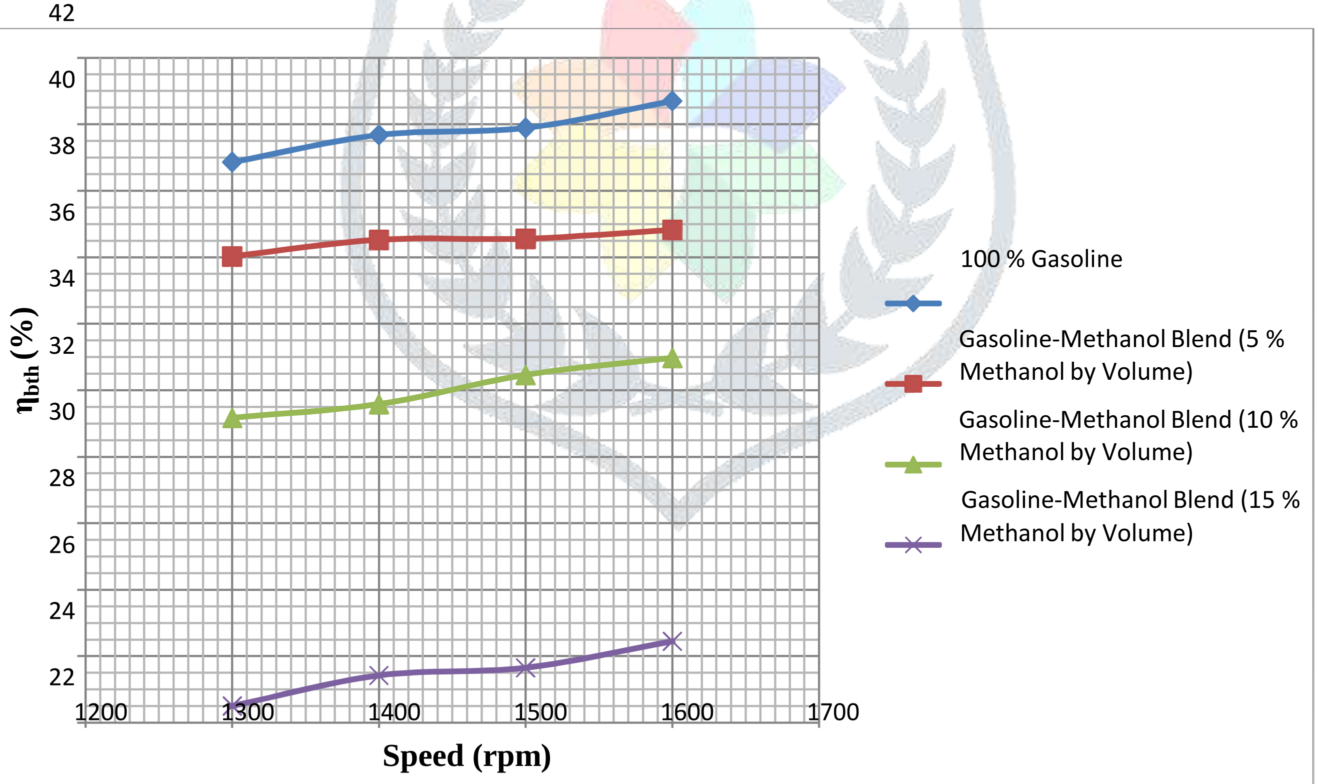

Fig. 7 Variation of Brake Thermal Efficiency with speed at Constant Load (5 kg)

4.CONCLUSIONS

From analysis of results, following conclusions can be drawn:

- Methanol is a good SI engine fuel because of its physical and chemical properties (especially its high octane number).
- Performance parameters such as brake specific fuel consumption and brake thermal efficiency for 5 % blend of methanol with gasoline are nearly equal to that of pure gasoline.
- As the percentage of methanol is increased up to 15 %, thermal efficiency decreases and brake specific fuel consumption increases. The lowest thermal efficiency and highest brake specific fuel consumption is found for 15 % methanol blend almost at all loads and speeds.
- It was also noticed that fuel separation occurred after a period of time when 10 and 15 % methanol was added with gasoline. Only minor engine modifications such as enlargement of fuel nozzles and addition of ignition improver are needed. Hence, satisfactory use of methanol in gasoline up to 5 % level by volume may be recommended.

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