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Energy and Exergy Analysis on Si Engine by Blend of Ethanol with Petrol

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Abstract— *Need to use renewable energy in the form of ethanol fuel derived using agriculture waste to reduce load on petrol derived from crude oil, which is available in limited quantity. This is mostly due to stock of petroleum product are depleting day by day, hence more use of renewable fuels gets attraction in developing country like India. In recent years, Considerable efforts made to develop and introduce alternative renewable fuel, to replace conventional petroleum-base fuels.The main objective of the current work id to investigate influences of blends of ethanol-petrol blend used in IC engine performance using energy and exergy analysis. Here, experimental work divided into mainly two parts. In first part, Engine performance carried out using E0, E25, E40 and E100 blends of ethanol-petrol blends. In other part, exergy analysis carried out. Experimental test set-up developed in laboratory. The stationary petrol engine was run in laboratory at a medium speed, variable load condition experienced in most urban driving conditions and various measurements like fuel flow, exhaust temperature, exhaust emission measurement and exhaust smoke test were carried out. The fuel properties of biodiesel such as kinematic viscosity, calorific value, flash point, carbon residue and specific gravity investigated. Heat balance sheet and availability calculated for different condition like E0, E25, E40 and E100 blends of ethanol-petrol blends.*

Keyword— ethanol , SI engine, exergy ,energy.

I. INTRODUCTION

Energy flows and energy efficiencies in the operation of a modern automobile expressed in terms of simple relations. One purpose is to convert any internal combustion engine energy into useful work. The overall energy use depends on two factors, vehicle load and power train efficiency. The former depends on speed, acceleration, and key vehicle characteristics such as mass. The latter depends on internal combustion engine thermodynamic efficiency, and engine and transmission frictions.

Energy conservation and efficiency have been the quest of engineers concerned with internal combustion engines. From the heat, energy of the fuel offered by diesel engine goes one third to the coolant, one-third to exhaust and leaving only about one-third as useful power output. Theoretically, if the heat rejected could reduce, then the thermal efficiency would be improved. Low Heat Rejection engines aim to do this by reducing the heat lost to the coolant.

Reason for Alternate fuels

IC engines are the major consumer of the fossil fuels. Petrol and diesel will become very costly. It is also that there will be emissions of gases like CO_2 NO_X and HC.Require to reduce emissions from engines by different fossil fuel.Due to these reason Alternate fuels are require. Alkali base renewable fuels more prefer to of alternative fuels because of the possibilities of cleaner combustion. The use of new, alternative, and clean-burning fuels as primary energy resources in internal combustion (IC) engines. Main reason behind to use of alternative fuel is to achieve lower pollutant emissions and higher fuel economy and low content of Sulphur. The compression ignition (CI) engine of the dual fuel type has employed to utilize various alternative renewable fuels resources in place of conventional petrol engine.

Ethanol is better alternative of fossil fuel

a. Ethanol has high octane number, low flame temperature, high density, and high latent heat of vaporization.
b. Ethanol can reduce country's dependence on fossil fuel, it should foreign supplies be interrupted.
c. The ethanol is improving quality of the environment. It reduced Carbon monoxide emissions, lead and other carcinogens (cancer causing agents) which removed from gasoline.
d. Ethanol-blended fuels can clean the fuel system also absorb moisture

Energy and Exergy in Engines:

Energy is physical quantity. It is a state of thermodynamics. Energy is present in various forms such as electrical, mechanical, chemical magnetic energy etc. Energy conversion from one form to another. The machine, which is use to energy conversion, known as engine. In general, engines have efficiencies of about 35% and about 50% of fuel energy is lost in cooling water and exhaust gases.

Exergy defined as the maximum theoretical useful work obtained from a system. Exergy is not stored as energy but destroyed in the system. Exergy destroyed whenever an irreversible process occurs.

An Energy analysis is based on first law of thermodynamics.From the 1st law analysis we can find the energy transformations and there losses.

An Exergy analysis based on the second law of thermodynamics. It can removes the limitations of an energy-based analysis. Exergy analysis is a detail analysis of energy transformations and there losses. This provides useful information to improve the overall efficiency and cost effectiveness of a system.

II. LITERATURE SURVEY

Paolo Iodice et al. [2016] [1]is investigated that the Effect of ethanol–gasoline blends on CO and HC emissions in last generation four stork SI engines within the cold-start transient. Which work with ethanol-gasoline mixture by 10%, 20%, and 30% by volume called G10, G20, and G30 . This paper is reducing the CO and HC emission at cold-start transient commercial gasoline, with the 20% v/v ethanol blend achieving the highest emission reduction.**Golmohammad Khoobbakht et al. [2016] [2]** worked on Optimization of operating factors and blended levels of diesel, biodiesel and ethanol fuels to minimize exhaust emissions of diesel engine using response surface methodology**.** Aim of this paper investigated on operating of engine speed and load as well as different level of blends of ethanol in biodiesel. It is work on the diesel engine. This experiment is work on the statistical tool known as Design of Experiments (DoE) based on central composite rotatable design (CCRD) of response surface methodology (RSM). Surface methodology is also use to predict the amount of fuel emission like CO, HC, NOX, and THC. This paper indicated that the amount of CO and HC is reducing at the end of experiment. When the amount CO_2 is increasing at the end of the experiment but adding diesel fuel blend in ethanol is reducing the amount of CO2. An engine load of 80% of full load bar, speed of 2800 rpm and a blend of 26% biodiesel, 11% ethanol and 63% diesel were found to be optimal values with a high desirability of 74% for the test engine having 0.013% of CO, 41 ppm of HC, 643 ppm of NOx, 12% of smoke opacity and 7.3% of CO_2.

W.M. Ambrós et al. [2016] [3] worked on Experimental analysis and Modeling of internal combustion engine operating with wet ethanol. In this paper using ethanol with different mixture of different percentage of ethanol and water and improving the efficiency of SI and di engine. The experiment take place based on first law of thermodynamic. The trials and the results found confirm that the engine is capable of operating with mixtures of wet ethanol up to 40% by volume of water. E70W30 blend showed the best values of power, torque, efficiency and specific consumption.**N. M. Al-Najem et al [1992] [4]** is worked on energy-exergy analysis of diesel engine. This analysis is based on 1^{st} and 2^{nd} law of thermodynamic. Exergy analysis is based on 2^{nd} law of thermodynamic. Using this law, we can find the availability of energy, losses of energy in diesel engine.2nd law indicated different between high-grade energy and low-grade energy. 1^{st} law indicated some lost energy due to the process. 1^{st} and 2^{nd} law combined indicated the datum (zero level) of energy and exergy. At that level, we find the enthalpy losses and other losses, which take place at near of datum. Diesel engines have efficiencies of about 35% and about 50% of the input fuel energy is lost in cooling water and exhaust gases. The wasted energy in the cooling water usually considered useless due to its low temperature level. In this paper, we focused on the exhaust gas. The present analysis is to illustrate the capability of the exergy analysis to provide a systematic approach to pinpoint the waste and lost energy within diesel engines.

A.Vamshikrishna Reddy et al. [2014] [5] is worked on diesel engine by using dual fuel mode. Biogas and diesel used for the dual fuel mode and find the fuel consumption, brake thermal efficiency, exergy efficiency and different availabilities with the varying load. Biogas used as alternative renewable fuel in diesel engine, find the performance of diesel engine. The performance of the engine check on the bases of the 1^{st} and 2^{nd} law of thermodynamic. 1^{st} low of thermodynamic gives the energy analysis and 2^{nd} law of thermodynamic give the exergy analysis of dual fuel mode. **Chongqing Feng et al [2016] [6]** is worked on Availability analysis of using is-octane/n-butanol blends in spark ignition engine. This is representing a detailed energy and exergy analysis of an iso-octane/n-butanol blend-fueled spark-ignition (SI) engine, investigate exergy loss mechanisms and understand how the exergy destruction changes with different iso-octane/n-butanol blend fuels. **Rakhi Maheta et al [2012] [7]** have experimentally investigated that the alcohol like ethanol and butanol properties compare with diesel and experimental analysis of ethanol-diesel blend or butanol-diesel bland use as fuel. This paper is show the different characteristics of both ethanol and butanol compare with diesel as per ASTM standards. The ethanol shows properties like calorific value, density, flash point, cetane number with pure diesel. There is only flashpoint reduce due to alcohol blend. **Alvydas Pikunas et**

al [2015] [8] have to investigate 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 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 is used, the engine power and specific fuel consumption of the engine slightly increase; CO emission decreases dramatically because 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. Using ethanol–gasoline blend, CO emission may reduce 10–30%, while CO_2 emission increases by 5–10% depending on engine conditions. The engine power and specific fuel consumption increase approximately by 5% and 2–3%, respectively, in all working conditions. **Dattatray Bapu et al. [2014] [9]** have worked about injection timing on which ethanol blend run the engine. The blends tested are D70/E20/B10 (blend A), D50/E30/B20 (blend B) D50/E40/B10 (blend C), and Diesel (D100). The blends are prepared to get maximum percentage of oxygen content but keeping important properties such as density, viscosity and Cetane index within acceptable limits. Experiments conducted on a multi cylinder, DI diesel engine, whose original injection timing was 13° BTDC. The engine did not run on blends B and C at this injection timing and it was required to advance timing to 18° and 21° BTDC to enable the use of blends B and C Respectively However advancing injection timing almost doubled the NO emissions and increased peak firing pressure. Smoke reduced remarkably for blends especially at medium and high loads of both speeds and all injection timings. Maximum reduction is about 60% to 70% at higher loads for respective high ethanol content blend at all injection timing and speeds. Advancing injection timing reduced the smoke for all blends and diesel fuel at both speeds. Significant reduction in smoke observed for high ethanol content blends; however, reduction in smoke does not indicate the reduction in particulate matter in same proportion.

Objectives

1) To blend ethanol with petrol fuel and observe the performance of I.C. Engine and improve performance of engine.
2) To do the analysis of the Ethanol on various parameters like input parameter like load, output parameter like specific fuel consumption, brake power, and brake thermal efficiency.
3) Experimental energy and exergy analysis on SI engine by ethanol-petrol blend(E0, E25, E40,E100)

Table.1: Properties of ethanol and blends of petrol

Properties	E0	E25	E40	E100
Specific Gravity 25° C gm/cc	0.765	0.7792	0.7792	0.789
Calorific Value (KJ/Kg)	48000	38809	37160	26900
Octane number	88	97	97	118
Flash point	-43 ° C	-13.5 ° C	-13.5 ° C	-12.5 ° C
Auto Ignition Temp.	246° C	294° C	294° C	365° C

III. EXPERIMENTAL SETUP AND PROCEDURES

Experimental set up

The single cylinder, four-stroke petrol engine connected with an electrical load bank. The engine set-up developed to measure the parameters like fuel consumption, cooling water temperature, and inlet air and exhaust gas temperature.

The test carried out with variation in engine load from low to high load conditions. At each operating stage, the observations of various parameters taken for both ethanol blend with petrol and base fuel as petrol.

Apparatus specifications

Table.2: Engine Specification

Type	Honda,4-Stroke, Side valve, One Cylinder
Dynamometer	Self-Exciting, two Pole, Rotating Field Type
Displacement	76 Cm^3
Bore X Stroke	46x46 Mm
Max Horse Power	1.6HP @ 3600 Rpm
Compression Ratio	6.0:1
Fuel Consumption	0.53/5
Cooling System	Forced Air
Lubricating System	Splash
Oil Capacity	0.35 Liter
Fuel Tank Capacity	2.8 Liter
Oil	SAE10W-40

Measurement

a) Calibrated burette for fuel intake measurement.

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b) Orifice meter - Fitted to the air inlet tank with water manometer for air intake measurement.
c) Lesser Gun used to measure temperature at various points.
d) Exhaust gas calorimeter to measure heat carried away by exhaust gas.
e) Measure the water flow rate of engine jacket and calorimeter.

At each operating condition, the dynamometer load, speed, fuel, and airflow recorded after allowing time for the engine to stabilize.

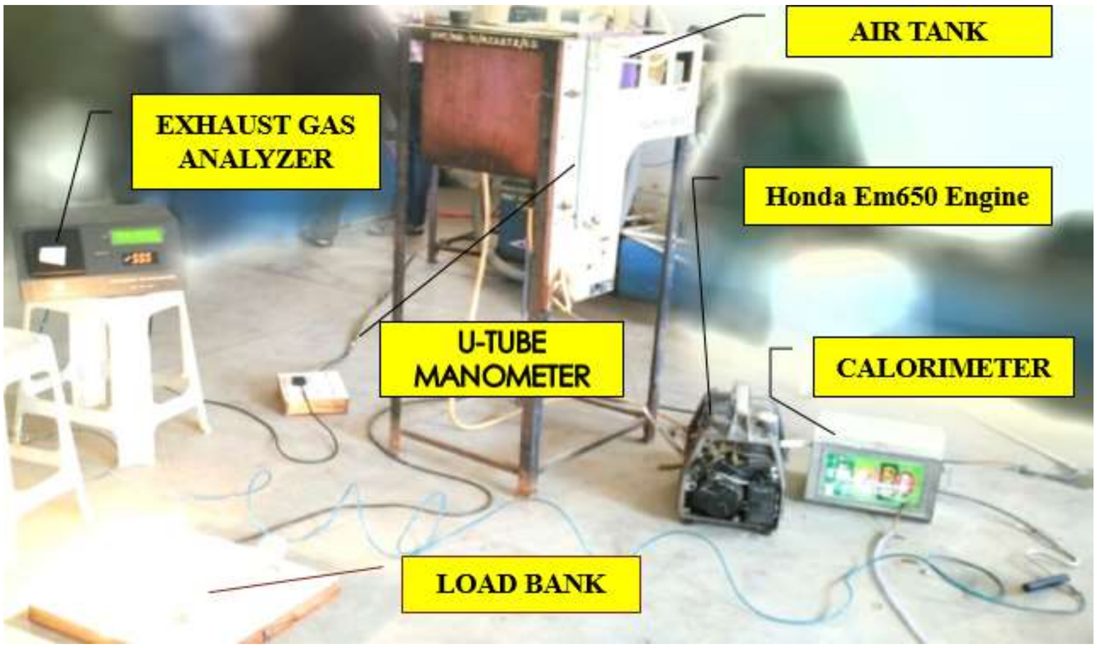

Fig.1: Experimental set-up

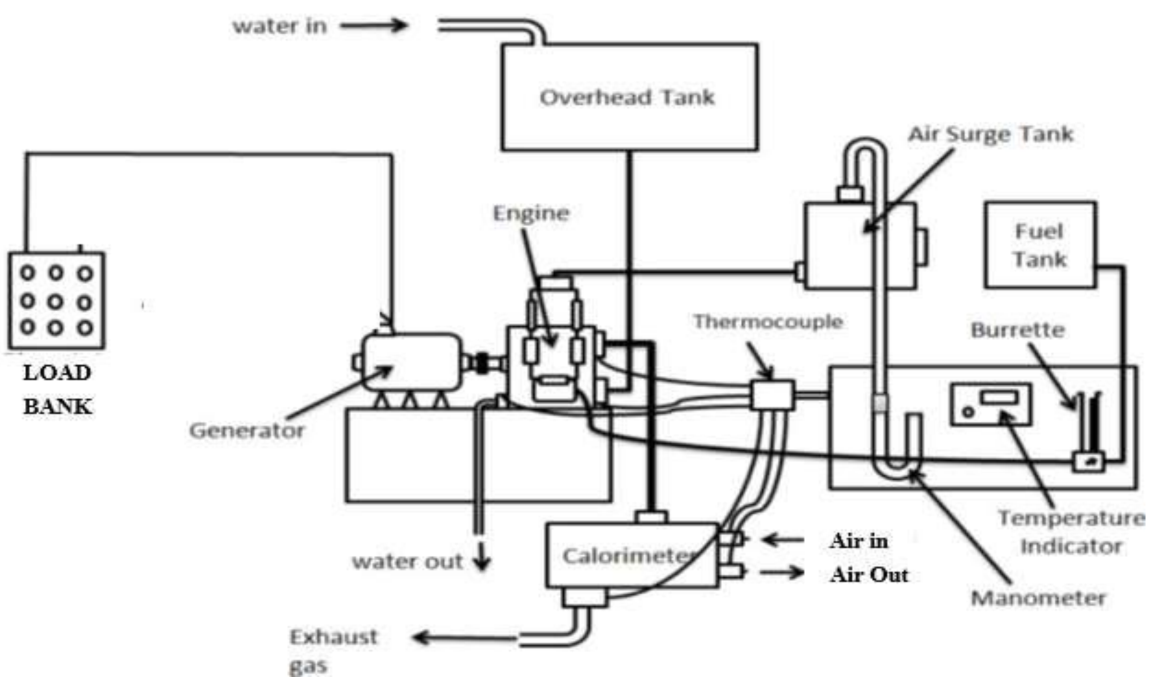

Fig.2: Block diagram of the experimental setup

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Energy Analysis

(1) Fuel energy supplied per unit time ,

$$Q_{in} = m_f * LCV \text{ , kW}$$

Where m_f = mass of fuel consume per unit time
LCV= lower calorific value of fuel

(2) Energy in exhaust gas per unit time,

$$Q_e = (m_a + m_f) * \mathrm{C_{pe}} * (\mathrm{T_{e1}} - \mathrm{T_{e2}}) \text{ , kW}$$

Where T_{e1} , T_{e2} are exhaust gas inlet and outlet temperature

C_{pe} is the specific heat of exhaust gases
m_a is mass of intake air

(3) Energy in cooling water and Unaccounted per unit time

$$\mathrm{Q_{colling+uncountable}} = Q_{in} - (Q_s + Q_e) \text{ , kW}$$

Exergy Analysis

(1) Input availability,

$$A_{in} = [m_f * \mathrm{LCV}] * [1.0401 + 0.1728(O/C) + 0.0432(O/C) + 0.2169(S/C)\{1 - 0.2689(H/C)\}]Q$$

Where H, C, O, S are mass fraction of hydrogen, carbon, oxygen, Sulphur

(2) Shaft power availability,

As = brake power of engine, kW

(3) Exhaust gas availability,

$$A_e = Q_e + [(m_a + m_f) * T_{amb} * \{c_{pe} \ln(T_{amb}/T_{e1})\} - R_e * \ln(P_{amb}$$

(4) Colling water and destructed availability,

$$A_d = \{A_{in} - (A_s + A_w + A_e)\}$$

(5) The exergy efficiency

$\eta_{II} = 1 - (A_{destroyed} / A_{in})$

IV. RESULTS AND DISCUSSION

From the dual fuel mode viewpoint, it is very essential to have the knowledge of available fuel energy losses or destroys whereabouts in the engine operations. Therefore, in this chapter, the first and second law coupled in order to get a clear view of the dual fuel operation of Ethanol.

Therefore, in this chapter the effect of load and pilot fuel variation in the energy and exergy balances of the dual fuel operations evaluated and compared to that of the baseline petrol mode.

Specific fuel consumption (SFC)

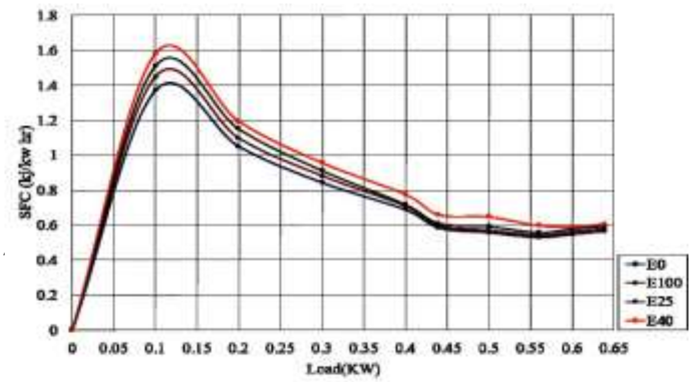

Fig.3: Variation of SFC with varying loads

Ethanol addition reduces the heating value of the petrol–ethanol blends, therefore, more fuel is needed (by mass) to obtain same power when blended fuels are used instead of petrol.However, as mentioned previously, ethanol addition to petrol makes the engine operation leaner and improves engine combustion and performance, as shown in fig 5.1 SFC measured for different loadings

It can be seen in fig 3, at low load (0 to 0.2 kW), SFC increases with increase in load by 5%, 9%, and 15% for E100, E25, E40 respectively compare to E0. At medium load (0.2 to 0.5 kW), SFC consumption is increasing by 2%, 4%, and 12% for E100, E25, E40 respectively compare to E0. At High load (0.5 to 0.65 kW), SFC is increasing by 2%, 5%, and 7% for E100, E25, E40 respectively compare to E0.

Brake Thermal Efficiency

Presence of oxygen in ethanol composition allow better combustion product, complete combustion results in high temperature and pressure inside cylinder thus results in higher power output.

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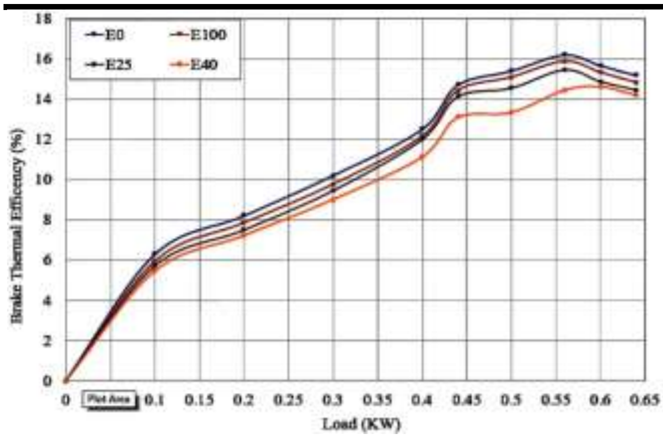

Fig.4: Variation of brake thermal efficiency with load

Fig 4 Shows variation of brake thermal efficiency with varying loads. As increase in load, brake thermal efficiency of engine reduces for Fuel blend. The vaporization of fuel continues increasing during the intake and compression stroke.This tends to decrease the temperature of the working charge, which reduces compression work of engine at high engine speed there is less time for completion of combustion, which takes place in later stage of cycle, which increase thermal efficiency.

When the latent heat of the fuel used is low, as in the case of Petrol, the effect of cooling is not sufficient to overcome the effect of additional vapor. Increasing the latent heat of the fuel blend used by increasing the ethanol percentage increases the effect of cooling, which results in increase thermal efficiency thus higher engine power output.

It can be seen in fig 5.2 at low load (0 to 0.2 kW), BTE is reducing with increases in load by 5%, 9%, and 13% for E100, E25, E40 respectively compare to E0.At medium load (0.2 to 0.5 kW) BTE is reducing by 2%, 4%, and 11% for E100, E25, E40 respectively compare to E0. At High load (0.5 to 0.65 kW), BTE is reducing by 3%, 5%, and 7% for E100, E25, E40 respectively compare to E0.

Heat balance sheet:

Heat balance sheet (E0)

Heat balance sheet of petrol and Ethanol show in fig 5 to fig 8. This balance sheet is represent the total amount of heat and how many heat utilized by shaft power, exhaust gas, and Colling water at different load. At low load, the amount of exhaust energy is low and cooling water energy is high. When load is increases, the exhaust gas energy increases rapidly with decrease with cooling water energy as shown in fig 5 to fig 8.

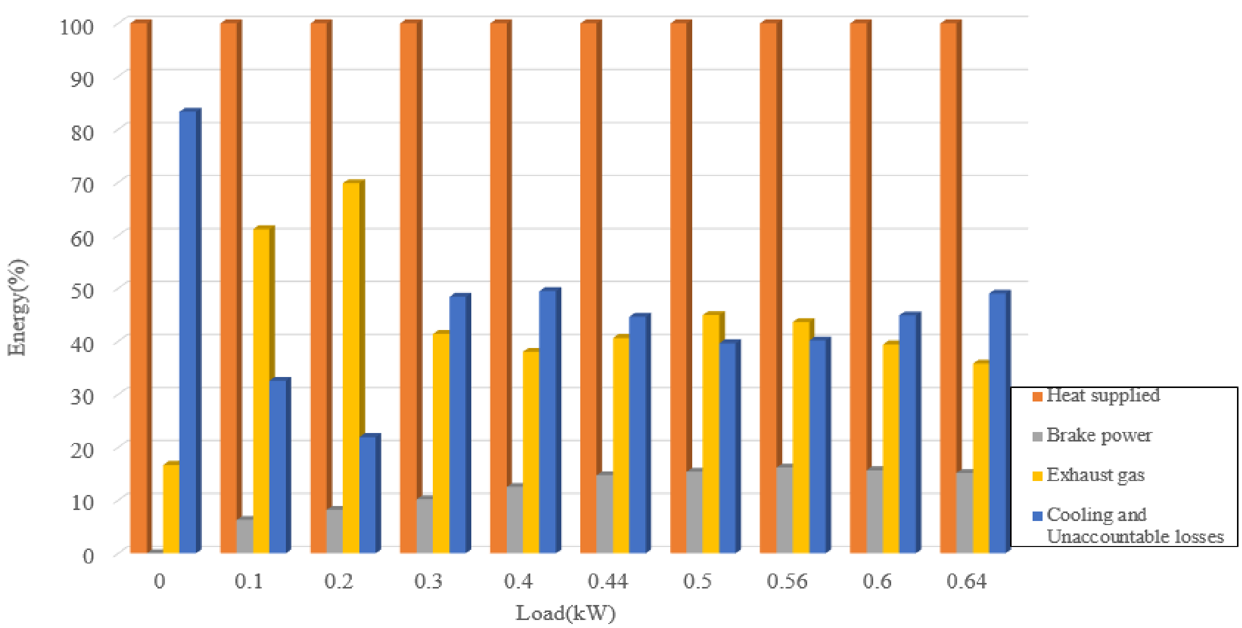

Fig.5: Heat Balance sheet for - E0

Fig 5 represents the heat balance sheet of E0. At low load (0 to 0.2 kW), out of total power generated the brake power of the engine varies 6% to 10%, heat carried out by the exhaust gas is varies 60% to 70% and heat carried out by the Colling water varies 20% to 35%. Similarly for lower load (0.2 to 0.5 kW) out of total power generated 15%, 45% 40% energy carried by brake power, exhaust gas and Colling water. In addition, at higher load (0.5 to 0.65 kW) out of total power generated 15%, 35%, 50% energy carried by brake power, exhaust gas and Colling water.

Heat balance sheet (E25)

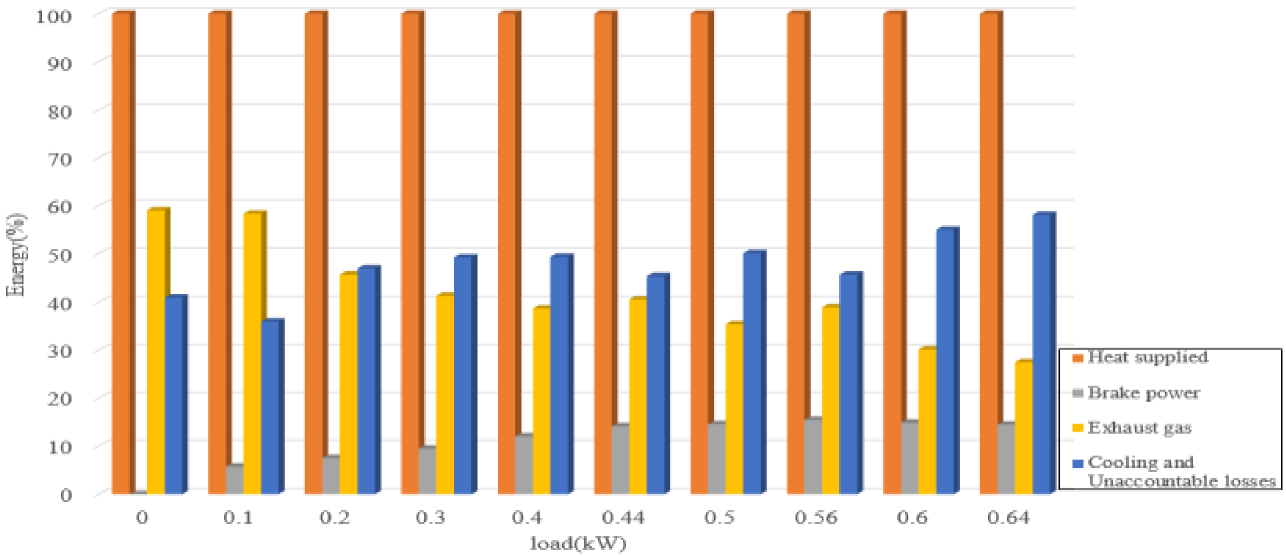

Fig.6: Heat balance sheet for – E25

Fig 6 represents the heat balance sheet of E-25.At low load (0 to 0.2 kW) and Medium load (0.2 to 0.5 kW) out of total power generated brake power, exhaust gas and Colling water energy is same compare to E0 respectively. However, for higher load (0.5 to 0.65 kW) out of total power generated brake, power is same but exhaust gas energy is reducing 10% and Colling water energy increases 10% to E0 respectively.

Heat balance sheet (E40)

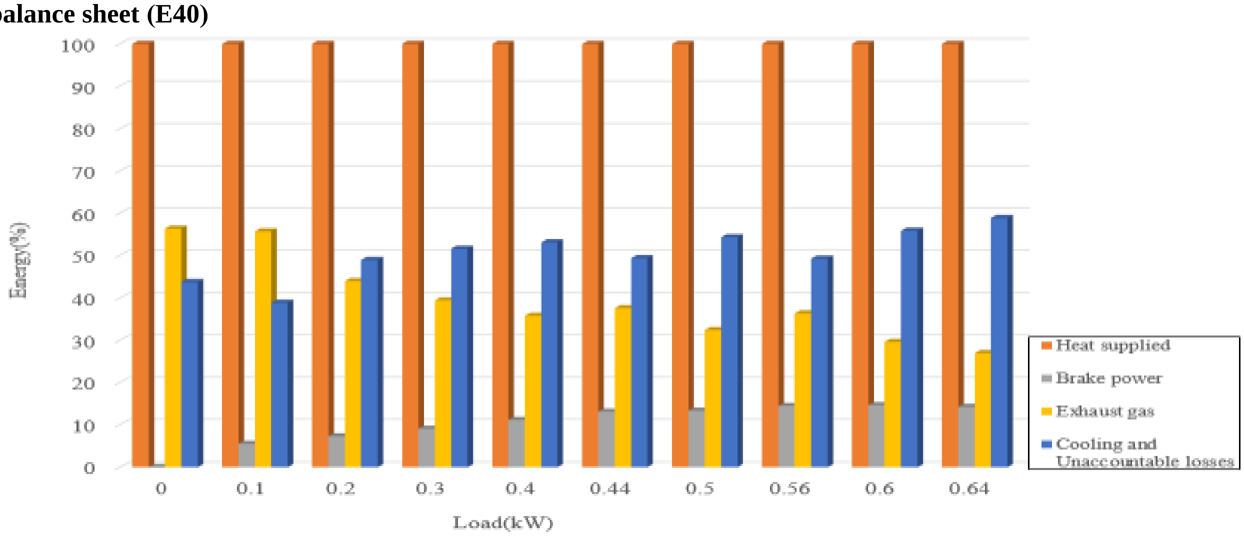

Fig.7: Heat Balance sheet for – E40

Fig 7 represents the heat balance sheet of E-25.At low load (0 to 0.2 kW) and Medium load (0.2 to 0.5 kW) out of total power generated brake power, exhaust gas and Colling water energy is same compare to E0. However, for higher load (0.5 to 0.65 kW) out of total power generated brake power is same but, exhaust gas energy is reducing 15% and Colling water energy increases 15% to E0 respectively.

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Heat balance sheet (E100)

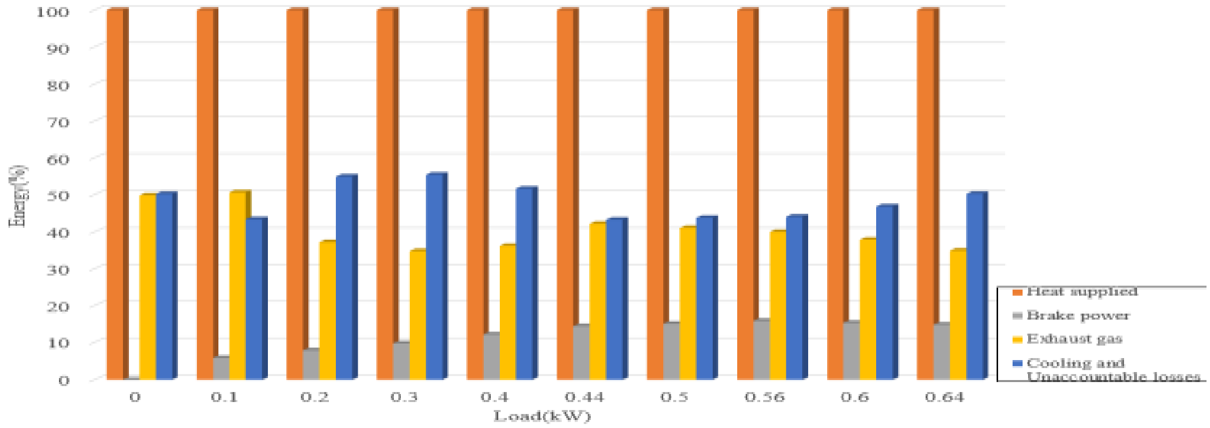

Fig.8: Heat Balance sheet for – E100

Fig 8 represents the heat balance sheet of E-100.At low load (0 to 0.2 kW) out of total power generated brake power of the engine reduces 2%, heat carried out by the exhaust gas reduces between 15% and heat carried out by the Colling water reduces 20% respectively compare to E0. Similarly, for medium load (0.2 to 0.5 kW) and higher load (0.5 to 0.65 kW) out of total power generated brake power , exhaust gas and Colling water energy is same compare to E0.

Availability Analysis:

Availability Analysis (E0)

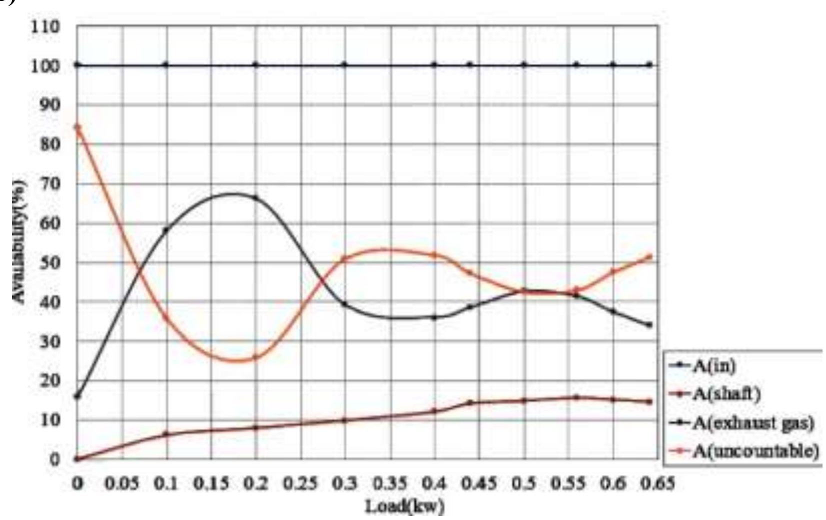

Fig.8: Availability input VS load (E0)

Fig 8 represents the availability of the E0.At low load (0 to 0.2 kW), available energy of shaft increases 0% to 9% with increases in load, exhaust gas availability increases to 15% to 67% with increases in load, but uncountable available energy is reduces 85% to 25% with increases in load respectively compare to the E0. At medium load (0.2 to 0.5 kW) available energy of shaft increases 9% to 13% increases with load, exhaust gas availability increases to 39% to 45% with increases in load, but uncountable available energy is reducing 51% to 42% with increases in load respectively compare to the E0. At higher load (0.5 to 0.65 kW), available energy of shaft is increases 13% to 15% increases with load, exhaust gas availability reduces to 41% to 35% with increases in load, but uncountable available energy increases 35% to 41% with increases in load respectively compare to the E0.

Availability Analysis (E25)

Fig 9 represents the availability of the E25. When we saw that at low load (0 to 0.2 kW) available energy of shaft is equal to the E0 respectively, exhaust gas availability reduces to 12% to 16% compare to E0 respectively.but uncountable

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available energy increases 15% to 18% respectively compare to E0. At medium load (0.2 to 0.5 kW) available energy of shaft is equal to the E0 respectively, exhaust gas availability reduces to 5% to 10% respectively compare to E0. However, uncountable available energy increases 9% to 11% respectively compare to E0.At higher load (0.5 to 0.65 kW) available energy of shaft, exhaust gas availability reduces to 5% to 10% respectively compare to E0, but uncountable available energy increases 9% to 11% respectively compare to E0.

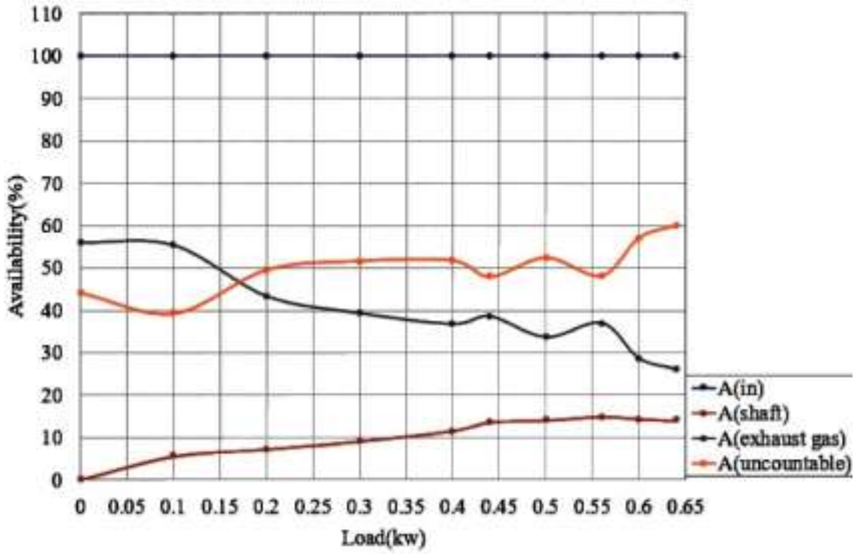

Fig.9: Availability input VS load (E25)

Availability Analysis (E40)

Fig 10 represents the availability of the E40. At low load (0 to 0.2 kW) available energy of shaft is reducing 3% to 5% respectively compare to E0. Exhaust gas availability is almost same to E0. Uncountable available energy increases 2% to 5% compare to E0 respectively. At medium load (0.2 to 0.5 kW) available energy of shaft reduces 3% to 5% respectively compare to E0. Exhaust gas availability also reduces to 5% to 7% compare to E0 respectively . but uncountable available energy increases 9% to 11% respectively compare to E0.At higher load (0.5 to 0.65 kW) available energy of shaft, exhaust gas availability also reduces to 5% to 10% respectively compare to E0,but uncountable available energy increases 9% to 11% compare to E0 respectively.

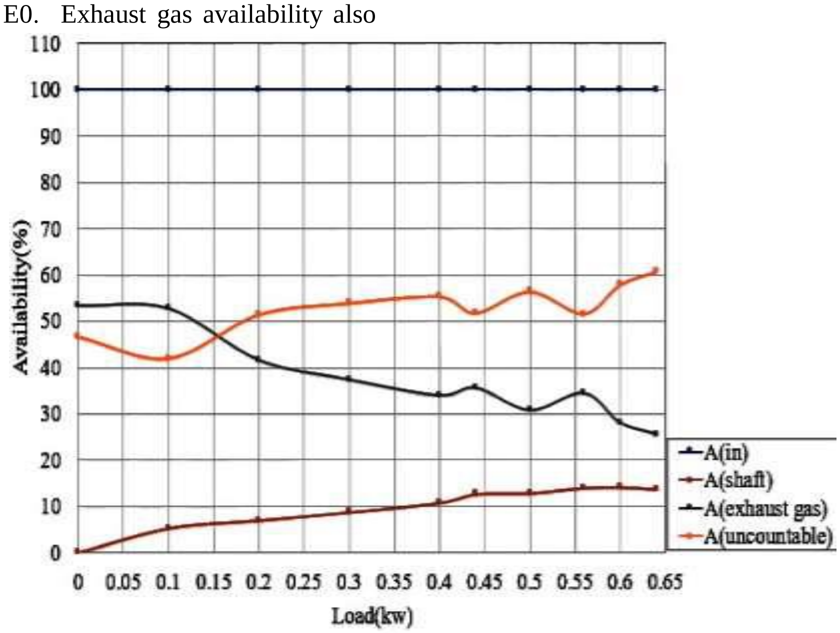

Fig.10: Availability input VS load (E40)

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Availability Analysis (E100)

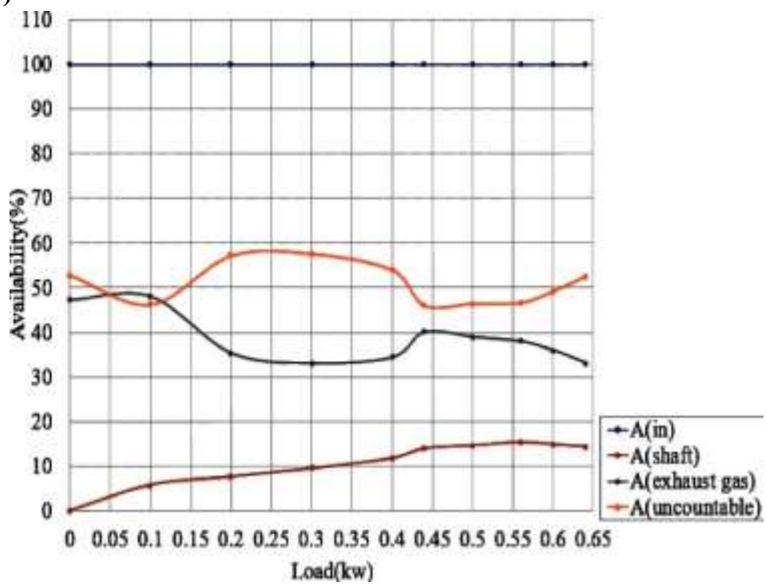

Fig.11: Availability input VS load (E100)

Fig 11 represents the availability of the E100.At low load (0 to 0.2 kW) available energy of shaft is equal to the E0, exhaust gas availability reduces to 30% respectively compare to E0, but uncountable available energy increases 30% compare to E0. At medium load (0.2 to 0.5 kW) available energy of shaft is equal to the E0. Exhaust gas availability reduces to 5% to E0, but uncountable available energy increases 5% to 9% respectively compare to E0.At higher load (0.5 to 0.65 kW) available energy of shaft, exhaust gas availability and uncountable available energy is same respectively compare to E0.

Destroyed availability

Fig 12 represents destroyed availability distribution at different engine load for operation with petrol and blends of ethanol. To maintain an equal power output as of ethanol mode, dual fuel mode required higher chemical fuel exergy than the ethanol mode due to the poor combustion and low energetic petrol fuel.

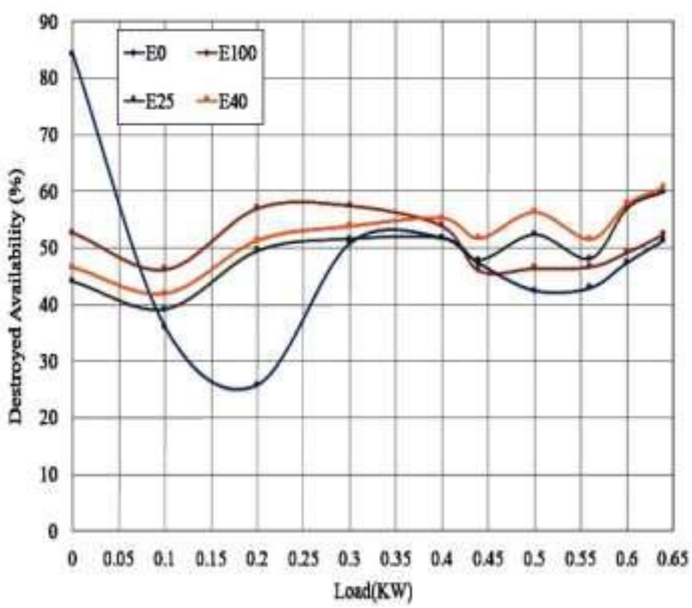

Fig.12: Destroyed availability distribution at different engine load

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For lower load (0 to 0.2 kW), destroyed availability increases 11%, 10%, 17% for E25, E40 and E100 respectively compare to E0. At medium load (0.2 to 0.5 kW) destroyed availability reducing 1% for E25 and increases 3% for E40 increases 2% for E100, respectively compare to E0.At higher load (0.5 to 0.65 kW) destroyed availability increases 8%, 10% , 1% for E25, E40 and E100, respectively compare to E0.

Energy efficiency

From the fig 13 it is clear that as the load increases the exergy efficiency increases. This is due to as load increases during engine operation, the rich fuel mixture increased the combustion temperature. Therefore, increased work availability and reduced heat transfer availability losses obtained, as percentages of the fuel chemical availability. For this, an increase in the exergy efficiency resulted at higher loads for all the tested fuels. In case of Ethanol, at higher loads the exergy efficiency improves significantly than compared to lower loads due to the improved combustion of Ethanol at higher load and decreased ignition delay. Because of the improved combustion of Ethanol at higher loads, the exhaust gas availability was increased. In addition, the shaft availability of the fuels was higher for an increased load.

For lower load (0 to 0.2 kW), exergy efficiency reduces 11%, 10%, 17% for E25, E40 and E100 respectively compare to E0. At medium load (0.2 to 0.5 kW) exergy efficiency increasing 1% for E25 and reducing 3% for E40 reduces 2% for E100, compare to E0 respectively. At higher load (0.5 to 0.65 kW) exergy efficiency is reducing 8%, 10%, 1% for, E25, E40 and E100 respectively compare to E0.

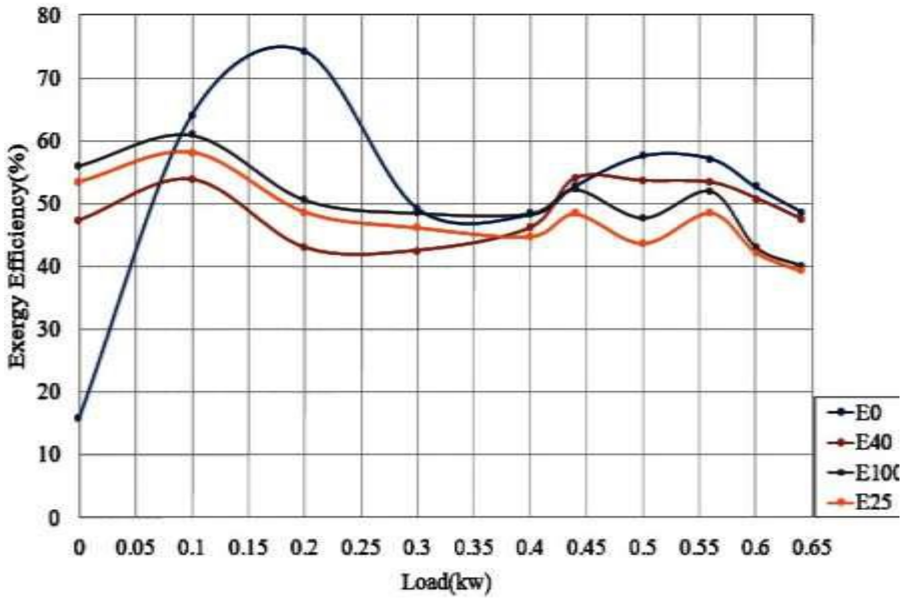

Fig.13: Exergy efficiency versus Load

V. CONCLUSION

From performance analysis of SI engine following concluding remarks obtained-

1. The general performance of E40 found to be better compeer to E0. SFC 7-12% lower than E0 at high load condition. SFC was increased 5% to 15% for E40 then E0 low to high load. Ethanol addition reduces the heating value of the petrol–ethanol blends, therefore, more fuel is needed (by mass) to obtain same power when blended fuels are used instead of petrol.
2. The mechanical efficiency reduces by 10-16%, 9-5%,5-3% for E25 E40 and E100 respectively compare to E0 at varying load condition.When the latent heat of the ethanol is low, as in the case of ethanol, the effect of cooling is not sufficient to overcome the effect of vapor.Which results in reducing thermal efficiency.
3. The heat balance sheet indicates that some amount of heat wasted by fuel. This heat utilized to increase the brake power and some amount of heat is lost in exhaust gas.For lower load to higher load out of total power generated brake power of the engine is same for different fuel blend E25, E40, E100 compare to E0.For exhaust gas energy however it is reducing for lower load to higher load. It reduces 15% to 25% for different blend like E25, E40, and E100 compare to E0 respectively. For Colling water energy, however it increases for lower load to higher load by 10% to 17% for different blend like E25, E40, and E100 compare to E0.

From Exergy analysis of SI engine following concluding remarks obtained-

1. The increase in load resulted in increase of availability for all blend of ethanol and petrol (E0, E25, E40, and E100).For E25, E40, E100 availability increases by 9-13%, 13-19% and 3-5% respectively compare to E0 at varying load condition. For lower to higher load condition, availability increases due to improvement of combustion for different blends of ethanol-petrol (E0, E100, E25, and E40) at high temperature.
2. Due to poor combustion of fuel and lower energy content, it observed that dual fuel (E0, E25, E40, and E100) mode more fuel exergy require to produce same amount of shaft work for E25, E40, E100 respectively then E0. Exergy efficiency increases 5-7% and 9-13% for low and high load respectively for all blend of ethanol-petrol.Exergy efficiency reduces 3-5% for medium load for all blend of ethanol-petrol.
3. Even though destroyed availability decreases as the load increases due to the presence of CO_2 in ethanol blend. Destroyed availability reduces by 7- 9% for lower load and higher load condition for all blend of ethanol-petrol. Destroyed availability increase by 3-5% for medium load condition for all blend of ethanol-petrol

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Definitions

E0 - Neat petroleum fuel

E25 - Blend of 10% Ethanol with 90% of Conventional petrol

B40 - Blend of 15% Ethanol with 85% of Conventional petrol

B100 - Neat Ethanol fuel

BTE - Brake Thermal Efficiency

BP - Brake Power

HC - Hydrocarbon

CO - Carbon Monoxide

NO_x - Nitrogen oxide

SFC - Specific Fuel Consumption