Performance and Emission Analysis of Diesel Engine by Using Mixing of Two Biodiesel Blends

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Abstract – The aim of the present study is to analyze the performance and emission characteristics of a compression ignition (CI) engine using a suitable biodiesel as fuel. The experimental investigation is to conduct by using Annona-Citrus Methyl Ester (ACME) with diesel. The selection of ACME is based on an extensive review of literature which indicated that this is relatively unexplored as fuel on a diesel engine. The performance and emission characteristics are evaluated by operating the engine at different loads. The performance parameters evaluated are Brake thermal efficiency (BTE), specific fuel consumption (SFC) and Total fuel consumption (TFC). The emission constituents measured are Carbon monoxide (CO), Carbon dioxide (CO2), unburned hydrocarbons (HC), Oxides of nitrogen (NOx) and smoke. It is found that B20 (20% ACME + 80% diesel) blend showed better performance and reduced emission. However, B20 can be used as an alternate fuel for CI Diesel engine without any modifications.

Index Terms – Annona Citrus Methyl Ester, Performance, Exhaust Emission, Transesterification, Diesel Engine.

1. INTRODUCTION

The increasing industrialization, ever increasing petroleum price, continuous release of greenhouse gases by fossil fuel combustion, the rapid addition of on road vehicles and the depletion of petroleum resources makes an intensive search of an alternative fuel[1]. Many alternative fuels have been identified in the past and tested successfully in the existing engines with and without engine modification. But still each one has one or fewer undesirable fuel characteristics. This prevents the complete substitution of alternative fuel in the place of existing one[2]. Many researchers have also proved that the alternative fuels are a partial substitute for the existing fuels. However, the various fuel admission techniques experimented.

Earlier are giving a good solution to apply larger fraction of alternative fuel in the existing engines[3]. Alternative fuels are broadly classified under two categories such as mineral based oils and biological based oils. The mineral based alternative fuels are non-renewable and causing greenhouse gas emission but biological based fuels are renewable and eco-friendly[4]. The biological based alternative fuels called bio-fuels have been identified well before the exploration of the other promising alternative fuels[5].

Commercial biodiesel is currently produced from animal fat, waste frying oil and vegetable oils, whose competition with edible vegetable oil for agricultural land is still a controversial issue[6]. Consequently, microalgae that can grow rapidly and convert solar energy to chemical energy via CO_2 fixation are now being considered as a promising oil source for making biodiesel.

Biodiesel, an alternative diesel fuel, is made from renewable biological sources such as vegetable oils and animal fats. It is biodegradable and nontoxic has low emission profiles and so is environmentally beneficial. One hundred years ago, Rudolf Diesel tested vegetable oil as fuel for his engine with the advent of cheap petroleum, appropriate crude oil fractions were refined to serve as fuel and diesel fuels and diesel engines evolved together[7]. In the 1930s and 1940s vegetable oils were used as diesel fuels from time to time, but usually only in emergency situations. Recently, because of increases in crude oil prices, limited resources of fossil oil and environmental concerns there has been are renewed focus on vegetable oils and animal fats to make biodiesel fuels.

Annona squamosa is a member of the family of Custard apple trees called Annonaceae and a species of the genus Annona known mostly for its edible fruits Annona[8]. It is commonly found in India and Cultivated in Thailand and originates from the West Indies and South America. Annona squamosa produces fruits that are usually called sugar apple or custard apple in English, sitafal in Marathi, sharifa in Hindiand sitaphalam in Tamil & Telugu in india and corossolier and cailleux, pommiercannelle in French. It is mainly grown in gardens for its fruits and ornamental value. It is considered as beneficial for cardiac disease, diabetes hyperthyroidism and cancer. The root is considered as a drastic purgative.

Citrus plants belong to the Rutaceae family and include Citrus paradisi (grapefruits), and Citrus limon (lemons), all of which are among the most popular fruits in the world especially in tropical and sub-tropical countries[9]. In Pakistan, C. reticulate is locally known as "kinnow". Large varieties of citrus fruit are produced in many countries within Southeast Asia. Citrus is the best natural source of Vitamin C (ascorbic acid) and folic acid, besides being an excellent source of fiber. The main purpose of citrus fruits is to produce citrus juice, however, the waste of the citrus industry such as peel, seeds and pulps are also a potential source of by-products.

India's self-sufficiency in petroleum oil as consistently declined 60% in 1950 to 30% in 2010 and is expected to go down to 8% by 2020. As India is deficient in edible oil and demand for edible oil exceeds supply, the Government decided to use nonedible oil from Jatropha oil seeds as biodiesel feedstock[10]. Therefore, in this work an unexplored biodiesel Annona – Citrus Methyl ester derived from Annona Squamosa and Citrus sinensis is used as an alternate fuel in the diesel engine. The present work is focused on the performance and emission characteristics of Annona-Citrus Methyl Ester by using different type's blends, to find its suitability as fuel for CI engine [11].

2. MATERIALS AND METHODS

- Annona squamosa Biodiesel
- Citrus sinensis Biodiesel

2.1 ANNONA SQUAMOSA SEEDS

Annona squamosa seeds were sun dried for a week to the required dry weight and moisture content and then the hard nuts of the seeds were removed by physically hitting with a hard metal and the kernel obtained. The seeds for this study were collected from ripened fruit, and grinded using home-blender without a prior drying process.

2.2 CITRUS SINENSIS PEEL

Citrus reticulate peel were collected in various place. The peels were cleaned manually to remove unwanted materials. The peels were stored in suitable bags at ambient temperature prior to extraction. Pure standards of fatty acid methyl esters (FAMEs) were purchased from domestic Chemical Company. Other analytical grade chemicals and reagents used were acquired from domestic Chemical Company.

3. TRANSESTERIFICATION REACTION

Transesterification is a reversible reaction between triglyceride and alcohol in presence of catalyst to produce glycerol and mono alkyl ester which is known as biodiesel. Weight of the mono alkyl ester is one third of that of typical oil and therefore has lower viscosity. Alkali (NaOH, KOH), acid (H2SO4, HCL) or enzymes (lipase) catalyzed reaction. Acid catalyzed transesterification is most commonly used process because it is a reversible reaction. In the transesterification process methanol and ethanol are more common. Methanol is more extensively used due to its low cost and physiochemical advantages with triglycerides and alkali are dissolved in it. Studies have been carried out in different oils like soyabean, sunflower, jathropa, karanja, neem, etc. Mostly biodiesel is produced by base catalyzed transesterification process of oil and it is more economical. Here the process is a reaction of triglyceride with alcohol to form mono alkyl ester commonly known as biodiesel and glycerol as by product. The main reason for doing titration to biodieselis to find out the amount alkaline needed to completely neutralize any free fatty acid present, thus ensuring a complete transesterification.

The chemical reaction which describes the preparation of biodiesel is:

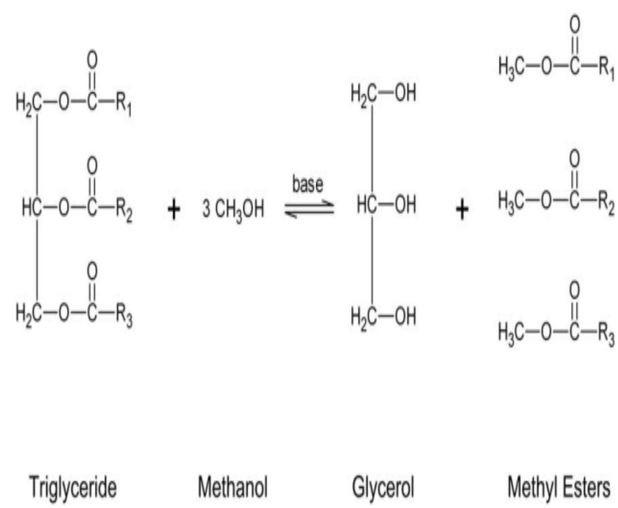

Figure 1 Reaction process for transesterification

In this figure R1, R2, R3 represent long carbon chains.

Properties	**Diesel**	**Annona-citrus Methyl Ester**
Cetane no	48	48
Specific gravity	0.83	0.8712
Viscosity @40 c	3.9	4.80
Grass Calorific value (KJ/Kg)	43000	39701
Density (Kg/m^3)	830	878.7
Flash point (OC)	56	192
Fire point (OC)	64	202

4. FUEL PROPERTIES OF ACME AND DIESEL

5. EXPERIMENTAL SETUP

The present work is carried out to study the performance and emission characteristics of a single cylinder, four stroke, water cooled, DI diesel engine using Annona Citrus Methyl Ester (AME) as a fuel. An electric dynamometer is connected with this engine to determine the engine performance with constant engine speed. Exhaust gas analyzer and smoke meter are used with this diesel engine to determine the emission characteristics of the engine. The schematic diagram of the experimental setup is shown in Fig .

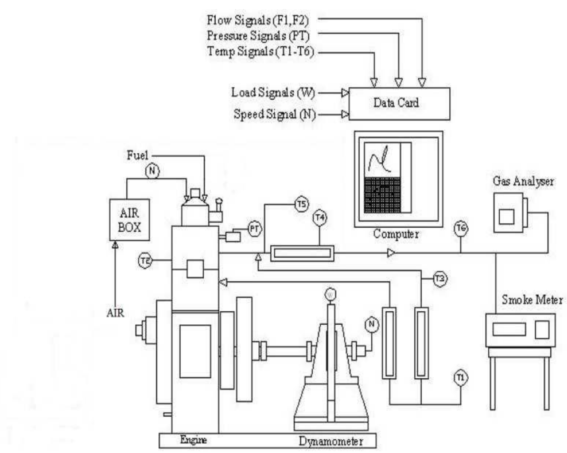

Fig 1 Experimental setup

5.1 Engine Specification:

No. of cylinders	1
No. of strokes	4
Cylinder diameter	87.5mm
Stroke length	110mm
Connecting rod length	234mm
Orifice diameter	20mm
Dynamometer arm length	185mm
Fuel	Diesel
Power	3.5kw
Speed	1500rpm
CR range	12:1 to 18:1
Injection point variation	0 to 25° BTDC

6. RESULTS

6.1PERFORMANCE RESULTS

6.1.1 BP vs SFC

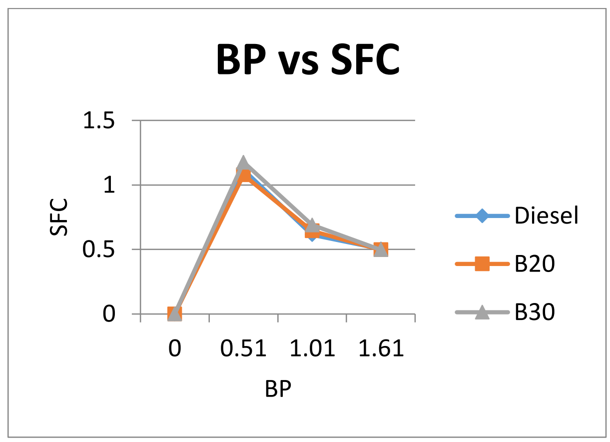

Fig 1 BP vs SFC

6.1.2 BP vs Mechanical Efficiency

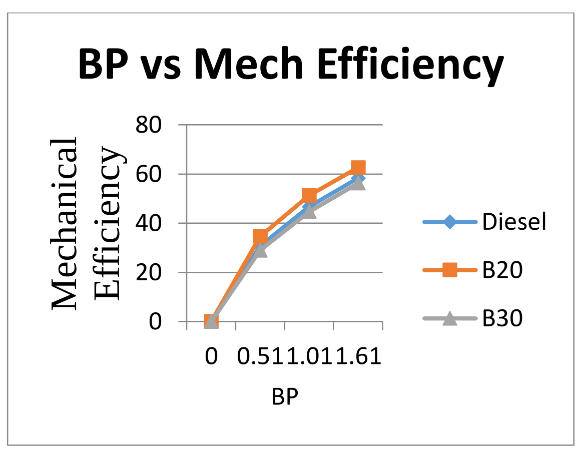

Fig 2 BP vs Mechanical Efficiency

6.1.3 BP vs Brake Thermal Efficiency

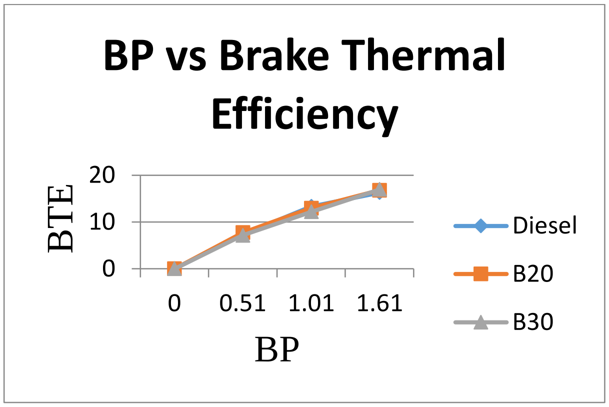

Fig 3 BP vs Brake thermal Efficiency

6.2 EMISSION RESULTS

6.2.1 BP vs HC

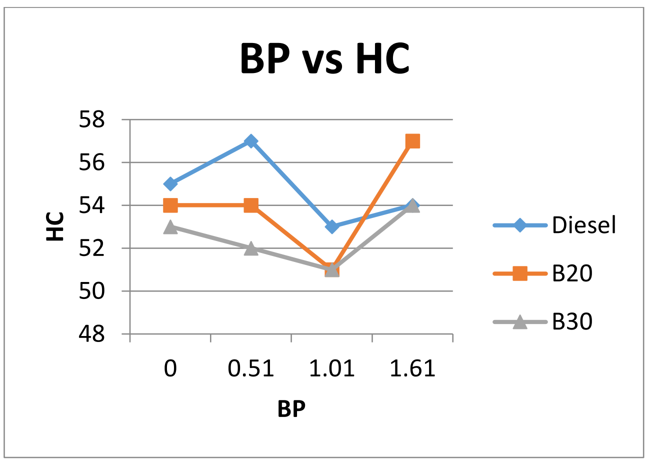

Fig 4 BP vs HC

6.2.2 BP vs CO

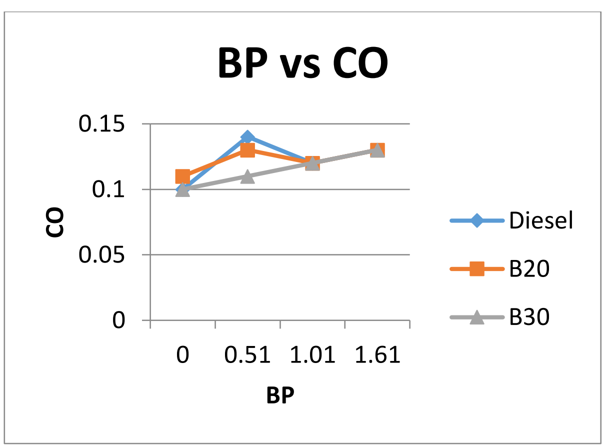

Fig 5 BP vs CO

6.2.3 BP vs CO2

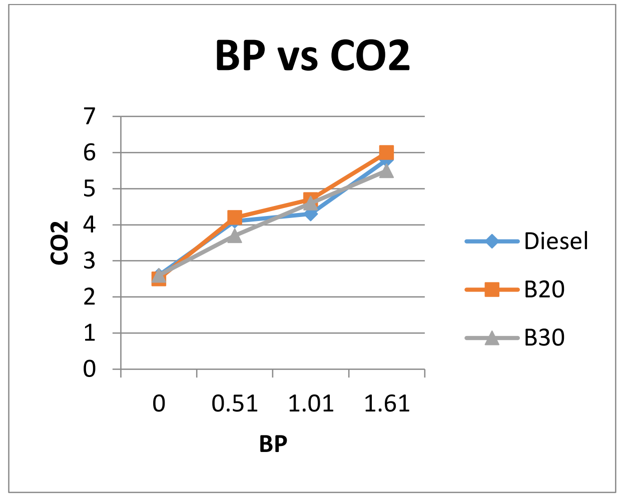

Fig 6 BP vs CO2

6.2.4 BP vs NOx

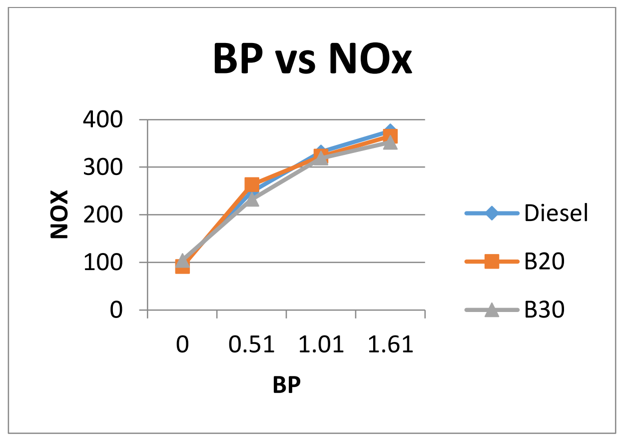

Fig 7 BP vs NOx

7. CONCLUSION

Thus the performance and emission characteristics on a four stroke, diesel engine using Annona Citrus Methyl Ester and its blends have been discussed and compared with diesel fuel. The performance and emission characteristics are evaluated by operating the engine at different loads. It is found that the brake thermal efficiency of B20 is closer to that of diesel. The experimental results reveal that the BTE for B20 is 30% and 33% for diesel fuel. So the diesel engine can perform satisfactorily on biodiesel and its blends without any engine modifications. It is very clear from the graph that CO, HC and smoke emission are less for ACME compared to diesel. But, the NOx emission ACME was slightly higher than that of diesel. Therefore, it is concluded that 20% Annona Citrus Methyl Ester blended with 80% of diesel can be used as an alternate fuel in diesel engine without any modifications.

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