iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** IV **Month of publication:** April 2019

DOI: https://doi.org/10.22214/ijraset.2019.4028

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

Effects of Copper oxide Nanoparticle addition in Diesel and Biodiesel Blends on the Performance and Emission Characteristics of a Diesel Engine

T. Karthikeyan[1], T. Alwarsamy[2]
[1,2]Department of Mechanical, Government College of Technology, Coimbatore, Tamilnadu, India

Abstract*: currently, the world faces two major crises, depletion of fossil fuel and environmental degradation. So, to solve both problems, renewable alternative fuel is necessary with a minimum impact on the environment. Therefore, the search for biofuels has been raised in the earth world, to preserve the global environment and to replace fossil fuels by biodiesel. In this work, performance and emission characteristics of a diesel engine are studied using cottonseed oil methyl ester as biodiesel and CuO nanoparticle as an additive in a single cylinder four strokes computerized variable compression ratio engine. The copper oxide acts as a catalyst to provide oxygen for the oxidation of CO or otherwise absorbs oxygen for the reduction of NO_X. The carbon deposits within the engine cylinder are burned by the activation energy of copper oxide at the wall temperature and also it restricts the deposition of non-polar compounds on the cylinder wall results, diminution in hydrocarbon emissions. The tests revealed that copper oxide nanoparticles can be used as an additive in diesel and diesel-biodiesel-methanol blend to improve complete combustion of the fuel and reduce the exhaust emissions significantly.
***Keywords*: Biodiesel, Cotton seed, CuO nanoparticle, Emission.**

I. INTRODUCTION

Biodiesel is renewable, biodegradable and oxygenated fuel. Research has proved that the blending of biodiesel with neat diesel enhances the property and also the performance of diesel engines. The production of biodiesel from the biomass is becoming cost competitive with fossil fuels due to the open spread availability of biomass resources. Currently, various products are being used to extract biodiesel. Thus, at a time when conventional energy resources are under a constant threat of extinction, biodiesel is raising as one of the most promising environmentally friendly renewable energy options. Nowadays the properties of the diesel fuel can be improved with help of some additives characteristics of diesel fuel can be improved by the use of additives [14-26]. There are many additives are available in the market they are classified based on chemistry, usability, etc. With increasing demand for improved ignition quality and increasing cetane number specifications, the use of ignition improver additives has also risen. The rapid growth of nanotechnology in the past decade, nanoparticles are now widely commercialized in many products such as paint, coatings, catalysts, cosmetics and many other applications. Distinctive physicochemical characteristics (e.g. magnetic, optical and electrical) make the use of nanoparticle ideal in the manufacture and other related industries. Ignition delay, Specific fuel consumption, harmful emission, smoke are reduced by adding nanoparticle in diesel getting tremendous attention towards the scientific community. And also the addition increases brake thermal efficiency of the engine and reduces emission because the addition of nanoparticles in the fuel increases the surface area to volume ratio which leads to the rapid oxidation process. The most popularly used nanoparticles are Cerium oxide (CeO_2), copper oxide (CuO) and zinc oxide. Addition of some metal and metal oxide in the form of nano-powder to the base fuel may enhance the properties of the fuels. This is due to the unique properties of nanoparticles like higher specific surface area, thermal conductivity, catalytic activity, and chemical properties as compared to their bulk form. Many researchers have used nanoparticles as additives in diesel as well as biodiesel as new hybrid fuel blends. The use of fuel-borne catalyst has the advantage of an increase in fuel efficiency and reducing harmful greenhouse gas emissions. However, the stability of liquid-based fuels with metal additives was so important because of the rapid precipitation of the metal particles.

II. BIODIESEL PREPARATION

The transesterification process of cottonseed oil was performed using 13 gm of sodium hydroxide and 250 ml of methanol per liter of raw cottonseed oil. First, raw cottonseed oil was taken in a container and stirred with a mechanical stirrer and simultaneously oil was heated with the help of a heating coil. The speed of the stirrer should be minimal till the temperature of the raw cottonseed oil reaches 55ºC. Then the NaOH was mixed with methanol separately in a beaker and stirred until they were properly dissolved. The solution was then added to the preheated cottonseed oil in the reactor and the reactor was closed with an airtight lid. Now the

solution was stirred at a high speed of 650 rpm, care should be taken that the temperature does not exceed 60ºC as methanol evaporates at the temperature of 65ºC. Also, the NaOH- alcohol solution was mixed with cottonseed oil only at 55ºC because heat generated when NaOH - alcohol were mixed together and the temperature of the raw oil should be more than this when the mixing was done if the reactions have to take place properly. After the mixture was stirred for 30 minutes at a fixed temperature of 60ºC, the solution was transferred to a glass container where the separation of glycerin takes place and permitted to settle down for 15 hrs.
After that, the methyl ester of cottonseed oil (biodiesel) gets collected in the upper portion of the glass container whereas glycerin gets collected at the base of the container and drain the bottom layer containing glycerin. Then the biodiesel was washed with water, again glycerin gets separated from biodiesel and was removed. The biodiesel was washed with water repeatedly for 4 to 5 times at a time interval of 1 hr until no glycerin was there in the biodiesel. Now the biodiesel was heated for 103 to 105ºC in order to remove water contained in it. Finally, the produced methyl ester of cottonseed oil (MECSO) was left to cool down and was ready for use. A maximum of 800 ml methyl ester of cottonseed oil (biodiesel) production was observed for 1 liter of raw cottonseed oil, 250 ml of methanol and 13 gm of sodium hydroxide at 60ºC [1-7].

Fig. 1(a) Glycerin precipitation

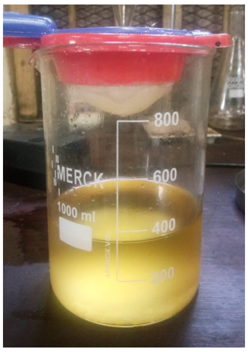


Fig. 1(a) pure CSME

III.NANOPARTICLE

Generally, Sol-Gel method involves the evolution of inorganic networks through the formation of a colloidal suspension (sol) and gelation of the sol to form a network in a liquid phase (gel). In this, the synthesis of CuO is performed by Sol-Gel route because this method is easy and economical. The precursors for synthesizing these colloids consist usually of a metal or metalloid element surrounded by various reactive legends. The aqueous solution of $CuCl_2 \cdot 2H_2O$ (0.2 M) is prepared in the cleaned round bottom flask. The obtained aqueous solution was added 1 ml of acetic acid and heated to 100 °C in a magnetic stirrer with constant stirring and then 8 M NaOH is added to previous heated solution till pH reaches to 7. The color of the solution turned from green to black immediately and a large amount of black precipitate is formed immediately. The entire process is depicted in Figs. 2(a) and 2(b). The precipitated nanoparticles are centrifuged and washed 3-4 times with de-ionized water. The obtained precipitate was dried in air for 24 hours. This powder is further used for the characterization of CuO nanoparticles. The chemical reaction was;

$$CuCl_2 + 2NaOH \longrightarrow Cu(OH)_2 + 2NaCl_2$$

$Cu(OH)_2$ decomposes into CuO on heating:

$$Cu(OH)_2 \longrightarrow CuO + H_2O$$

A. Nano Characterization

A large number of techniques are available to measure the properties of nanoparticles, but different techniques measure different properties of the nanoparticle, and hence, the results are not identical. Since, the nanoparticles used in this study were synthesized; a few characterization tests were conducted to understand the properties of the prepared nanoparticle [8-11].
The morphology of CuO nanoparticle was studied by passing a fine beam of high energy electrons on the surface of the sample. The image formed, as shown in Fig.3, due to the scattered electron beam and sampled interaction, shows that the synthesized nanoparticles are needle in shape.

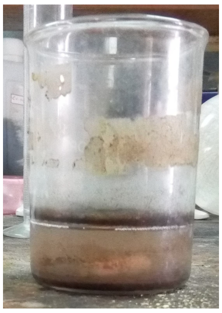


Fig. 2(a) CuO nanofluid

Fig. 2(b) CuO nanoparticle

The EDX method is used to characterized the elemental composition of the sample, by analyzing the emitted X-rays from the sample after being bombarded by the SEM electron beam. From Fig.4, it was observed that the peaks obtained correspond to the copper and oxygen elements. No other peaks where suggesting the absence of any impurity formed.

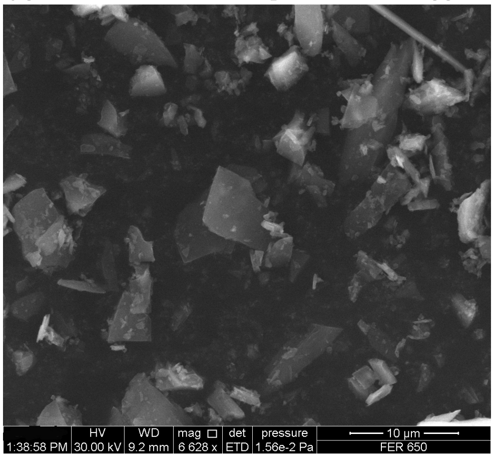


Fig. 3 SEM photograph of CuO nano particles

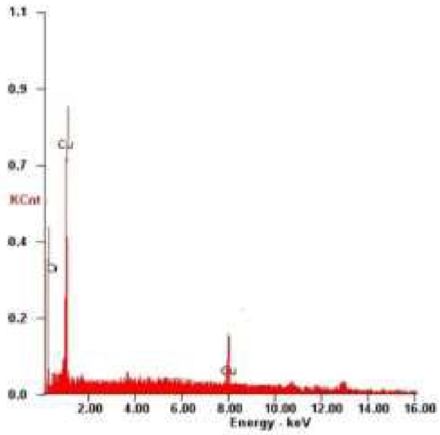


Fig. 4 EDX photograph of Cu2O nano particles

Fig. 5 shows the peak at 2094.38 cm^{-1} which indicates the presence of primary amines and the C-H stretches of alkenes appearing at 1457.81 cm^{-1}. The three infrared absorption peaks reveal the vibrational modes of CuO nano structures. The major peaks were found with 500.74 cm^{-1}, 642.35 cm^{-1} and 996.02 cm^{-1} respectively. The vibration at the region of 500.74 cm^{-1} has been attributed to CuO. The EDX analysis was used for further confirmation of the structure.

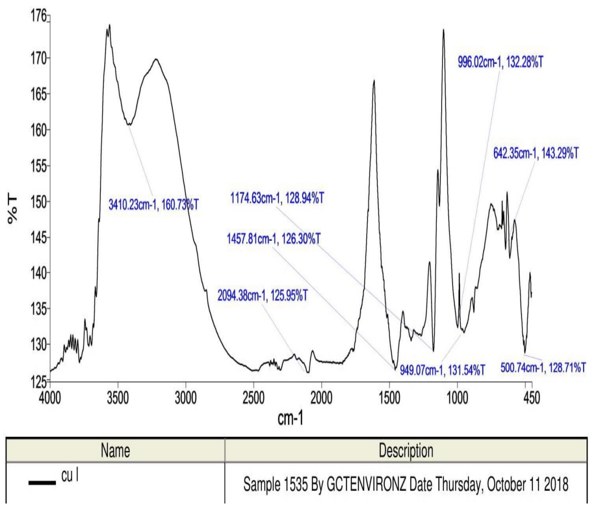


Fig. 5 FTIR spectroscopy

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

IV. EXPERIMENTL SETUP

Fig. 6 shows the experimental setup of the testing engine. The performance tests for the stable Diesel-biodiesel-ethanol blends and neat diesel with cerium oxide nanoparticles as fuel-borne catalyst additive are carried out on a computerized single cylinder four stroke direct injection variable compression ratio engine. Figure-1 shows the schematic diagram of the experimental setup and the Table-2 shows the specification of the engine. The experimental setup consists of a variable compression ratio engine is coupled to an eddy current dynamometer. A computerized data acquisition system is used to collect, store and analyze the data during the engine testing.

Fig. 6 Computerized variable compression ratio test rig.

The gas analyzer used for measuring the engine exhaust gas is AVL DITEST MDS 250. It has the capability to measure five exhaust gas emissions namely CO, CO_2, HC, O_2,and NO_x. Here CO, CO_2, and O_2 are measured in % vol of the sample and HC, and NO_x are measured in ppm.

V. REULTS AND DISCUSSIONS

The following section illustrates the results obtained from the performance and emission characteristics of the CI engine.

A. Performance Study of C. I. Engine

Fig. 7 shows the variation of Brake Thermal Efficiency Vs load for different blends. It is clear that brake thermal efficiency (BTE) increases with an increase in load and also among the various blends, B20+50 ppm of CuO has the highest brake thermal efficiency when compared with other blends. With the addition of CuO nanoparticles, the BTE has increased marginally compared to the same of biodiesel. The average increase in BTE was 6.84% for up to 50 ppm addition of CuO nanoparticle in biodiesel blend.

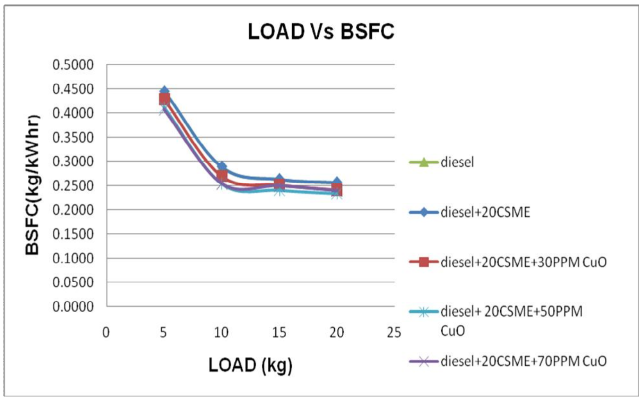


Fig. 7 Load Vs BSFC

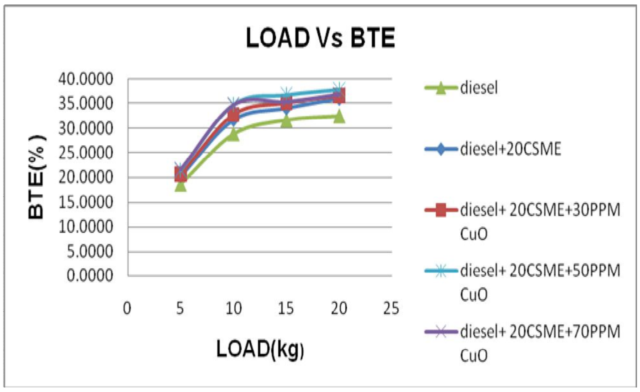


Fig. 8 Load Vs BTE

Fig. 8, it is evident that an increase in load causes a parallel decrease in brake specific fuel consumption (BSFC). Comparing the BSFC of various blends, we infer that the addition of CuO nanoparticles to biodiesel decreases the BSFC. Among all the blends, we note that B20+50 ppm CuO has the least BSFC. The average decrease in BSFC was 6.16%. It is observed that the BTE increases as the additive percentage increases. This is due to that the addition of CuO nanoparticle enhances the complete combustion of the fuel and the requisite power is generated using a low amount of fuel consumption. This directly results in an increase in BTE. It can also be inferred that the BSFC decreases as the additive percentage increases which are due to the vice versa of the above-mentioned explanation. But after 50 ppm addition of CuO, It decreases the BTE because the CuO nanoparticles are precipitated in the biodiesel blend.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

B. Emissions Study of C. I. Engine

From Fig. 9, we note that an increase in load causes an Increase in hydrocarbon (HC) emissions. The additive added biodiesel reduced the emissions of HC, significantly compared to the non additive biodiesel blend. This is because the addition of CuO reduced the peak pressure and peak temperature inside the engine cylinder.

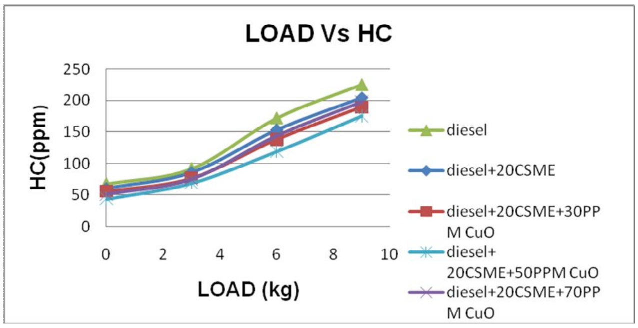


Fig. 9 Load Vs Hydrocarbon

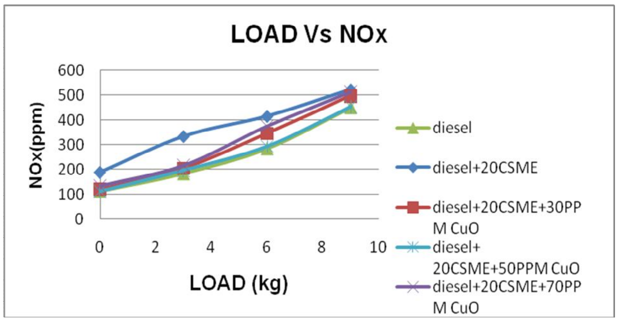


Fig. 10 Load Vs No_x

Fig.11 indicates that the increase in load gives a corresponding increase in CO emissions. We note that the addition of nanoparticles to biodiesel decreases the CO emissions. The maximum reduction in CO was noticed as 15.48% for 50 ppm addition of CuO in biodiesel blend.

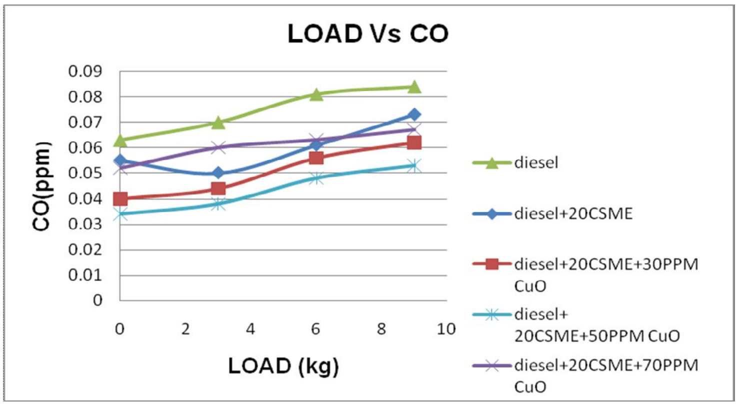


Fig. 11 Load Vs CO

VI. CONCLUSIONS

The experiments were conducted with CSME biodiesel and CuO as an additive has been studied and investigated the performance and emission characteristics. The following conclusions based on the experiment are

A. The performance, emission characteristics were analyzed at 20% blend with and without the presence of Copper oxide nano additive in single cylinder 4 stroke direct injection diesel engine.

B. Brake specific fuel consumption (BSFC) has been reduced for all the additivated blends. Brake specific fuel consumption for B20+50 ppm increased by 6.16% when compared with biodiesel without additives.

C. Break Thermal Efficiency (BTE) has been reduced for all the additivated blends. The brake thermal efficiency for B20+50ppm increased by 6-7% when compared with biodiesel without additives.

D. The reduction in CO emission by using B20+50 ppm has observed when compared with diesel. The CO emissions reduced by 13% when compared with diesel.

E. The HC emissions are obtained minimum for B20+50 ppm when compared with diesel and other biodiesel nano-fuel additives.

F. NO_x emissions are decreased for almost all biodiesel nano fuel additives when compared to biodiesel without additives.

G. The cottonseed oil methyl ester can be a potential source for biodiesel production and can also be used as potential fuel for diesel engine without any engine modifications.

REFERENCES

[1] N. Hoda (2010), 'Optimization of Biodiesel Production from Cottonseed Oil by Transesterification Using NaOH and Methanol,' Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 32:5, 434-441.

[2] Gopal BV, Sridevi V, Sarma AJN, and Rao PV, '(2015) Processing and Characterization of Cotton Seed Methyl Ester,' Austin Chem Eng. 2015; 2(2): 1020.

[3] Ashish Naha Payl and Mohammad Mashud (2017), 'Experimental investigation on fuel properties of biodiesel prepared from cottonseed oil,' American Institute of Physics AIP Conference Proceedings 1851, 020018.

[4] Dominic Okechukwu Onukwuli, Lovet Nwanneka Emembolu, Callistus Nonso Ude, Sandra Ogechukwu Aliozo, Mathew Chukwudi Menkiti (2017), 'Optimization of biodiesel production from refined cotton seed oil and its characterization,' Egyptian Journal of Petroleum (2017) 26, 103–110**.**

[5] Y. Alhassan, N. Kumar, I.M. Bugaje, H.S. Pali, P. Kathkar (2014), 'Co-solvents transesterification of cotton seed oil into biodiesel: Effects of reaction conditions on quality of fatty acids methyl esters', Energy Conversion and Management vol 84 : 640–648.

[6] T. Eevera & K. Pazhanichamy (2013), 'Cotton Seed Oil: A Feasible Oil Source for Biodiesel Production,' Energy Sources, Part A, 35:1118–1128.

[7] Hariram Venkatesan, Godwin John J, Seralathan Sivamani (2017), 'Cotton Seed Biodiesel as Alternative Fuel: Production and Its Characterization Analysis Using Spectroscopic Studies,' Der Pharma Chemica, 2017, 9(5):1-6.

[8] Soner Gumus, Hakan Ozcan, Mustafa Ozbey, Bahattin Topaloglu (2016), 'Aluminum oxide and copper oxide nanodiesel fuel properties and usage in a compression ignition engine,' Fuel 163 (2016) 80–87.

[9] Heydar Khadivi Ayask, Jalil Vahdati Khaki, Mohsen Haddad Sabzevar (2015), 'Facile synthesis of copper oxide nanoparticles using copper hydroxide by mechanochemical process,' Journal of Ultrafine Grained and Nanostructured Materials, *Vol.48, No.1, June 2015, pp.37-44.*

[10] K. Vijayashree, K. Sheshappa Rai, T. Demappa (2016), 'Synthesis of Nanosized Copper Oxide by Assimilating Microwave Radiation and its Characterizations,' Indian Journal of Advances in Chemical Science S1 (2016) 6-9.

[11] Rintu Varghese and Joy Prabu. Hand Johnson. I (2017), 'synthesis and characterizations of needle- shaped cuo nanoparticles for biodiesel application,' Int. J. Adv. Res. 5(1), 1642-1648.

[12] Jagdeep M. Kshirsagar, Ramakant Shrivastava, and Prakash S. Adwani (2017), 'Preparation and Characterization of Copper Oxide Nanoparticles and Determination of Enhancement in Critical Heat Flux.

[13] M. Leenus Jesu Martin, V. Edwin Geo*, B. Nagalingam(2015), 'Effect of fuel inlet temperature on cottonseed oil diesel mixture composition and performance in a DI diesel engine,' Journal of the Energy Institute xxx (2016) 1-11.

[14] Basavaraj Avari, Dr. K.G. Satish , Prof. Manjunath (2017),' Experimental Study of B20 Blend Honne Oil and Diesel Fuel CuO Nano Additives,' International Research Journal of Engineering and Technology Volume: 04 : 2395-0056.

[15] Milind A. Pelagade, Madhavi S. Harne, Dr. Ramakant Shrivastava (2017), 'Performance Evaluation of CI Engine Using Cottonseed Oil as an Alternate Fuel,' IJSRST- Volume3 ,Issue 6,2395-6011.

[16] V. Arul Mozhi Selvan, R. B. Anand and M. Udayakumar (2009), ' Effects of cerium oxide nanoparticle addition in diesel and diesel-biodiesel-ethanol blends on the performance and emission characteristics of a CI engine,' Asian Research Publishing Network, VOL. 4, NO. 7, Sep 2009,1819-6608.

[17] Rolvin D'Silva, Mohammed Hafeez, Joyal Fernandez, Faheem Paloth, Ibrahim Abdul Rahiz, Binu K. G., Raju K, Thirumaleshwara Bhat (2017), 'Effect of Copper oxide Nanoadditives on the Performance and Emissions Characteristics of a C.I. Engine,' Energy and Power 2017, 7(4): 99-104.

[18] Dominic Okechukwu Onukwuli , Lovet Nwanneka Emembolu , Callistus Nonso Ude, Sandra Ogechukwu Aliozo , Mathew Chukwudi Menkiti (2016), 'Optimization of biodiesel production from refined cotton seed oil and its characterization,' Egyptian Journal of Petroleum (2017) 26, 103–110.

[19] Muhammad Aminul Islam, Godwin A. Ayoko, Richard Brown, Doug Stuart, Marie Magnusson, Kirsten Heimann (2013) 'Influence of fatty acid structure on fuel properties of algae derived Biodiesel,' Procedia Engineering 56 (2013) 591 – 596

[20] Duple Sinha, S. Murugavelh (2016), 'Biodiesel production from waste cottonseed oil using low cost catalyst: Engineperformance and emission characteristics,' Perspectives in Science (2016) 8, 237—240.

[21] Md. Nurun Nabi *, Md. Mustafizur Rahman, Md. Shamim Akhter (2008), 'Biodiesel from cotton seed oil and its effect on engine performance and exhaust emissions,' Applied Thermal Engineering 29 (2009) 2265–2270.

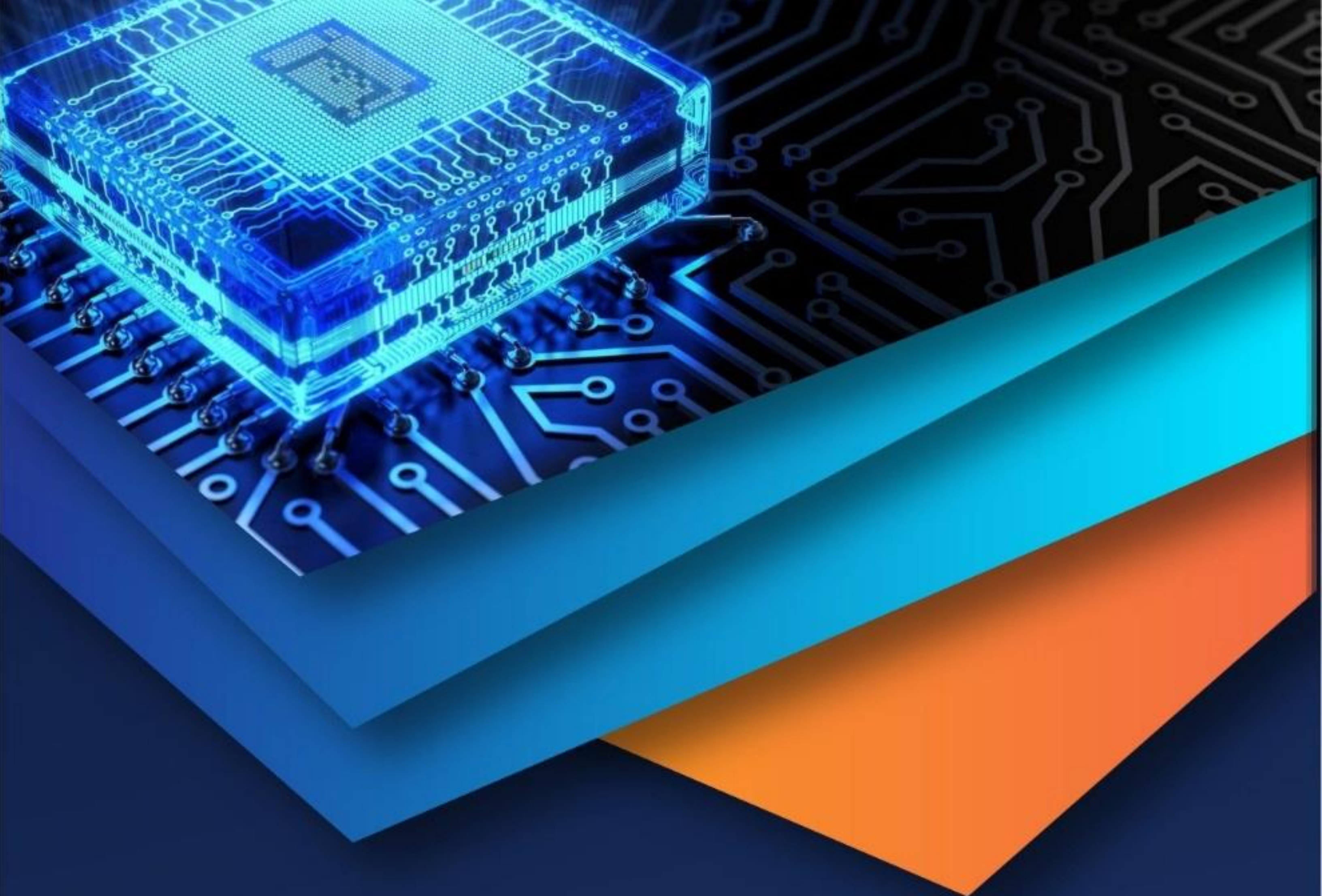
[22] K. Vijayaraj & A. P. Sathiyagnanam (2018), 'Comparative Study on Properties of Methyl Ester of Cotton Seed Oil and Methyl Ester of Mango Seed Oil with Diesel.' Global Journals Inc, Volume 14 Issue 2, 2249-4596.

[23] Xiaohu Fan, Xi Wang, Feng Chen, Daniel P. Geller, Peter J. Wan (2015), 'Engine Performance Test of Cottonseed Oil Biodiesel,' *The Open Fuels & Energy Science Journal,* 2008, *1,* 40-45.

[24] Ehsan-o-llah Ettefaghi, Hojjat Ahmadi, Alimorad Rashidi, Seyed Saeid Mohtasebi and Mahshad Alaeib (2013), 'Experimental evaluation of engine oil properties containing copper oxide nanoparticles as a nanoadditive,' Ettefaghi et al. International Journal of Industrial Chemistry 2013, 4:28.

[25] P.Jayanthi, Srinivasa Rao M (2016), 'Effects of nanoparticles additives on performance and emissions characteristics of a DI diesel engine fuelled with biodiesel,' IJAET, Vol. 9, Issue 6, pp. 689-695.

[26] Y. V. H. Rao, R. S. Voleti, A. V. S. Raju & P. N. Reddy (2010): The effect of cottonseed oil methyl ester on the performance and exhaust emissions of a diesel engine, International Journal of Ambient Energy, 31:4, 203-210.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY