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Paper Authors

J SRIKANTH, SK SALEEM

Ramachandra College of Engineering, Eluru, A.P, India

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PERFORMANCE AND EMISSIONS OF 4-STOKE SI ENGINE WITH ETHANOL BLENDED PETROL

[1]J SRIKANTH, [2]SK SALEEM
[1,2]Mechanical Engineering,Ramachandra College Of Engineering,Eluru, India
[1]jujjuvarapusrikanth1994@gmail.com, [2]saleem.mech7@gmail.com

Abstract— A blend is a mixture of two or more different things or substances. Several common ethanol fuel mixtures are in use around the world. Ethanol has been a gasoline additive since late 1970's and the primary role was air quality improvement. The use of pure hydrous or anhydrous ethanol in internal combustion engines are designed for that purpose. Mixture of hydrous and anhydrous in petrol called ethanol blended petrol. .Ethanol fuel mixtures have “E” numbers which describes the percentage of ethanol in the mixture by volume.

The project aims to decrease the pollution released to the atmosphere by a automobile without effecting the performance of the engine by adding different mixtures of ethanol with petrol. Since the ethanol is abstracted from molasses of sugar cane, wheat, corn, grains so it is Eco-friendly

Keywords: Blended petrol, Additive, IC Engine Equipment, Blender Pump, Performance Testing Machine, Emissions Testing Machine.

Introduction

Ethanol, an anhydrous ethyl alcohol having chemical formula of C2H5OH, can be produced from sugarcane, maize, wheat, etc. which are having high starch content. In India, ethanol is mainly produced from sugarcane molasses by fermentation process. Ethanol can be mixed with gasoline to form different blends. As the ethanol molecule contains oxygen, it allows the engine to more completely combust the fuel, resulting in fewer emissions and thereby reducing the occurrence of environmental pollution. Since ethanol is produced from plants that harness the power of the sun, ethanol is also considered as renewable fuel.

Procurement of ethanol

The OMCs are to procure ethanol from domestic sources. Government has notified administered price of ethanol since 2014. For the previous ethanol supply year 2017-18, the blending quantity of ethanol with petrol was 149.54 crore litres and the average blend percentage was 4.19 % which is the highest in the history of EBP Program.

For ethanol supply year 2018-19 (i.e. 1st December 2018 to 30th November 2019), the Government has fixed remunerative price for ethanol procurement based on raw material utilized for ethanol production as follows:

1. From C-heavy molasses at Rs. 43.46 per litre.
2. From B heavy molasses / partial sugarcane juice at
Rs.52.43 per litre.
3. Price of ethanol for the mills, who will divert 100% sugarcane juice for production of ethanol thereby not producing sugar, has been fixed at Rs.59.19 per litre. This price will be paid by OMCs to those sugar mills that will divert 100% sugarcane juice for production of ethanol

thereby not producing any sugar. If a sugar mill produces ethanol with a combination of B heavy molasses and sugarcane juice, the ethanol price derived from B heavy molasses route shall be payable by OMCs.

Types Of Alternate Fuels

Gasoline and diesel are still fossil fuel kings of the fuel supply chain but alternative fuels are now swinging the scale more toward green. Alternative fuels generally have lower vehicle emissions that contribute to smog, air pollution and global warming. Most alternative fuels don't come from finite fossil-fuel resources and are sustainable. Alternative fuels can help nations become more energy independent

1. An alcohol-based alternative fuel made by fermenting and distilling crops such as corn, barley or wheat. It can be blended with gasoline to increase octane levels and improve emissions quality. Positive: Materials are renewable. Negative: Ethanol subsidies have a negative impact on food prices and availability.
2. Natural gas is an alternative fuel that burns clean and is already widely available to people in many countries through utilities that provide natural gas to homes and businesses. Positive: Cars and trucks with specially designed engines produce fewer harmful emissions than gasoline or diesel. Negative: Natural gas production creates methane, a greenhouse gas that is 21 times worse for global warming than CO2.

Methods Of Production Of Ethanol

Synthetic ethanol

Ethane, produced by the breaking down of oil, is converted to ethanol using steam and a catalyst. Since this reaction also produces toxic by-products, synthetic ethanol is never used for human consumption. A further purification process is necessary to remove water and by-products, and newer methods are making use of safer re-agents.

Fermented ethanol

Fermentation has been carried out since ancient times as a method to produce alcohol. Most of the world's ethanol production plant generates ethanol using fermentation process where crops such as sugar cane, sugar beet, corn, rice and maize are used. Municipal waste can also be used as feedstock, thereby reducing landfill and promoting recycling. The fermentation is a complex series of reactions that convert carbohydrates, mainly sugars and starches, into ethanol and carbon dioxide. It works best at temperatures in the range 25°C - 37°C in the absence of oxygen (anaerobic), and will produce aqueous solutions of up to 14% ethanol. Higher alcohol contents require further distillation.

Biotechnology

Recent advancements in Bioethanol production have led to the development of a process to produce ethanol from waste biomass using bacteria. Genetically engineered bacteria are used to convert plant sugars into ethanol, rather than to ethnic or lactic acid as usually happen. This allows ethanol to be processed from bagasse such as forestry waste, rice hulls, sugar cane residues and the main crop can be grown as a food source. It is expected that in time ethanol will be able to compete economically with fossil fuels, removing the need for an ethanol fuel subsidy. Biotechnology promotes the use of waste to produce ethanol, which in turn, helps solve the problem of disposal that has arisen since many places have begun to ban burning crop residues because of environmental concerns over its impact, or where ploughingin waste is not possible because of the soil type.

Introduction To Performance

1. Indicated thermal efficiency
2. Brake thermal efficiency
3. Mechanical efficiency

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4. Specific fuel consumption

5. Indicated power

6. Brake power

Introduction To Engine Exhaust Emissions

Theoretically, if the combustion in the combustion chamber is complete, the exhaust will contain only carbon dioxide (CO2) and water vapour (H2O). But when the fuel quantity supplied is more, there is no sufficient oxygen available for complete combustion and part of the carbon converts into CO. Whereas, fuel quantity supplied is less, excess oxygen is made available to react with nitrogen which results in formation of NO. The different constituents which are exhausted from petrol engine and different factors which affect the formation.

Litertature Review

Introduction

As the part of literature survey is done on the area under ethanol blended petrol as alternate fuel in spark ignition engines used as a fuel of many research papers, conference papers, books and some of the research articles are referred. The details are discussed in below article.

International journal of ambient energy

The objective of this investigation was to find the effect of ethanol–gasoline blends as fuel on the performance and exhaust emission of a spark ignition (SI) engine. A four-stroke three-cylinder SI engine was used for this study. Performance tests were conducted for the three blends E5 (5% ethanol), E10 (10% ethanol) and E15 (15% of ethanol) as well as E0(100% gasoline) to evaluate their brake thermal efficiency, specific fuel consumption and mechanical efficiency, while exhaust emissions were also analyzed for carbon monoxide (CO), hydrocarbons (HC), carbon dioxide (CO2) and oxides of nitrogen (NOX) with varying torque conditions and constant speed of the engine. The results showed that blends of gasoline and ethanol increased the brake power, brake thermal efficiency and the fuel consumption. The CO and HC emissions concentration in the engine exhaust decreased while the NOX concentration increased.

SCOPE OF PRESENT WORK

The present study covers the various aspects of ethanol blends with petrol and performance, emissions study on four stroke single cylinder spark ignition engine with E5, E10, E20, E30, E40 blends of petrol. The engine was air cooled setup so performance parameters are calculated on low loads and emission test is conducted up to E20 blends. The performance parameters and emission analysis are compared with normal petrol line.

Preparation Of Ethanol Petrol Blends

Procedure

1. The ethanol is first filtered from impurities.
2. Required amount of fuel and ethanol is taken into the measuring jar and mixed

thoroughly shown in table 3.1

Notation	Fuel Quantity	Ethanol quantity	Petrol quantity
E5	1 litre fuel	50 ml	950 ml
E10	1 litre fuel	100 ml	900 ml
E20	1 litre fuel	200 ml	800 ml
E30	1 litre fuel	300 ml	700 ml
E40	1 litre fuel	400 ml	600 ml

blending percentage of fuel

FLASH AND FIRE POINTS

The fire hazards involved in the storage and handling are indicated by the flash and fire points. Flash point of their given oil is the temperature at which it will give off sufficient

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vapors to form a combustible mixture with air. It will ignite momentarily when a flame is brought close to it. In this case fire only takes place and extinguishes but does not burn continuously; practically all lubricating oils have flash points sufficiently high to eliminate fire hazards in storage as well as during use.

DETERMINATION OF CALORIFIC VALUES

The calorific value of the fuel is the amount of heat generated by burning unit mass or unit volume of the fuel. A fuel is more desirable whose heat generating capacity is high. This heat generated by the fuel per unit mass or volume is known as Calorific value of the fuel (C.V.).In case of liquid fuels, this is measured on mass (per kg) or volume (per liter) basis.

The calorific value has two values as Higher Calorific and Lower Calorific values. The C.V. of the fuel determined by experiment gives H.C.V. as the products of combustion are cooled to atmospheric temperature at which most water-vapour in the exhaust is cooled and condensed and its latent heat is given to the cooling medium. In actual practice, the latent heat of water vapour in exhaust is carried with the water-vapour and is not available. Therefore the lower C.V. of the fuel is calculated by deducting latent heat of water vapour from HCV (determined by experiment).

$$C_V = \frac{\text{mass of water} \times c_p \times (T_2 - T_1)}{\text{mass of fuel}} \quad \text{KJ/Kg}$$

Where, C_P= constant pressure of water

S.NO	FUEL	Cv (KJ/Kg)
1	PETROL	48000
2	E5	47720
3	E10	46046
4	E20	45208
5	E30	44371
6	E40	43534

calorific values of ethanol blends

Bomb Calorimeter

DETERMINATION OF VISCOSITIES

The selection of a suitable lubricant for a particular purpose requires knowledge of its properties in the working condition as well as the performance of this proportion under condition of service. In order to determine the quality of lubricants, physical or chemical tests in the laboratory are necessary. Viscosity is the most important property of lubricating oil because it determines how effectively the oil film operates the moving metal surfaces and keeps them from resting directly on each other. Viscosity of oil is the measure of its

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fluid resistance to flow and is regarded as its internal or fluid friction. High viscosity oil is thick and flows slowly. Low viscosity oil is thin and flows readily. Kinematics viscosity is defined as the absolute viscosity divided by density and its units are stokes and centistokes.

Brook Field Viscometer

DENSITY

A material's density is defined as its mass per unit volume. It is essentially, a measurement of how tightly matter is crammed together.

FUEL	BLEND Wt. + BOTTLE Wt. (gm)	VOLUME (ml)	BOTTLE Wt. (gm)	DENSITY
PETROL	37.28025	25	18.9	0.73521
E5	37.342	25	18.9	0.73768
E10	38.133	25	18.9	0.76932
E20	38.296	25	18.9	0.77584
E30	38.444	25	18.9	0.78176
E40	38.667	25	18.9	0.79068

densities of blends

EXPERIMENTAL SETUP AND PROCEDURE

PETROL ENGINE TEST RIG

The experimental setup consists of a single cylinder four stroke air cooled engine which is mounted on channels and is coupled to a brake drum with belt and spring balance setup. The air cooled single cylinder petrol engine is coupled to a rope pulley break arrangement to absorb the power produced. Necessary weights and spring balances are included to apply load on the break drum. Suitable cooling water arrangement for the break is provided. Separate cooling water lines fitted with temperature measuring thermocouples are provided for the engine cooling. A fuel measuring system consisting of a fuel tank mounted on a system, burette. Three way cock and a stop watch is provided. Air intake is measured using an air tank fitted with an orifice and a water manometer.

Single Cylinder Petrol Engine Test Rig

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SPECIFICATIONS OF THE ENGINE

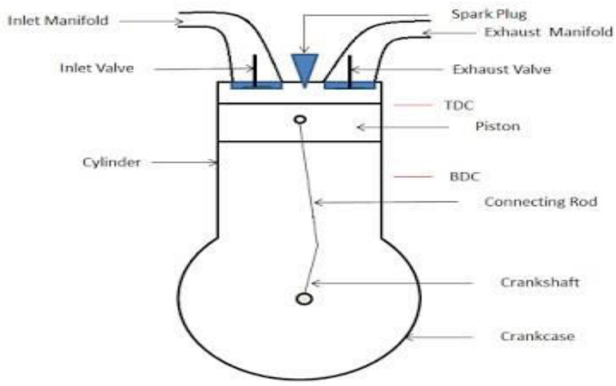
ENGINE	:	FOUR STROKE 1 CYLINDER
MAKE	:	KIRLOSKAR
BP	:	5 HP
RPM	:	1500 RPM
BORE	:	80 mm
STROKE LENGTH	:	110 mm
STARTING	:	ROPE
WORKING CYCLE	:	FOUR STROKE
FUEL	:	PETROL
METHOD OF COOLING	:	AIR COOLED
METHOD OF IGNITION	:	SPARK IGNITION

EXPERIMENTAL PROCEDURE

1. Open with three way cork so that fuel flows to the engine directly from the tank.
2. Start the engine and allow it to run on no load for few minutes.
3. Operate the throttle valve so that the engine picks up the speed to the required level.
4. Load engine with dynamometer and loading is done by turning the handle in the marked direction.
5. Allow the engine to run for few minutes.
6. Note down the readings.

WORKING PRINCIPLE OF S.I ENGINE

It is an internal combustion engine in which the ignition of the air-fuel mixture takes place by the spark. The spark is generated with the help of spark plug. Since in this engine, the spark is responsible for the ignition of the fuel, it is named as spark ignition engine (SI engine). This engine uses petrol as a fuel for its working. It works on the principle of Otto cycle. The fuel in this engine is injected through carburetor during suction stroke. The compression ratio of this engine is usually 6 to 10. It has light weight engine and used in light duty vehicles like motorcycle, cars etc.



S.I engine components

EXPERIMENTAL OBSERVATIONS FOR PURE PETROL

S.no	Load in(kg)		Speed in RPM(N)	Air Consumption	Time taken for 10ml of petrol consumption
1	0	0	1641	18	39.16
2	2	0.2	1592	18	31.5
3	4	0.8	1559	18	28.21
4	6	1.2	1524	18	21.31

Experimental observation for pure petrol

Load In Kg	Speed In RPM	B.P In KW	TFC In KJ/hr	SFC In Kg/kw-hr	Mf In Kg/min	H.I	I.P	BTE	η_{mech} %	ITE
0	1641	0	0.82	∞	0.014	11.2	0	0	0	0
1.8	1592	0.7221	0.8342	1.139	0.0139	11.12	0.976	6.58%	75%	8.776%
3.2	1559	0.7474	0.9315	1.298	0.0155	12.42	0.956	5.77%	76.23%	7.7%
4.8	1524	1.0523	1.2332	1.174	0.02	16.4	1.346	6.4%	78%	8.5%

Table: Result using pure petrol

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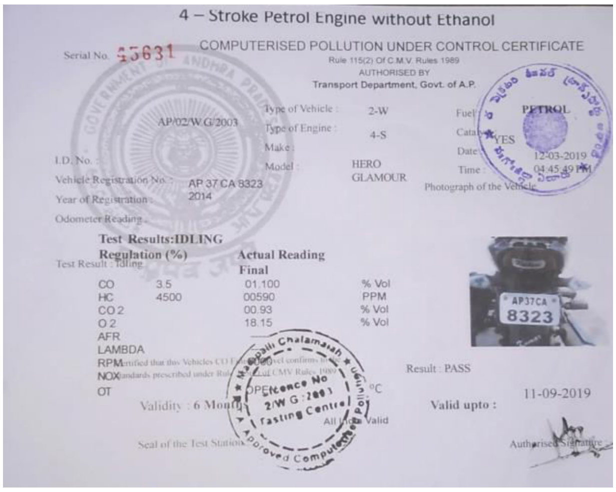
POLLUTION CERTIFICATE BY RTA APPROVED VEHICLE


4 – Stroke Petrol Engine without Ethanol

Serial No. 45631 COMPUTERISED POLLUTION UNDER CONTROL CERTIFICATE
Rule 115(2) Of C.M.V. Rules 1989
AUTHORISED BY
Transport Department, Govt. of A.P.

AP/02/W.G/2003
Type of Vehicle : 2-W
Type of Engine : 4-S
Make :
Model : HERO GLAMOUR
Fuel : PETROL
Catalyst : YES
Date : 12-03-2019
Time : 04:45:49 PM
I.D. No. :
Vehicle Registration No. : AP 37 CA 8323
Year of Registration : 2014
Odometer Reading :
Photograph of the Vehicle

Test Results:IDLING

	Regulation (%)	Actual Reading Final	
CO	3.5	01.100	% Vol
HC	4500	00590	PPM
CO 2		00.93	% Vol
O 2		18.15	% Vol
AFR			
LAMBDA			
RPM			
NOX			
OT			°C

Result : PASS
Validity : 6 Months
Valid upto : 11-09-2019
Seal of the Test Station
Authorised Signature

S.NO	CONTENT	VALUE	UNIT
1	CO	01.100	% VOL
2	HC	00590	PPM
3	CO2	00.93	% VOL
4	O2	18.15	% VOL

Table:Result using pure petrol

EXPERIMENTAL OBSERVATIONS FOR E5

S.no	Load in(kg)		Speed in RPM(N)	Air Consumption	Time taken for 10ml of petrol consumption
1	0	0	1642	18	39.19
2	2	0.2	1595	18	31.7
3	4	0.8	1561	18	28.25
4	6	1.2	1525	18	21.4

Experimental observation for E5

Load In Kg	Speed In RPM	B.P In KW	TFC In KJ/hr	SFC In Kg/kw-hr	Mf In Kg/min	H.I	I.P	BTE	η_{mech} %	ITE
0	1642	0	0.6776	∞	0.0112	8.98	0	0	0	0
1.8	1595	0.412	0.8322	2.01	0.0138	11.03	0.549	3.73%	75.04%	4.97%
3.2	1561	0.7184	0.94	1.3084	0.015	12.46	0.957	5.71%	76%	7.6%
4.8	1525	1.0527	1.236	1.174	0.0206	16.38	1.4036	6.42%	79%	8.56%

Table:Result using E5

POLLUTION CERTIFICATE BY RTA APPROVED VEHICLE


4 – Stroke Petrol Engine with 5% Ethanol

Serial No. 45632 COMPUTERISED POLLUTION UNDER CONTROL CERTIFICATE
Rule 115(2) Of C.M.V. Rules 1989
AUTHORISED BY
Transport Department, Govt. of A.P.

AP/02/W.G/2003
Type of Vehicle : 2-W
Type of Engine : 4-S
Make :
Model : HERO GLAMOUR
Fuel : PETROL
Catalyst : YES
Date : 12-03-2019
Time : 04:58:21 PM
I.D. No. :
Vehicle Registration No. : AP 37 CA 8323
Year of Registration : 2014
Odometer Reading :
Photograph of the Vehicle

Test Results:IDLING

	Regulation (%)	Actual Reading Final	
CO	3.5	00.900	% Vol
HC	4500	00410	PPM
CO 2		00.81	% Vol
O 2		18.49	% Vol
AFR			
LAMBDA			
RPM			
NOX			
OT			°C

Result : PASS
Validity : 6 Months
Valid upto : 11-09-2019
Seal of the Test Station
Authorised Signature

EXPERIMENTAL OBSERVATIONS FOR E10

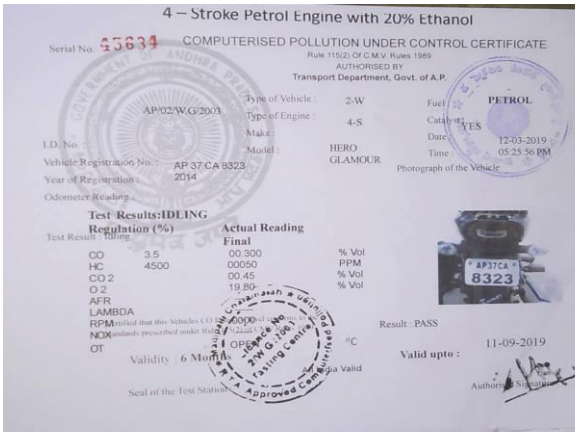
S.no	Load in(kg)		Speed in RPM(N)	Air Consumption	Time taken for 10ml of petrol consumption
1	0	0	1643	18	39.48
2	2	0.2	1596	18	31.91
3	4	0.8	1561	18	28.47
4	6	1.2	1526	18	21.58

Table :experimental observation for E10

Load In Kg	Speed In RPM	B.P In KW	TFC In KJ/hr	SFC In Kg/kw-hr	Mf In Kg/min	H.I	I.P	BTE	η_{mech} %	ITE
0	1643	0	0.702	∞	0.0117	8.97	0	0	0	0
1.8	1596	0.413	0.8676	2.1	0.0144	11.09	0.5506	3.72%	75.2%	4.9%
3.2	1561	0.7184	0.9727	1.3539	0.0162	12.44	0.9578	5.7%	76.8%	7.6%
4.8	1526	1.0534	1.2833	1.2182	0.0213	16.41	1.4045	6.4%	78%	8.5%

Table: Result in using E10

POLLUTION CERTIFICATE BY RTA APPROVED VEHICLE


4 – Stroke Petrol Engine with 20% Ethanol

Serial No. 45634 COMPUTERISED POLLUTION UNDER CONTROL CERTIFICATE
Rule 115(2) Of C.M.V. Rules 1989
AUTHORISED BY
Transport Department, Govt. of A.P.

AP/02/W.G/2003
Type of Vehicle : 2-W
Type of Engine : 4-S
Make :
Model : HERO GLAMOUR
Fuel : PETROL
Catalyst : YES
Date : 12-03-2019
Time : 05:25:56 PM
I.D. No. :
Vehicle Registration No. : AP 37 CA 8323
Year of Registration : 2014
Odometer Reading :
Photograph of the Vehicle

Test Results:IDLING

	Regulation (%)	Actual Reading Final	
CO	3.5	00.300	% Vol
HC	4500	00050	PPM
CO 2		00.45	% Vol
O 2		19.80	% Vol
AFR			
LAMBDA			
RPM			
NOX			
OT			°C

Result : PASS
Validity : 6 Months
Valid upto : 11-09-2019
Seal of the Test Station
Authorised Signature

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S.NO	CONTENT	VALUE	UNIT
1	CO	00.300	% VOL
2	HC	00050	PPM
3	CO2	00.45	% VOL
4	O2	19.80	% VOL

Table: Result in using pure E20

Result and Discussion

Brake thermal efficiency

Brake thermal efficiency of different ethanol blends are varied with different loads is shown fig.From the plot it is observed that brake thermal efficiency at E40 is greater at compared to the pure petrol almost all blends are showing better results than usual petrol.

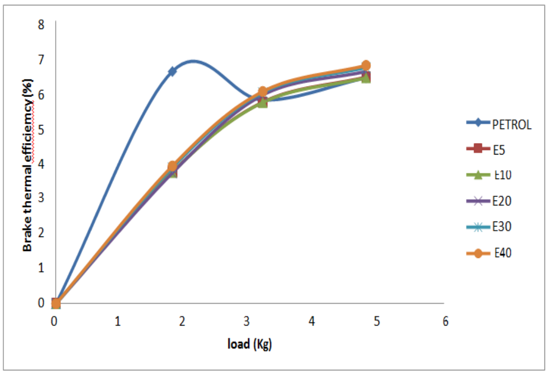

Fig 6.1 variation brake thermal efficiency with load using petrol blends of ethanol

Mechanical efficiency

Mechanical efficiency of different ethanol blends are varied with different loads is shown From the plot it is observed that mechanical efficiency at E5 is greater at compared to the pure petrol almost all blends are showing better results with usual petrol

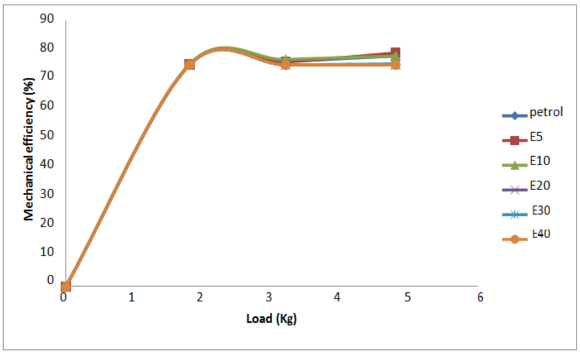

Fig. 6.2 variation of mechanical efficiency with load using petrol blends of ethanol

Specific Fuel Consumption

Specific fuel consumption of different ethanol blends are varied with different loads is shown fig. 6.3. From the plot it is observed that E40 consumes more SFC.

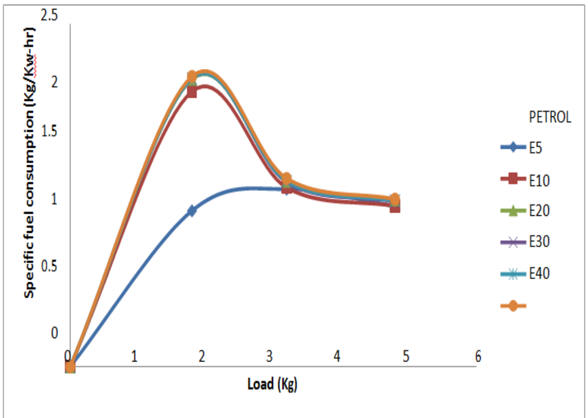

Fig 6.3 variation of SFC with load using petrol blends of ethanol

Brake Power

Brake power of different blends is shown in the figure 6.4. E40, E5, E10 are showing the same results.

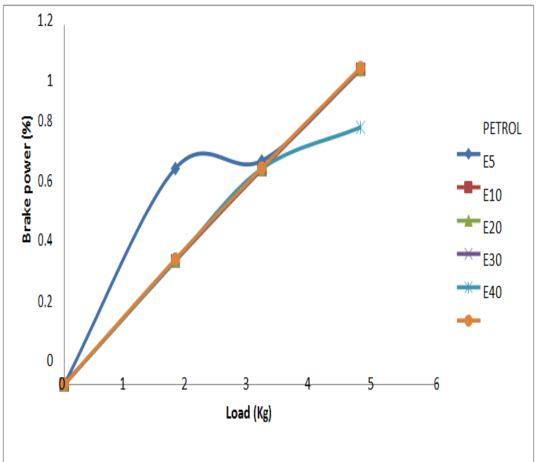

Fig 6.4 variation of brake power with loads using ethanol blends of ethanol

Indicated Power

Indicated power is the total power available from the expanding of the gases in the cylinders negating any friction, heat loss or entropy within the system.Brake power is the power output of the drive shaft of an engine without the power loss caused by gear, transitionfriction,

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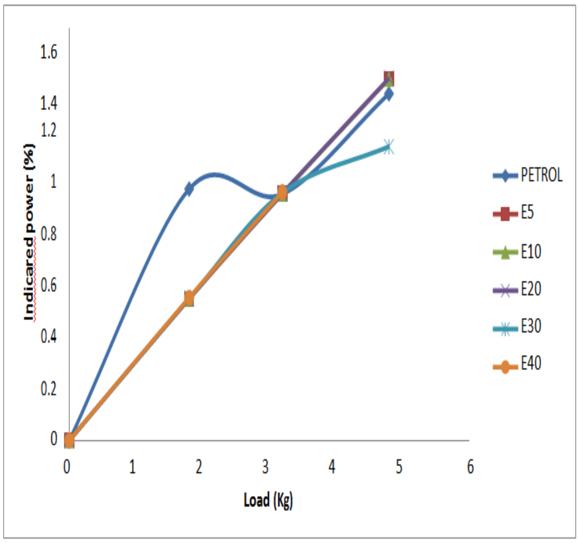

Fig 6.5 variation of indicated power with loads using ethanol blends of ethanol

Carbon Oxide (CO)

In the complete combustion of hydrocarbons the products are carbon dioxide, water and unaffected nitrogen. However with the incomplete combustion of hydrocarbons in automobiles the products include unburned hydrocarbons, nitrogen oxides, carbon monoxide, carbon dioxide and water. These types of auto emissions are responsible carbon monoxide poisoning and affect global environmental trends. In 1970 Congress established the Environmental Protection Agency with the responsibility for regulating motor vehicle pollution. Congress enacted the Clean Air Act in 1990 to investigate and reduce auto emissions by establishment of emission standards. Two-thirds of the carbon monoxide emissions were found to come from transportation sources.

What has been done to decrease carbon monoxide emissions? In 1975 most new cars were equipped with catalytic converters designed to convert carbon monoxide to carbon dioxide while using unleaded fuel. The catalytic converter is installed in the exhaust line between the exhaust

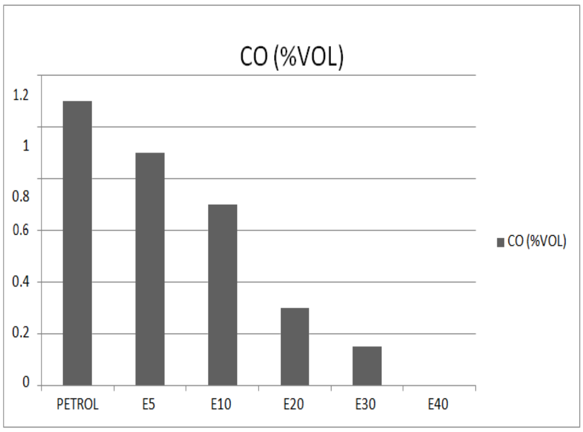

Fig 6.7 CO percentage volume in ethanol blended petrol

Carbon dioxide

Carbon dioxide (CO2) makes up the largest share of "greenhouse gases". The addition of man-made greenhouse gases to the Atmosphere disturbs the earths radioactive.

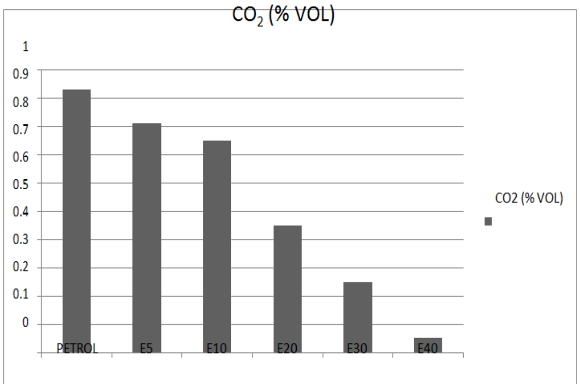

Fig 6.7 carbon dioxide percentage in petrol ethanol blends

Oxygen

Originally called a "Lambda Sensor" when it was first used in fuel-injected European cars, the oxygen sensor monitors the level of oxygen (O2) in the exhaust so an onboard computer can regulate the air/fuel mixture to reduce emissions. The sensor is mounted in the exhaust manifold downpipe(s) before the catalytic converter or between the exhaust manifold(s) and the catalytic converter(s). It generates a voltage signal proportional to the amount of oxygen in the exhaust.

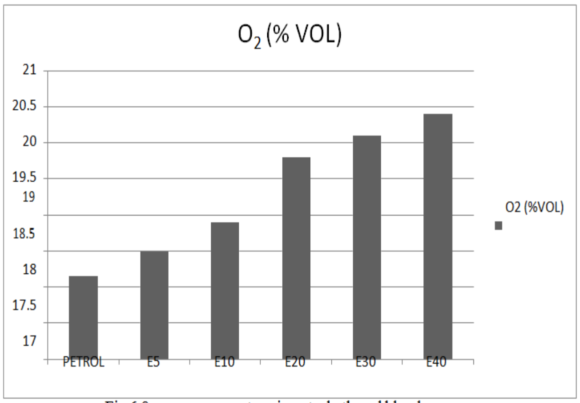

Fig 6.8 oxygen percentage in petrol ethanol blends

Hydro Carbons

Hydrocarbons are basically raw fuel, otherwise known as Gasoline. High Hydrocarbon (HC) emissions are almost always a sign of poor fuel ignition. However, it's not always that the engine's ignition system is responsible for high Hydrocarbon emissions. Engine ignition timing is measured in degrees before or after Top Dead Center (TDC). Example of an ignition timing failure would be in the case where an engine's ignition timing is required to be set at 10 degrees Before Top Dead Center (BTDC) and instead is set to 15 degrees BTDC. This fault will not only cause a smog check "functional failure", but will increase Hydrocarbon (HC) emissions as well. Any condition which will cause unmetered air to enter the intake manifold, and ultimately the combustion chambers, will cause high hydrocarbons. This condition is called a lean miss-fire. Such faults as vacuum leaks and gasket leaks will cause lean fuel/air mixtures.

CONCLUSION

By conducting the experiment on 4 stroke single cylinder SI engine in I.C Engine Lab of following Conclusions have been drawn:- Brake specific fuel consumption decreases from blending E0 to E10, further increase in blend ratio, the BSFC• increases. The minimum BSFC achieved at E10. Brake thermal efficiency increases from blending E0 to E10, further increase in blend ratio, the BTE decreases.• The maximum BTE achieved at E10. From the results, it can be concluded that ethanol blends are quite successful in replacing pure gasoline in four stroke spark ignition engine. Results clearly show that Brake thermal efficiency is increasing for a particular percentage of blending of alcohol. After a particular fixed percentage of blending the performance of SI engine decreases. The blending of ethanol in gasoline provides good combustion property. If we add alcohols after a particular percentage than it is incapable in proper combustion of fuel which results in lowering thermal efficiency. Performance of E10 shows better result within group of various blends of ethanol with gasoline. It shows least brake specific fuel consumption and better engine performance. So from the result it is seen that E10 ethanol blended Gasoline is the best choice for use in the existing Spark Ignition Engines without any modification to increase Efficiency.

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