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EXPLORING THE IMPACT OF METHANOL-PETROL FUSION ON SI ENGINE TEST RIG PERFORMANCE

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ABSTRACT :- Fossil fuels remain the primary energy source today, but their rising costs and environmental concerns are pushing the need for cleaner, alternative energy. Both CI and SI engines are now exploring alternative fuels to reduce reliance on gasoline. Countless studies have delved into alternative fuels, aiming to minimize their impact on fuel consumption while enhancing engine performance.

The urgency to find alternatives stems from future energy resource availability and the imperative to curb carbon dioxide emissions. This research focuses on commercial petrol blended with 10%, 15%, and 20% methanol. We evaluated the physical properties of these gasoline blends and tested them on a three-cylinder, four-stroke, variable RPM petrol MPFI engine. Our aim was to measure performance characteristics and exhaust temperature.

The results indicated reduced petrol consumption and improved Brake Power, Brake Thermal Efficiency, and volumetric efficiency with blending. Notably, the 15% methanol blend proved most effective. It suggests that this blend could be further utilized in SI engines with minimal constraints on materials, capable of sustaining a slight increase in pressure without requiring engine modifications.

1.Introduction

The escalating demand for petroleum energy in recent decades has led to increased costs due to the diminishing fossil fuel sources. This highlights the critical need to explore alternative fuels that can either replace or reduce our reliance on petroleum. Alcohols have emerged as promising candidates for SI engines. Their properties closely resemble those of gasoline, and when blended in small proportions, they often don't require modifications to existing engines. The impact of gasoline extends beyond its energy properties. Harmful gases emitted during its combustion, such as Carbon Monoxide (CO), Carbon Dioxide (CO2), and unburnt hydrocarbons (UBHC), severely impact the environment. These gases, resulting from incomplete fuel combustion, contribute to various health issues in humans. They can cause disorders like asthma, bronchitis, emphysema, and affect reflexes, leading to symptoms like vomiting, dizziness, and drowsiness. Moreover, they are linked to severe health conditions such as cardiovascular problems, neurobehavioral disorders, pulmonary cancer, and premature death. **[1]**

In the environment, various gases contribute to pollution and the greenhouse effect, with transportation being a significant contributor. Vehicles emit gases like carbon monoxide, carbon dioxide, and unburnt hydrocarbons, playing a major role in environmental degradation. Numerous summits and political decisions aim to curb these emissions in the future. Carbon dioxide (CO2) mainly stems from petroleum and diesel oils in transport, alongside other fossil fuels like natural gas and Liquefied Petroleum Gas (LPG). To reduce CO2 emissions nationally and globally, minimizing the use of fossil fuel products in commercial transportation is imperative.[2]

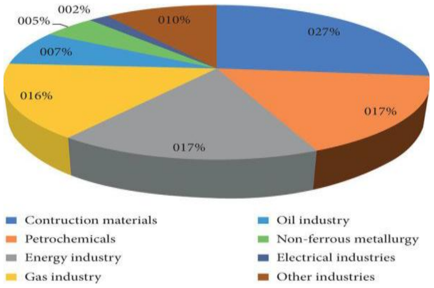

Fig.1 Air pollution Sources

In India, the transportation sector consumes a significant two-thirds portion of the yearly fuel energy, relying predominantly on petrol and diesel. The incessant demand for these fuels triggers frequent price escalations. To counter this, researchers are introducing diverse liquid fuel alternatives to supplement traditional fuels. The objective is to balance fuel consumption rates and diminish the detrimental emissions linked to using petroleum products as the sole fuel source.**[2-3]**.

Methanol emerges as a renewable and environmentally appealing alternative fuel, particularly favored for conventional fossil fuel-based engines. Its properties closely resemble those of gasoline, making it an attractive option for internal combustion engines. Derived from non-petroleum sources like natural gas, coal, and biomass, methanol boasts clean-burning characteristics and a high-octane rating. Its combustion generates no toxic gases like carbon dioxide, carbon monoxide, or unburnt hydrocarbons. Additionally, its oxygen content enhances combustion efficiency, while its high-octane value promotes smoother burning. Methanol's low boiling temperature is advantageous for cold start engines, and its high hydrogen-to-carbon ratio results in lower carbon intensity. Moreover, its lack of sulfur contamination further solidifies its position as a superior alternative fuel. [5].

1.3 Production of Methanol

Methanol synthesis has seen advancements, allowing for its production through various methods today. It can be derived from natural gas, biomass, recovered through flashing vaporization during continuous biodiesel production, or manufactured using coke oven gas. Numerous technologies have been adopted for methanol production, including low-pressure synthesis and advanced reforming technologies. Currently, methanol is primarily produced from synthesis gas, which comprises carbon monoxide and hydrogen. The chemical reaction for methanol synthesis from syngas, a mixture of CO and hydrogen, is described below.

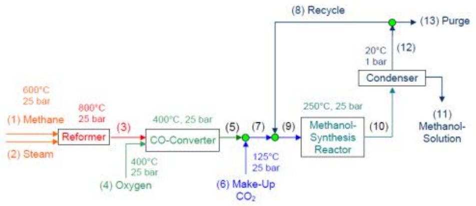

Fig 1.2: Methanol Synthesis Process

2. LITERATURE REVIEW

Dhaliwal at al. [11]- They explored emission effects on heavy and light-duty vehicles, comparing various fuels like liquid petroleum gas, compressed natural gas (CNG), gasoline, M-85, and M-100 against conventional gasoline and diesel. Findings indicated that M-100 exhibited variable emission effects in heavy-duty vehicles. Notably, it consistently showed favorable results for NOx and particulate matter, addressing significant concerns faced by diesel vehicles.

Li at al. [12]- Explored methanol's influence on engine performance through injection and timing adjustments. Found that optimizing these factors significantly improved engine efficiency and reduced emissions, requiring a 10%+ enhancement in the Brake Air Fuel Controller (BAFC) across various loads and at 1600 rpm compared to the non-optimized setup.

Abu-zaid M. [13]- In an experimental setup examining the impact of adding methanol to gasoline in a spark ignition (SI) engine, performance was tested at open throttle across variable speeds from 1000 to 2500 rpm. Different ratios of methanol-gasoline blends were used. The findings revealed a notable effect on the engine's performance due to methanol. The study demonstrated that the engine achieved its peak power output and maximum fuel efficiency when using a blend consisting of 15% methanol and 85% gasoline.

Shenghua at al. [14]- An experiment was conducted on a three-cylinder spark ignition (SI) engine, employing various methanol-gasoline blends (10%, 15%, 20%, 25%, 30%) under full load conditions. The findings indicated a consistent trend: as the methanol blend increased, both engine power and torque decreased. However, this decrease in power and torque was coupled with an increase in brake thermal efficiency.

Yanju at al. [15]- In an experiment conducted on a three-cylinder spark ignition (SI) engine utilizing methanol-gasoline blends M10, M20, and M85, the findings revealed a correlation between the blend ratio and CO emissions. As the ratio of methanol to gasoline increased, there was a consistent reduction in CO emissions. Notably, for the M85 blend, there was a substantial 25% decrease in CO emissions. However, the study indicated that lower methanol ratios in fuel blends did not significantly impact the reduction of NOx emissions, except for the M85 blend, which demonstrated an impressive 80% reduction in NOx emissions.

Bilgin and sezer [16]- In their investigation on engine performance using various ratios of methanol-gasoline blends (both leaded and unleaded) at different engine RPMs, the study highlighted that the optimal engine performance was achieved with the M5 fuel blend. Specifically, at this particular blend ratio, the brake mean effective pressure demonstrated its highest value, indicating peak performance for the engine**.**

Mallikarjun and venkataa Ramesh mamilla [17]- In their experiment on a four-cylinder spark ignition (SI) engine, methanol was introduced into gasoline, coupled with modifications to the engine systems to accommodate different load conditions. The findings revealed notable changes in engine performance across various blend ratios (ranging from 0% to 15% methanol). The observations included a slight increase in the octane rating of gasoline, alongside improvements in brake thermal efficiency and indicated thermal efficiency. Moreover, the introduction of methanol led to a reduction in engine knocking.

Turner et al. [18] In an experimental study focusing on the impact of ethanol-methanol-gasoline blends on exhaust gases (specifically NOx and CO2 emissions) utilizing different fuel ratios (G29.5 + E42.5 + M28, G37 + E21 + M42, G42 + E5 + M53, G40 + E10 + M50), the findings indicated that the use of dual fuel blends resulted in reduced emissions of NOx and CO2 compared to using pure gasoline. Additionally, the study noted a slight improvement in engine performance as a result of these dual fuel blends.

Sileghem et al. [19] In an experiment comparing two rates of ethanol-methanol-gasoline blends, the findings revealed reduced NOx emissions compared to pure gasoline, but higher NOx emissions compared to pure methanol. Additionally, the study showed that dual fuel blends resulted in lower CO emissions in comparison to both pure fuels and single blend alternatives.

Altun et al. [20] The investigation focused on blending 5% and 10% ethanol and methanol with unleaded gasoline, assessing engine performance and exhaust emissions. The findings highlighted that M10 and E10 blends demonstrated the most favorable outcomes in exhaust emissions. Specifically, M10 and E10 showed reductions of 10.6% and 9.8% in CO emissions, and 13% and 15% in CO2 emissions, respectively. However, the blending effect resulted in increased Break-Specific Fuel Consumption (BSFC) and decreased Break Thermal Efficiency compared to pure unleaded gasoline.

Tiegang Hu [21] studied the performance of engine and exhaust emission by using a three- cylinder engine with bore 68.5mm port fuel injection operated with methanol-gasoline blend during cold start and warm up. The study's cylinder pressure analysis highlighted an enhancement in engine combustion when methanol was added to gasoline. This improvement was evidenced by higher indicated mean effective pressure observed across 50 cycles, attributable to a shortened flame development period and faster burning facilitated by increased methanol-gasoline proportions.

3. Testing of Engine

3.1 Testing of methanol petrol on Maruti 3 cylinder MPFI four stroke engine.

3.1.1-: Experimental Procedure

The engine was initially started without a load, adjusting the fuel feed control to reach the rated speed of 1500rpm. We let the engine run until it reached a steady state. Using a fuel measuring unit and stopwatch, we measured the time taken for the consumption of 10cc, 20cc, and 30cc of fuel and averaged these values. Additionally, we recorded fuel consumption, rpm, exhaust temperature, and power output.

As we gradually applied load to the engine while keeping the speed within the permissible range, we observed and documented each parameter to establish baseline data. We also conducted short-term performance tests on the engine.

Subsequently, we tested methanol-petrol blends to assess their potential suitability as fuel. After each reading, we drained the remaining blend from the engine via a drain pipe and refilled it with a new methanol-petrol blend to take fresh readings.

3.1.2. Engine Specifications

Table 3.1 Specification of engine

Specification of Engine		
1	Engine Make	Maruti MPFI
2	Fuel	Petrol
3	No. of Cylinder	3
4	No. of stroke/cycles	4
5	Rated power	5hp
6	Rated RPM	1500rpm
7	Bore	67mm
8	Stroke Length	72mm
9	Starting Condition	Cold Start
10	Method Cooling	Water cooled
11	Method of ignition	Spark ignition

Experimental Setup

Fig.3.1 Engine Testing Setup

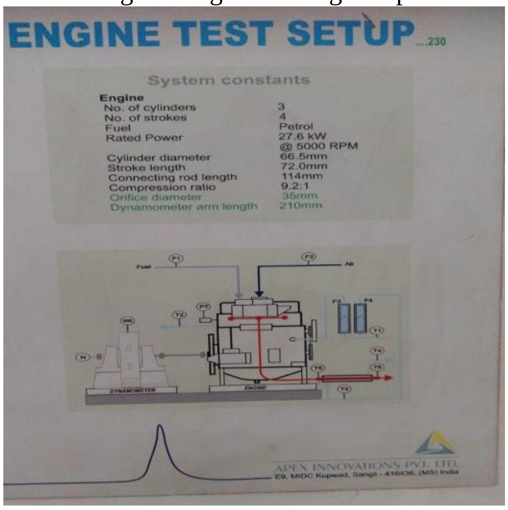

Fig.3.2 Testing Rig

Fig 3.3 Break Torque Measuring system

3.1.3 Fuel Measurement

Fig 3.3 Break Torque Measuring system

Fuel is delivered to the engine from the main fuel tank via a graduated measuring fuel gauge, often referred to as a burette. The process involves closing the stopcock, initiating the stopwatch, and measuring the duration it takes for the consumption of Xcc amount of fuel.

3.1.4 Air Intake Measurement

The air tank is linked to the suction side, allowing the tank to draw air into the cylinder. A manometer is integrated to gauge the pressure variation across an orifice within the intake pipe connected to the air tank. This pressure variance serves as a basis for computing the volume of air pulled into the cylinder.

3.1.5 Temperature Measurement

A digital temperature indicator is located at the different section of the engine to measure the temperature and switch is provided on the panel to read the temperature.

The thermocouple details are given below-:

$T1$ – Inlet water temperature to engine and calorimeter
$T2$- Outlet water temperature from engine jacket
$T3$- Inlet water temperature to Calorimeter
$T4$- Water outlet temperature from calorimeter
$T5$- Exhaust gas inlet temperature
$T6$- Exhaust gas outlet temperature

3.1.6 Water Flow Measurement

A rotameter within the engine jacket serves to measure the water quantity permitted into the jacket. Valves are incorporated to control and regulate this water flow. The rate of flow, measured in cc/sec, can be directly observed and noted from the rotameter.

3.1.7 Test Procedure

1. Pour methanol petrol blends into the main tank.
2. Connect the instrumentation power input of 230V power source.
3. Attach the water line to both the engine jacket and break drum.
4. Ensure the fuel valve is open and free of any trapped air in fuel tank.
5. Initiate the engine and allow it to stabilize at rated 1500rpm.
6. Now load engine in steps of ¼, ½, and ¾ full loads and allow stabilizing engine at each load.
7. Recording all the parameter given on digital indicator.

4. Reading of Pure Petrol

Engine test setup multi cylinder 4- stroke, Petrol			
Product no. 230H			
Note- Do not enter values in cells with yellow background			
System Constants			
Engine make	Maruti MPFI	Cylinder diameter(m)	0.067
Orifice diameter (m)	0.035	Stroke (m) L	0.072
Dynamo. Arm length (m)	0.2	No. of cylinder	3
Coeff. Of discharge of orifice Cd	0.6	No of rev./cycle	2
Ambient temperature (Deg C)	30	Sp. Heat limit min (kJ/kg deg K)	1.4
Fuel density (kg/sec^2)	740	Sp. Heat limit max (kJ/kg deg K	1.8
Fuel calorific value (KJ/kg)	44000		

Table-: 4.1 Engine Specifications Table-: 4.2 Observation table for pure petrol

Engine speed (rpm)	Load (kg)	Mano defl. (mm)	Fuel flow sec/100ml	Engine cooling water(Lph)	Calo.water (Lph)	T1 inlet Engine water in °C	T2 Engine water out °C	T3 inlet water temp to calor.	T4 Cal water out °C	T5 Exhaut in	T6 Exhaut out
1550	0.6	36	31.2	990	220	27	34	27	31	194	89
1905	0.9	45	28.6	990	230	27	33	27	30	211	100
2420	1.5	60	27.1	990	230	27	34	27	32	267	137
2952	2.4	75	22.3	990	230	27	34	27	34	323	162

4.2 Result reading for pure petrol
Air density Kg/$m3$ = 1.6

Table-: 4.3 Reading of pure petrol

Brake Power	BMEP (bar)	Torque (Nm)	BSFC kg/kwH	B.Th eff.(%)	Air flow (kg/hr)	Vol.eff (%)
0.54	0.4	0.5	0.95	7.83	11.9	23.8
0.69	0.5	2	0.91	8.87	12.2	25.8
0.75	0.6	2.7	0.85	13.26	18.2	27.6
0.86	0.9	4	0.97	12.21	23.4	26.3

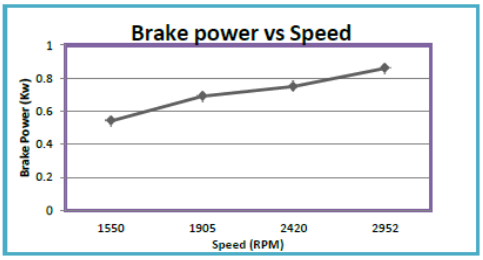

Fig. 4.1 Graph for B.P vs Speed for pure petrol

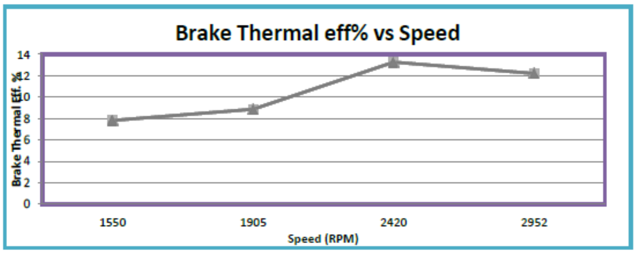

Fig. 4.2 Graph for Brake Thermal Efficiency vs Speed for pure petrol

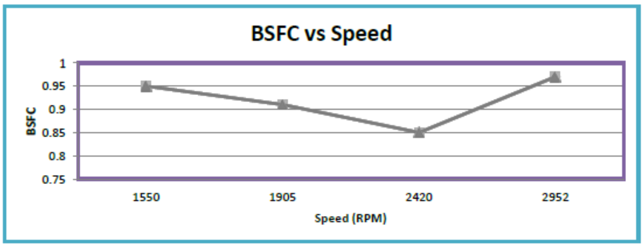

Fig. 4.3 Graph for BSFC vs Speed

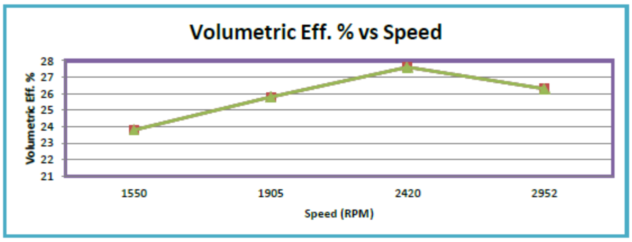

Fig 4.4 Graph for Volumetric Eff. % vs Speed Table 4.4 Reading of 10 % of methanol with petrol

Engine test setup multi-cylinder 4- stroke, Petrol				
Product no. 230H				
Note- Do not enter values in cells with yellow background				
System Constants				
Engine make	Maruti MPFI		Cylinder diameter(m)	0.067
Orifice diameter (m)	0.035		Stroke (m) L	0.072
Dynamo. Arm length (m)	0.2		No. of cylinder	3
Coeff. Of discharge of orifice Cd	0.6		No of rev./cycle	2
Ambient temperature (Deg C)	30		Sp. Heat limit min (kJ/kg Deg K)	1.4
Fuel density (kg/sec^2)	745		Sp. Heat limit max (kJ/kg Deg K	1.8
Fuel calorific value (KJ/kg)	41815			

Table 4.5 Observation of 10 % blend

Engine speed (rpm)	Load (kg)	Mano defl. (mm)	Fuel flow sec/100ml	Engine cooling water(Lph)	Calo.water (Lph)	T1 inlet Engine water in °C	T2 Engine water out °C	T3 inlet water temp to calor.	T4 Cal water out °C	T5 Exhaut in	T6 Exhaut out
1565	0.5	36	30.8	910	250	27	32	27	31	193	92
1923	0.9	45	28.6	910	250	27	33	27	31	240	114
2473	1.5	61	24.6	910	250	27	34	24	31	271	141
2965	2.4	73	18.6	910	250	27	35	27	33	310	171

Table 4.6 Result of 10% Blends

Brake Power	BMEP (bar)	Torque (Nm)	BSFC kg/kwH	B.Th eff.(%)	Air flow (kg/hr)	Vol.eff (%)
0.55	0.3	0.5	0.96	7.89	11.7	21.2
0.74	0.5	1.9	0.89	9.14	12.1	23.9
0.77	0.7	2.8	0.84	13.41	16.6	25.9
0.87	0.8	4.7	0.98	12.25	19.9	24.2

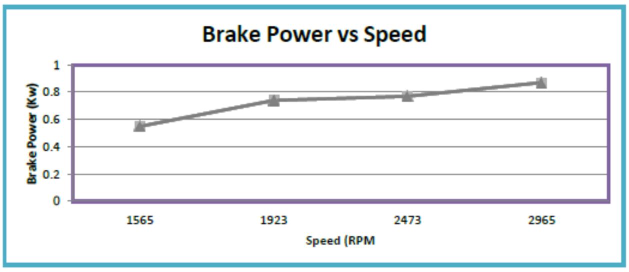

Fig. 4.5 Brake Power vs Speed for 10% Blend

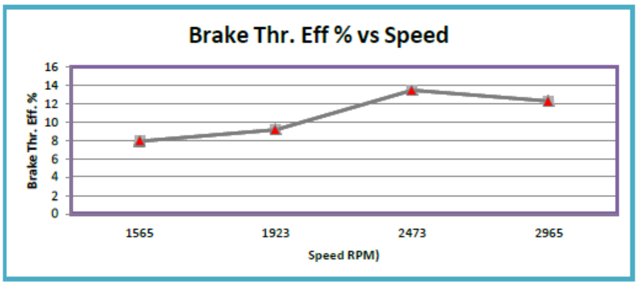

Fig.4.6 Brake Thermal Efficiency vs Speed for 10% blend

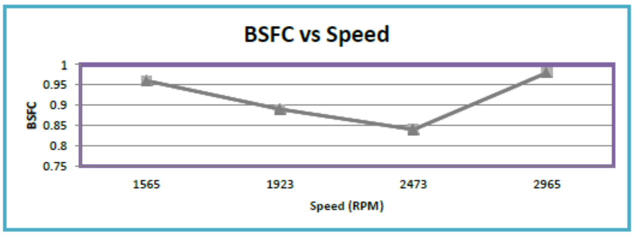

Fig. 4.7 BSFC vs Speed For 10% blend

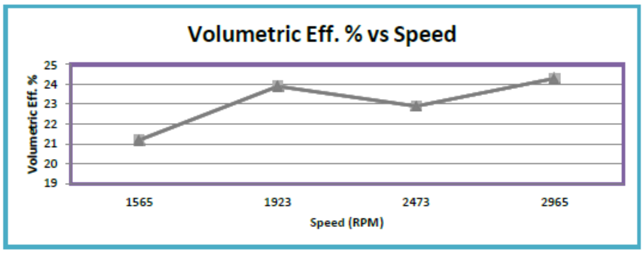

Fig. 4.8 Volumetric Efficiency vs Speed for 10% blend Table 4.7-: Reading of 15% Methanol

Engine test setup multi cylinder 4- stroke, Petrol				
Product no. 230H				
Note- Do not enter values in cells with yellow background				
System Constants				
Engine make	Maruti MPFI		Cylinder diameter(m)	0.067
Orifice diameter (m)	0.035		Stroke (m) L	0.072
Dynamo. Arm length (m)	0.2		No. of cylender	3
Coeff. Of discharge of orifice Cd	0.6		No of rev./cycle	2
Ambient temperature (Deg C)	30		Sp. Heat limit min (Kj/kg Deg K)	1.4
Fuel density (kg/sec^2)	742		Sp. Heat limit max (Kj/kg Deg K	1.8
Fuel calorific value (KJ/kg)	41597			

Table 4.8 Observation of 15% blend

Engine speed (rpm)	Load (kg)	Mano defl. (mm)	Fuel flow sec/100ml	Engine cooling water(Lph)	Calo.water (Lph)	T1 inlet Engine water in °C	T2 Engine water out °C	T3 inlet water temp to calor.	T4 Cal water out °C	T5 Exhaut in	T6 Exhaut out
1450	0.6	35	28.6	900	200	27	35	27	33	229	124
1921	0.9	45	27.2	900	200	27	33	27	31	242	117
2488	1.5	60	22.3	900	200	28	38	28	34	250	120
2963	2.4	72	17.2	900	200	27	33	27	31	242	117

Table 4.9 Result of 15% methanol

Brake Power	BMEP (bar)	Torque (Nm)	BSFC kg/kwH	B.Th eff.(%)	Air flow (kg/hr)	Vol.eff (%)
0.54	0.19	0.8	1.11	7.95	11.9	32.6
0.71	0.37	2	0.98	9.41	12.4	25.2
0.81	0.53	3.1	0.86	13.65	18.4	27.9
0.88	0.66	5.1	1.05	12.15	21.6	29.6

4.4 Comparison of results

Methanol blending of ratio 10%, 15%, 20% by volume with petrol is observed in given graph and now by comparing these graphs in single graph will show the best result of experiment. The values are calculated and fed into the software for desired result. The result was obtained and noted, plotted for clear understanding of variation of different parameter by using different blend.

1. **Graph for Brake Power vs Load**

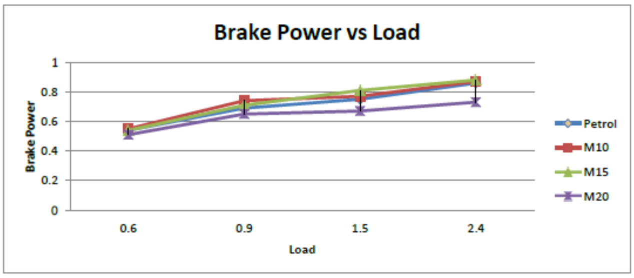

Fig 4.17 Brake Power vs Load

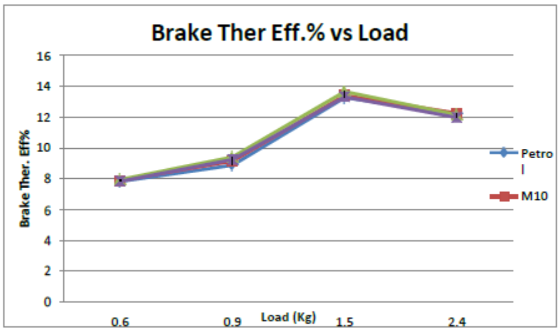

Fig.4.18 Brake Thermal Efficiency vs Load

BSFC vs LOAD

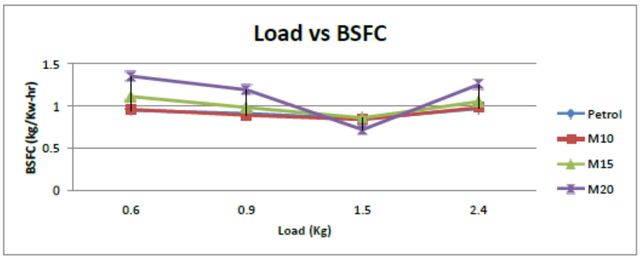

Fig. 4.19 Load vs BCFC

6. CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

The study involved experimental testing of engine performance using various methanol-petrol blends (0%, 10%, 15%, 20% by volume) at different loads on a 3-cylinder, 4-stroke, SI engine (Product code-230H) with a maximum RPM of 3000. The findings indicate that operating the experiment on an M15 blend results in a lean shift, contributing to increased brake power and thermal efficiency.

At around 2500rpm, there's a noticeable increase in brake thermal efficiency, followed by a subsequent decrease. This improvement in thermal efficiency is linked to the higher percentage of methanol added, leading to enhanced combustion processes. Brake thermal efficiency relies on brake power values and calorific value, which demonstrate improvements due to methanol addition.

Specific fuel consumption (SFC) decreases with an increase in the blending ratio, showing higher values for pure petrol at constant loads. Methanol additives exhibit lower SFC compared to pure petrol, owing to the higher oxygen content in methanol. SFC decreases with increasing loads and brake thermal efficiency.

The utilization of a methanol blend (M15) in the engine not only enhances its performance but also reduces harmful exhaust emissions because of the elevated oxygen content in methanol. This underscores the potential benefits of employing methanol blends in engines, reflecting improved efficiency and reduced environmental impact.

6.2 Future Work

Indeed, Analyzing the reasons behind the consistency among different results can significantly enhance our comprehension of the necessity to minimize pollutant emissions by operating engines on methanol fuels. Exploring this correlation could shed light on the requirements and advantages of employing methanol as a fuel option to reduce emissions.

Fuel options play a crucial role in mitigating emissions. One approach involves reformulating fuels by either reducing or increasing specific components to optimize engine performance and minimize emissions. Alternatively, utilizing alternative fuels like methanol offers a promising avenue for emission reduction. Methanol, due to its unique properties and higher oxygen content, has shown potential in reducing emissions when used as a fuel in engines. Understanding the correlation between various results can help in making informed decisions regarding fuel formulation or selection to effectively curb pollutant emissions.

REFERENCES

1. Kumar. S.Narasimha, Krishna. V. V,. Murthyp.V.K, (Comparative studies on Performance Parameter and Exhaust Emission from the two stroke copper coated spark ignition engine with alcohol blend gasoline with catalytic converter), international journal of engineering science & technology,February,2014[593-599]

2. Shahir SA, Masjuki HH, Kalam MA, Imran A, Ashraful AM.(Performance and emission assessment of diesel–biodiesel–ethanol/ bioethanol blend as a fuel indiesel engines): A review. Renewable and Sustainable Energy Reviews 2015;48:[62–78].

3. A. Elfasakhany, (Investigation on performance and emissions characteristics of an internal combustion engine fuelled with petroleum gasoline and a hybrid methanol–gasoline fuel), Int. J. Eng. Tech. 13 (2013) 24–43.

4. Koc M, Sekmen Y, Topgul T, Yucesu HS. (The effects of ethanol–unleaded gasoline blend on engine performance

and exhaust emissions in a spark-ignition engine).Renewable Energy 2009;34:2101–6.

5. M. Canaksi, AN. Ozsezen, E. Alptekin,(Impact of alcohol-gasoline fuel blends on exhaust emission on an SI engine), Renewable Energy, 52:111-17, 2013

6. Singh, Pratap,Devendra. Tiwari, kumar, Dhramendra, (Impact of bio fuel utilization in engine fuel): an 59 eco friendly products, IOSR journal of environmental science, toxicology and food technology (IOSR-JESTFT) e-ISSN :2319-2

7. Balki MK, Sayin C, Canakci M. (The effect of different alcohol fuel on theperformance, emissions and combustion characteristic of a gasoline engine). Fuel 2014;115:901–6

8. Y. Varol, C. Oner, HF. Oztop, S. Altun (Comparison of methanol, ethanol, or n-butanol blending with unleaded gasoline on exhaust emissions of an SI engine), Energy Sourse, Part A 36:938-948, 2014.

9. A.K. Agarwal, Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines, Prog. Energy Combust. Sci. 33 (2007) 233-71.

10. L. Shenghua, E.R.C. Clemente, H. Tiegang, W. Yanjv, (Study of spark ignition engine fueled with methanol–gasoline fuel blends), Appl. Therm. Eng. 27 (2007) 1904–1910.

11. Dhaliwal B, Yi N, Checkel D. (Eissions effects of alternative fuels in light-duty and heavy- duty vehicles). SAE technical paper No. 2000-01-0692; 2000.