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# Influence of Diesel Fuel Blended With Water (S20T80) Emulsified Biodiesel Produced From Mango Seed Oil on SCWCDI Diesel Engine Performance & Emission Characteristics

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***Abstract* — *a combination of biodiesel and water is one of the probable approaches those have been used to overwhelmed diesel engine pollution. In this paper a single cylinder constant speed water-cooled four-stroke direct injection diesel engine is been chosen for the experimental investigations to assess the performance and emission characteristics fuelled with Mango seed oil and its blends (10%, 20%, 30%, 40% and 50%). Experiments have been conducted to determine the required hydrophile lipophile balance (HLB) for carrying out emulsification of biodiesel blend emulsified with water by 5% and 10% volume basis. The recital parameters are analyzed include Brake thermal efficiency while exhaust emissions include oxides of nitrogen, HC, Smoke and CO. The results of the experimentation in each case have been equated with baseline data of diesel fuel. It concluded that lower blend of biodiesel 20% mango seed oil (B20) act as finest alternative fuel among all tested fuel at full load condition and emulsified biodiesel containing 5 % and 10 % water were utilized for the Engine tests. During the experimental work, the engine was set up 1700 rpm and 20 % to 60 % loads. The result demonstrates the reduction in NOx formation when the water content in emulsified biodiesel increased from 5% to 10%. For the performance, there were no significant differences between the engine break powers measured for emulsified biodiesel containing 5 % water and diesel fuel.*

***Keywords* — *Trans-esterification, Mango seed oil, Emulsification, Performance, Emission.*

## I. INTRODUCTION

Strict emission regulations and faster depletion of fossil fuels drive the researchers to search for alternative fuels. For diesel engines. Exertions are being made to use straight vegetable oils as fuel in diesel engines. But higher viscosity of vegetable oil restricts its direct use in diesel engines. As a result the vegetable oils are transformed in to biodiesel using transesterification process. Biodiesel is encouraging substitute fuel which gives reasonably adequate performance, reduced emissions except oxides of nitrogen (NOx) and there is no need of any engine modifications. But, the only drawback recounted in using biodiesel in diesel engine is production of more NOx due to availability of higher oxygen and temperature. This type of problem can be overwhelmed by either retarding the injection timing which needs engine modification or by using exhaust gas recirculation (EGR) system in the engine; however volumetric efficiency will be reduced as a result of higher temperature and pressure of air. Hence, the other probability of reducing NOx emission from engine running with biodiesel could be by using its emulsion with water. The reduction in emissions achieved by properly designed diesel-water emulsification is universal regardless of engine. The primary advantage of water-diesel emulsions in diesel engines is a notable reduction in NOx emissions [1], [2]. The addition of water in the form of emulsion enriched combustion efficiency. It was found that brake power, engine power and also the engine torque have been improved with the emulsified fuels for both diesel and benzene till addition of 25% water. Adding water to diesel-benzene might decrease bad emissions of the vehicles [3], [4]. Water blended fuels are accorded more priority due to the simultaneous reduction of NOx and smoke. No engine amendment is essential to use the emulsified fuel directly into the cylinder. But emulsification process is difficult as immiscibility of water and fuel. Surfactant is added to overwhelmed this difficulty and improve the stability for longer period. The presence of surfactant is essential for stability of water fuel emulsion. It decreases the interfacial tension between water and fuel and stabilizes the emulsion for longer hours. The added water acts as diluents, which lowers the combustion temperature and suppresses NOx formation.

## II. METHODOLOGY

A two-step 'acid–base' process; acid-pretreatment followed by main base-transesterification reaction; using methanol as reagent and H2SO4 and KOH as catalysts for acid and base reactions, correspondingly, was followed to produce biodiesel from crude mango seed oil. After that B20 (20% Mango seed biodiesel and 80% Diesel) was prepared by amalgamation Selection of Surfactant & Preparation of Emulsified Fuel.

### 2.1 Selection of Surfactant

Nonionic surfactants Span 20 (HLB 8.6) and Tween 80 (HLB 15.0) surfactant were been selected. To increase the steadiness of emulsion, combination of two surfactants has been used. Span 20 (Sorbitan monolaurate) and Tween 80 (Polysorbate 80 or Polyoxyethylene sorbitan mono oleate) are non-ionic surface active agent. Both are regarded as nonirritating, non-toxic, non-corrosive in nature without any source of secondary pollutants formation in engines. It does not generate any toxic byproducts during combustion [3-4]. To stabilize the emulsion, two surfactants (emulsifiers) have been blended; resulting in hydrophile lipophile balance (HLB) of the blend was easily calculated using Equations 1 & 2.

$$\%(A) = \frac{100(X - HLB_{(B)})}{HLB_{(A)} - HLB_{(B)}} \quad (1)$$

$$\%(B) = 100 - \%(A) \quad (2)$$

Where,

| | |
|---|---|
| X | - Required Hydrophile Lipophile Balance (HLB). |
| $\%(A)$ | - Required Amount of Span 20 to attain above HLB. |
| $HLB_{(A)}$ | - Predefined Value of Span 20's Hydrophile Lipophile Balance (HLB 8.6) |
| $\%(B)$ | - Required Amount of Tween 80 to attain above HLB. |
| $HLB_{(A)}$ | - Predefined Value of Tween 80's Hydrophile Lipophile Balance (HLB 15.0 |

**Table.1.Properties of biodiesel Properties**

| | Diesel | B20 | S3W05 B20 | S5W10B20 |
|---|---|---|---|---|
| **Kinematic Viscosity (Cst), 40⁰C** | 4.0 | 5.9 | 5.46 | 5.72 |
| **Specific gravity** | 0.830 | 0.920 | 0.845 | 0.848 |
| **Calorific value (kJ/kg)** | 43200 | 39600 | 39700 | 38460 |
| **Cetane number** | 50 | 52 | 48 | 47 |

There exist two distinct emulsion types for oil and water; water-in-oil type and oil-in-water type. Water–in–oil type is suited best type of fuel for internal combustion engines rather than oil–in–water type. The reason behind the use of water– in–oil emulsion (WOE) is as engine fuel is mainly due to the micro –explosion phenomenon of droplet of water, which caused large fragmentation of the oil and less change in viscosity with water content. While using emulsion as fuel, caution must be taken so that there may be no side effects and it should be manufactured economically. The quantity of emulsifiers which were used to prepare W/O emulsions with HLB values of 5.3 to 9.0. To determine desired HLB, a sample was prepared for HLB 8.92 by taking SPAN 20 and TWEEN 80 such as HLB 8.92 (SPAN 20 95% and TWEEN 80 5%).

### 2.2 Preparation of Emulsified Fuel (BEF)

At first B20 (20 % Mango seed biodiesel and 80 % Diesel) were prepared. Then, homogenizer were used to prepare the emulsified fuel by mixing B20, water (5% and 10% by volume) and surfactant (HLB 8.92) mixer (3% by volume).

## III. EXPERIMENTAL SETUP

The schematic layout of experimental test and its instrumentation is shown in Fig.1A.This study is carried on to find the enactment and emission characteristics of preheated diesel to diesel. This value is also compared with diesel values. The power developed by the engine is directly displayed by the engine control panel. T1- Inlet engine water temperature, PT - Pressure transducer , N - RPM Decoder, F1- Fuel Flow (Differential Pressure unit), T2 - Outlet engine jacket water temperature, Di-Diesel inlet, Do-Diesel outlet, Ei-Exhaust in, Eo-Exhaust out, EGA - Exhaust Gas Analyzer, SM – Smoke Meter.

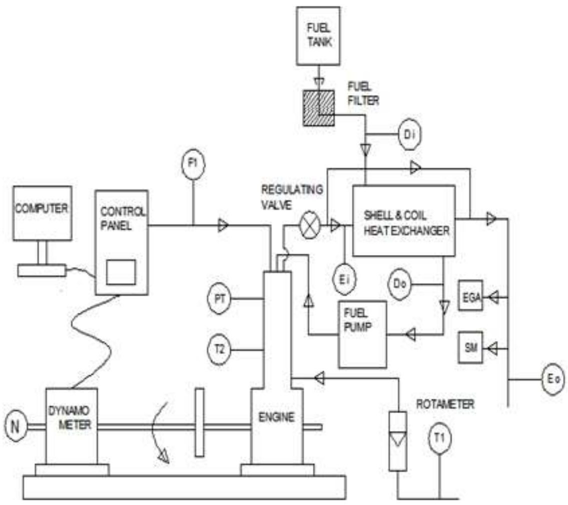


Figure 1 Experimental setup of Kirloskar Compression ignition engine

## IV. RESULT AND DISCUSSION

### 4.1 Brake Thermal Efficiency (BTE)

The variations of brake thermal efficiency with different loads for different fuels have been revealed in figure 1. The brake thermal efficiency escalations with increase in load. The brake thermal efficiency of B20 biodiesel is less than diesel because of its lower calorific value. The 5% and 10% water emulsified fuels exhibit lower brake thermal efficiencies in low loads equated to diesel and show minor improvement in higher loads. The cause for this is the micro explosion phenomenon due to volatility difference between water and fuels enriches air fuel mixing during higher engine torque and hence the development in combustion efficiency. This could be the probable reason for higher brake thermal efficiencies even though the calorific values of the emulsions are less than that of diesel.

### 4.2 Brake Specific Fuel Consumption (BSFC)

The variants of BSFC for different loads for different fuels are shown in figure 2. Emulsified fuel is heated the droplet form of water is vapored quicker than diesel fuel. This kind of vaporization causes to disintegration of hydrocarbon chain rapidly. This event which occurred about 280ºC is called micro-explosion and provides good atomization. In this case combustion efficiency increases and fuel consumption decreases because increasing the amount of water in emulsion increases the micro-explosion effect. The 5% and 10% water emulsified fuels have lower fuel consumption equated than B20 biodiesel.

### 4.3 Emission characteristics

### 4.3.1 Carbon Monoxide (CO)

The carbon monoxide emissions at different loads for different fuels are shown in figure 3. It is generated in an engine as a product of incomplete combustion of the fuel. CO emissions for emulsified fuels were found to be higher than diesel at lower engine loads however maximum engine load, CO emissions for the emulsified blends were found to be 30 to 50% higher than the diesel due to lower air fuel ratio.

### 4.3.2 Hydro Carbon (HC)

Emissions the hydro carbon emissions at different loads for different fuels as shown in figure 4. Biodiesel shows significant reduction in HC emissions due to its efficient burning than diesel. HC emissions of emulsions are found decreasing when compared to that of diesel in higher loads. This happens because the enhancement of air fuel mixing due to micro explosion phenomenon as discussed already that improves the combustion process and thus the reduction of HC emissions.

### 4.3.3 Nitrogen Oxide (NOx)

Emissions NOx emission increases while the load is increased that has been shown in figure 5. In case of B20 biodiesel, burning continuous even during exhaust because of heavier molecules of biodiesel and exhaust temperature increases as seen already and this is the reason for slightly higher content of NOx compared to diesel. By oxidation, the atmospheric nitrogen forms NOx at adequately high temperatures. NOx emissions of emulsions are found decreasing compared to that of diesel as shown in figure 5. This is because the existence of lower adiabatic flame temperature because of the presence of water in the emulsions decreases the formation of NOx. 10% water emulsion shows 10% NOx reduction than that of diesel, whereas 8% reduction is observed for 5% water emulsion at full loads.

### 4.3.4 Smoke Opacity

The smoke opacity at different loads for different fuels is shown in figure 6. The smoke opacity of B20 biodiesel is slightly higher than that of diesel due to the heavier molecules of biodiesel. Water emulsified fuels are found to produce reduced smoke opacity compared to diesel. This is because water gets vaporized by gripping the heat energy during combustion procedure. This increases the ignition delay time. The ignition delay times of 5% and 7.5% emulsified fuels were found to be 14.2 degrees and 14.4 degrees respectively while diesel had a delay of 13.6 degrees. This increase in delay time and improves the mixing process which leads to enhanced combustion reaction and so the reduction of smoke opacity. 10% water emulsion shows 5% smoke opacity reduction than that of diesel, where as 2.5% reduction is observed for 5% water emulsion at full load.

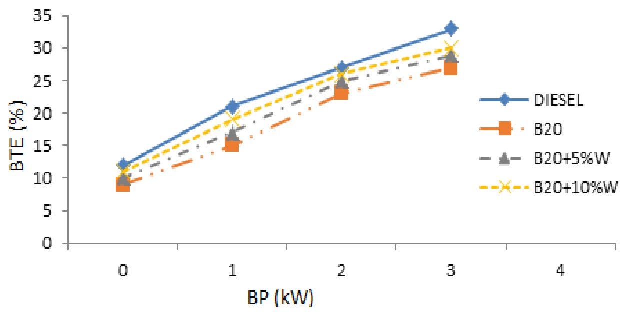


**Fig 1 Brake power vs BTE**

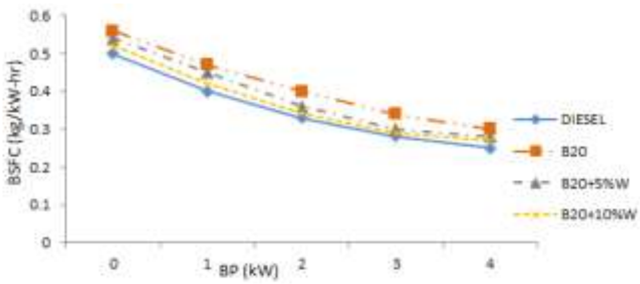


**Fig 2 Brake power vs BSFC**

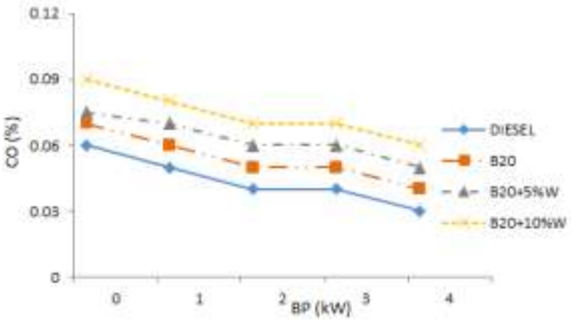


**Fig 3 Brake power vs CO**

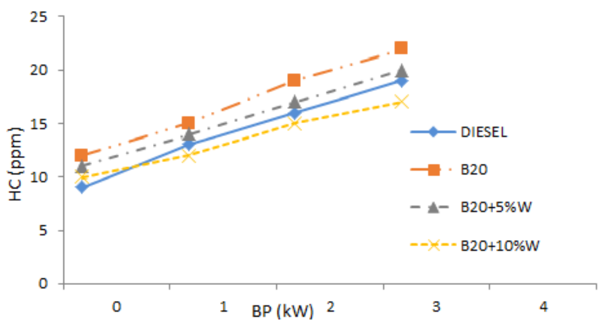


**Fig 4 Brake power vs HC**

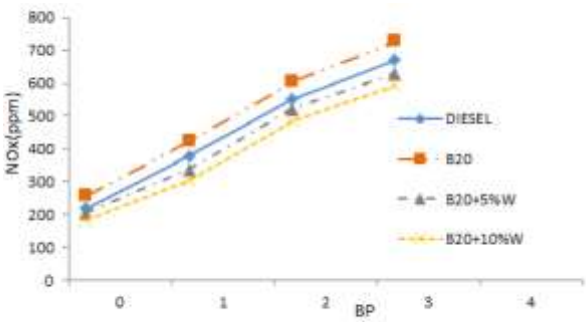


**Fig 5 Brake power vs NOx**

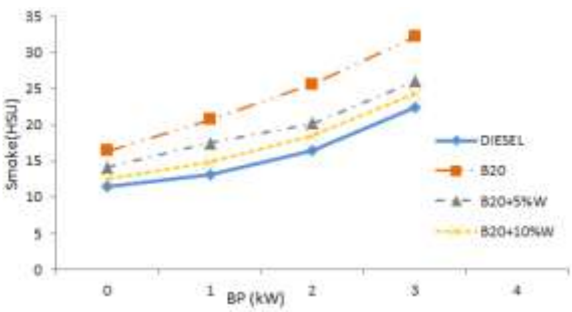


**Fig 6 Brake power vs Smoke**

## V. CONCLUSION

Mango seed biodiesel was prepared in the laboratory and it was observed that the properties were similar to that of diesel. Emulsified B20 biodiesel (diesel and 20% biodiesel) with water in the ratios of 5% and 10% have been prepared and utilized as fuels. B20 biodiesel presented slightly lesser BTE compared to diesel due to its lower calorific value. But water emulsified fuels were found to increase the BTE compared to that of diesel at full load. The continuous burning of B20 biodiesel even during exhaust led to the formation of higher EGT and hence increased NOx emissions than diesel. But emulsified fuels exhibited lower exhaust gas temperatures and so reduced NOx emissions. A reduction of 10% in NOx emissions were found for 10% water emulsified fuel and 8% reduction for 5% water emulsified fuel. Significant reduction in HC emissions were noted for B20 biodiesel because of its efficient burning than diesel. In the case of emulsified fuels, improvement of air fuel mixing during micro explosion phenomenon in higher loads improved the combustion process thereby reducing the HC emissions. The smoke opacity of B20 biodiesel was marginally higher than that of diesel due to the heavier molecules of biodiesel. Emulsified fuels exhibited reduction in smoke opacity. This happened due to the faster combustion reaction. 5% reduction in smoke opacity was noted for 10% water emulsified fuel, and 2.5% reduction for 5% water emulsified fuel.

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## REFERENCES

[1]. R. V. Babu and S. Sendilvelan, "Reduction of pollutants in CI engine using emulsion fuels to reduce overall traffic-induced emissions," Global Journal of Research Engineering USA, 11(2), ISSN: 0975-5861, 2011.

[2]. J. S. Basha and R. B. Anand, "Role of Nano additive blended biodiesel emulsion fuel on the working Characteristics of a diesel engine," Journal of

Renewable and Sustainable Energy, 3, 023106, 2011.
[3]. M. Abu-Zaid, "Performance of single cylinder, direct injection Diesel engine using water fuel emulsions," Energy Conversion and Management, vol. 45, pp. 697–705, 2004.
[4]. S. M. Fayyad, S. Abu-Ein, G. Al-Marahleh, W. Al-Momani, M. Al-Momani, Z. Abulghanam, O. Badran and T. Abu-Rahmah, "Experimental emulsified diesel and benzene investigation," Research Journal of Applied Sciences, Engineering and Technology, vol. 2(3), pp. 268-273, 2010.
[5]. Abu-zaid, Performance of single cylinder, direct injection Diesel engine using water fuel emulsions Energy conservation and management, 45, 2004, 697-705.
[6]. Anna lif, Krister Holm berg, Water in diesel emulsions and related systems. Advances in colloid and interface science, 23-126, 2006, 231-239.
[7]. Armas O Ballesteros, R Martos, Agudelo, Characterization of light duty Diesel engine pollutant emissions using water emulsified fuels Fuel, 84, 2005, 1011-1018.
[8]. Cherng-Yuan Lin, Kuo-Hua Wang, Diesel engine performance and emission characteristics using three phase emulsions as fuel, 83, 2004, 537- 545 .
[9]. Kass MD, Lewis, S. A, Utilizing water emulsification to reduce NOx and particulate emissions associated with biodiesel, Transactions of the ASABE, 52, 2009, 5-13.

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