AUJoGR-22406

TO EXPERIMENTALLY ANALYSE THE IMPACT OF BIOSYNTHETIC FUEL ON PERFORMANCE AND EMISSION CHARACTERISTICS OF AN IC ENGINE

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Abstract
Conventional fuels such like gasoline and diesel are used in most car sectors but constant increases in demand and environmental degradation due to recent rise in population, urbanization, scientific and technological advancements. Through use of renewable energy, such as biofuels and biosynthetic fuel, seems to be the only solution for humanity's growth and achievement. For this environmental degradation, Climate act of UK was passed in 2008. Later Paris Agreement 2015 on Climate Goals came into existence. USA clean air agreement also played its part. With the passage of time demand for energy is constantly increasing but the resources are getting limited so a new fuel known as Biofuel is introduced to the world. They refer to fuels that derive their energy from biomass i.e. organic materials. This is considered to be one of the most efficient alternate energy source in modern times. Biofuels can be divided into three generations. The first generation, second generation and third generation. Third generation biofuels are the advanced ones. The biggest concern about fuel in the future will be its depletion and the negative environmental impact of increasing greenhouse gas emissions. We must identify alternate routes that are both renewable and capable of replacing petroleum-based products. These alternative renewable fuels will reduce the demand for fossil fuels, which are diminishing at an alarming rate, while also improving engine emission and performance aspects. The primary goal of this research project is to produce new biosynthetic renewable fuels and evaluate their effects on engine performance and emissions.

Keywords: fossil fuels, biofuels; renewable fuels; alcoholic fuels; UK act; Paris agreement act; emissions; IC engine refining; biosynthetic.

1. INTRODUCTION

The importance of fossil fuels, which include gasoline or diesel, natural gas, and coal, which meet 90% of our energy requirement, cannot be emphasised. However, their all-purpose utility comes with a price. The gases released during the combustion of fossil fuels, particularly CO2, which of the following are the biggest factors as a due to climate change [1]. Furthermore, with the passage of time, fossil fuels are diminishing at an alarming rate [2] of time .These reasons are causing countries to exert pressure in the form of new laws and regulations. Legislation aimed at ensuring the environment's and people's safety. England was the very first country to pass the Climate Act of 2008, which aims to cut emissions by approximately 80% by 2050 compared with 1990 levels [3]. Additionally, the US Environmental Agency has enacted the Clean Air Act, which attempts to limit air pollution [4]. The only option for humanity's survival, success, and development is to adopt alternative renewable energy sources to address this worldwide crisis. [5]. This research project's primary purpose is to examine the stability, ignition, and emission characteristics of novel biosynthetic fuels, as well as their effects on regulated, unregulated, and GHG emissions, to enhance engine productivity and deliver a complex decrease in exhaust emissions. Biofuels are viewed as appealing alternative fuels with the potential to decrease GHG and pollution emissions. As a result, biofuels constitute a viable renewable and sustainable energy source. Biomass had already long been emerged as a potential substitute for fossil fuels, and attempts have been undertaken all over the world to transform renewable organic matter into biofuels. The technologies developed thus far to convert agricultural wastes for energy purposes have resulted in solid, liquid, and gaseous fuels. resources for energy purposes [6]. A summary of the research on the use of various biomass-based solid fuels in diesel engines, like coal, charcoal, carbon, and carbon black-based sludge's, was also published. [7]. The literatures contain information on the application of both gaseous and liquid biofuels. [8] , [9].

Generation	Feedstocks	Biofuels produced
1st	Sugar crops, starch crops	Bioethanol, SVO[a], biodiesel
	Vegetable oils, animal fats	Biosyngas
2nd	Nonfood crops, wheat straw solid waste, energy crops	Bioalcohols, DMF[a], BTL[a] diesel
		Biohydrogen, bio-oil
3rd	Algae, see weeds	Bioalcohols, biodiesel
		Biohydrogen
4th	Vegetable oil, biodiesel	Bio-gasoline

Table 15: Classification of biofuels obtained from feedstock [9]

Through the use of computational tools and system metabolic engineering, some microorganisms have recently been used as a biosynthetic platform to effectively create both non-natural and natural biofuels [11], [12].

2. LITERATURE REVIEW

2.1 Fossil fuel limitations and climate change: Most of the energy is coming from fossil fuels. But two more problems comes with it which are limited resources of fossil fuels and climate effect of fossil fuels [13]. The desire for more efficient modes of travel led to the railroad, but then to steam locomotives. In the eighteenth century, a need for power in coalfields helped lead to the invention of the steam engine. [14] According to the World Energy Outlook (WEO) 2007, energy generated from fossil fuels [15]. The combustion of fuel emits so-called greenhouse gases, which are harmful to the planet's ecology and continue to be a major contributor to global warming and thus climate change. [16]

2.2 Climate act UK 2018: At the end of November 2008, the UK Parliament approved the world's first Climate Change Act (henceforth 'the Act,' constructing a legally enforceable greenhouse gas reduction aim of an 80% reduction from 1990 levels by 2050. The Act has now become central to the UK's image as a ruler in climate change. During its movement through Parliament, the rules was largely viewed as a historic step.[17]

2.3 Paris agreement 2015 on climate goals: Over the next century, the Mediterranean basin is likely to generate ecosystems that have no derivative in the world, even if temperature goes up by 1.5 ° Celsius above pre - industrial times. A temperature increase of 2 °C, on either hand, is unsupportable. Different climate-change circumstances Holocene observations of greenery and land act as a base upon which to try comparing climate models and grasses suppositions.[18]

2.4 USA clean air act: A governmental tactic in which a benchmark is indicated that cannot be met with available systems, or at least not at an affordable fee, is known as technology trying to force. Using the 1970 U.S. Clean Air Act for attempting to control automobiles emissions as a benchmark example, we demonstrate the importance of governmental project delivery if policies and guidelines are to nurture technological change. [19]

2.5 Advantages of biofuel: Biomass is the production of biofuel and biomaterials, and enhancing its use will indeed assist in meeting a variety of social concerns. The advantages of biomass conversion into fuel sources were among the first motivation factors for physiological and biological research.[20]. Biofuels have the potential to be a reduced energy source, but this depends on how they are produced [21]. The use of corn for ethanol increases the price of beef, chicken, pork, eggs, breads, cereals, and milk in the United States by 10% to 30% [22]. New market opportunities and aids in agricultural expansion Products, resulting in increased income for farmers. Another advantage is that when sugar and starch-bearing plants are fermented, co-products such as necessary supplements are produced in large quantities. [23] The effects of a variety of energy-related emissions, such as suspended fine particles and precursors of city's air pollution and ecosystem degradation are exacerbated by ozone and acid deposition. [24] Furthermore, no gum formation is associated with. There is no need for ethanol, anti-oxidants, or detergent additives. [25].

2.6 Biofuel generations:

2.6.1 First generation biofuel: These biofuels are obtained from edible crops like sugarcane and corn crop. The first-generation biofuels are in market in a very large quantity and it is the most matured generation of biofuels because a great work has been done on this.

2.6.2 Second generation biofuels: These are basically the upgraded version of first generation biofuels. These are the advanced biofuels and the positive thing which is different from the first-generation biofuels is that they are derived from biomass.

2.6.3 Third generation biofuel: Algal biomass is basically a feasible and renewable feedstock for biofuel production. These algae are the photosynthetic organisms which have the natural ability to accumulate carbohydrates which is in most of the cases in the form of starch. These products are further used as a substrate for the sugar-based biofuels like bioethanol and biobutanol. Third generation biofuels are derived from algal biomass.

2.7 Blending biofuel: Instead of completely replacing the traditional fuels with these biofuels, a median can be adopted, known as blended fuel. The blending biofuels such as ethanol with traditional fuels means mixing them in specific ratios.

2.8 Biomethanol: Methanol is regarded among the most engine-friendly energy sources. Adding a specific amount of methanol to fuel enhance the effectiveness of ICEs in all conditions. Some countries are already using methanol-gasoline blends commercially.

2.9 Bioethanol: Properties of bioethanol: The higher octane number of bioethanol prevents engine knocking and early ignition, resulting in a high antiknock value.

2.10 Biobutanol: Bio-butanol is yet another clean alternative fuel with a number of benefits for usage in ICEs. Butanols, such as n-butanol, iso-butanol, and tert-butanol, can be utilized as gasoline additives since they have straight-chain or branched architectures. Some of its advantages are: Butanol has a volumetric energy density that is roughly 50% higher than ethanol. In reality, this means that reduced fuel consumption and higher mileage are possible.[44]

2.11 Economic approach towards advanced biofuels: Biomass energy already has a key role in the global energy market, and its increased use is a vital component of future low-carbon scenarios, where it may help reduce greenhouse gas (GHG) pollution from the transportation sector in particular. However, their manufacture alone has reached a small scale so far. However, these advanced biofuels are significantly more expensive than the fossil fuels they can replace, as well as more traditional biofuels like ethanol from sugar or corn or biodiesel. As a result, it's critical to explore what might be done to lower the manufacturing costs of a variety of advanced biofuels, as well as the conditions under which they might become feasible [46] , [47].

3. METHODOLOGY

3.1 Internal combustion engine alternative fuels: Acetylene (C_nH_{2n2}), when formed from calcium carbide, the first member of the alkynes is a colourless and odourless gas with a garlic-like odour. Although acetylene gas is seldom found in great quantities in nature, it is frequently created by mixing calcium carbide with water. Calcium carbide (CaC2) is created by heating a mixture of quicklime and coke to a high temperature. 2000–2100 °C in electric arc furnaces. Calcium carbonate ($CaCO_3$) is heated to roughly 900 °C to make quicklime (CaO). Production of calcium carbide is given by chemical equation as:

$$CaCO_3 + heat \rightarrow CaO + CO2 \quad (1)$$

$$CaO + 3C \rightarrow CaC_2 + CO \quad (2)$$

Load (%)	Gasoline (g/h)	Acetylene (g/h)	Acetylene (%)	Peak Pressure (bar)	Spark Advance (CA BTDC)
25	1877	0	0	16.6	21
	1320	500	27.5	16.5	13
	840	1000	54.3	15.6	2
50	2805	0	0	25.4	18
	2145	500	18.9	26.5	11
	1800	1000	35.7	20.9	1
75	3730	0	0	31.5	15
	3250	500	13.3	24.6	3
	2750	1000	26.7	23.8	0
100	4265	0	0	40.6	11
	3890	500	11.6	30.9	1
	3390	1000	22.8	29.0	-2

Table 2: Mass flows of fuels, peak pressure and spark advance [53]

At all loads, hydrocarbon emissions were greatly decreased. Working with gasoline resulted in lower nitrogen oxide emissions at full loads.

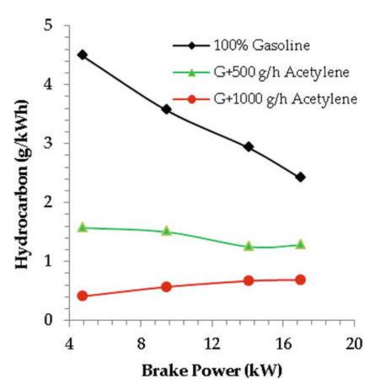

Figure 1: Variety of HC with brake power [53]

With SI engines, acetylene enhances the poor combustion limit in partial loads. With gasoline-acetylene mixes, the engine can run under leaner conditions.

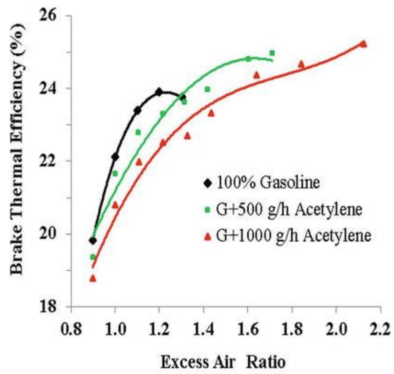

Figure 2: The variation of Brake thermal efficiency with excess air ratio [53]

So we can conclude that Acetylene offers a number of desirable characteristics, including a high energy density, a high flame temperature, a high flame speed, and a low emission rate. It improves brake thermal efficiency while lowering fuel consumption and overall emission levels. However, some research should be done to improve acetylene's knock resistance. A well to tank analysis should be undertaken to assess whether acetylene is cost-effective. [53]. Experiments observations of various fuels like petrol, acetylene gas, acetylene +methanol are represented in following tables.

Speed (rpm)	Dead weight(kg)	Spring balance Reading (grams)	Torque (N-m)	Break Power (W)
730	2	250	1.422	108.74
700	4	600	2.76	202.5
670	6	950	4.103	288
610	8	1450	5.322	340.1
570	10	1950	6.541	390.6

Table 3: Only acetylene gas [54]

Speed(rpm)	Dead weight(kg)	Spring balance Reading(grams)	Torque (N-m)	Break power (W)
420	2	350	1.341	58.987
410	4	650	2.722	116.911
390	6	1050	4.790	195.693
370	8	1450	5.332	206.286
360	10	1850	6.622	249.739

Table 4: Only petrol [54]

The performance tests are done by the following equations.

$$T = (W-S) * \left(\frac{D+d}{2}\right) \quad (3)$$

$$BP = (22/7)*(WS)*(D+d) * N/60 \quad (4)$$

$$BHP = BP/746 \quad (5)$$

Equation (3) is for torque. Equation (4) is Brake Power of engine. Equation (5) shows the Brake Horse Power of engine.

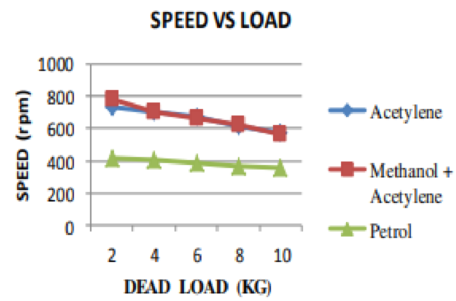

Figure 3: Speed vs dead load graph [54]

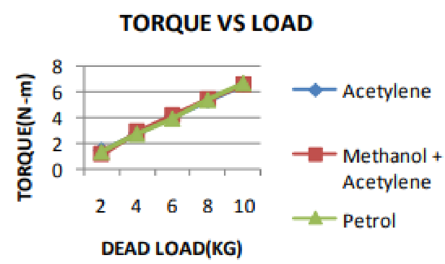

Figure 4: Torque vs dead load [54]

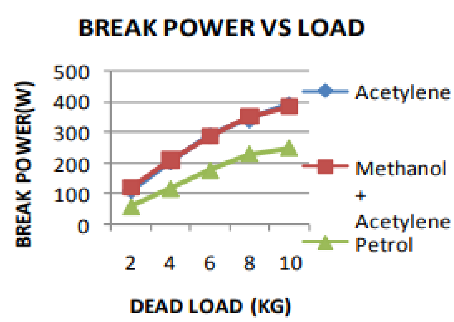

Figure 5: Break power vs dead load [54]

So we can conclude here that Acetylene, like petrol and gasoline, is easily produced and relatively inexpensive. Numerous safety precautions must be taken when storing petrol due to its low flash point and fire point, whereas acetylene can be produced in the amount required by adding water to the petrol. The graphical solution obtained are as following which include comparison of Physical-Chemical Characteristics of bio-butanol Important for Biofuels, with Bioethanol and Other Types of Fuels.

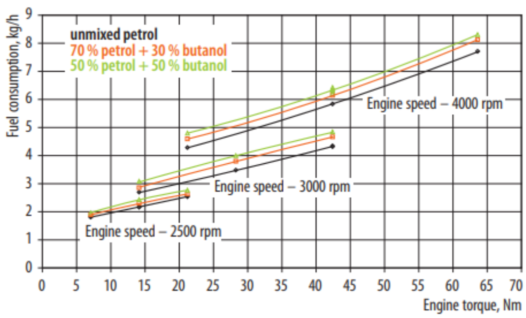

Figure 6: The relationship between fuel consumption and the engine torque [55]

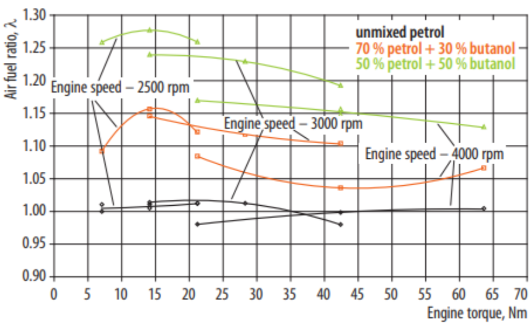

Figure 7: The relationship between air fuel ratio and the engine torque for the engine using various fuel mixtures [55]

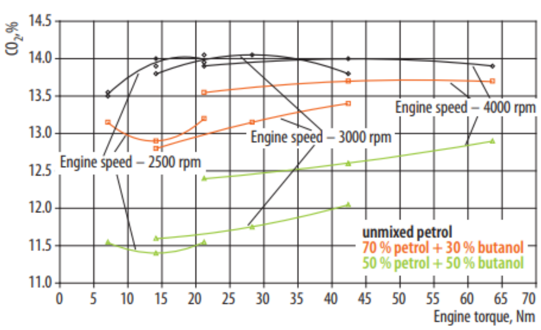

Figure 8: The relationship CO_2 and the engine torque for the engine using various fuel mixtures [55]

Engine parameters are very crucial for experimental analysis. The equations for these parameters is discussed below. In an IC engine, work is obtained as a result of combustion of gases in the cylinder's chamber.

$$W = \int F\, dx \qquad (6)$$

$$W = \int P \times A_p \times dx \qquad (6.1)$$

$$W = \int P \times dV \qquad (6.2)$$

Equations (6), (6.1), (6.3) shows the work done in one cycle.

In specific terms (per unit mass), work can be expressed as in Equation (7), (7.1).

$$w = \int P \times dv \qquad (7)$$

$$w = \int mep \times \Delta v \qquad (7.1)$$

Mean effective pressure can be expressed as:

$$mep = \frac{w}{\Delta v} \qquad (8)$$

$$bmep = \frac{w_b}{\Delta v} \qquad (9)$$

$$imep = = \frac{w_i}{\Delta v} \qquad (10)$$

$$(imep)_{gross} = \frac{(imep)_{gross}}{\Delta v} \qquad (11)$$

$$(imep)_{net} = \frac{(w_i)_{net}}{\Delta v} \qquad (12)$$

$$pmep = \frac{w_{pump}}{\Delta v} \qquad (13)$$

$$fmep = \frac{w_f}{\Delta v} \qquad (14)$$

Toque is another parameter that shows the ability that how much an engine work.

Equation (15) is for two stroke engine.

$$\tau = (bmep) \times \frac{V_d}{2\pi} \qquad (15)$$

Equation (16) is for four stroke engine.

$$\tau = (bmep) \times \frac{V_d}{4\pi} \qquad (16)$$

If the engine speed is between 4000-6000 revolution per minute, the maximum torque that is produced is about 200-300 N-m. Maximum torque speed term is used for maximum torque point. If we compare torque of CI engine with SI engine, CI engine produces more torque. Power of engine is expressed as:

$$\dot{W} = \frac{W \times N}{n} \qquad (17)$$

For two stroke engine power is expresses as:

$$\dot{W} = \frac{(mep) \times A_p \times \bar{U}_p}{2} \qquad (17.1)$$

For two stroke engine power is expresses as:

$$\dot{W} = \frac{(mep)\times A_p \times \bar{U}_p}{4} \quad (17.2)$$

Air fuel or fuel air ratio tells us about how much ratio of fuel and air is present.

$$AF = \frac{m_a}{m_f} \quad (18)$$

$$FA = \frac{m_f}{m_a} \quad (19)$$

Actual Fuel Ratio(φ) is expressed as:

$$\varphi = \frac{(FA)_{actual}}{(FA)_{Stiochiometric}} \quad (20)$$

$$\varphi = \frac{(AF)_{actual}}{(AF)_{Stiochiometric}} \quad (20.1)$$

Specific fuel consumption is the fuel consumption per unit of thrust. It is expressed as:

$$sfc = \frac{\dot{m}_f}{\dot{W}} \quad (21)$$

The fuel efficiency of any prime mover that consumes fuel and generates rotational, or shaft, power is measured by brake-specific fuel consumption. It is expressed as:

$$bsfc = \frac{\dot{m}_f}{\dot{W}_b} \quad (22)$$

Brake specific fuel consumption has an inverse relation with speed of engine. By increasing the engine speed, brake specific fuel consumption will decrease.

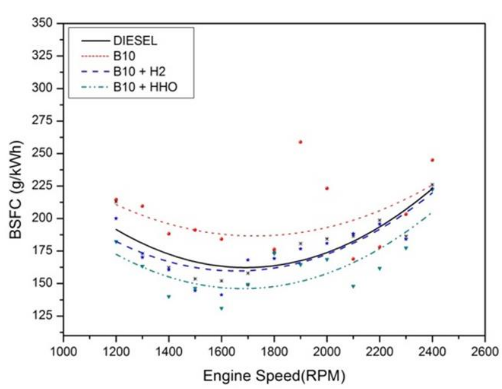

Figure 9: BSFC as a function of Engine speed (RPM) [56]

There is indicated specific fuel consumption which indicates power of engine.

$$isfc = \frac{\dot{m}_f}{\dot{W}_i} \quad (23)$$

Mechanical efficiency of engine, η_m is expressed by:

$$\eta_m = \frac{\dot{W}_b}{\dot{W}_i} \quad (24)$$

$$\eta_m = (isfc)/(bsfc) \quad (25)$$

Thermal efficiency of engine is expressed as:

$$\eta_t = \frac{W}{Q_{in}} = \frac{\eta_f}{\eta_c} \quad (26)$$

For mechanical efficiency:

$$\eta_m = \frac{(\eta_t)_b}{(\eta_t)_i} \quad (27)$$

Also fuel conversion efficiency:

$$\eta_m = \frac{1}{(sfc)\times Q_{HV}} \quad (28)$$

[56]

4. CONCLUSION

After studying all the above research papers our main focus was on working the acetylene and bio-butanol as a biosynthetic acetylene fuel on IC engine. That Acetylene offers a number of desirable characteristics, including a high energy density, a high flame temperature, a high flame speed, and a low emission rate. It improves brake thermal efficiency while lowering fuel consumption and overall emission levels. It is also easily produced and relatively inexpensive. Acetylene and methanol with acetylene have a stronger breaking force than petrol. Break Horsepower is better than Petrol when utilising acetylene and methanol plus acetylene. The engine's power is higher when methanol and acetylene are used together than when acetylene is used alone. The experimental results of the novel biosynthetic fuel butanol shows that exiting engine can be run using small concentration of n-butanol blended with gasoline without any hardware changes because the rise in peak pressure and temperature is very small. Better performance was observed while using iso-butanol because it improves the octane number that leads to better combustion. When the concentration of N-pentanol is increased, the oxygen content increases, resulting in tidy and clean burning. As a result, CO_2 emissions are on the rise, whereas CO and HC emissions are on the decline. Throughout the 200 hp operation, the power remained steady. Engine torque levels were found to be higher with mixes than with pure diesel operation.

5. RECOMMENDATIONS

Some of the errors that were present in these experiments were many much research work is still left to increase the efficiency of fuel. The experiment should be done on multiple engines to check the result. Mainly torque and power parameters were discussed in these researches. Mean effective pressure, thermal efficiency and specific fuel consumption can also be calculated. In future we will also discuss power consumption of engine using different isomers of butanol other than n-butanol and iso-butanol.

NOMENCLATURE

Capital

T torque transmitted by the engine
W dead load
S spring balance reading
D diameter of the wheel
N speed of the engine shaft
P combustion chamber's pressure
N speed of the Engine Shaft
dV differential volume
W work done in one cycle
$\dot{W}$ power of engine

Lowercase letters

x piston's distance as it moves
w specific work done in one cycle
d diameter of the rope
n number of revolution per cycle

Greek capital symbols

Δ change
φ actual fuel ratio

Greek lower case

η efficiency
τ torque

Subscripts

A_p area against the piston face
m_a air's mass
m_f fuel's mass

$\dot{m}_f$ fuel flow rate's ratio
$\bar{U}_p$ average speed of piston
η_m mechanical efficiency
η_t thermal efficiency
Q_{HV} heating value of fuel

Abbreviations

BP break power
BHP brake horse power
TDC top dead centre
BDC bottom dead centre
mep mean effective pressure
$bmep$ brake mean effective pressure
$imep$ indicated mean effective pressure
$(imep)_{gross}$ gross indicated mean pressure
$(imep)_{net}$ net indicated mean effective pressure
$pmep$ pump mean effective pressure
$isfc$ friction mean effective pressure
$fmep$ indicated specific fuel consumption
AF air fuel ratio
FA fuel air ratio

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