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# Evaluation of Common Rail Direct Injection Engine Performance, and Emission Characteristics by using Cotton seed oil

**N Subrahmanya Phani Kumar, Balaji Bhukya, Nagarjuna Kumma, Srinivas Viswanath Valeti, Radha Krishna Gopidesi**

***Abstract:*** ***The present investigation is carried out on Common Rail Diesel Injection (CRDI) engine at various loads. The research engine is operated with cotton seed oil blend (B20) as fuel at various fuel injection timings (IT). Initially run the engine at standard injection timing of 23° before top dead centre (BTDC), then operate the engine with retarded angle of 20° BTDC and advance angle of 26° BTDC. The B20 at injection timing of 23° BTDC showed higher Brake Thermal Efficiency (Bthe) when compared to the diesel and other injection timings. B20 with IT23 showed drastic reduction HC emissions about 50% when compared with the pure diesel operation. At injection timing 20° BTDC showed the clear reduction in*** $NO_X$ ***emissions when compared with the diesel.***

***Keywords: Performance, Emission, Combustion, Cotton seed oil, Injection Pressure***

## I. INTRODUCTION

In recent times the usage of fossil fuels has increased exponentially[1]. Utilization of diesel engines is increasing rapidly due to its higher power ratio [2]. But the fast depletion of diesel resources and stringent emission norms are motivated the researchers for alternative fuels [3]. Biodiesel is one of the best alternative fuel for the replace diesel. It controls the emission as well as improves the combustion efficiency due to the higher oxygen content [4]. Additional to this rising prices of fossil fuel and increasing demand from the industry and customers alternative fuel plays key role in energy generation [5].

### *1.1 Types of bio fuels*

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Bio fuels are broadly classified into three generations [6]. They are first generation bio fuels, second generation bio fuels and third generation bio fuels Each generation of bio fuels contains a number of different fuels [2]. Fig 1 shows the different types of liquid bio fuels. However; engine modification is also not required to utilize Bio diesel in a conventional diesel engine [7].

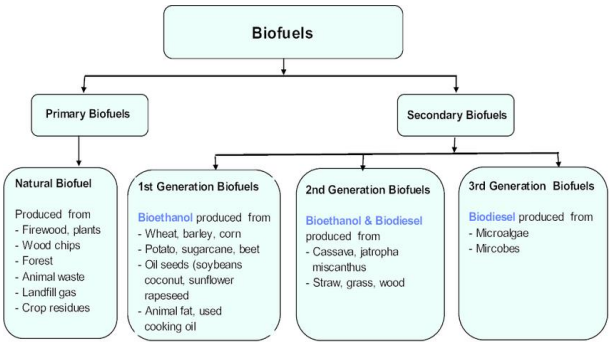


**Fig. 1 Types of bio fuels**

## II. MATERIALS AND EXPERIMENTAL PROCEDURE

India is agricultural based country; the climatic conditions are more familiar for the cotton crop. It is one of the most mercantile crops of India, plays a governing role in its agrarian and industrial economy as the backbone of textile industry.

### *2.1. Production of bio diesel*

Refined cottonseed oil accumulates from a local marketplace in Andhra Pradesh, India. To prepare biodiesel from refined cottonseed oil, transesterification process was adopted. Free Fatty Acid (FFA) test plays a very important role for finding the number of transesterification process required [8]. The FFA value is below three. It requires single stage and for more than three, it requires two-stage transesterification process. The FFA value of cottonseed oil showed 2.8, from that single stage transesterification process was carried out in the present work. At initial conditions heat was provided to refine cottonseed oil at temperature above 100°C for a time period of 2 hr, purpose of this is to remove moisture from refined cottonseed oil [9].The transesterification process, NaOH is used as the base catalyst. After that refined cotton seed oil is mixed with methanol at a constant temperature as well as the speed of stirrer, which is 50°C and 500-600 RPM, respectively.

This process continues for 1 hr, later on this the mixed solution is kept for cooling down at room temperature. There after this properly mixed solution is transferred to conical funnel to stand for overnight stability As result of this overnight stability time period in conical funnel two different layers are formed at bottom layer glycerol and top layer other layer methyl ester. The cotton Methyl ester is containing dust particles. It requires cleaning that is done by a warm water wash Maintained temperature at 60ºC, this cleaning was done for 4-5 times until Crude biodiesel become clean when it was confirmed that biodiesel is totally clean thereafter, it allows to heat at 80ºC temperature to remove moisture from it.Formulated methyl ester is mixed through diesel for making blends of fuel. For this experimental work Cotton Seed Oil Methyl Ester (COME), with different volume concentration are utilised such as B10 (10% COME + 90% diesel) and B20 (20% COME + 80% diesel), B30 (30% COME + 70% diesel). The properties of prepared biodiesel depends on transesterification process, according to that there are chances to find different characterization in same base oil biodiesel. Moreover, present research work concentrates on experimental analysis of the basic combustion phenomenon, engine performance and emission characteristics by utilizing biodiesel made from cottonseed oil and it is mixed with diesel to form blends.

### *2.2 Experimental Setup*

In this present investigation used four stroke single cylinder CRDI engine at a constant speed of 1500RPM. The technical specifications are listed in table 1. The engine was loaded by eddy current dynamometer. In addition, a common rail direct injection (CRDI) system consists of high pressure pump increase the fuel injection pressure up to 600 bars. The exhaust gas emissions CO, $CO_2$, HC and $NO_X$ were measured by AVL Di gas exhaust gas emissions analyzer [9]. AVL 437C smoke meter was used to determine the smoke content in the engine exhaust. The schematic diagram of experimental setup is shown in Fig. 2.

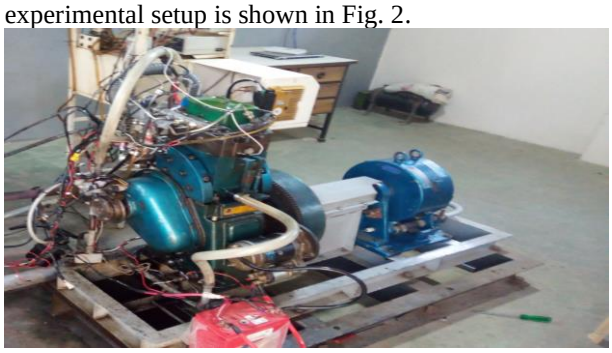

**Fig. 2 CRDI CI engine setup with relevant sensors**

## III. RESULTS AND DISCUSSIONS

### *3.1 Break thermal efficiency (Bthe)*

It is the significance effective utilization of fuel to power generation. The Fig.3 depicts effect of brake thermal efficiency (BTE) on brake power. It showed significantly higher BTE for B20 at IT23˚ BTDC around 19.4% when compared to the diesel. It is 5.48%, and 13.4% higher when compared to B20 at IT20˚ BTDC and B20 at IT26˚ BTDC respectively. The Break thermal efficiency obtained for B20 fuel at IT23 is best when compared to other IT strategies.

### *3.2 Brake specific fuel consumption (BSFC)*

It is a parameter that reflects the efficiency of a combustion engine which burns fuel and produces rotational power. Fig.4 illustrated the relation between BSFC and BP. It showed blend B20 at IT 23˚ less in BSFC around 16.2% when compared to the diesel.

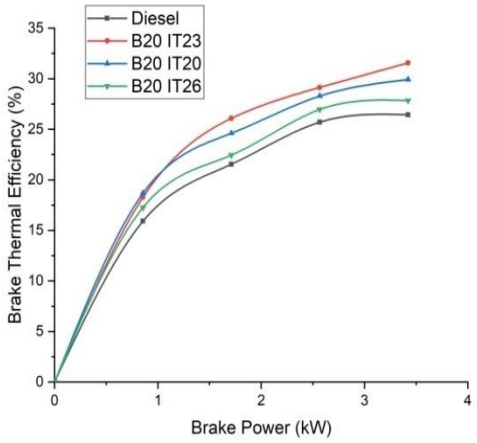


**Fig. 3 Brake Power Vs Bthe**

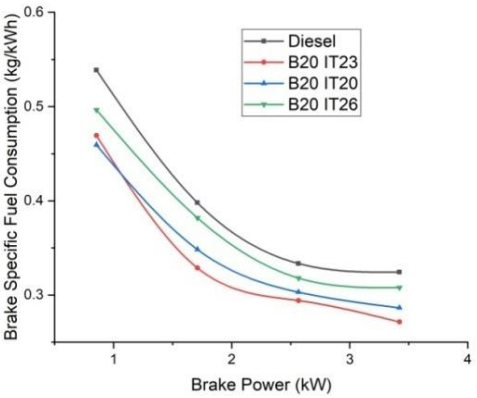


**Fig.4 Brake Power Vs BSFC**

### *3.3 HC Emissions*

The variation of unburned hydrocarbon (HC) emissions of cotton seed oil blend on varying brake power and modifying the injection time strategies is illustrated in Fig. 5. From that observed the blend B20 at IT23˚ gives the less amount HC emissions around 54% when compared to the diesel. This is due the lean fuel mixture carried out in the compression chamber and perfect IT is takes place and combustion is done properly when compared to diesel.

### *4.2.2 $NO_X$ emissions*

The variation of $NO_X$ emissions of cotton seed oil blend on varying brake power and modifying the injection time strategies is illustrated in fig.6. Here, diesel showed the more amount $NO_X$ emissions at all IT strategies. Here, observed that the blend B20 at IT20˚ gives the less amount $NO_X$ emissions nearly 20.4% when compared to the diesel at IT26˚ respectively.


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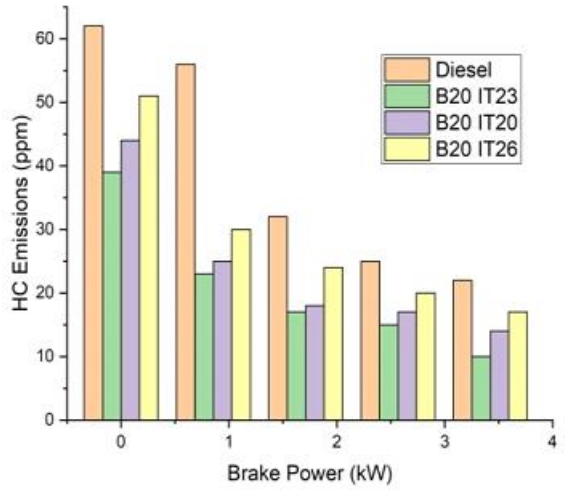


**Fig. 5 Brake Power Vs HC Emissions**

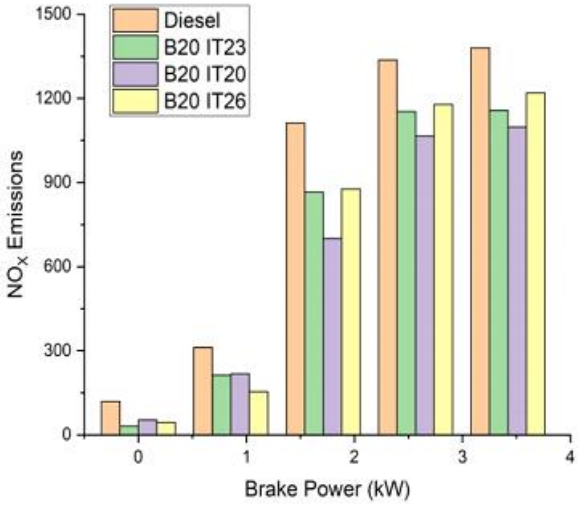


**Fig. 6 Brake Power Vs $NO_X$ Emissions**

## IV. CONCLUSION

In this present investigation is carried out on a CRDI engine. The diesel engine is fuelled with cotton seed oil biodiesel at a blend of 20% methyl ester and 80% diesel. The engine was operated at various injection timings. Based on the obtained results the following conclusions are drawn.The cotton seed biodiesel oil showed the improved thermal efficiency when compared to the pure diesel. This is due to the higher oxygen content of cotton seed oil. The B20 at injection timing of 23°BTDC showed higher Brake Thermal Efficiency (Bthe) when compared to the diesel and other injection timings. B20 with IT23 showed drastic reduction HC emissions about 50% when compared with the pure diesel operation. At B20 with injection timing 20° BTDC showed the clear reduction in $NO_X$ emissions when compared with the diesel. It is showed 20.4% less than the diesel operation.

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