iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** VI **Month of publication:** June 2025

DOI: https://doi.org/10.22214/ijraset.2025.72708

Emission Characteristics of a Diesel Engine Fueled with Fish Oil Biodiesel Blends Using EGR and Cetane Improver

Samudrala Rama[1], Banka Hemasunder[2]
[1]Assistant Professor, Department of Mechanical Engineering, Jayamukhi Institute of Technological Sciences,Narsampet, Warangal, Telangana, India
[2]Research Scholar, Department of Mechanical Engineering, University College of Engineering, Osmania University, Hyderabad, Telangana, India

Abstract: This study examines the emission characteristics of a single-cylinder, four-stroke diesel engine operating on fish oil biodiesel blends (B20, B30, B40) containing 0.5% ethylhexyl nitrate (EHN) as a cetane improver. Exhaust gas recirculation (EGR) was applied at rates of 0%, 10%, and 20%. Results indicate a notable reduction in nitrogen oxide (NOx) emissions—B40E0.5 with 20% EGR reduced NOx by 34.89% (1112 ppm) compared to diesel (1500 ppm) at full load. Carbon monoxide (CO) and hydrocarbon (HC) emissions were lower with biodiesel blends but showed slight increases with higher EGR due to oxygen deficiency. Smoke opacity increased with both biodiesel proportion and EGR, a result of shorter ignition delays caused by EHN. A B40 blend with 15% EGR provided the most balanced emission profile, minimizing NOx while managing CO, HC, and smoke levels.
Keywords: Fish oil biodiesel, nitrogen oxide emissions, exhaust gas recirculation, cetane improver, smoke opacity

I. INTRODUCTION

Fish oil biodiesel, a renewable fuel from waste fish processing, offers environmental benefits such as reductions in carbon monoxide, hydrocarbons, and smoke emissions. However, its high oxygen content can increase nitrogen oxide (NOx) emissions. EGR helps reduce NOx by lowering combustion temperatures, while cetane improvers like ethylhexyl nitrate (EHN) enhance ignition quality, offering further NOx reduction potential. The challenge lies in managing emissions without compromising engine performance due to biodiesel's higher viscosity and lower calorific value.

This paper evaluates NOx, CO, HC, and smoke emissions from a diesel engine running on fish oil biodiesel blends with EHN across various EGR settings, aiming to identify conditions for optimal emission control.

II. METHODOLOGY

A. *Experimental Setup*

The experiments were carried out on a single-cylinder, four-stroke, air-cooled, direct-injection diesel engine operating at a constant speed of 1500 rpm. The engine was equipped with an exhaust gas recirculation (EGR) system, allowing for recirculation rates of 0% (baseline), 10%, and 20%. This setup enabled the study of combustion and emission characteristics under varying EGR conditions.

Engine emissions were measured using a multi-gas analyzer, which recorded levels of nitrogen oxides (NOx), carbon monoxide (CO), and unburned hydrocarbons (HC). In addition, smoke opacity was monitored using a calibrated smoke meter to evaluate particulate emissions. Combustion data, including cylinder pressure variations, were collected through a pressure transducer linked to a data acquisition system for real-time recording and analysis.

B. *Test Fuels*

The test fuels consisted of standard diesel blended with fish oil biodiesel at volumetric proportions of 20% (B20), 30% (B30), and 40% (B40). To enhance ignition quality, 0.5% ethylhexyl nitrate (EHN) was added as a cetane improver to each blend. These blends were selected to assess the combined effect of biodiesel concentration and cetane enhancement on engine performance, combustion behavior, and emissions.

Property	Diesel	B20E0.5	B30E0.5	B40E0.5
Flash Point (°C)	60	37	39	41
Density (g/cm³)	0.83	0.84	0.845	0.849
Viscosity (cSt)	3.15	5.14	5.43	5.72

C. *Measurement Parameters*

NOx, CO, and HC were measured with an AVL gas analyzer, and smoke opacity was recorded using an AVL 437 smoke meter under steady-state conditions at each load and EGR setting.

III. RESULTS & DISCUSSIONS

A. *CO Emissions*

Carbon monoxide (CO) emissions showed a consistent reduction across all load conditions when using biodiesel blends with EHN—specifically B20E0.5, B30E0.5, and B40E0.5—in comparison to pure diesel fuel. This reduction can be attributed to the improved ignition quality provided by the addition of 0.5% ethylhexyl nitrate (EHN), which led to a shorter ignition delay and promoted more complete combustion. As a result, less CO was formed due to a reduction in zones of incomplete combustion.

These results clearly demonstrate that increasing the proportion of fish oil biodiesel in the blend, along with cetane enhancement from EHN, contributes to better oxidation of carbon, thereby lowering CO output.

EGR (%)	Diesel CO (%)	B20E0.5 CO (%)	B30E0.5 CO (%)	B40E0.5 CO (%)
0	0.077	0.072	0.068	0.064
10	0.078	0.073	0.069	0.065
20	0.080	0.075	0.071	0.067

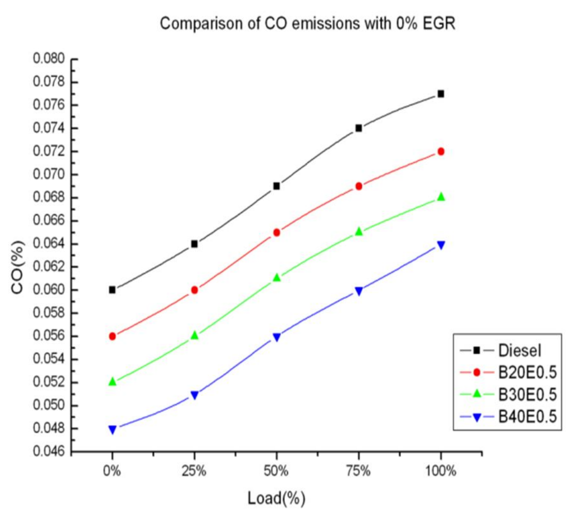


Fig 3(a): Comparison of CO emissions for 0% EGR with EHN (0.5%)

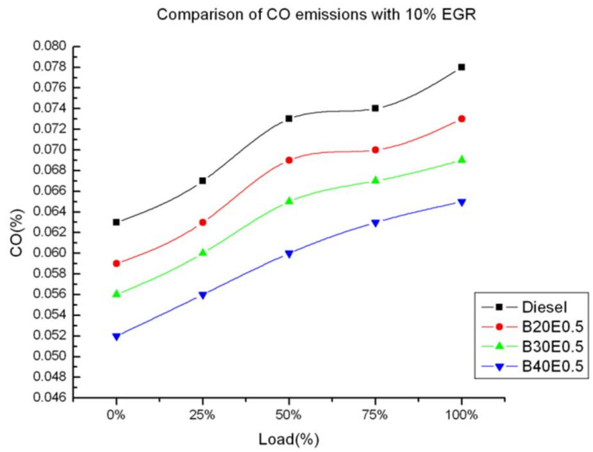


Fig 3(b): Comparison of CO emissions for 10% EGR with EHN (0.5%)

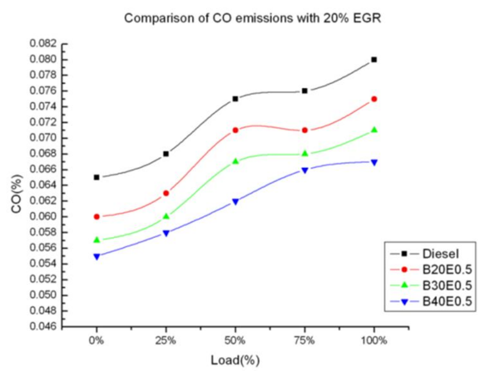


Fig 3(c): Comparison of CO emissions for 20% EGR with EHN (0.5%)

B. NOx Emissions

NOx emissions dropped notably with both increasing biodiesel blend ratio and higher EGR. The combination of EHN's cetane improvement and EGR's charge dilution lowered peak temperatures and reduced NOx formation. Example full load NOx values:

EGR (%)	Diesel NOx (ppm)	B20E0.5 NOx (ppm)	B30E0.5 NOx (ppm)	B40E0.5 NOx (ppm)
0	1595	1419	1332	1199
10	1559	1399	1319	1163
20	1500	1362	1274	1112

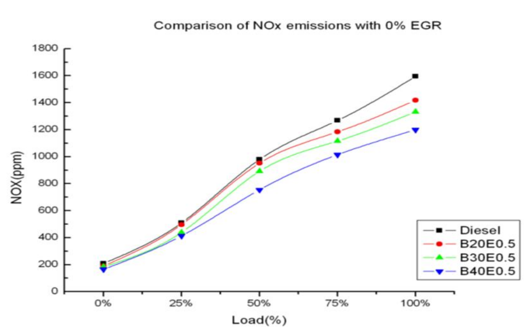


Fig 3(f): Comparison of NOx emissions for 0% EGR with EHN (0.5%)

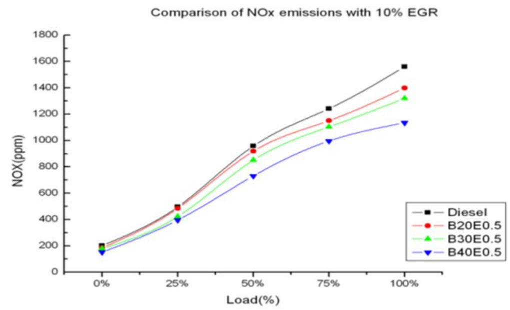


Fig 3(g): Comparison of NOx emissions for 10% EGR with EHN (0.5%)

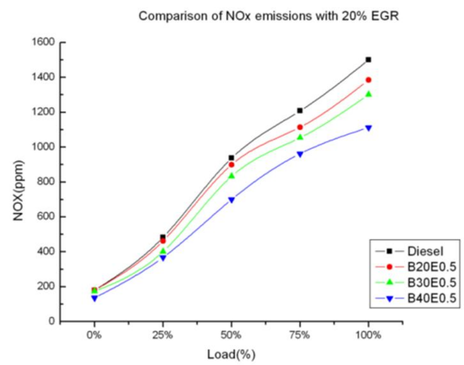


Fig 3(h): Comparison of NOx emissions for 20% EGR with EHN (0.5%)

C. HC Emissions

HC emissions were lower for biodiesel blends compared to diesel across all load and EGR conditions due to enhanced combustion. Example full load HC values:

EGR (%)	Diesel HC (ppm)	B20E0.5 HC (ppm)	B30E0.5 HC (ppm)	B40E0.5 HC (ppm)
0	34	31	30	29
10	36	33	32	31
20	35	32	31	30

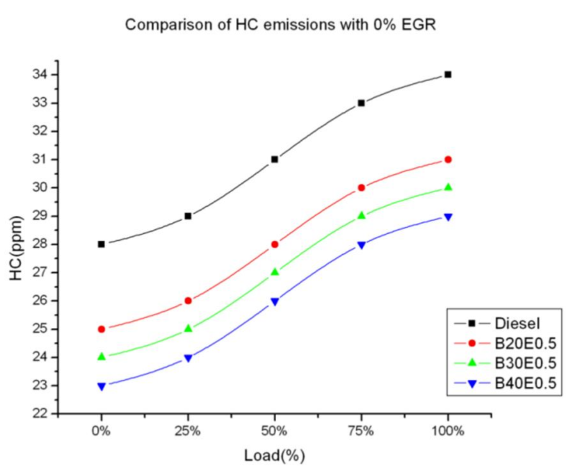


Fig 3(k): Comparison of HC emissions for 0% EGR with EHN (0.5%)

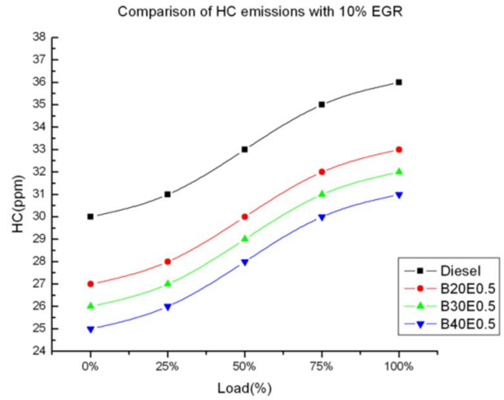


Fig 3(l): Comparison of HC emissions for 10% EGR with EHN (0.5%)

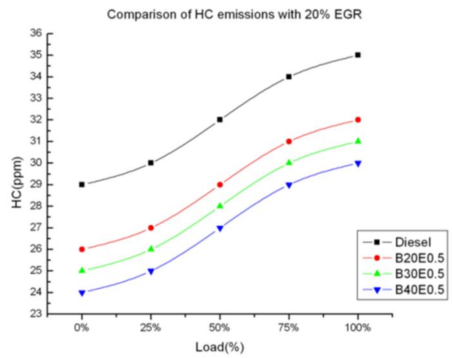


Fig 3(m): Comparison of HC emissions for 20% EGR with EHN (0.5%)

D. Smoke Opacity

Smoke opacity increased with biodiesel percentage and EGR due to richer local combustion zones and reduced oxygen availability. Example full load values:

EGR (%)	Diesel Smoke (%)	B20E0.5 Smoke (%)	B30E0.5 Smoke (%)	B40E0.5 Smoke (%)
0	30.7	31.2	34.6	36.1
10	31.6	32.1	35.5	37.0
20	33.0	33.5	36.8	38.3

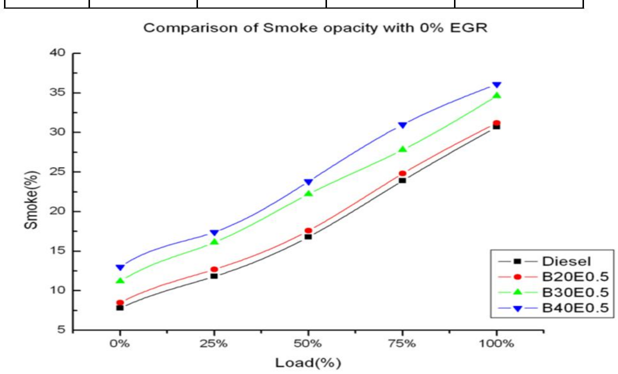


Fig 3(p): Comparison of Smoke opacity for 0% EGR with EHN (0.5%)

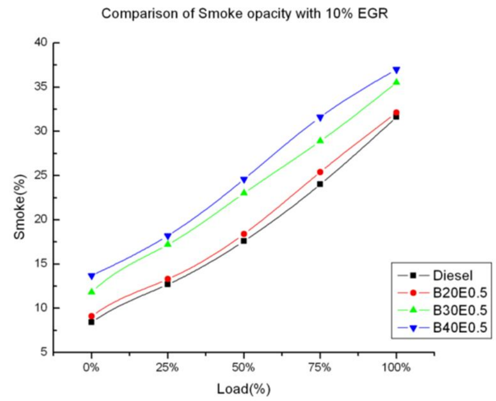


Fig 3(q): Comparison of Smoke opacity for 10% EGR with EHN (0.5%)

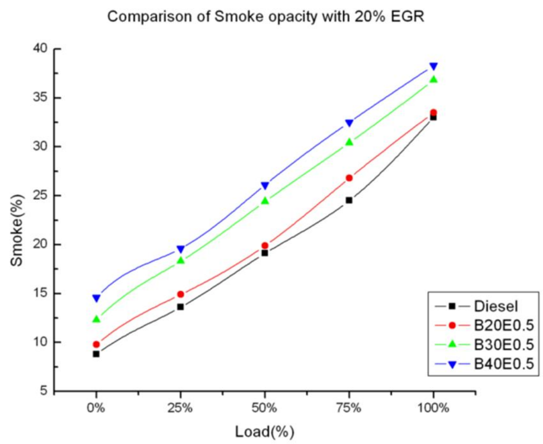


Fig 3(r): Comparison of Smoke opacity for 20% EGR with EHN (0.5%)

The results demonstrate that fish oil biodiesel blends with EHN and EGR effectively reduce NOx emissions through lower combustion temperatures and advanced ignition. The oxygen content of biodiesel supports complete combustion, lowering CO and HC levels. However, higher EGR rates slightly increase CO and HC due to oxygen dilution.

Smoke opacity rises with biodiesel and EGR due to richer mixtures and shorter ignition delays. A 15% EGR rate with B40E0.5 strikes the best compromise—achieving substantial NOx reduction while limiting CO, HC, and smoke penalties.

IV. CONCLUSION

The use of fish oil biodiesel blends, combined with 0.5% ethylhexyl nitrate (EHN) and moderate exhaust gas recirculation (EGR) at 15%, has proven to be an effective strategy for reducing emissions in diesel engines. The incorporation of EGR plays a crucial role in lowering NOx emissions by recirculating a portion of the exhaust gases back into the intake, thereby reducing peak combustion temperatures. In particular, the B40E0.5 blend (40% fish oil biodiesel with 0.5% EHN) achieved a significant 34.89% reduction in NOx emissions at 20% EGR compared to baseline diesel operation. This demonstrates the strong potential of this combination in addressing stringent NOx regulations.

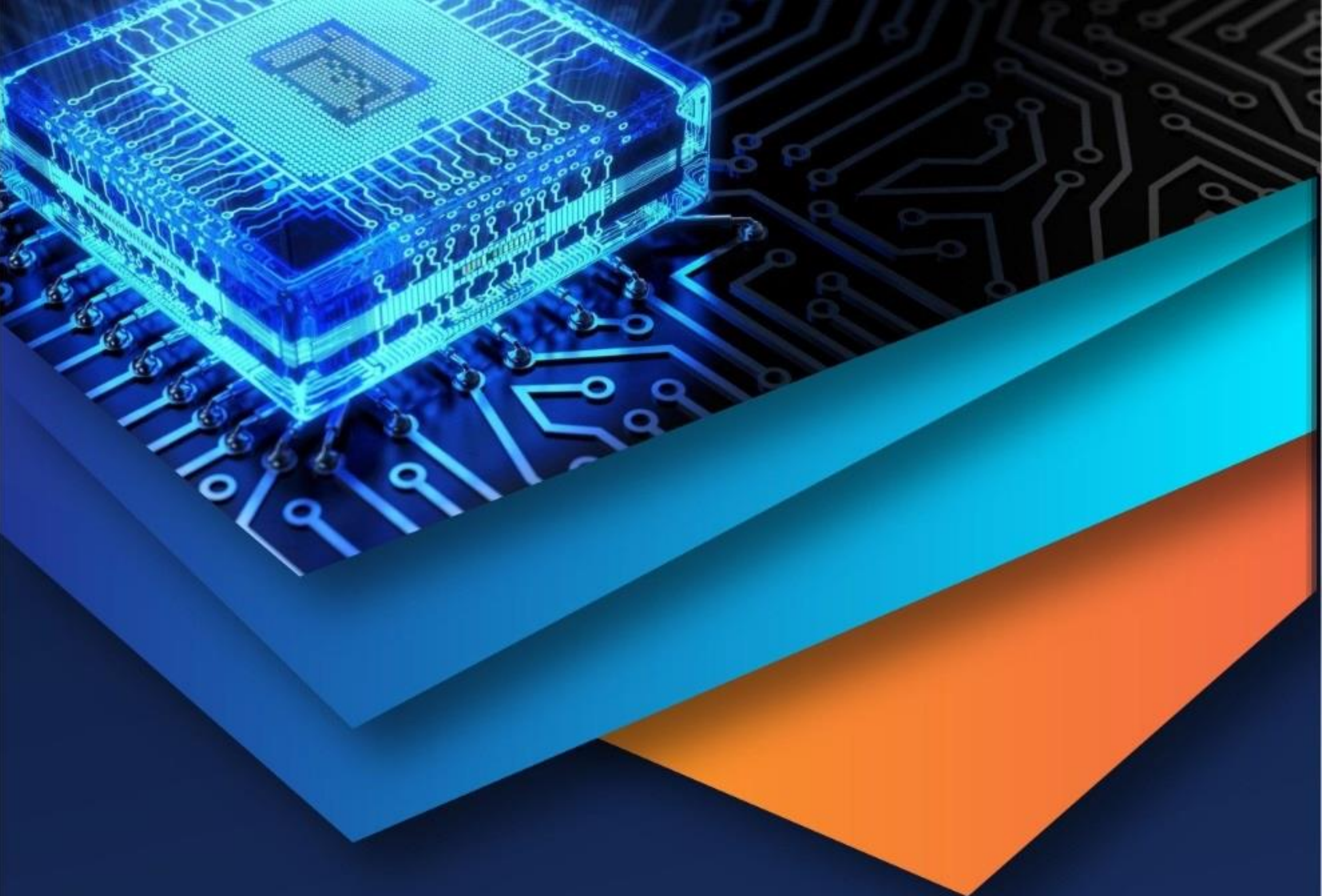
In addition to NOx reduction, the oxygenated nature of biodiesel contributes positively to the reduction of carbon monoxide (CO) and unburned hydrocarbons (HC). The inherent oxygen in the biodiesel promotes more complete combustion, thereby lowering CO and HC formation. However, the introduction of EGR, while beneficial for NOx control, tends to slightly increase CO and HC emissions due to the dilution of the intake charge and the consequent reduction in oxygen availability for combustion.

Smoke opacity—a key indicator of particulate emissions—also reflects the complex interplay between blend composition and EGR rate. While biodiesel's cleaner-burning characteristics help reduce smoke under certain conditions, excessive EGR or suboptimal blend ratios can lead to increased soot formation. Therefore, achieving minimal smoke levels requires careful optimization of both EGR rate and biodiesel blend percentage to ensure the right balance between temperature control and oxygen availability.

Overall, the combination of fish oil biodiesel, EHN additive, and moderate EGR (15%) offers a practical and sustainable approach for reducing harmful emissions in diesel engines without significantly compromising performance. This strategy not only helps in meeting environmental regulations but also supports the transition towards cleaner, renewable fuel alternatives. Future work should aim to fine-tune these parameters under varying load and speed conditions, and explore advanced EGR technologies (e.g., cold EGR) to further enhance the emission reduction potential.

REFERENCES

[1] R. M. Alagu and E. G. Sundaram, "Nitrogen oxide emissions in biodiesel-fueled CI engines: A comprehensive review," Frontiers Autom. Mech. Eng., 2010.
[2] V. K. Belagur and V. R. Chitimini, "Injector opening pressure effects on performance and emissions of honne oil-diesel blends," Thermal Sci., vol. 14, 2010.
[3] M. M. Roy, "Diesel engine performance and emissions with biodiesel blends: Emphasis on exhaust odor," Can. J. Mech. Sci. Eng., vol. 2, 2011.
[4] N. Ladommatos et al., "Impact of CO_2 in EGR on diesel emissions," Proc. Inst. Mech. Eng. D, vol. 212, 1998.
[5] H. Yokomura et al., "Venturi EGR system in turbocharged diesel engines," Tech. Rev., no. 15, 2003.
[6] M. Gomaa et al., "EGR effects on NOx and smoke in Jatropha biodiesel-fueled engines," Int. J. Energy Environ., vol. 2, 2011.
[7] V. Pradeep and R. P. Sharma, "Hot EGR for NOx control in Jatropha biodiesel CI engines," Renewable Energy, vol. 32, 2007.
[8] K. Rajana and K. R. Senthilkumar, "Diesel engine performance with sunflower biodiesel and EGR," Jordan J. Mech. Ind. Eng., vol. 3, 2009.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY