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# Oxidation Stability Improvement of Biodiesel by using Antioxidant and its effect on Engine Performance Combustion and Emission

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***Abstract: The present investigation of contributing a synergetic impact of additised biodiesel on engine performance, combustion, emission helps in embracing biodiesel as an alternative fuel. Trial examination of jatropha biodiesel with additives (pyrogallol) has been completed to investigate performance, combustion and emission, attributes in diesel engine with blends with the diesel (0%, 10%, 20%) by changing compression ratio and engine load. The use of antioxidant in the biodiesel proved improvement in the oxidation stability. The oxidation stability improvement increases with increasing proportion of additive or antioxidants. The jatropha curcas seeds has been changed in biodiesel in two stage process .Two stages utilized for transformation into biodiesel are extraction of seed oil and change of seed oil into biodiesel by transesterification process the emissions from the diesel engine obtained by using smoke meter and gas analyzer. NOX emission from the diesel engine decreases at all load conditions and variable compression ratio.***
***Keywords: Biodiesel, Antioxidant, Oxidation stability, performance, Emission***

## I. INTRODUCTION

Biodiesel production from low price containing feedstock oil having poor oxidation stability, such as Jatropha curcas could be an economical way to meet the current cost issues involved in its production. To improve the oxidation stability biodiesel need to additive treatment such as metal based additive oxygenated additive, antioxidant additive, cetane number improver additive. Apart from the additive treatment antioxidant additive are effective to improve the oxidation stability. Terminalia belerica biodiesel the comparative efficacy of six antioxidant additives, viz., Vitamin E (α-tocopherol), butylated hydroxyanisole (BHA), Pyrogallol (PY), Propylgallate (PG), tert-butylhydroxytoluene (BHT) and tert-butylhydroxyquinone (TBHQ) at varying concentration levels (100 ppm, 500 ppm, 1000 ppm and 1500 ppm) on freshly prepared terminalia biodiesel is investigated. Overall, selected antioxidants could be ranked as PG>PY>TBHQ>BHT>BHA>α-tocopherol, on the basis of its efficacy to generate higher IP of freshly prepared samples of T. belerica biodiesel (B100). Further, only PY (6.23 h) and PG (6.45 h) additives could improve the IP of pure biodiesel (B100) above the minimum limit of 6 h (EN14214) with minimum dose of 1000 ppm [25]. Impact of antioxidant additives on the oxidation stability of biodiesel produced from Croton Megalocarpus oil in this paper author investigated the effectiveness of three antioxidants: 1,2,3 tri-hydroxy benzene (Pyrogallol, PY), 3,4,5-tri hydroxy benzoic acid (Propyl Gallate, PG) and 2-tert butyl-4-methoxy phenol (Butylated Hydroxyanisole, BHA) on oxidation stability of COME. The result showed that the effectiveness of these antioxidants was in the order of PY>PG>BHA [26]. Studies on the effect of antioxidants on the long-term storage and oxidation stability of Pongamia pinnata (L.) Pierre biodiesel in this paper author investigates the impact of various synthetic phenolic antioxidants on the oxidation stability and storage stability of Pongamia (karanja) biodiesel (PBD). The study reveals pyrogallol (PY) to be the best antioxidant to show the best improvement in the oxidative stability of PBD, the induction time being enhanced to 34.35 h at a PY concentration of 3000 ppm at 110°C [27]. It was also found that PY is the best effective antioxidant for biodiesel followed by BHA and BHT .Lately, the utilization of oil based commodities in India has been expanded fundamentally. To the extent India is concerned the need to look through an alternative fills argent to take care of the demand for transportation, farming segment. Every one of the examinations did Biodiesel, an alternative diesel fuel, containing alkyl monoesters of unsaturated fats got from contemporary feedstocks, for example, vegetable oils, creature fat and waste cooking oil, and so forth. In the current past, unsaturated fat methyl esters, delivered from various feedstocks have been utilized as an alternative fuel for regular diesel in pressure start engines. Because of its biodegradability and nontoxic nature, biodiesel pulled in the consideration of worldwide analysts. Be that as it may, the original biodiesel created from the edible oil experienced the issues of edible oil versus fuel alongside its higher feedstock cost and vitality approaches. Then again, the generation of biodiesel from the non-edible feedstocks,

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for example, Jatropha, Pongamia Mahua, Neem was observed to be more costly contrasted with petrodiesel. The biodiesel generation cost incorporates around 85% feedstock value, which brings about higher cost of biodiesel (Cunshan et al.,2011). In any case, the creation of biodiesel from jatropha curcas oil was observed to be bring down contrasted with petrodiesel. Not with standing oxidation dependability, the impacts of antioxidant on engine performance and emissions have been introduced. In this examination, oxidation strength of biodiesel got from non-edible feedstocks, for example, Neem, Karanja, and Jatropha, balanced out with antioxidant pyrogallol (PY) was investigated by Rancimat test. It was discovered that improvement in oxidation stability has been done by increasing dose of antioxidants et Al. [1] (Khurana and Agarwal,2011). Impact of antioxidant added substances on the performance and emission of VCR Diesel engine utilizing with jatropha curcas oil – diesel blend the impact of antioxidant additives on the performance and engine emissions has been considered. The test fuel utilized as a part of this investigation was slick jatropha curcas oil - diesel blend. The emission results showed a significant reduction of NOx et Al [2](Sathiyamoorthi 2016). Emission like HC,CO, and smoke reduced while using biodiesel and its blends due to presence of oxygen in biodiesel but NOx emission increases and increase in peak temperature in combustion et Al. [3](Selvan and Nagarajan, 2012). The main objective of this work is to analyze the oxidation stability, engine performance, combustion and emission characteristics of diesel engines fuelled with biodiesel produced from jatropha curcas oil blends with antioxidant with diesel which will help in the direction of controlling oxidation stability, emission problems of biodiesel and search of alternative fuel for diesel engine.

## II. LITERATURE REVIEW

### *A. Review of Research andDevelopment in the Subject*

Biodiesel development technology is limited due to its adverse properties. Biodiesel showed poor cold flow behaviour and oxidation instability. This section presents the review of literature available on the oxidation instability along with additive treatment. According to Jain and Sharma, (2011) Rancimat test (EN 14214, ASTM D6408- 08, D5304-06) has been recommended as a significant method to determine the thermal stability of oils, fats and biodiesel fuels.

In addition to oxidation stability, the effects of antioxidant on engine performance and emission have been presented by Khurana and Agarwal (2011). In this investigation, oxidation stability of biodiesel derived from non-edible feedstocks such as Neem, Karanja and Jatropha, stabilized with anti-oxidant pyrogallol (PY) was studied by DSC. The higher onset temperature was recorded for methyl esters of Neem and Karanja oil. The higher the onset temperature value the more stable the biodiesel. It was found that stability increases with increasing the dosage of antioxidants.

According to Cunshan 2011 The generation of biodiesel from the non-edible feedstocks, for example, Jatropha, Pongamia Mahua, Neem was observed to be more costly contrasted with petrodiesel. The biodiesel generation cost incorporates around 85% feedstock value, which brings about higher cost of biodiesel Review of literature showed that, though the biodiesel were additives to improve its cold flow and oxidation parameters, but the synergetic effect of those additives on the performance, combustion and emissions is not investigated sufficiently.

### *B. Test procedure and Experimental Setup*

Test fuel blend was prepared by jatropha biodiesel with antioxidant pyrogallol (ppm). Experiments are conducted in kirloskar engine by using biodiesel blended with diesel and with an antioxidant by volume as B10, B20 by changing compression ratio and engine load.

Table 1Engine specification

| | |
|---|---|
| Make & model TYPE | Kirloskar SV1 single cylinder, 4stroke, DI, water cooled, Diesel Engine |
| Power (hp) | 5.7 |
| Speed (rpm) | 1500 |
| Bore (mm) | 87.5 |
| Stroke length (mm) | 110 |
| Injection bar (bar) | 210 |
| load type | Eddy current dynamometer |
| Compression ratio | 16,17,18 |

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After start engine is run on diesel for 15 min to remove out carbon particle present inside cylinder block. Here test is taken at a constant speed of 1600 rpm with varying compression ratio from 16 to 18 in step of one. At the same time, different loads are applied on the engine using dynamometer. The range selected here is 0 to 9 in a step of 3. Software used is "EnginesoftLV" for Engine performance analysis. Test engine coupled with an electrical dynamometer to apply load to the engine. Electrical Dynamometer consists of electrical power bank which applies loads in the range of 0 to 50 kg loads on an engine and it is controlled with the aid of ammeter and voltmeter. The engine is connected to the computer to record and analyze the output data. The performance analysis combustion parameters such as cylinder pressure, instant heat release rate, mean gas temperature and rate of pressure rise are evaluated. Exhaust gas analyzer is used to measure engine emissions such as $NO_x$, unburnt hydrocarbon (HC), carbon monoxide(CO) and Carbon dioxide($CO_2$).

### C. *Fuel properties*

Table 2 Physical properties of test fuels.

| Properties | Limit | B100 | Diesel |
|---|---|---|---|
| Density at 15 $^0$C, kg/m$^3$ | 860-900 | 869 | 820 |
| Kinematic Viscosity At 40 $^0$C, mm$^2$/s | 1.9-6.0 | 4.63 | 2.5 |
| Acid value, mg KOH/g | Max.0.5 | 0.35 | - |
| Calorific value, MJ/kg | - | 37.5 | 42.5 |
| Flash point , $^0$C | Min 130 | 174 | 55 |
| Cloud point, $^0$C | Report | 6 | -18 |
| FAME content, % | Min 96.5 | 98.3 | - |
| Pour point, $^0$C | -25 | 2 | -23 |
| Cetane number | Min. 51 | 49 | - |
| Oxidation stability at 110 $^0$C,h | Min. 6 | 2.6 | - |

## III. RESULTS AND DISCUSSIONS

### A. *Oxidation stability*

Oxidation stability of biodiesel was lower than the standard limit because of jatropha curcas oil containing high FFA. Pyrogallol a suitable antioxidant was selected based on the previous experimental work reported by the authors (Dwivedi and Sharma, 2016; Tang et al 2010; Obadiah et al., 2012; Chen et al., 2011; Kivevele et al.,2011; Chakraborty and Baruah,2012; Jain and Sharma,2010). The biodiesel (B100) samples was dosed with an antioxidant (pyrogallol) in the concentration of 1000, 2000 ppm and stored at room temperature. For reference, the biodiesel (B100) sample without an antioxidant was stored for the same period under similar conditions. Samples were stored in bottles. During the storage period, the room temperature was noted to be within the range of 18°C to 44°C. Check the oxidation stability for different ppm.

#### 4.1.1 *Rancimat test*

The oxidative stability (EN 14112) was determined by the Rancimat method. As per standard biodiesel, manufacture to have at least 6 h of induction period at 110°C Oxidation stability was found to be only 2.6 h at 110°C as determined by Rancimat apparatus. The presence of polyunsaturated and unsaturated fatty acid derivatives are the important factor for the biodiesel. To improve oxidation stability of biodiesel, it is dosed with pyrogallol in concentration, i.e. 1000, 2000 ppm. This study reveals the best improvement in oxidation stability of jatropha curcas oil biodiesel (B100) is 8 h at a concentration of 2000 ppm of pyrogallol. The addition of antioxidant increases the oxidation stability.

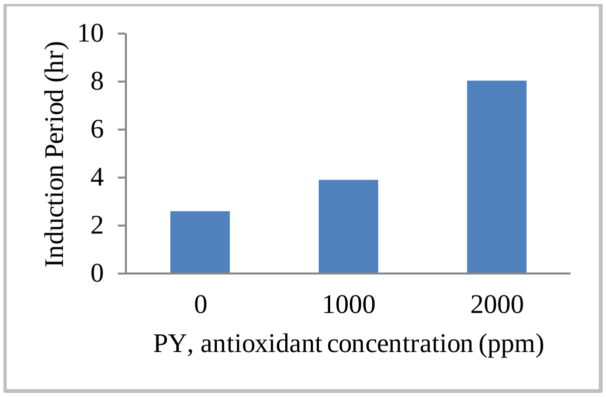
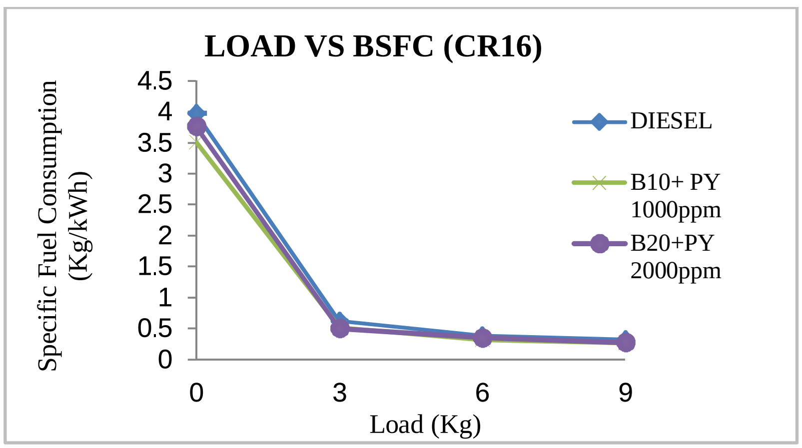
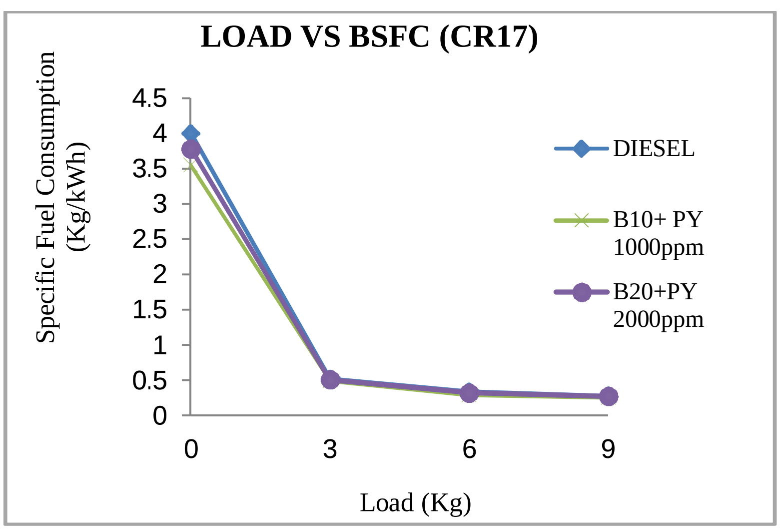



Fig.1.Effect of pyrogallol on the stability of biodiesel.

*B. Performance Characteristics*

1) *Brake specific fuel consumption*: The variation of brake specific fuel consumption (BSFC) with respect to load at various compression ratio & various load is shown in Fig .2. The BSFC was found higher at low loads and lower at higher loads. It was found that specific fuel consumption decreases with an increase in loads. Also, it was observed that BSFC for biodiesel with antioxidant is decreased than diesel fuel.



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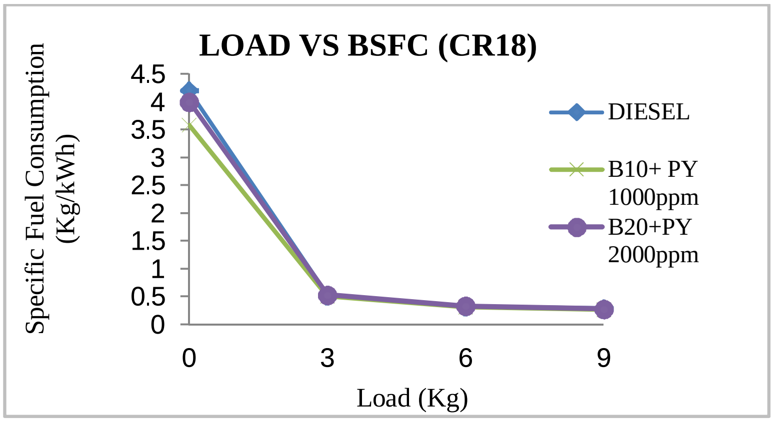
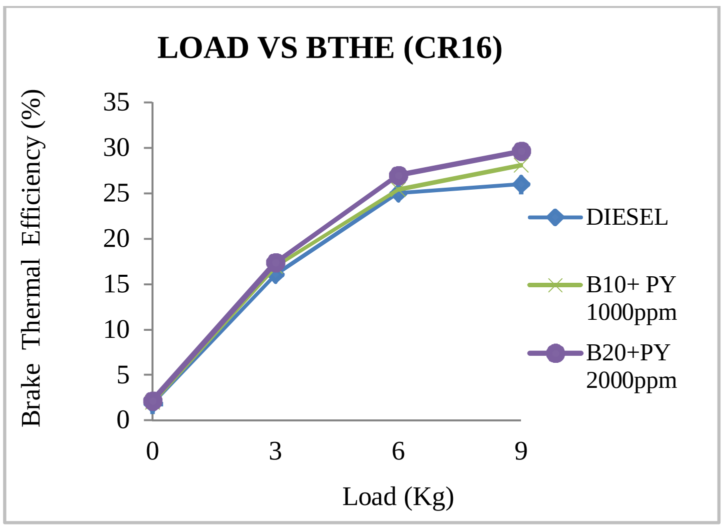
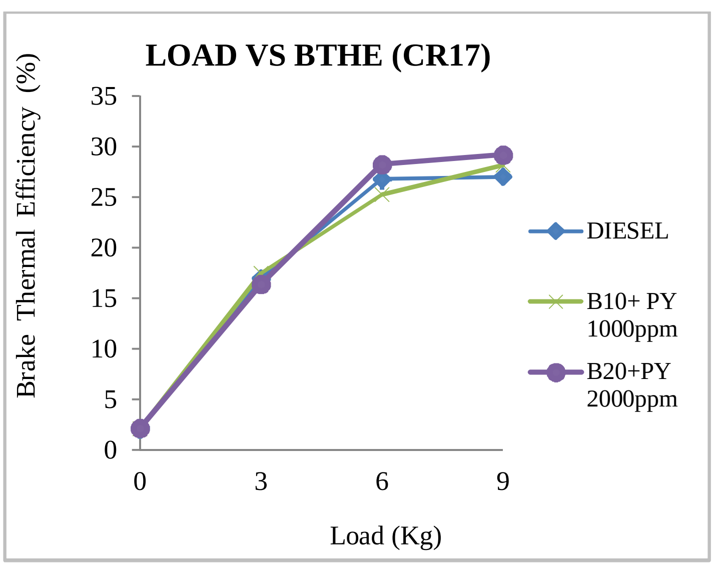



Fig.2. Variation of BSFC with respect to Load

2) *Brake Thermal Efficiency*: The variation of brake thermal efficiency with load is shown in Figure 3. From the test results, it was observed that the brake thermal efficiency of biodiesel with antioxidant increases gradually. Also, it was observed that BTE for biodiesel with antioxidant is increased than diesel fuel.



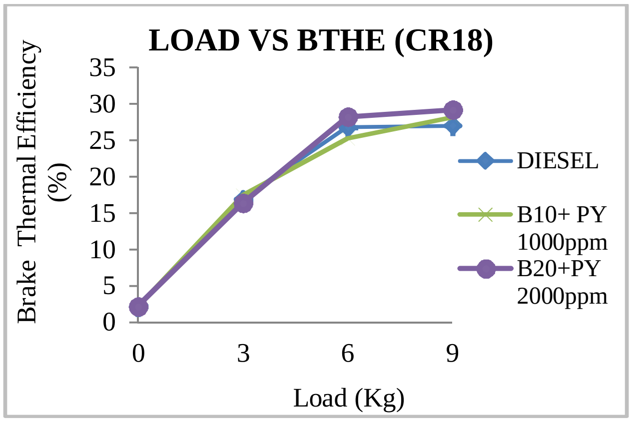



Fig.3. Variation of BTE with respect to Load

*C. Combustion Characteristics*

1) *Cylinder Pressure and Peak Pressure*: The pressure generated for diesel and biodiesel with antioxidant shown in figure 4. It was clear that maximum cylinder pressure is lower for biodiesel with antioxidant at all engine loads. In CI engine, the peak pressure depends on combustion rate in initial stages.

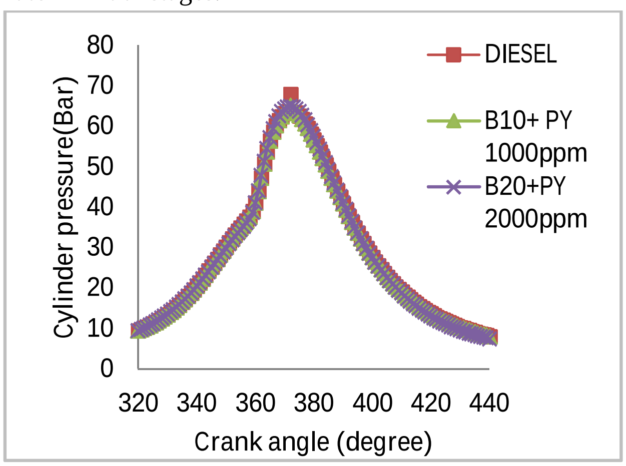



Fig. 4.Variation of cylinder pressure with crank angle

2) *Net heat release rate (NHRR):* The net heat release rate is shown for diesel and biodiesel with an antioxidant in figure 5. The NHRR curves show the potential availability of heat energy which can be converted into useful work. It can be observed from figure 5 that the NHRR for biodiesel with an antioxidant is lower than diesel.

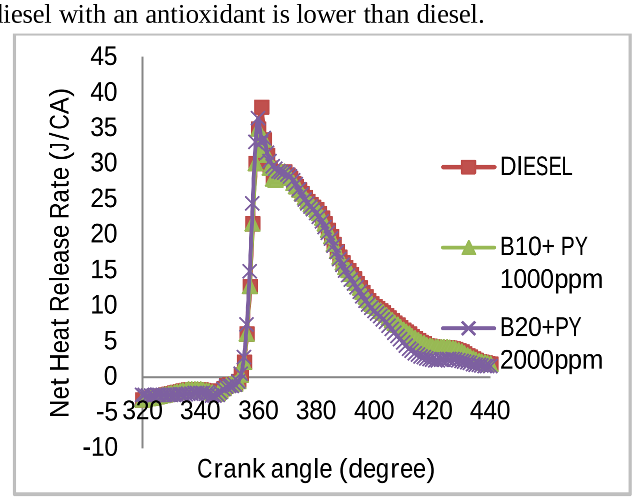



Fig.5. Variation of net heat release rate with crank angle

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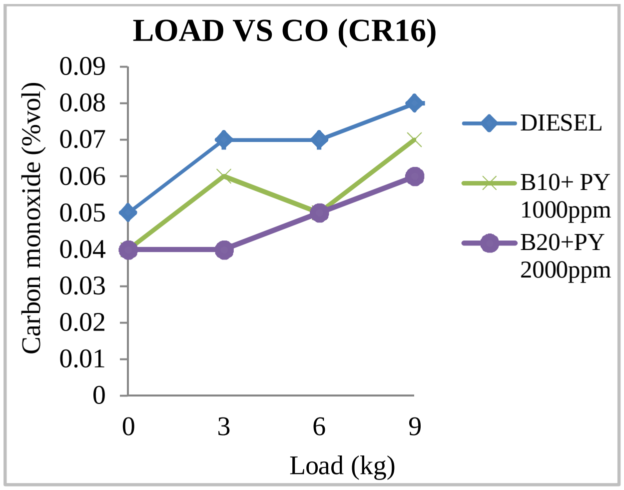
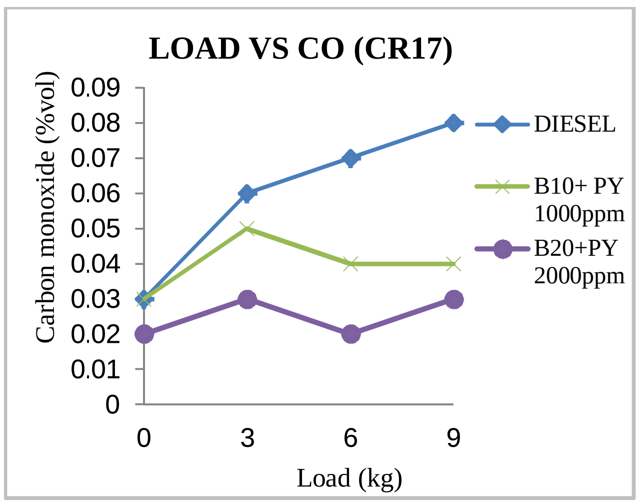
*D. Emissions characteristics*

1) *Carbon monoxide emission (CO):* The variation of CO emission with load is shown in Fig. 7. It can be observed from Fig.7 that the CO emission for biodiesel with antioxidant is lower than diesel fuel at various compression ratio and engine load due to the presence of an antioxidant.



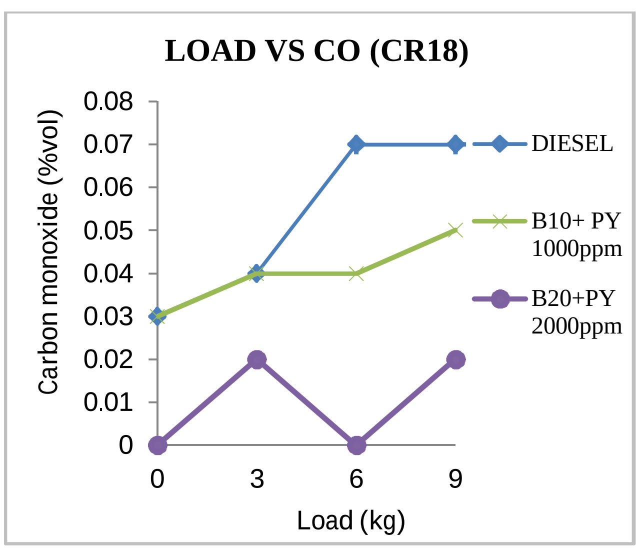




Fig.7. Variation of carbon monoxide with load

2) *Hydrocarbon emission (HC)*: The variation of HC emission with load is shown in Fig. 8. It can be observed from Fig.8 that the HC emission for biodiesel with an antioxidant is lower than diesel fuel at various compression ratio and engine load due to the presence of oxygen in biodiesel and higher cetane number.

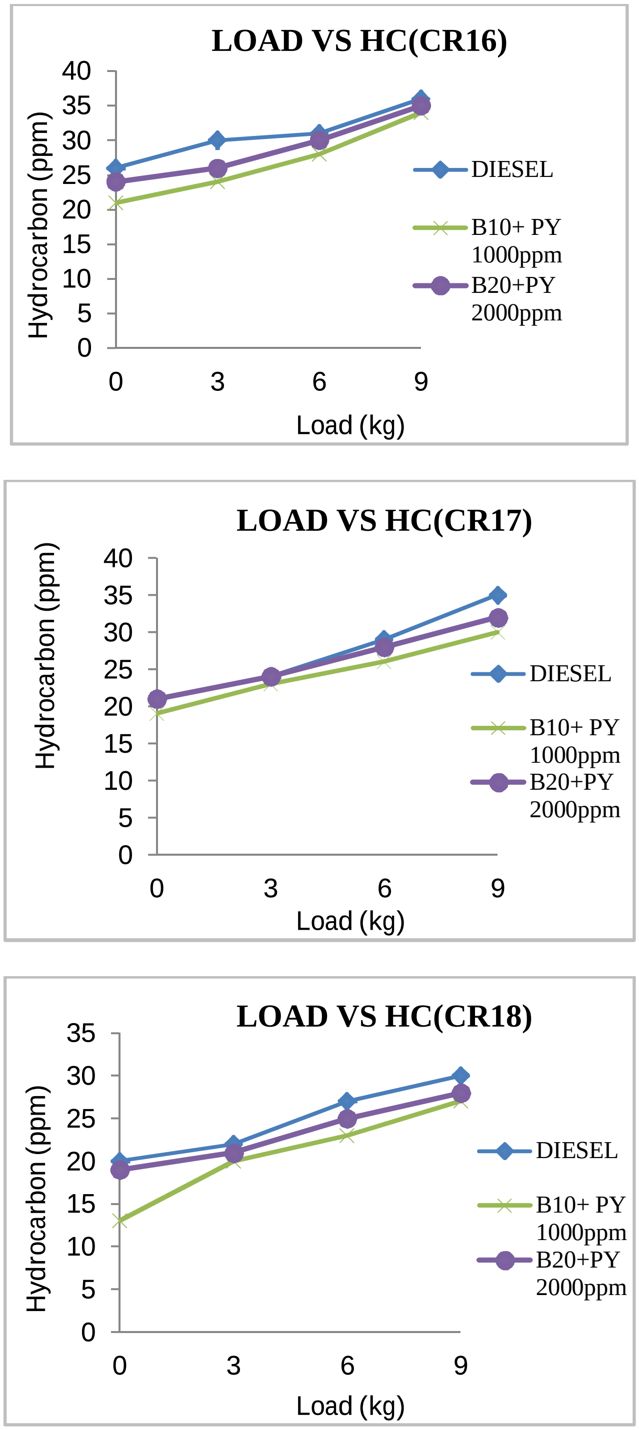



Fig. 8. Variation of hydrocarbon with load

3) *Oxides of nitrogen emission ($NO_X$)*: Temperature plays main role in $NO_x$ formation. When combustion temperature exceeds 1500°c in the combustion chamber will lead to $NO_x$ formation. The variation of $NO_x$ emission with load is shown in Fig. 9. It can be observed from Fig. 9 that the $NO_x$ emission for biodiesel with an antioxidant is lower than diesel fuel at various compression ratio and engine load due to addition of an antioxidant.

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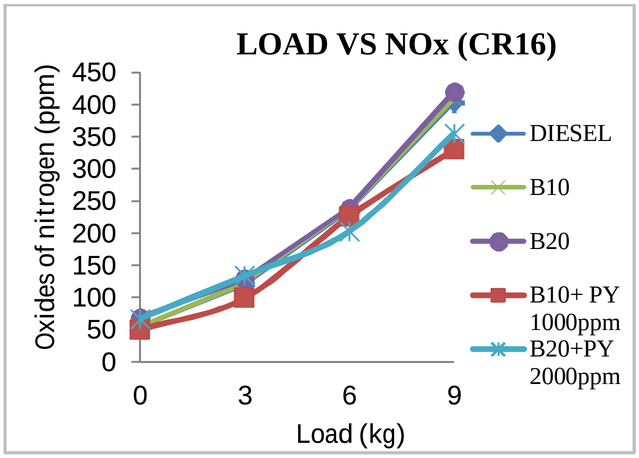


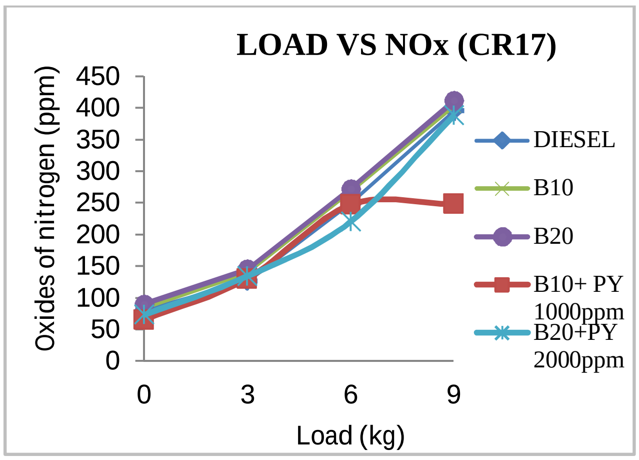


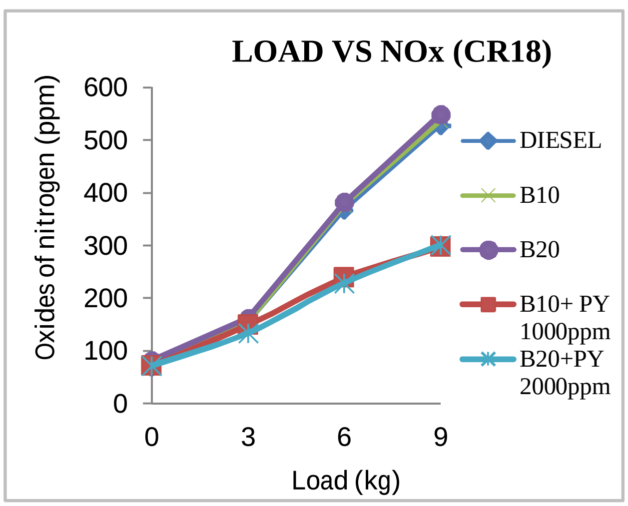


Fig. 9. Variation of oxides of nitrogen with load

## IV. CONCLUSION

Test were conducted in VCR diesel engine, with diesel, jatropha curcas oil with additive or antioxidant and the accompanying conclusion were arrived.

On the basis of above experiment work, it is observed that viscosity of biodiesel close to diesel.

In the present examination, of jatropha curcas oil biodiesel has poor oxidation stability. It has been found that utilizing antioxidant (pyrogallol) enhance the oxidation stability.

NOX emissions from the engine decreased at all load conditions and variable compression ratio when contrasted with that of pure diesel. Hence it is concluded that, pyrogallol can be utilized as an renewable substitution for synthetic fuel additive while utilizing biodiesel mix in the diesel.

## V. ACKNOWLEDGEMENT

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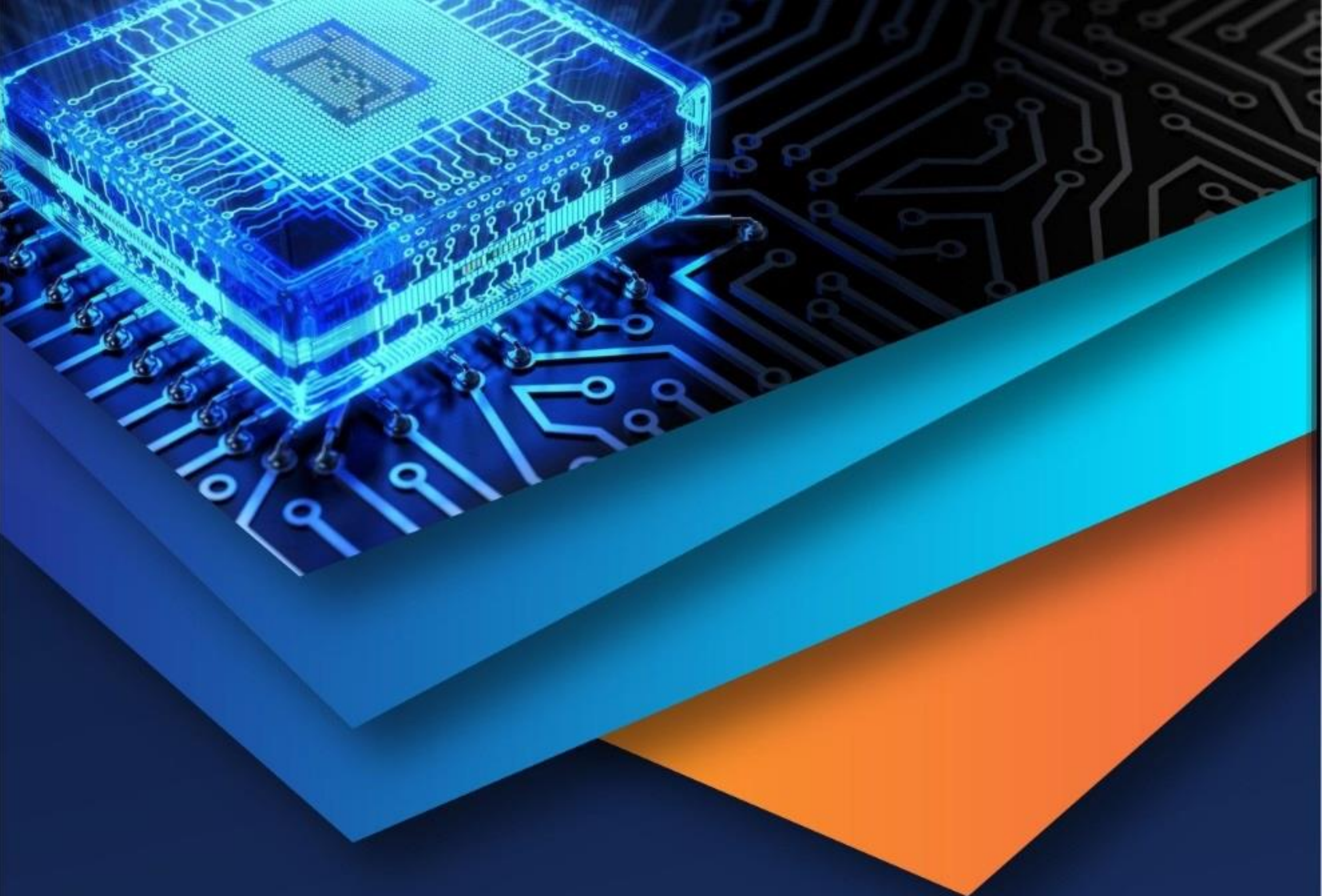


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