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PERFORMANCE EVALUATION OF GASOLINE AND E50 FOR INTER COMBUSTION ENGINE

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Abstract

The present work represents the performance evaluation of Gasoline and E50 for the internal combustion (IC) engine. There is a lot of scope for performance evaluation to understand and adopt the various fuels for the internal combustion engine. In this work the various performance characteristics are analyzed for both the fuels. Then a comparison is made among both the fuels to understand the adoptability of these fuels. The first fuel used is 100% gasoline and the later one is 50% gasoline and 50% ethanol. In order to the performance of the engine with these fuels the emphasis is also made on compression ratio for these fuels. After the investigation it is observed that from gasoline to E50 the compression ratio is enhanced without any trouble of knocking. The investigation has resulted in two important results. First, E50 has shown a rise in power generation, engine torque and fuel consumption. Second a fall in emissions of nitrogen oxide, carbon monoxide and hydro carbon. Particularly at high compression ratio for the spark ignition engines E50 fuel gave a better performance than gasoline alone. The blending of gasoline with ethanol is a better choice for the IC engines.
***Keywords**:* Performance evaluation, Gasoline, E50, Internal Combustion Engine.

1. Introduction: With the growing needs for mechanization, industrialization and auto mobilization it is important to develop alternative fuel for the petroleum products. Alcohol is one of the best alternatives for the gasoline since ages. [1,2,3] Particularly ethanol is a best alternative fuel because of production process. Usually the ethanol is generated from the renewable energy sources such as cassava, sugarcane, barley, corn and many other types of biomass (waste) materials. Most of the raw materials for production of ethanol are from the waste of the plants and their products. Hence it's a renewable source in such a way that the ethanol becomes the best alternative for the gasoline. [4,5,6] This is not a recent innovation but still it's an active and best alternative for the IC engines. The E50 has higher evaporation heat, flammable temperature and octane number as compared to gasoline alone. Because of this positivity E50 has good impact on performance of engine and reduction of exhaust emissions. [8,9,10]

Abbreviations:

SFC= Specific fuel consumption

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BSFC = Brake Specific fuel consumption

CO = Carbon monoxide

HC = Hydro carbon

NO= Nitrogen oxide

rpm = revolutions per minute

IC = Internal Combustion

SO = Sulphur Oxide

2. Methodology:

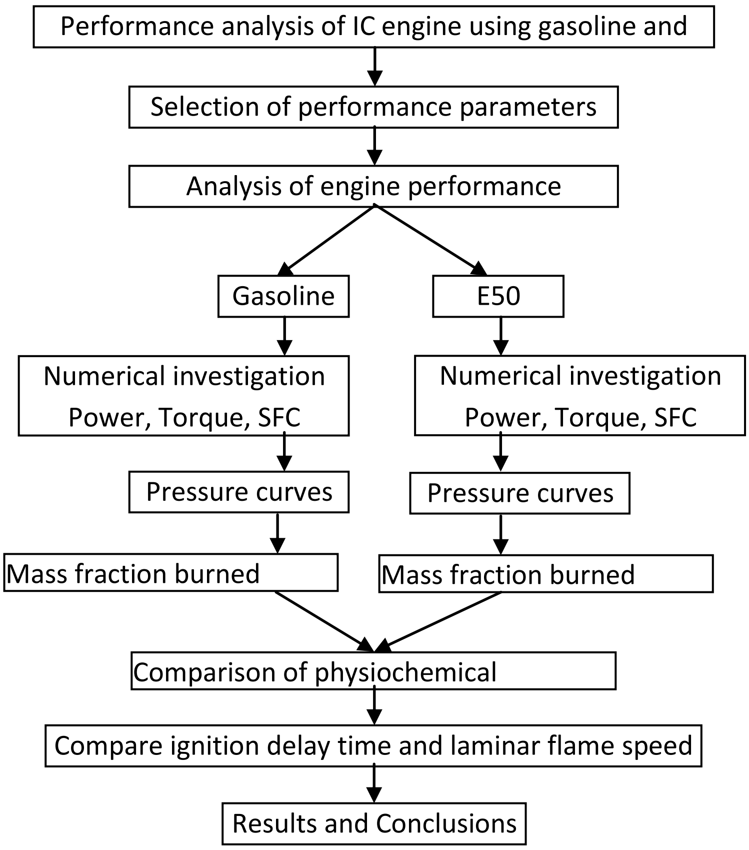

Figure 1: Detailed procedure for analysis of gasoline and E50

The work is made by detailed analysis of IC engine with two fuels gasoline and E50. During the analysis the emphasis is made on power generated, torque required, specific fuel consumption as well as pressure generated inside the cylinder for the crank angle.[11,12]

3. Experimentation:

The performance evaluation of the two fuels is examined on IC engine of the following specifications. Bore = 75mm, Stroke = 50mm, Engine speed = 1800 rpm, Maximum power output = 3000W at 3600 rpm, Maximum torque = 7 Nm at 2800 rpm, connecting rod length = 63 mm, compression ratio = 8:1, Inlet pressure = 100 kPa, Inlet Temperature = 310K, Volumetric efficiency = 48%, Ignition timing = 20^o before top dead centre (TDC), Cylinder wall temperature = 350K. Mechanical efficiency of the engine = 100%.

Brake power BP = 2ΠNT = 2*Π*1800*7 = 79168.134 W = 79.168 kW

Indicated power IP = Brake power = 79.168 kW, because mechanical efficiency is given as 100%. That means there is no frictional loss in the engine.

Indicated Mean effective pressure P_{mi}

$IP = n*P_{mi}*LANk = 1*P_{mi}*0.05*\frac{\Pi}{4}*.075^2*1800*\frac{1}{2}$

- ⇨ $79168 = 0.19P_{mi}$
- ⇨ $P_{mi} = 398221.54\ N/m^2$

Brake Mean effective pressure B_{mi} = Indicated mean effective pressure P_{mi}

Because mechanical efficiency = 100%.

Engine displacement

For the single engine diameter of 75mm and stroke length of 50mm the displacement is 220.89cc = 220890 mm^3.

Engine work = $W = P_{me}*V_d = 398221.54*0.00022089 = 87.96$ J

Power = $P = \frac{W*n_e}{n_r} = \frac{87.96*1800}{2} = 79166.733\ W = 79.166\ kW$

Cylinder volume or engine swept volume = V_c = Cylinder area * Stroke length

$$= A_c*L = \frac{\Pi}{4}*d_c^2*L = \frac{\Pi}{4}*75^2*50 = 220893.23\ mm^3$$

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Bore / stroke = $\frac{75}{50}$ = 1.5 hence it is an over square engine.

Compression ratio = $\frac{8}{1}$ = 8

$$= \frac{Cylinder\ volume + Cylinder\ clearance\ volume}{Cylinder\ clearance\ volume}$$

⇨ $\frac{220893.23 + cylinder\ clearance\ volume}{Cylinder\ clearance\ volume} = 8$

⇨ Cylinder clearance volume = 31556.175 mm^3

The stoichiometric ratio of air and gasoline is 14.7 : 1 (w/w).

Fuel mass flow rate consumed by the engine = m_f (kg/s) = $\frac{bsfc * bmep * V_d * n}{2 * 60 * 3.6 * 10^9}$

Volumetric efficiency = $\eta_v = \frac{Actual\ volume}{Theoritical\ Volume} = \frac{V_a}{V_t}$ but $V_a = \frac{m_a * R * T_1}{P_1}$

By calculating and comparing the volumetric efficiency for the specific fuel consumption it is found that for the idle running of the single cylinder 4 stroke spark ignition engine 0.3696 grams of gasoline and 5.4816 grams of air is required per one cycle of operation. As the density of the ethanol is 789.45 kg/m^3 and density of gasoline is 800 kg/m^3, the specific fuel consumption does not vary much but for the same fuel consumption performance wise the difference is significant.[13,14,15,16]

Engine speed (rpm) vs Torque (Nm)

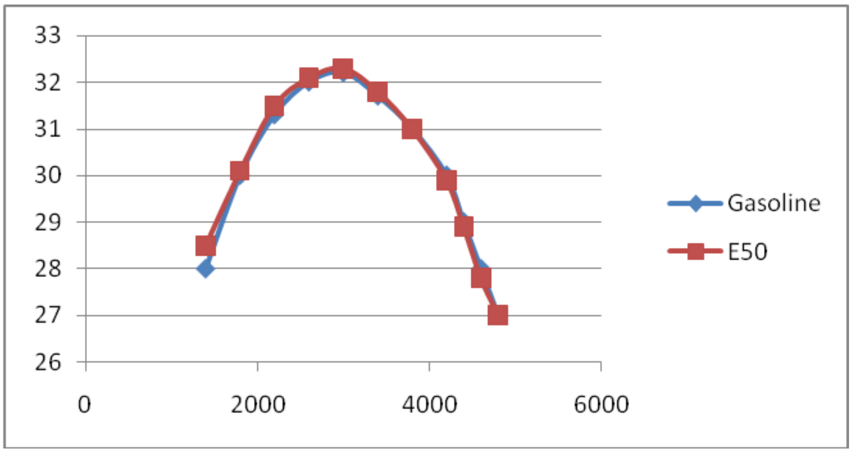

Figure 2: Engine speed vs Torque comparison for Gasoline and E50

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The above figure 2 shows the engine speed versus torque generated in the engine. X axis is the engine speed and Y axis denotes the torque. The blue colour line indicates the gasoline performance and the red colour line indicates the E50 fuel. The compression ratio is considered as 8:1. For the specified speed almost both the fuels are yielding the same outcome but slightly E50 has more torque.[17]

Brake specific fuel consumption vs Engine speed

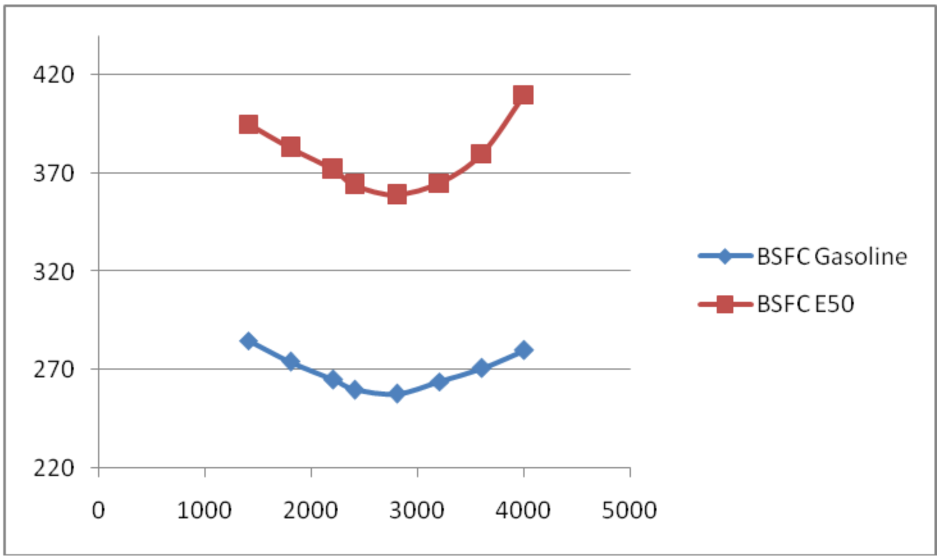

Figure 3: Brake specific fuel consumption vs Engine speed comparison for Gasoline and E50

The above figure 3 shows the engine speed versus brake specific fuel consumption in the engine. X axis is the engine speed and Y axis denotes the break specific fuel consumption. The blue colour line indicates the gasoline performance and the red colour line indicates the E50 fuel. [18] For the specified speed gasoline has the low break specific fuel consumption than the E50. The minimum consumption is observed at a speed of 2700 rpm for E50 and 2800 rpm for gasoline.

Engine speed vs CO %

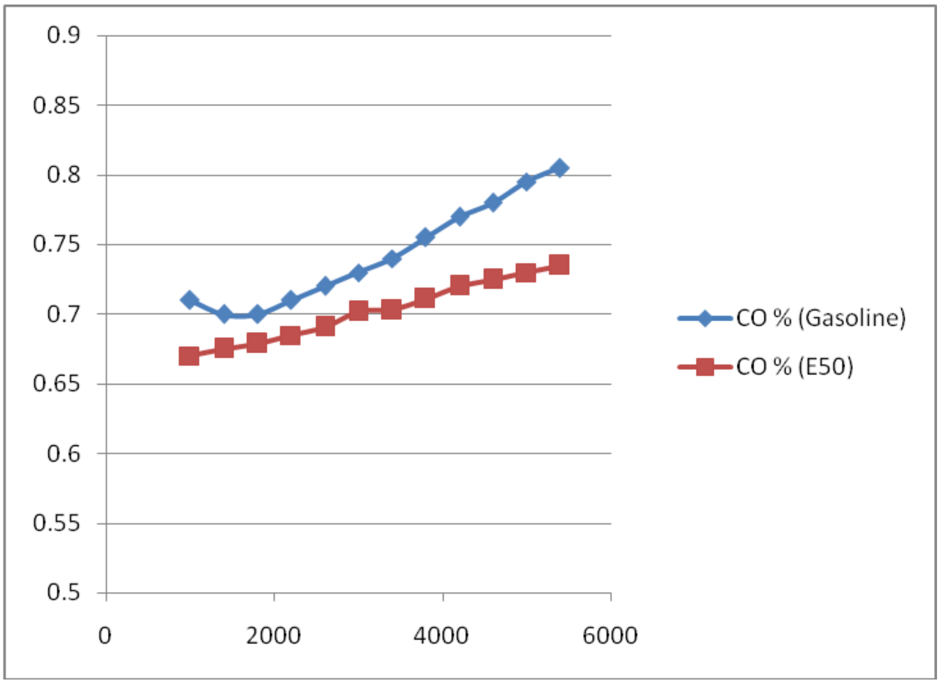

Figure 4: Engine speed vs CO% comparison for Gasoline and E50

The above figure 4 shows the engine speed versus carbon monoxide emissions generated in the engine. X axis is the engine speed and Y axis denotes the CO % emissions. The blue colour line indicates the gasoline performance and the red colour line indicates the E50 fuel. For the specified speeds gasoline is generating more amounts of carbon mono oxide emissions than E50. But there is small fall in the CO emissions at a speed of 1800-1900 rpm. As the speed increasing, the % of CO emissions is also increasing for both the fuels.

Engine speed vs HC %

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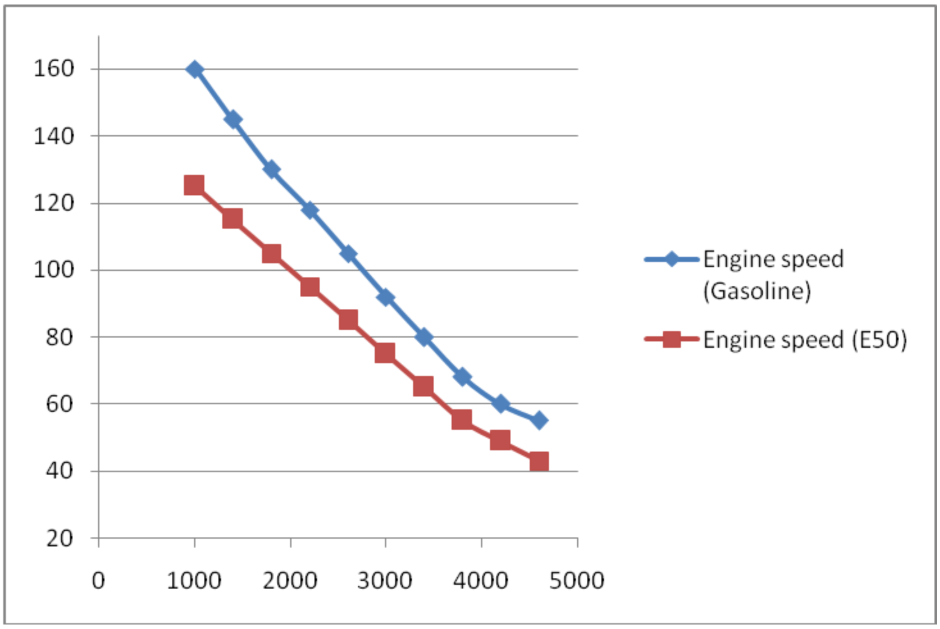

Figure 5: Engine speed vs HC% comparison for Gasoline and E50

The above figure 5 shows the engine speed versus hydro carbon emissions generated in the engine. X axis is the engine speed and Y axis denotes the HC % emissions. The blue colour line indicates the gasoline performance and the red colour line indicates the E50 fuel. For the specified speeds gasoline is generating more amounts of hydro carbon emissions than E50. As the speed increasing, the % of HC emissions is decreasing for both the fuels.

Engine speed NOx %

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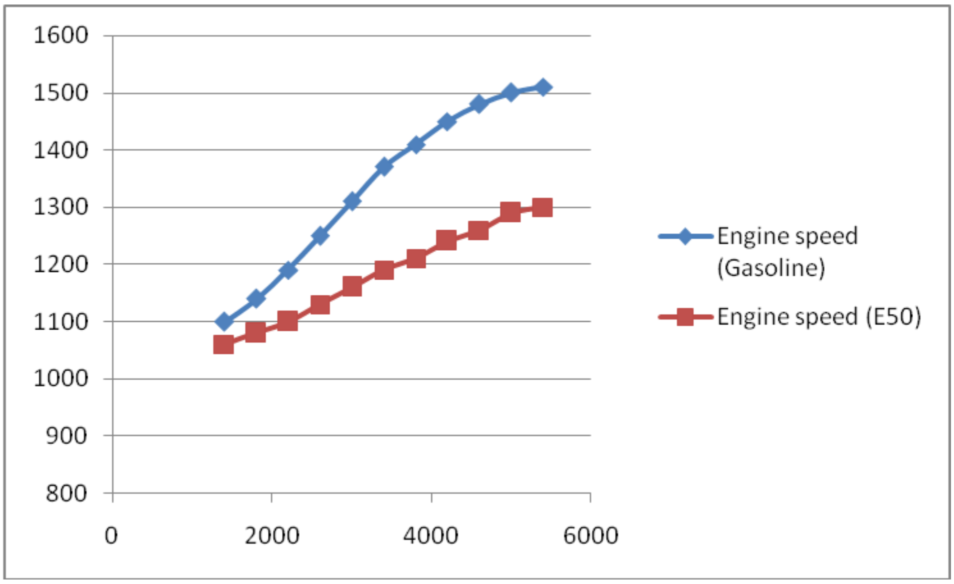

Figure 6: Engine speed vs NOx % comparison for Gasoline and E50

The above figure 6 shows the engine speed versus Nitrogen oxides emissions generated in the engine. X axis is the engine speed and Y axis denotes the NOx % emissions. The blue colour line indicates the gasoline performance and the red colour line indicates the E50 fuel. For the specified speeds gasoline is generating more amounts of nitrogen oxide emissions than E50. As the speed increasing, the % of CO emissions is also increasing for both the fuels.

Pressure vs Crank angle

Gasoline and E50

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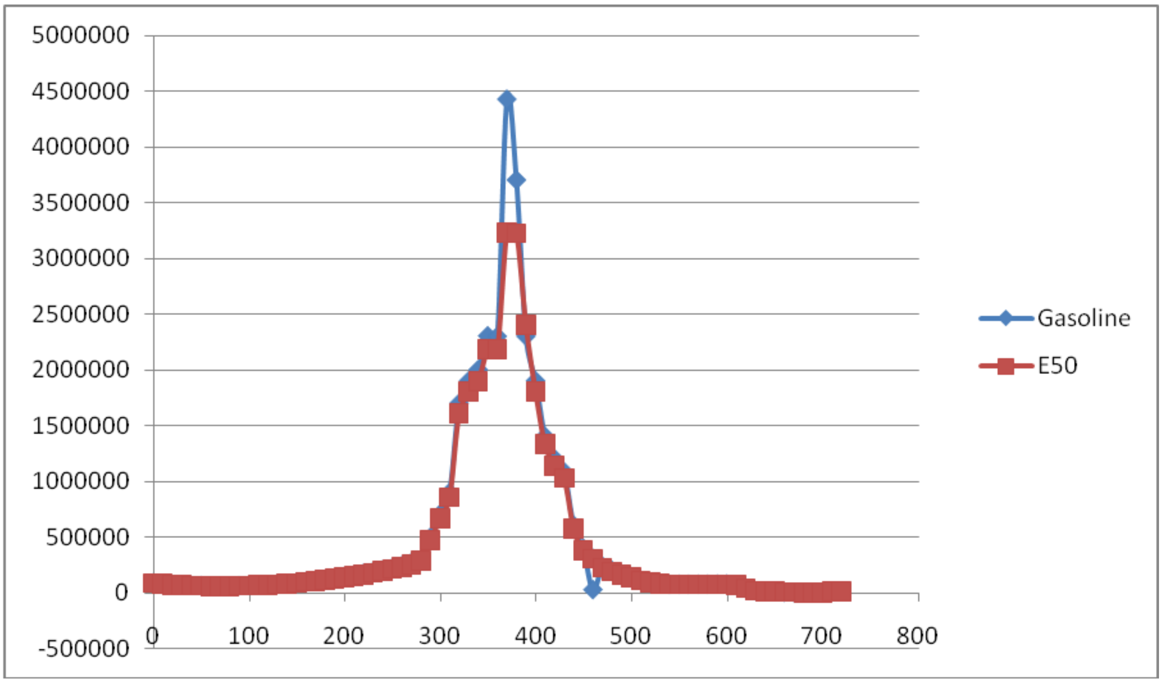

Figure 7: Crank angle vs Engine pressure for Gasoline and E50

The above figure 7 shows the crank angle versus cylinder pressure generated in the engine. X axis is the engine speed and Y axis denotes the cylinder pressure. The blue colour line indicates the gasoline performance and the red colour line indicates the E50 fuel. As the crank angle increasing the cylinder pressure is also increasing for both the fuels. But the maximum pressure is generated by Gasoline at angle of 370^{o} and there is a small drop in pressure is observed for E50 at an angle of 460^{o}. The maximum pressure generated by Gasoline engine is 442689 MPa. And the minimum pressure generated by Gasoline engine is 11 MPa at angle of 700^{o}. The maximum pressure generated by E50 engine is 3689049 MPa at angle of 373^{o}. The minimum pressure generated by E50 engine is 10.45 MPa at angle of 700^{o}.

Mass fraction burned

The mass fraction burned analysis is useful understanding the burning and burnable characteristics of the fuels for the specified conditions. The mass fraction curves are drawn for the data as follows. Engine speed = 1800 rpm, Maximum power output = 3000W at 3600 rpm, Maximum torque = 7 Nm at 2800 rpm, connecting rod length = 63 mm, compression ratio = 8:1, Inlet pressure = 100 kPa, Inlet Temperature = 310K, Volumetric efficiency = 48%, Ignition timing = 20^{o} before top dead centre (TDC), Cylinder wall temperature = 350K. Mechanical efficiency of the engine = 100%. The mass fraction burned curves are been generated using the weibe fitted parameter analysis as shown in table 1. [19,20]

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Table 1: Mass fraction burned data for Gasoline and E50

	Wiebe fitted parameter	Mass fraction burned of engine data	LSM (b,m,ca0,ca90)	LSM (m,ca0,ca90)
Gasoline	a		2.4	2.4
	m		2.53	2.53
	Θ_o	-20.00	-20	-20
	$\Delta\ \Theta_{o\text{-}90\%}$	35.32	34.10	31.12
	b		1.05	1.06
	SSE		0.03	0.10
	Net IMEP %		0.02	-0.20
	Max $\Delta\Theta$ difference		0.66	1.20
E50	a		2.3	2.3
	m		2.58	2.905
	Θ_o	-20.00	-20	-20
	$\Delta\ \Theta_{o\text{-}90\%}$	27.35	30.90	28.89
	b		1.085	1.085
	SSE		0.03	0.085
	Net IMEP %		0.025	-0.175
	Max $\Delta\Theta$ difference		0.77	1.265

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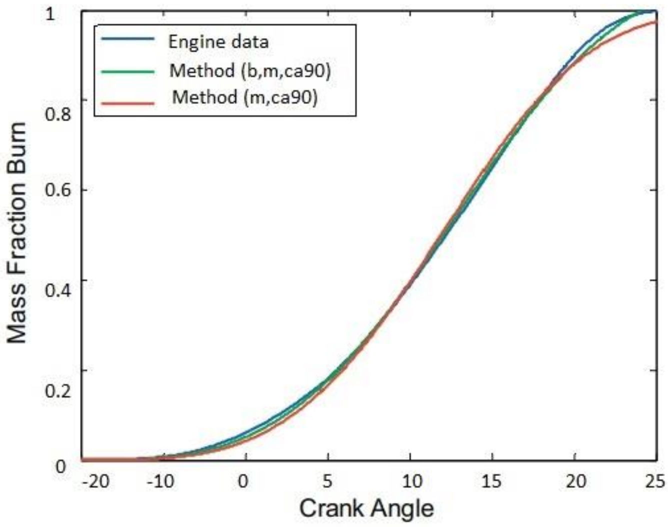

Figure 8: Mass Fraction Burn vs Crank angle for Gasoline

The above figure 8 shows the mass fraction curve vs crank angle for the gasoline engine. X axis shows the crank angle and y axis shows the mass fraction burned. From the beginning of ignition timing 20^o (-20^o) the mass fraction burned is started from 0% and it reaches to 1% for the crank angle of 25^o. In the above figure 8 blue colour line represent the mass fraction burned curve of engine data and green colour is the curve derived from method of analysis using b,m,ca90. Red colour is the curve derived from method of analysis using m,ca90. Gasoline

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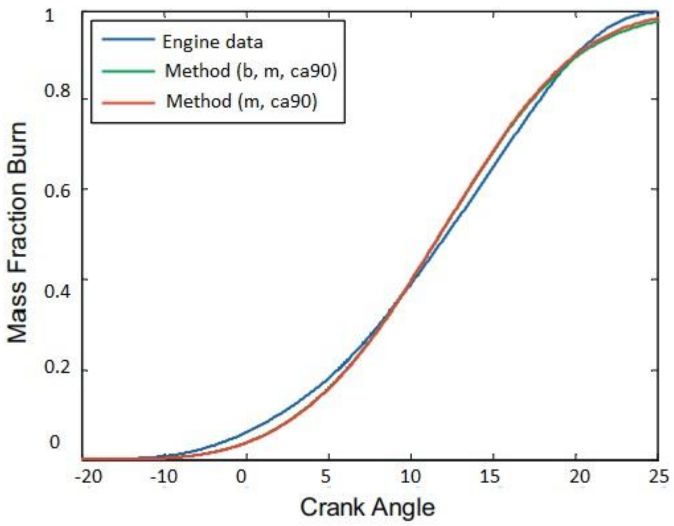

Figure 9: Mass Fraction Burn vs Crank angle for E50

The above figure 8 shows the mass fraction curve vs crank angle for the E50 engine. X axis shows the crank angle and y axis shows the mass fraction burned. From the beginning of ignition timing 20^o (-20^o) the mass fraction burned is started from 0% and it reaches to 1% for the crank angle of 25^o. In the above figure 9 blue colour line represent the mass fraction burned curve of engine data and green colour is the curve derived from method of analysis using b,m,ca90. Red colour is the curve derived from method of analysis using m,ca90.

4. Results and Discussions:

The above analysis is resulted the following outcomes.

- Both the engines generating maximum torque at a speed of 2500 rpm.
- The minimum brake fuel consumption is observed at a speed of 2700 rpm for E50 and 2800 rpm for gasoline. But for the specified speed gasoline has the low break specific fuel consumption than the E50.
- As the speed increasing, the % of CO emissions is also increasing for both the fuels.
- As the speed increasing, the % of HC emissions is decreasing for both the fuels.
- As the speed increasing, the % of CO emissions is also increasing for both the fuels.
- The maximum pressure generated by Gasoline engine is 442689 MPa. And the minimum pressure generated by Gasoline engine is 11 MPa at angle of 700^o. The maximum pressure generated by E50 engine is 3689049 MPa at angle of 373^o. The minimum pressure generated by E50 engine is 10.45 MPa at angle of 700^o.

- From the beginning of ignition timing 20^o (-20^o) the mass fraction burned is started from 0% and it reaches to 1% for the crank angle of 25^o for both the engines.

5. Conclusions:

From the above analysis it is concluded that as a whole E50 has better performance characteristics than gasoline. And there is a lot of further scope in this area to improve the performance and reduce the emissions.

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