International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 07 | July 2019 www.irjet.net p-ISSN: 2395-0072

FABRICATION OF TEST RIG AND TESTING OF PERFORMANCE AND EMISSION PARAMETERS OF BLENDED ETHANOL AND GASOLINE

Saroj Karki[1], Prakash Chapagain[2], Sanskriti Adhikari[3], Astik Sunar[4],Aashaya Regmi[5], Ashok Adhikari[6] , Sobhit Pokhrel[7], Roshan Bhattarai[8], Shiva Shanker Pandey[9], Sujan Dahal[10]

[1,2,3,4,5,6,7,8,9]Students, Institute of Engineering-IOE Purwanchal Campus, Dharan-8 Tinkune, Nepal
[10] Lecturer, Department of Mechanical Engineering, Institute of Engineering-IOE Purwanchal Campus, Dharan-8 Tinkune, Nepal

---***---

Abstract - *The project is about studying the effect of using gasoline-ethanol (GE) blends on performance and exhaust emission on four stroke engine. The test was one done by fabricating the test rig which consists of four stroke single cylinder air cooled spark ignition (SI) engine and using various ratios of GE blends. Each experiment were conducted at (1/4) th (7kg) of maximum load and at different engine speeds ranging from 500 to 2000 rpm, without catalytic converter by varying Ethanol content from 5 percentages to 20 percentages by volume and different blends (E5, E10, E15, E20) were tested. Brake power, Brake specific fuel consumption and Brake thermal efficiency were calculated for various blends. The result showed by E15 was best among all in each of the four accelerator position due to increase in octane number causing complete combustion, lower stoichiometric ratio and greater anti-knocking properties of ethanol.*

Key Words*: *Fabrication, Blend, Emissions.

1. BACKGROUND

In many developing countries the increase in demand for agriculturally produced alcohol has increased dramatically over the past few years. This demand has been increasing day by day because the use of alcohol as a blending material with petrol has significantly decreased the pricing of fuel. Also from the ecological point of view, it is very environmental friendly as it facilitates complete burning of fuel and thus reduces carbon monoxide during burning. The practice of using ethanol blended fuel came from Brazil. They have used up to 25% ethanol blended fuel with some modification in engine. In the context of Nepal, ethanol hasn't been used as fuel yet. If we went into some fact and try to reduce 14% of gasoline import, annual savings of US$ 10 million could be achieved through the introduction of the blended ethanol [1]. This could draw huge difference in fuel economy. The practice of using more than 20% ethanol may require slight engine modification.

1.1 OBJECTIVE

The main objectives of our project are:

- To fabricate the test rig and conduct the performance test of blended ethanol and gasoline.
- To investigate the emission parameters like CO, CO_2, HC of various blends.

1.2 LITERATURE REVIEW

The concept of ethanol as a fuel is nothing new. Henry ford in 1896 designed his first car "Quardicycle" to run on pure ethanol [2]. But at that context the ethanol fuel was not economical. However, increasing global concern due to air pollution has generated much interest in the environmental friendly alternative fuels. Ethanol is good nominees as alternative fuels since it is a liquid and has several physical and chemical properties similar to those of gasoline and diesel fuels.

N. Seshaiah et al tested the variable compression ratio spark ignition engine designed to run on gasoline blended with ethanol 10%, 15%, 25% and 35% by volume. Also, the gasoline mixed with kerosene at 15%, 25% and 35% by volume without any engine modifications has been tested and presented the result. Using ethanol as a fuel additive to the mineral gasoline, (up to 30% by volume) without any engine modification and without any loses of efficiency, it has been observed that the petrol mixed with ethanol at 10% by volume is better at all loads and compression ratios.[3]

Juozas Grabys investigated experimentally and compare the engine performance and pollutant emission of a SI engine using ethanol–gasoline blended fuel and pure gasoline. The results showed that when ethanol was added, the heating value of the blended fuel decreases, while the octane number of the blended fuel increases. The results of the engine test indicated that when ethanol–gasoline blended fuel was used, the engine power and specific fuel consumption of the engine slightly increase; CO emission decreases dramatically as a result of the leaning effect caused by the ethanol addition; HC emission decreases in some engine working conditions; and CO2 emission increases because of the improved combustion.[4]

Hakan Bayraktar studied the effects of ethanol addition to gasoline on an SI engine performance and exhaust emissions are investigated experimentally and theoretically. Experimental applications were carried out with the blends containing 1.5, 3, 4.5, 6, 7.5, 9, 10.5 and 12 vol% ethanol. Numerical applications were performed up to 21% volume ethanol. Engine was operated with each blend at 1500 rpm for compression ratios of 7.75 and 8.25 and at full throttle setting. Experimental results showed that among the various blends, the blend of 7.5% ethanol was the most suitable one from the engine performance and CO emissions points of view. However, theoretical comparisons showed that the blend containing 16.5% ethanol was the most suited blend for SI engines.[5]

Yinn Lin investigated the influence of using ethanol-gasoline blends (E0, E3, E6 & E9) on energy efficiency and emission of a small generator at different loads and at a constant speed. Test results showed that the E6 blend gave the best results of the exhaust emissions, and the E9 blend gave the best results of engine performance and the particle emissions.[6]

Ravishankar and Kumar examined the performance of two wheelers (4-stroke, BAJAJ, SI) using ethanol- gasoline blends (E0, E5, E8, E10, E12, E14, E16 and E18). They concluded that E8 and E16 blends showed a comparatively better engine performance than pure gasoline. [10]

K.Kapil &N.Ashish observed that ethanol–gasoline blended fuel allows increasing compression ratio without knocking also CO and HC concentrations were decreased while the concentrations ofCO2 and NOx were increased when ethanol gasoline blends are used. The SFC, CO, CO2, HC and NOx emissions were reduced by about 3%, 53%, 10%, 12% and 19%, respectively.[9]

Nallamothu evaluated performance and exhaust emission of a SI engine by using two blends of ethanol – gasoline (E0, E5 and E10). Finally, they recommended using E10 at a compression ratio of 8:1. [7]

Elfasakhany tested The Ethanol/Gasoline Blends as Bio-fuel for 4 stoke single cylinder SI engine showed that blending unleaded gasoline with ethanol increases the brake power, torque, volumetric efficiency, exhaust gas temperature and cylinder pressure, while it decreases the brake specific fuel consumption. Also CO and UHC emissions concentrations in the engine exhaust decrease, while the CO2 concentration increases. Finally concluded that 10% vol. ethanol in fuel blend gave the best results for all measured parameters at all engine speeds. [8]

2. METHODOLOGY

2.1 Material Selection

Material selection is one of the most important processes during the construction of test-rig. Knowledge of material science plays an important role in the selection of materials and the selection of material determines the outcome of the test-rig. Selection of materials for test-rig depends on number of factors, which can be grouped into three main categories: economic factors, operational factors, and design factors. While selecting a material we encountered many obstacles and we had considered the following factors to get rid of those obstacles which are listed below:

- Functional requirements and constraints
- Material properties
- Manufacturing process considerations
- Fabricability
- Design configuration
- Available and alternate materials
- Corrosion and degradation in service
- Thermal stability
- And finally & importantly, Cost

The material for the test-rig, the metal selected must satisfy following properties:

- Weldability
- Strength & Versatility

All above factors needs to be considered before fabrication of the test-rig.

2.2 Fabrication of Test Rig

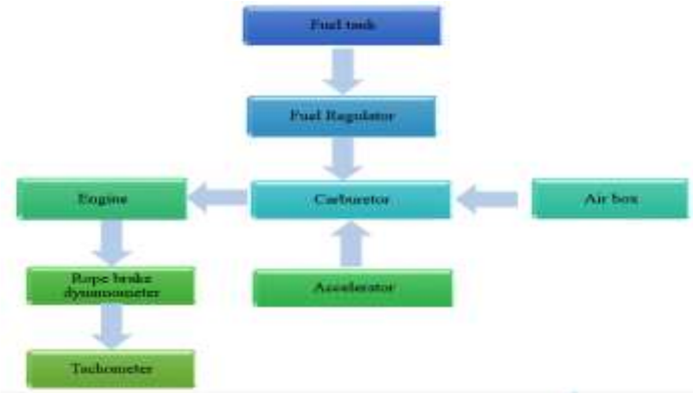

Fig -1: Schematic diagram of the Test Rig

For the fabrication process, zinc plated slotted angle and L-section rod were prepared using various machines and machining processes. Engine, Panel board, Air box and other components were fabricated separately and were later mounted on the Zinc plate slot.

The various part of the Test-rig constructed are given below:-

2.1.1 Yamaha YBX four stroke engine

Table1: Engine specifications.

S.N.	PARAMETERS	SPECIFICATIONS
1.	Engine Displacement	123.7 CC
2.	Max Power	11.2 PS @8000 rpm
3.	Max Torque	11.0 Nm @6500 rpm
4.	Bore x Stroke	54.0 x 54.0 mm
5.	Valves Per Cylinder	2
6.	Fuel Type	Petrol
7.	Starter	Kick
8.	Number of Cylinders	1

Fig -2: Four stroke Yamaha YBX engine

2.1.2 Zinc Plated slotted angle

Zinc plated slotted angle is a system of reusable metal strips used to construct shelving, frames, work benches, equipment stands and other structures.

Fig -3: Zinc platted slotted angle rod

2.1.3 Pulley

A pulley is a grooved wheel with a rope, chain or cable running along the groove.

Fig -4: pulley

2.1.4 Panel Board and Valves

A panel board is basically a distribution board containing multiple items such as fuel tank, different valves, burette, and scale and U-tube manometer. Valves and glass burette were attached on the panel board.

Fig -5: Panel board with valves and burette

2.1.5 Spring Balance and Air Box

Spring balance was attached to the frame and connected to the pulley with the help of ropes. It measures the tension in the ropes and thus load applied. An air box is an empty chamber on the inlet of most combustion engines. It collects air from outside and feeds it to the intake hoses of each cylinder.

Fig -6: Spring Balance

Fig 7: Test Rig

3. Engine Performance analysis

The following observations was based on the performance test of blended gasoline and ethanol (99.99% pure) at various blends E0, E5, E10, E15 and E20.the experiment was conducted on four stoke SI engine of YBX bike using rope brake dynamometer.

All the test were carried out at constant load $(1/4)^{th}$ of the maximum load (7kg). For each blend, the four accelerator position was marked. Initial position of the accelerator was marked as first position. Second, third and fourth accelerator positions are marked at 2.5, 2.75,3 turns from initial position respectively. For each position of the

Accelerator, time required to consume 10ml of fuel was recorded using stop watch. During the same time speed of the pulley was measured by using tachometer and the exhaust temperature was also measured at the marked position of exhaust pipe. At the end of each experiment pollution test of blend was conducted separately at Transportation management office at constant load of 7kg.

At first, the performance and emission parameters at I.P.O.A (initial position of the accelerator) were calculated. For second and third accelerator position i.e. at 2.75 and 3 turns from I.P.O.A. the performance parameters were calculated.

The parameters that have been evaluated are performance test and emission test of E0, E5, E10, E15, E20. In performance test brake power, brake specific fuel consumption, brake thermal efficiency and exhaust pipe temperature were measured. Whereas in emission test, Emission of CO, CO2 and HC were evaluated.

Before performing any calculation, the calorific value of each fuel mixtures was measured at Renewable Energy Test Station (RETS), Kathmandu, Nepal. Then the density of the mixtures was determined specific gravity bottle and weighing machine.

Table 2: Density and calorific values of various fuel blends

S.N.	Composition	Density(kg/m^3)	Calorific Value (MJ/Kg)
1.	E0	717.7	45.428
2.	E5	720.575	41.181
3.	E10	723.45	41.773
4.	E15	726.325	35.167
5.	E20	729.20	24.167

3.1 Engine performance parameters at

Initial Position Of Accelerator (I.P.O.A)

i. Brake power $= (w*\pi*D_R*N)/60$

$= (mg*\pi*D_R*N)/60$

ii. Mass of fuel consumed per hour ($\dot{m}_f$)

$= (X_{cc}*\rho*3600)/(1000*1000*T)$

$= (10*\rho*3600)/(1000*1000*T)$

$= 0.036*\rho/T$ (kg/hr)

iii. Brake Specific Fuel Consumption (B.S.F.C)

$= (\dot{m}_f)/(B.P)*1000$(kg/kwhr)

iv. Brake Thermal Efficiency ($\eta_{b.th}$)

$$= (BP*3600)/ ((\dot{m}_f) *CV)*100$$

v. swept volume (m3/hr) = $\pi/4*d^2*L*N/2*60$

w = weight applied on rope brake dynamometer = mg

m = mass applied at rope brake dynamometer = 7kg

g = acceleration due to gravity = 9.81m/s2

D_R= diameter of pulley + diameter of rope = 0.0709126m

d = bore diameter of cylinder

L = length of stoke

N = speed of pulley (Rpm)

X_{CC}=volume of fuel consumed

ρ = density of petrol = 717.7kg/m3

T = time in second

$\dot{m}f$ = mass of fuel consumed per hour

Table 3: Engine performance parameters at I.P.O.A

S.N.	Com-position	Time (s)	T.A.E after each test(^{0}C)	Swept volume (m^3/hr)
1.	E0	238	70	1.706
2.	E5	194	74	1.78
3.	E10	200	80	1.966
4.	E15	218	130	2.04
5.	E20	243	76	1.743

Mass of fuel consumed(kg/hr)	B.P (watt)	B.S.F.C (kh/kwhr)	B.T.E (%)
0.10886	119.85	0.908	8.691
0.1335	122.4	1.091	7.9845
0.1296	135.15	0.9585	8.95647
0.11885	140.25	0.8474	12.034
0.2019	119.85	0.901126	16.48

3.2 Engine performance parameters at 2.5 turns from I.P.O.A

Table 4: Engine Performance parameters at 2.5 turns from I.P.O.A

S.N.	Composition	Time (s)	T.A.E after each test(^{0}C)	Swept volume (m^3/hr)
1.	E0	107	115	3.15
2.	E5	112	111	3.71
3.	E10	100	119	3.8585
4.	E15	103	138	4.00
5.	E20	130	108	3.8585

Massof fuel Consumed (kg/hr)	B.P (watt)	B.S.F.C (kh/kwhr)	B.T.E
0.24214	216.75	1.11715	7.066
0.23133	255	0.90718	9.599
0.2591	265.2	0.9769	8.787
0.25154	275.4	0.9133	11.16
0.257	265.2	0.901126	19.50

3.3 Engine performance parameters at 2.75 turns from I.P.O.

Table 5: Engine Performance parameters at 2.75 turns From I.P.O.A

S.N.	Composition	Time(s)	Swept volume (m^3/hr)
1.	E0	104	5.12
2.	E5	82	5.1942
3.	E10	80	5.1942
4.	E15	92	5.305
5.	E20	102	5.12

Mass of fuel consumed (kg/hr)	B.P (watt)	B.S.F.C (kh/kwhr)	B.T.E (%)
0.24843	351.9	0.7059	11.225
0.31635	357	0.886	9.865
0.325	357	0.910	9.466
0.2842	364.65	0.7793	13.135
0.257	369.75	0.695	21.367

3.4 Engine performance parameters at 3 turns from I.P.O.A

Table 6 : Engine Performance parameters at 3 turns From I.P.O.A

S.N.	Composition	Time (s)	Swept volume (m^3/hr)
1.	E0	70	5.7878
2.	E5	74	5.889
3.	E10	76	5.9733
4.	E15	90	6.0475
5.	E20	88	5.9362

Mass of fuel consumed (kg/hr)	B.P (watt)	B.S.F.C (kh/kwhr)	B.T.E (%)
0.3691	397.8	0.9278	8.54
0.3505	405.45	0.864	10.11
0.34268	410.55	0.8346	10.325
0.29053	415.65	0.6989	14.64
0.2983	408	0.7311	20.373

3.5 Mass of Fuel Consumption

The effect of ethanol blend on gasoline on fuel consumption is shown in figure 8. As the C. V of ethanol is lower than that of gasoline the fuel consumption increases with increase in ethanol blend for low speed (initial position of accelerator) but the phenomena just reverse at higher speed (final position of accelerator) due to more dominant effect of complete combustion of fuel due to higher octane number of ethanol. Thus, it can be estimated that at low speed the lower C.V dominates over increase in octane number and vice- versa.

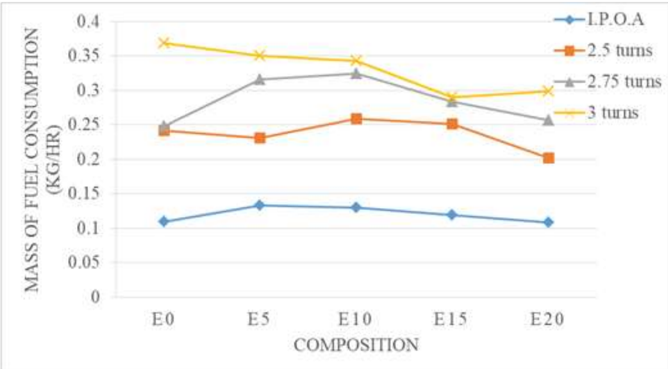

Fig 8: Fuel consumption at 0, 2.5, 2.75 and 3 turns from I.P.O.A.

3.6 Brake Specific Fuel Consumption (B.S.F.C)

The effect of ethanol blend on gasoline is shown in figure 9. With increase in ethanol blend on gasoline the B.S.F.C decreases because the octane number of ethanol is higher than that of gasoline resulting in complete combustion of blended fuel. Thus, B.S.F.C decreases with increase in ethanol fuel blend.

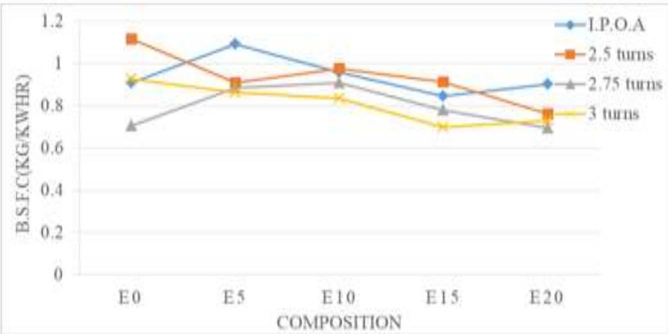

Fig 9: B.S.F.C. at 0, 2.5, 2.75 and 3 turns from I.P.O.A.

3.7 Brake Power

Figure 10 shows the effect of ethanol blend on brake power.

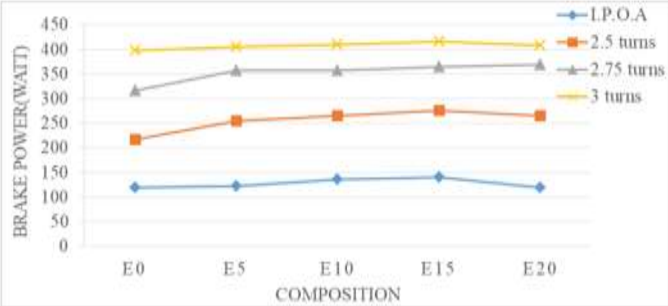

Fig 10: B.P. at at 0, 2.5, 2.75 and 3 turns from I.P.O.A.

3.8 Brake Thermal Efficiency (B.T.E)

The effect of ethanol blends on gasoline on brake thermal efficiency is shown in figure 11, Which shows slight decrease in brake thermal efficient at E5 and then increasing brake thermal efficiency with increase in ethanol blend. Here in the test the maximum B.T.E is obtained at 15% ethanol.

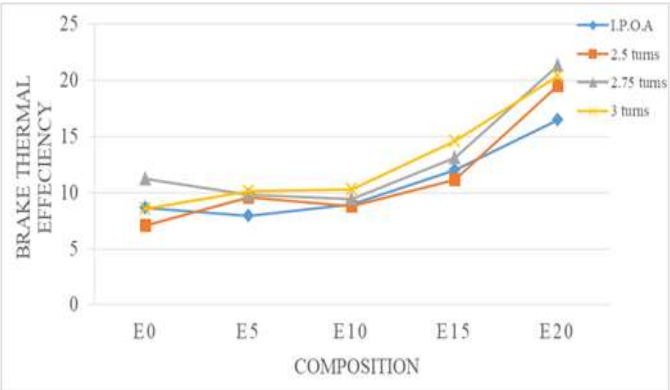

Fig 11: B.T.E at 0, 2.5, 2.75, 3 turns from I.P.O.A

3.9 Air Fuel Volumetric Flow Rate

The effect of ethanol blend on gasoline on Air Fuel Volumetric Flow Rate is shown in figure 4.5., with increase in ethanol blend increases the Air Fuel Volumetric Flow Rate. This is due to increase in speed with increase in blend resulting from complete combustion. After E15 there is decrease in swept volume which is due to reduction of speed.

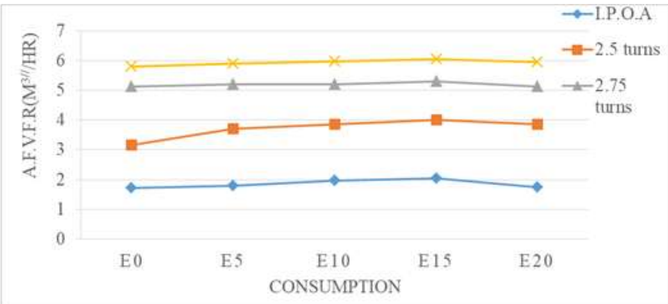

Fig 12: A.F.V.F.R at 0, 2.5, 2.75, 3 turns from I.P.O.A

3.11 Exhaust Pipe Temperature (E.P.T)

The effect of ethanol and gasoline blend on exhaust pipe temperature is shown in figure. The exhaust pipe temperature increases with increase in ethanol blend because of complete combustion of blended fuel as the amount of air required for combustion is lower for ethanol than gasoline. The maximum temperature at exhaust pipe is obtained at E20.

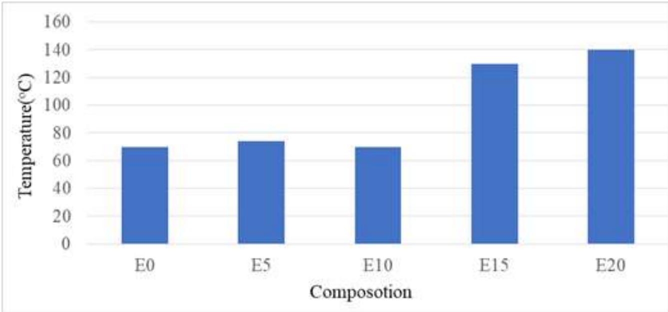

Fig 12: E.P.T. at I.P.O.A

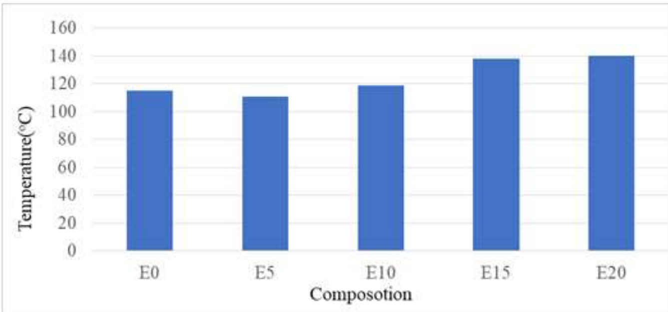

Fig 13: E.P.T at I.P.O.A and at 2.5 turns from I.P.O.A

4. Engine Emission Analysis

In emission test, the data for emission of CO, HC and CO_2 were recorded. The test was carried out at Transportation management department of Itahari, Nepal using a digital pollution test device. The data obtained during emission test are shown below in various graphs indicating the details of emission of CO, CO2 and HC for each blend respectively.

4.1: Exhaust Emissions (E.E)

The effect of ethanol and gasoline blend on E.E is shown in tables below. The table shows the decrease in CO, HC and increase in CO_2 emission with increase in ethanol blend on gasoline up to E10 relatively. Also, there was reduction of CO_2 along with CO and HC at E15.After E15 the phenomenon reverse. The maximum reduction of emissions was obtained at E15.

The emission of the CO, CO_2, HC were measured keeping constant load.

Table 7: CO, HC, CO2 emissions at I.P.O.A

S.N.	Composition	Load (Kg)	CO (% Volume)	CO2 (% Volume)	HC (Ppm Volume)
1.	E0	7	0.85	1.44	56
2.	E5	7	0.53	1.85	36
3.	E10	7	0.27	2.82	33
4.	E15	7	0.10	1.5	27
5.	E20	7	0.15	1.98	30

The above obtained results are also represented in following graphs.

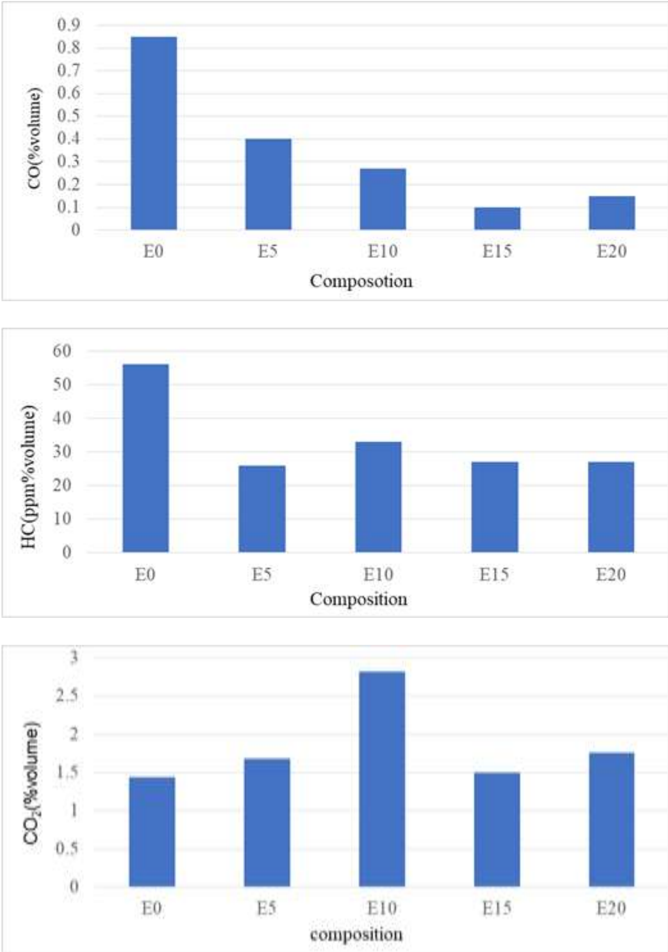

Fig 14: CO, HC, CO2 emissions at I.P.O.A

Table 8: CO, HC, CO2 emissions at 2.5 turns from I.P.O.A

S.N.	Composition	Load (Kg)	CO(% Volume)	CO_2(%Volume)	HC (Ppm Volume)
1.	E0	7	1.44	1.58	86
2.	E5	7	1.06	1.76	39
3.	E10	7	0.74	2.08	32
4.	E15	7	0.59	0.84	28
5.	E20	7	0.70	0.9	39

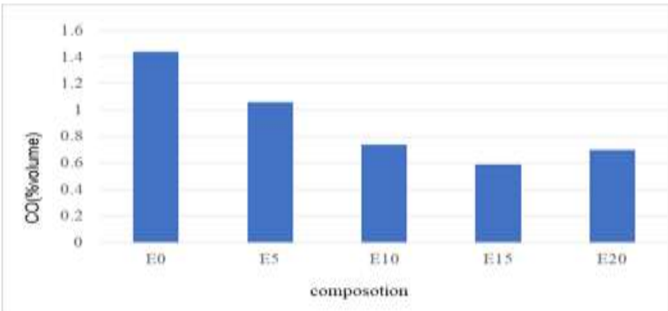

Fig 15: HC, CO2 at 2.5 turns from I.P.O.A

4.2: B.P. vs Carbon monoxide (CO)

Figure below shows the effect of various blends on B.P and CO emissions. Brake power increases the CO emission goes on decreasing for all blends .but with increase in brake power the emission from E15 is lower than all blends. There is 88% and 59% reduction of CO emission from E15 as compared to gasoline at 0, 2.5 turns from I.P.O.A.

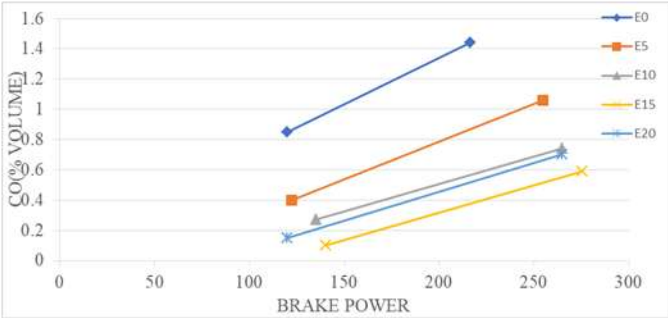

Fig 16: B.P Vs CO emissions

4.3 B.P Vs Unburnt Hydrocarbons (HC)

It is observed that as brake power increases the HC emission goes on decreasing for all blends. However, with the increase in brake power, the emission from E15 is lower than all blends. There is 57.7% and 67.44% reduction of HC emission from E15 as compared to gasoline at 0, 2.5 turns from I.P.O.A.

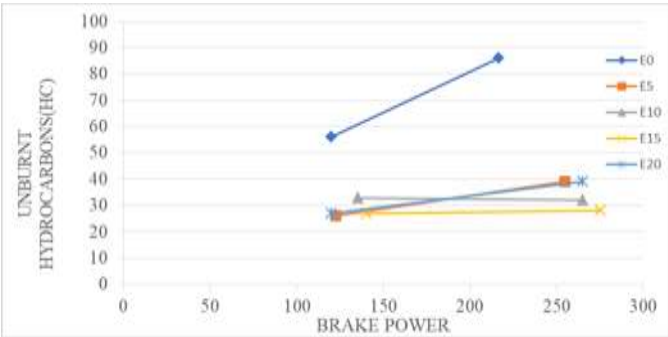

Fig 16: B.P Vs Unburnt Hydrocarbons (HC)

4.4 B.P. vs CO_2 Emission

Figure below shows the effect of various blends on B.P and CO_2 emissions. From figure it is clear that as brake power increases the CO_2 emission goes on increasing for all blends this is because of complete combustion that take place inside the combustion chamber due to increase in octane number of ethanol.

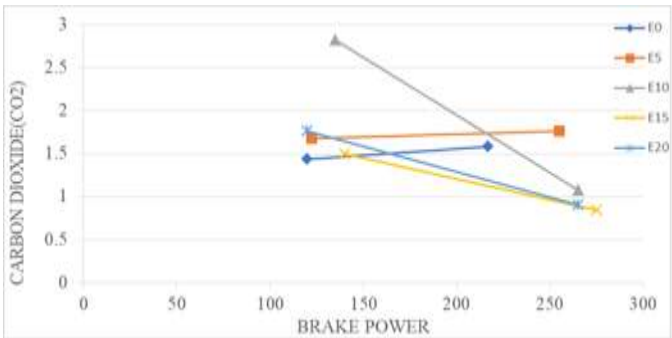

Fig 17: B.P Vs CO2

The reduction of CO and HC emissions with the ethanol blends on gasoline is also shown in tables below. Percentage reduction on emission of CO, HC compared to emission from gasoline at initial accelerator position.

Table 9: Emission reduction at I.P.O.A.

S.N.	Composition	CO(% reduced)	HC(% reduced)
1.	E5	37.64	35.7
2.	E10	68.23	41
3.	E15	88	51.70
4.	E20	82	46

Table 10: Emission reduction at 2.5 turns from I.P.O.A

S.N.	Composition	CO(% reduced)	HC(% reduced)
1.	E5	26.38	54.65
2.	E10	48.61	62.79
3.	E15	59	67.44
4.	E20	51.38	54.65

5. CONCLUSIONS

The main objective of this project is to carryout performance test and emission test of blended ethanol and gasoline. The experiment was conducted on four stoke SI engine of YBX bike using rope brake dynamometer. For the test the fuels that were investigated are E0(petrol), E5, E10, E15, E20.the performance of all the blended fuels were measured based on the brake power, brake specific fuel consumption, brake thermal efficiency. Also, the emission of various blend was determined in context of emission of CO, CO2, HC.

5.1 Performance Test

i. The use of E15 gave best result in both accelerator positions for brake power, Brake specific fuel consumption, brake thermal efficiency due to increase in octane number causing complete combustion, lower stoichiometric ratio and greater anti-knocking properties of ethanol. B.P of E15 is 17%, 27%, 3.6% and 4.5% higher than gasoline at 0(I.P.O.A), 2.5, 2.75, 3 turns from I.P.O.A.

ii. With ethanol blend on gasoline, there was increase in speed. Due to increase in speed there was increase in swept volume as swept volume depends on the speed foe constant bore diameter and length of stoke. The maximum swept volume was obtained at E15. For E15 swept volume is 19.87%, 26.98%, 3.6%, 4.48% higher than gasoline at 0, 2.5, 2.75, 3 turns from I.P.O.A.

iii. Regarding the B.T.E, maximum Brake Thermal Efficiency was obtained with E20 at almost all accelerator positions. But the B.T.E was in decreasing trend as the speed increase whereas the B.T.E of E15 was in increasing trend. B.T.E of E15 is 38.46%, 58%, 17% and 71% higher than gasoline at 0, 2.5, 2.75, 3 turns from I.P.O.A.

5.2 Emission test

i. E15 gave the lowest emission of CO, CO_2 and HC at both accelerator position (0 and 2.5 turns from I.P.O. A) as compared to other blends this is because of complete combustion of fuel due to dominant effect of increase in octane number. There was 88% and 59% reduction of CO emission from E15 as compared to gasoline at 0, 2.5 turns from I.P.O.A. and there was 57.7% and 67.44% reduction of HC emission from E15 as compared to gasoline at 0, 2.5 turns from I.P.O.A.

REFERENCES

[1] Silveira, S., & Khatiwada, D. (2010). Ethanol production and fuel substitution in Nepal—Opportunity to promote sustainable development and climate change mitigation. Renewable and Sustainable Energy Reviews,14,1644–1652

[2] Doeden, M (2007). Crazy Cars. Lerner Publications. ISBN 978-0-8225-6565-9.

[3] Seshaiah,N.(2010).Efficiency and exhaust gas analysis of variable compression ratio spark ignition engine fueled with alternative fuels. International journal of energy and environment 1(5), 861-870

[4] Pikunas,A.Pukalskas,S.&Grabys,J.(2003).Influence of composition of Gasoline-ethanol blends on parameters of internal combustion engines. Journal of KONES Internal Combustion Engines, 10, 3-4.

[5] Bayraktar,H.(2005).Experimental and theoretical investigation of using gasoline–ethanol blends in spark-ignition engines. Renewable Energy, Elsevier. 30(11),1733-1747.

[6] Yusaf,T.,Najafi,G.,&Buttsworth,D.(2009).Theoretical and experimental investigation of SI engine performance and exhaust emissions using ethanolgasoline blended fuels. International. Conference on Energy &environment.

[7] Nallamothu,R.B., Fekadu,G.,& Prof Appa Rao,B.V.(2013).Comparative performance evaluation of gasoline and its blends with ethanol in gasoline engine,2(4) ,100-106.

[8] Elfasakhany,A.(March 2014). The Effects of Ethanol-Gasoline Blends on Performance and Exhaust Emission Characteristics of Spark Ignition Engines. International Journal of Automotive Engineering.4(1),609-620.

[9] Karadia,K.,&Nayya,A.(Jan -2017). Effects of Ethanol-Gasoline blends on Performance and Emissions of Gasoline Engines. International Research Journal of Engineering and Technology (IRJET).4(01),1092-1100.

[10] Ravishankar,M.K.,&Premkumar,B.G.(2012).Comparative study of performance of two wheeler using ethanol-gasoline blends, International Journal of Science and Research, 3(10),1696-1699.