# Performance of Petrol-Ethanol Blended Spark Ignition EngineS

**Balappa Hadagali, N.R. Banapurmath, Kirankumar B., V.S. Yaliwal**

***Abstract:*** ***Experimental investigations were conducted to study the feasibility of alcohol (Ethanol) and its blends with petrol at varying proportions from 0 to 100% in a single cylinder diesel engine converted to operate in spark ignited (SI) mode. Performance and emission characteristics of the SI engine was evaluated and compared with base line petrol operation. Addition of ethanol to petrol provides lower carbon monoxide (CO), hydrocarbon (HC) and nitric oxide ($NO_x$) emissions. Among all blend ratio performance results E75 shows overall improved engine performance with increased brake thermal efficiency (BTE) with lower emissions.***

***Keywords: SI engine, ethanol, combustion, emissions..***

## I. INTRODUCTION

Energy demand and emission regulation in transportation area resulted motivation in all researchers to find suitable alternative fuels, which in turn provide better engine performance with low emissions. Engine modification is easy and economically affordable[Stephen et al (2016), Yuhan et al (2016), Phuangwongtrakul (2016), Michael (2016), Wua, (2004), Gholamhassan et al (2015), Fagundez (2017), Omar et al (2017)]. To meet the emission standard and norms alcoholic fuel and their additives promises for cleanest earth by providing more oxygen during combustion. Among all alcoholic fuel ethanol (C2H5OH) is one of the better performer and easily available by many sources like sugar cane, sugar beet and maize [Joshi et al (2017)]. All countries are facing major problem by emission of highly polluted gases from industry and automobiles and are considered as cause for greenhouse effect [Muhammad et al (2017)]. Few countries like Brazil and others were already adopted these alcohol alternative blends up to 10 % in public petroleum products. Many researchers investigated engine performance and emission levels [Sakai and Rothamer (2017)]. Sakai et al investigated performance and emission levels of single cylinder (SIDI) spark ignited direct injected engine which was fueled with ethanol-gasoline blends. They have operated the engine with pre-vaporized (PMPV) device under a fixed phasing and load. They have concluded that addition of ethanol decreases the formation of particulate matter in exhaust and decreases the diameter of particulate. Yuhan Huang et al (2016) experimented on spark ignition engine with ethanol direct injection (EDI) at 6.0 MPa using gasoline port injection (GPI) and varied injection timing. Ethanol blending is done with gasoline are 46%, 25% and10% by EDI plus GPI. NOx emissions were decreased at injection timing of 100 bTDC because of lower cylinder temperature and rich mixture, CO and HC emissions were increased at IT180 and 100 because of cooled surface. Increased particulate matter in the exhaust has been reported. Phuangwongtrakul et al (2016) experimentally analyzed the effect of different blend ratio of ethanol (E10 to E 100) and pure ethanol on engine performance running at different speed and low conditions. They observed that optimization of results under different operating condition at 58% to 73% wide open throttle and engine speed of 2000-2500 rpm, maximum brake thermal efficiency was noticed. Secondly at low speed, high ethanol content pure ethanol (E80), is suitable for engine power generation. Michael et al (2016) conducted experiment son constant volume, direct-injection spark-ignition (DISI) to study soot formation with the help of Laser extinction. Soot formation was reduced due to high enthalpy of evaporation of pure ethanol compared to E85 and isooctane. Wua et al (2014) conducted experiments on conventional engine by varying different air-fuel ratio and different throttle openings. They have reported emission and engine parameters. It was observed that due to better combustion, and at lower air-fuel ratio, increased torque output has been reported when between throttle opening at 60% to 100% and 3000rpm.Gholamhassanet al (2015) predicted relation between BSFC, BTE, BP, volumetric efficiency and torque. Najafi et al (2015) conducted experiments on four stroke gasoline engine fueled with gasoline and ethanol in different ratios (5 to 20 %) and compared with neat gasoline. Decreased CO and HC emission with increased carbon dioxide and nitrogen oxide has been reported. Artificial neural network (ANN) is used to analysis the performance of engine precisely, the constructed model for this complex problem proved as an effective tool for showing a very low RMSE. This model results are used to predict the performance and emission levels and can be compared with experimental values. Compared to other alcohol fuels, ethyl –alcohol can mix up with gasoline very easily and perform better with high compression ratio and at various speed of engine.

Manuscript published on November 30, 2019.
* Correspondence Author
**Balappa Hadagali***, VNR Vignan Jyothi Institute of Engineering & Technology,Hyderabad, Telangana, India
**N.R. Banapurmath**, B.V.B. College of Engineering and Technology, KLE Technological University Hubballi, India
**Kirankumar.B,** HITAM College of Engineering and Technology, Hyderabad., India
**V.S. Yaliwal,** S.D.M. College of Engineering and Technology, Dharwad, India

This can result in fewer emissions due to availability of more oxygen and increases brake power and torque noted.
From the literature survey on the utilization of alcohol fuels for petrol engines it is observed that ethanol addresses the emissions issues and hence the present work is an attempt towards use of petrol and ethanol blends in a modified diesel engine. The results were then compared with the baseline petrol operation.

## II. FUELS USED AND EXPERIMENTAL SETUP

Tables 1and 2show the properties of the fuels used in the study. Petrol and its blends with ethanol in varied percentage of ethanol from 25 to 75% were used in the study.

**Table 1 Properties of Petrol and ethanol**

| Sample code | Ethanol | %Gasoline | Calorific value ($C_V$) MJ/kg | Density Kg/m$^3$ | Specific gravity |
|---|---|---|---|---|---|
| E0 | 0 | 100 | 44.2 | 740 | 0.74 |
| E25 | 25 | 75 | 40.43 | 750 | 0.75 |
| E50 | 50 | 50 | 33.7 | 761 | 0.761 |
| E75 | 75 | 25 | 33.2 | 783 | 0.783 |
| E100 | 100 | 0 | 26.95 | 790 | 0.791 |

**Table 2 Comparison of ethanol and gasoline blends at different ratio**

| Property | Units | Petrol | Ethanol |
|---|---|---|---|
| Chemical formula | - | $C_5 – C_{12}$ | $C_2H_5OH$ |
| Molecular weight | Kg kmol$^{-1}$ | 114.15 | 46.07 |
| Specific gravity | - | 0.7-0.78 | 0.794 |
| Density(at 15˚C) | Kg m$^{-3}$ | 750-765 | 785-809.9 |
| Stoichiometric air-fuel ratio | W/W | 14.2-15.1 | 8.97 |
| Kinematic viscosity | mm$^2$/s | 0.5-0.6 | 1.2-1.5 |
| Octane number | - | 91-100 | 108.61-110 |
| Cetane number | - | 8 | 20-May |

A single cylinder four stroke direct injection CI engine developing 5.2 kW @1500 rpm was suitably modified to operate with petrol and its blends with ethanol respectively as shown in Figure 1. Engine had a conventional Hemispherical Combustion Chamber. The compression ratio was reduced to 10:1. Fuels selected were directly injected into the inlet manifold of the modified engine with suitable ECU using a low-pressure solenoid injector at an injection pressure of 5bar


**Fig. 1Modified diesel engine with low pressure petrol injection facility**

### Alcohol Injection System

Fig. 2 shows the alcohol injection system used in the modified diesel engine to operate on petrol and its blends with ethanol respectively. ECU was used to regulate and facilitate injection of selected fuel combinations at specified injecting timing. ECU actuates operation of pumping which injects the alcohol either at specified injection timing or at injection duration as well.

**Fig. 2 Alcohol injection system**

## III. RESULTS AND DISCUSSION

This section presents the emission and performance characteristics of converted diesel engine powered on petrol and its ethanol blends respectively.
The results are summarized as below.

**Emission Parameters:**

**HC Emissions**

HC emission in the exhaust reduced when engine was fueled with ethanol and their blends. Similar trends for HC emissions were observed as those with CO emissions. Ethanol blended fuels provided more oxygen supply during combustion which promoted higher combustion activity viz., leaning effect. Higher dosage of ethanol resulted into lowered HC emissions.

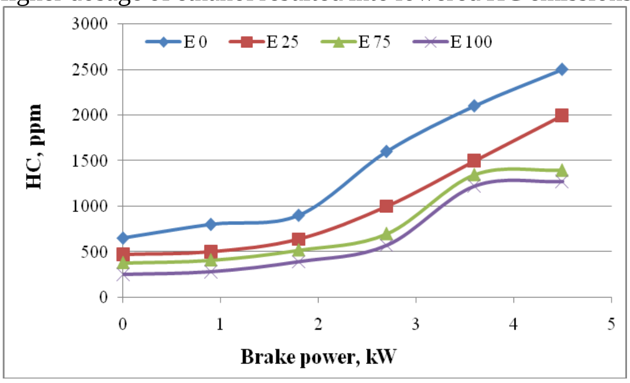


**Fig. 3 Deviation of HC with Brake power**

**CO Emissions**

From Fig. 4 it follows that as the load on the engine increases CO emission increases. For pure ethanol operation carbon monoxide emissions were lower at all the loads tested when compared to petrol. As the blending ratio of ethanol in gasoline increases high molecular diffusivity and flammability helps for better mixing which in turn improves combustion of blended fuels and results in decreased CO concentration in the exhaust.

*Retrieval Number: D9463118419/2019©BEIESP*
*DOI:10.35940/ijrte.D9463.118419*
*Journal Website: www.ijrte.org*



*Published By:*
*Blue Eyes Intelligence Engineering*
*& Sciences Publication*

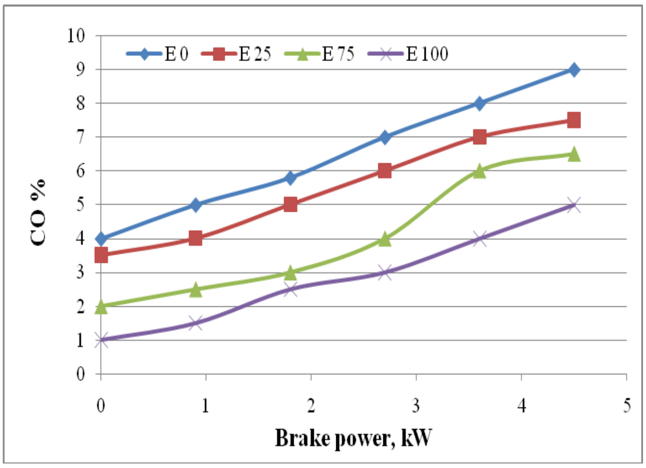


**Fig.4 deviation of CO with Brake power**

## NOx Emissions

It is observed that in Fig. 5 under different blend ratio concentration of $NO_x$ percentage decreased with increased ethanol blended fuels when compared to pure gasoline. This is because of high latent heat of vaporization of which promoted complete combustion of blended fuels in combustion chamber.

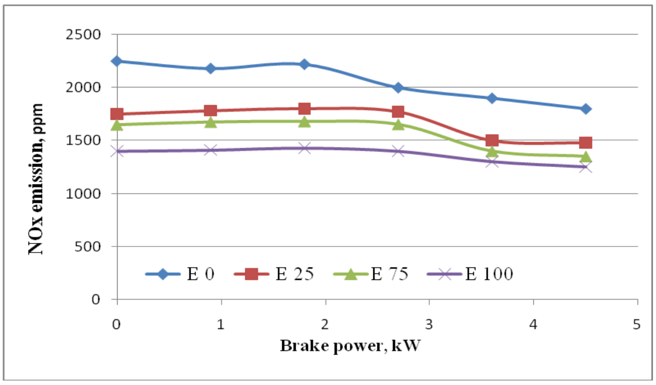


**Fig. 5 Deviation of HC with Brake power**

## Engine parameters

### Brake thermal efficiency:

The brake thermal efficiency increased for ethanol blended fuels when compared to base petrol. The higher LHV of ethanol fuel blends (E75, E25) increase the cooling effect and this reduces the compression work. Also, the pressure and temperature decrease at the starting of combustion i.e. delay period increases at which the maximum pressure is achieved. In addition, the increases in air-fuel ratio decrease the heat transfer to the cylinder (heat losses) due to incomplete combustion and therefore increase the maximum pressure in the cylinder.

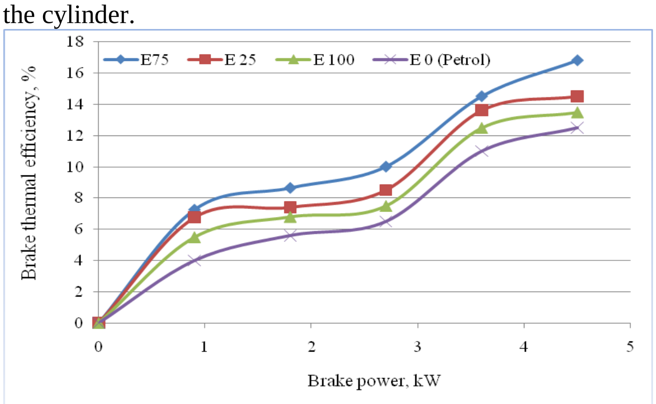


**Fig. 6 Deviation of Brake thermal efficiency with Brake power**

### Exhaust gas temperature (EGT)

EGT increases with increases in brake power for all the fuel combinations used. EGT refers to excess heat supplied to engine cylinder walls than that would be used for energy conversion. Higher EGT is found with petrol followed by its blends with ethanol. Higher dosage of ethanol reduced the EGT.

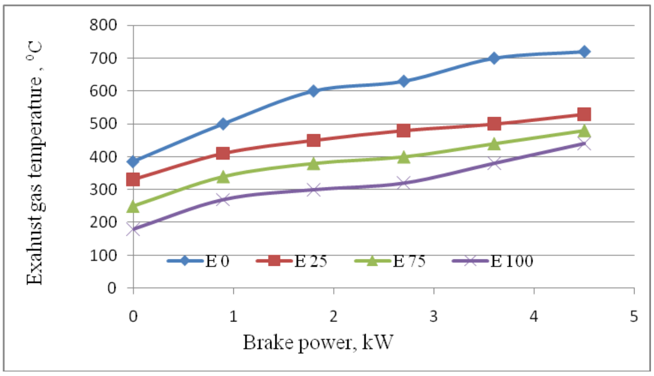


**Fig.7 Deviation of Brake thermal efficiency with Brake power**

## IV. CONCLUSIONS

From the study it is concluded that ethanol blending with gasoline gives more advantage on engine parameters. Brake thermal efficiency increased for ethanol blended fuels due to the higher LHV and reduced work of compression. Emissions of HC, CO and $NO_x$ decreased for ethanol blended fuels when compared to pure gasoline. Further the engine performance with higher brake thermal efficiency was observed for ethanol blended fuels.

## REFERENCES


1. Stephen Sakai, David Rothamer, "Effect of ethanol blending on particulate formation from premixed combustion in spark-ignition engines "(2016) Fuel 196 (2017) 154–168.
2. YuhanHuang,Guang Hong, Ronghua Huang. "Effect of injection timing on mixture formation and combustion in an ethanol direct injection plus gasoline port injection engine", Energy 111 (2016) (2016) 92-103.
3. PhuangwongtrakulW.,Wechsatol, T.,Sethaput, K.,Suktang, S., Wongwises, Experimental "study on sparking ignition engine performance for optimal mixing ratio of ethanol–gasoline blended fuels" (2016) S. Applied Thermal Engineering, 100 (2016) 869–879.
4. Michael Storch, Matthias Koegl, Michael Altenhoff, Stefan Will, Lars Zigan, "Investigation of soot formation of spark-ignited ethanol-blended gasoline sprays with single- and multi-component base fuels", Applied Energy, 181 (2016) 278–287.
5. Chan-Wei Wua, Rong-HorngChenb, Jen-YungPu a, Ta-Hui Lina, "The influence of air–fuel ratio on engine performance and pollutant emission of an SI engine using ethanol–gasoline-blended fuels, Atmospheric Environment", 38 (2004) 7093–7100.
6. GholamhassanNajafi, Barat Ghobadian, Talal Yusaf, Seyed Mohammad SafieddinArdebili, RizalmanMamat, "Optimization of performance and exhaust emission parameters of a SI (spark ignition) engine with gasoline ethanol blended fuels using response surface methodology Energy" 90 (2015). 1815-1829.
7. J.L.S. Fagundez, R.L. Sari, F.D. Mayer, M.E.S. Martins, N.P.G. Salau, "Determination of optimal wet ethanol composition as a fuel in spark ignition engine"
8. Omar I. Awad, Obed M. Ali, RizalmanMamat, A.A. Abdullah, G. Najafi M.KKamarulzaman, I.M. Yusri, M.M. Noor . "Using fusel oil as a blend in gasoline to improve SI engine efficiencies. Acomprehensive review Renewable and Sustainable Energy Reviews" 69 (2017) 1232–1242.

9. GirdharJoshia, Jitendra K. Pande, SravendraRanab, Devendra S. Rawat, "Challenges and opportunities for the application of biofuel. Renewable and Sustainable Energy Reviews". 79 (2017). 850–866.
10. Muhammad Yusri Ismail, RizalmanMamat. Gholamhassan Najafi, TarbiatModares,AzraaiRazman, Omar I Awad, W. H. Azmi, Faizal Wan ishak, Ishak M. "Alcohol based automotive fuels from first four alcohol family in compression and spark ignition engine" A review on engine performance and exhaust emissions, Renewable and Sustainable Energy Reviews 77 (2017) 169–181.


## AUTHORS PROFILE

**Balappa Hadagali** currently work as assistant professor in Department of automobile engineering at VNR vignan jyothi institute of engineering & technology, Hyderabad.

**N.R. Banapurmath** Received Doctor of Philosophy in Mechanical Engineering from Visvesvaraya Technological University (VTU) and Master's degree in Heat Power Engineering, National Institute of Technology Karnataka (NITK), Surathkal and Bachelor's degree in Mechanical Engineering.currently working as Professor at the School of Mechanical Engineering and Head of Centre for Material Science, KLE Technological University, B.V.Bhoomaraddi College of Engineering and Technology.

.

**Kirankumar.B** obtained his Masters from AIT, Chickmagalur. He is pursuing doctoral degree from VTU, Belgaum and his research center is BIET Davangere.

**V.S. Yaliwal** working as a assistant professor in Mechanical engineering department at S.D.M. College of Engineering and Technology, Dharwad, India. His area of interest includes alternative fuels for internal combustion engine, Thermal Engineering, Fluid Mechanics and Nano-Technology for energy applications.