Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 02, February-2021

A Review on Performance Characteristic of Compression Ignition Engine Fuelled with Ethanol-Diesel Blend

Bhojraj N. Kale [1*] Ashutosh Kumbhare[2], Vaibhav Rahangdale[3], Sagar Khandare[4], Pritesh Bhujade[5], Vinay Ingole[6], Rohit Kalkar[7], Shubham Kokare[8]
[1*] Assistant Professor, Department of Mechanical Engineering
[2,3,4,5,6,7,8] Projectee, Department of Mechanical Engineering
Dr. Babasaheb Ambedkar College of Engineering and Research, Nagpur, India.

***Abstract*:- Due to the daily high consumption of fossil fuels like petrol and Diesel, there is very high shortage of this fuels in future. That's why we have to look at some new alternative fuels which are renewable and give same performance as petrol and Diesel. Ethanol is one of the alternative fuel which give nearly same performance as diesel fuel when blended with it. It is better to develop the engine which can work on pure ethanol or one can add ethanol in the petrol or diesel and use the blends of that. In this paper the performance characteristics of compression ignition engine fuelled with ethanol-diesel blend were studied at different condition. The main contribution of this work is to compare previous performance characteristics with new one having different fuel blend ratio. This can help future engine designers to design according to more engine efficiency.**

***Keywords:- Ethanol, Ethanol Blends, CI Engine, Performance Characteristics*.**

INTRODUCTION

In 1970s, the global fuel crisis was held to create attention between people of many countries which made awareness about oil and its use in different fields. We all know that oils which come from crude or different layers of earth's crust are non renewable which led to decrease in amount of it after some time and it will not be able to be used by people.

As amount of these fuels is decreasing day by day, its limited source and high price of petroleum as well as the global warming have led to investigations for renewable fuels. According to Renewable Energy Directive, the consumed energy from renewable sources for transport sector must be 10% or higher of the total energy consumption. Hence, due to this it created attention on investigation of renewable fuels.

Petrol and diesel engines are majorly used for transport vehicles as they have high torque and efficiency. As these are majorly used, they produce maximum pollution emissions. For, eliminating this emission problem, we need to introduce the oxygenated compounds such as ethanol into diesel fuel which is one of the best alternative way to reduce smoke emission. Previously, investigations on different kinds of renewable fuels such as raw vegetable oil, waste cooking oil, biodiesel, methanol, and ethanol have been done out of which first three are able to be used in diesel engines and others are used in petrol engines.

Ethanol can be produced using raw materials such as sugarcane, sorghum, corn, barley, cassava, and sugar beets. As it has high octane rating, it is a biomass based renewable fuel. Investigation was done in 1980s by researchers about the possibilities of using ethanol and diesel blend where they concluded that it is a technically usable for diesel engines. But ethanol cannot be used 100% pure because it has low density and low viscosity and also its cetane number is not sufficient.

Ethanol-diesel blend fuel in diesel engine will improve smoke emission. Considering the price and rising demand of diesel fuel in recent years, production of ethanol will become much more favorable by cost.. Even though researchers have done study using ethanol-gasoline blend in spark ignition engines, ethanol-diesel blend in diesel engine has not been investigated enough yet. Also, a few researchers have accomplished their studies in heavy-duty diesel engines but performance and emissions of a light-duty diesel engine with ethanol-diesel blends must be investigated.

REVIEW OF LITERATURE

Nilesh Mohit et. al. discusses the different percentage of ethanol blend like 5%, 10%, 15%, 20% prepared with diesel and performed on Single cylinder four stroke compression ignition engine at different load using variable compression ratio to check the performance such as brake power, brake specific fuel consumption, fuel flow, brake thermal efficiency etc. It is obtained that, there is no significant change in Brake Power for Pure Diesel and each fuel blend. But, as the compression ratios changes the slightly reduction in Brake power occur. There is increase in BSFC in Pure Diesel and all blends except E20 with decrease in compression ratios. It is observed that with increase in blend proportion increase in Brake Thermal Efficiency. But, as compression ratios is decreasing there is decrease in efficiency. For fixed compression ratio CR 18 the fuel blend E5 has lower fuel flow among all the fuel blends. [1]

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 02, February-2021

Ho Young Kim et. al. carried out experiment using four types of ethanol-blended fuel. The blending ratios were 0% (DE0) for Pure Diesel, and 3% (DE3), 5% (DE5), 10% (DE10) for 3%, 5% & 10% ethanol mixture by volume %. The four stroke four-cylinder direct injection common rail direct injection diesel engine was used. The experiment was carried out at 750 rpm at low speed idle and the 40Nm engine load was applied. It is obtained that the BSFC increased with increase in ethanol blend ratio. Brake Thermal Efficiency of ethanol-blended fuel is lower than Pure Diesel fuel. As ethanol-blend ratio increases, the ignition delay increased, NOx and soot opacity decreased, but CO emission increased. The emission ratio of NO2 in NOx also increased. The coefficient of variation (COV) of the indicated mean effective pressure (IMEP) values of ethanol-blended fuels are lower than those of Pure Diesel fuel and tended to increase when ethanol-blending ratio increased above 3%. [2]

Tarkan Sandalci et. al. s has been investigated experimentally the performance of CI Engine using ethanol-diesel blend. The tested fuels were mineral diesel fuel (E0D100), 15%(v/v) ethanol/diesel fuel blend (E15D85), 30%(v/v) ethanol/diesel fuel blend (E30D70). The test is carried out in single cylinder four stroke compression ignition engine at full load operating condition at four different engine speed which are 1100rpm, 1350rpm, 1700rpm and 1950rpm. From experiment it is obtained that Maximum engine brake torque was obtained by E0D100 fuel, while operating below 1350rpm engine speed, engine brake torque reduced to 18.2% and 21.5% with E15D85 and E30D70 blends, respectively. The lowest BSFC was obtained with E0D100 fuel; however, a 14.5% increases with E30D70 fuel. The highest thermal efficiency was obtained with E0D100, when operating below 1100 rpm, thermal efficiency is reduced by 3.8% and 5.5% by using E15D85 and E30D70 fuels, respectively. [3]

Ismet Celikten et. al. was tested, blends of diesel fuel and ethanol with rapeseed oil and soybean oil methyl esters. The Tests were carried out using diesel fuel + rapeseed oil + ethanol (DRE) blends and diesel fuel + soybean oil + ethanol (DSE) blends in a four-stroke, four-cylinder, direct injection (DI) diesel engine at different engine speeds and full load operating condition and the results were compared with neat diesel fuel. It is obtained that The brake torque was decreased by 7.6% and 10% with DRE and DSE blends respectively, compared to No.2 diesel fuel. BSFC was increased by 3.7% and 10.7% with DRE and DSE blends respectively, compared to No. 2 diesel fuel. Significant reductions were obtained in smoke level, CO and HC emissions with DRE and DSE fuels. NOx emissions were increased with DRE and DSE fuels. As a result, DRE and DSE fuels decreased the engine performance. [4]

K. Rajesh et. al. discussion has been made on the effect on the performance of CI engine operating on the Diesel-biodiesel-ethanol blends. The blending ratios were 20% Biodiesel and 80% Diesel termed as B20; 5%Ethanol,15%Karanja Biodiesel and 80%Diesel termed as ET05; 10%Ethanol,10%Karanja Biodiesel and 80%Diesel termed as ET10; 15%Ethanol,15%Karanja Biodiesel and 70%Diesel termed as ET15; 20%Ethanol,10%Karanja Biodiesel and 70%Diesel termed as ET20. Test were conducted on the single cylinder water cooled diesel engine. It is obtained that in ET05 the specific fuel consumption (SFC) is lower and in ET20 the specific fuel consumption (SFC) is more. Increase in ethanol percentage lead to better combustion. [5]

Mehmet Celik et. al. evaluated performance characteristics of cottonseed and grapeseed biodiesels and blends containing bioethanol were investigated. The bioethanol was produced from cotton and canola at the percent of 4-8-12-16 % and 20 % by volume. The test carried out in single cylinder, four-stroke water cooled direct injection (DI) diesel engine. It is obtained that by adding bioethanol to cottonseed and canola biodiesel, the power values of bioethanol are reduced respectively by 12.23 % and 7.58 %, while specific fuel consumption values increase by approximately 9.48 % and 5.82 %, respectively. Reduction in the cetane number of biodiesel due to bioethanol addition led to an increase in the CO and THC emissions, respectively 11.49 % and 8.40 % for cotton biodiesel, 13.10 % and 18.85 % for canola biodiesel. As bioethanol rate in biodiesel increased, NOx emissions were reduced. [6]

Praveen A. Harari et. al. carried out experiment for investigating the performance characteristics of compression ignition engine fuelled with various blends of water melon biodiesel is analyzed. The test was carried out on kirloskar, 5.2KW, single cylinder, four-stroke, water cooled, direct injection (DI) diesel engine at 1500rpm engine speed with eddy current dynamometer. Different blends of water melon biodiesel such as B0, B20, B40, B60, B80 and B100 are prepared to analyze the performance characteristics. It is obtained that The Brake Thermal Efficiency of biodiesel blends was found to be lower compared to diesel at all power output. Total Fuel Consumption for diesel is less as compared to biodiesel blends. Brake Specific Fuel Consumption (BSFC) for blends of biodiesel blends is higher when compared with diesel. Among the biodiesel blends tested, B20 gave the best performance with reduced emissions. The BTE of the engine with the B20 blend at 80% power output which is closer to diesel operation. Hence B20 blend is recommended for existing diesel engine. [7]

Naresh Muddineni et. al. find out performance characteristics of kirloskar 5.2KW, single cylinder, four-stroke, variable compression ratio, water cooled diesel engine (Genset Engine) is with few biofuels like cottonseed oil, coconut oil and Rice bran oils and compared the results with conventional diesel fuel. It is obtained from results that among the investigated biofuels the rice bran biofuel shows good performance among other fuels in terms of performance parameters like BSFC, total fuel consumption etc. From the emission point of view, Rice bran oil shows fewer emission levels like NOx, CO and CO2 and UHC compared to other biofuels. Therefore, among the investigated biofuels, Rice bran oil is the best alternative fuel with various blends like B20, B40 etc. for the diesel engine. [8]

Nambaya Charyulu Tatikonda et. al. gives the comparative analysis of performance characteristics of compression ignition engine powered with conventional diesel, diesel and biodiesel blend were performed with and without piston coating where they found the results of this investigation at full load condition. The brake specific fuel consumption decreased with increase in load on the

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 02, February-2021

engine where CME10D90 (B10) with coated engine recorded lowest BSFC than all the other ratios. Diesel has recorded 33.40 % of BTE, CME10D90 (B10) with base engine has recorded 34.57% of BTE and with coated engine has recorded 35.97% BTE, therefore for coated engine the BTE of CME10D90 (B10) was increased by 7.69% compared to pure diesel and by 4.05% compared to base engine data. The TFC of CME10D90 (B10) with coated engine was improved by 3.91% compared to CME10D90 (B10) with base engine and by 6.12% compared to pure diesel. [9]

Ranjan Kumar Mishra et. al. did Biodiesel preparation from waste cooking oil (soybean oil) and the study of engine performance characteristics of 4-stroke compression ignition engine fuelled with blends (B10, B15, B20) of the extracted biodiesel. In this study it is observed that; due to the more calorific value of B10 blend of biodiesel than B15 and B20, it has the more brake power. BSFC decreased with increase in load. Diesel has the lowest brake specific fuel consumption. Among the three different blends of biodiesel B10 has the lowest value of brake specific fuel consumption. the brake thermal efficiency of diesel is more than that of biodiesel blends. Among the three different blends of biodiesel, B10 has higher brake thermal efficiency than B15 and B20. Among the three different blends of biodiesel, B10 has the better performance characteristics than B15 and B20 blend of biodiesel when fuelled in an internal combustion engine. [10]

Thanh Viet Nguyen et. al. produced waste cooking oil synthetic diesel from waste cooking oil by catalytic cracking in a batch reactor using MgO as a catalyst and used as investigated fuel. The engine was fueled with WCOSD and CD to compare the engine characteristics, including engine power, fuel consumption, combustion process, and emissions. Besides, the emissions of nitrogen oxides of the test engine fueled WCOSD were higher than those of CD at all tested conditions. The hydrocarbon was lower for WCOSD in comparison to thoseD at almost all operating conditions. The HC emission of an engine fueled by WCOSD averagely reduced by 26.3%. The smoke emission of the test engine in case of using WCOSD was 17% lower on average than that of CD. However, the carbon monoxide emissions were lower at the low and medium loads and higher at the full loads. [11]

Vaneet Bhardwaj et. al. studied the Performance Characteristics of Compression Ignition Engine Fuelled with Blends of Biodiesel from Used Cottonseed Oil. Experiments were conducted using a single cylinder direct-injection diesel engine with different loads. In this study, they found readings of different technical aspects and it is observed that Due to the more calorific value of B10 blend of biodiesel than B15 and B20, it produces the more brake power. Diesel has the lowest brake specific fuel consumption. Among the three different blends of biodiesel, B10 has the lowest value of brake specific fuel consumption. Among the three different blends of biodiesel, B10 has higher brake thermal efficiency than B15 and B20. Among the three different blends of biodiesel (B10, B15 and B20), B10 has the better performance than B15 and B20 blends of biodiesel. [12]

Y.H Teoh et. al. carried out experiment on medium-duty high pressure common-rail turbocharged four-cylinder diesel engine with different torque condition. They studied the effects of bioethanol as a fuel additive into a coconut biodiesel-diesel fuel blend. The fuel used for the experiment are fossil diesel fuel, B20(20% biodiesel blend), B20E5(20% biodiesel+5% bioethanol blend) and B20E10(20% biodiesel+10% bioethanol blend). They concluded that Brake Specific Energy Consumption(BSEC) and Brake Thermal Efficiency (BTE) is good as compared to diesel and the Brake Specific fuel consumption(BSFC) is increased. Higher percentage of bioethanol increased NOx at higher load and it is low at low load. Emission of CO is reduced for each blend but B20E10 has highest reduction of 9.3% and 52% in smoke and CO emission. Also, B20E10 disclosed shorter combustion duration, which reduced by an average of 1.375 degree CA. Overall they shows conclude that B20E10 blend which has good improvement in the diesel engine. [13]

T. K. Bhattacharya et. al. tested blends on a 3.73KW stationary constant speed CI engine. The fuels are Anhydrous (200-degree proof) and aqueous ethanol of 190, 180 and 170-degree proof mix with diesel. The micro emulsion of ethanol-ethyl acetate-diesel prepared and named as 200 degrees -10/9/81, 200 degree-15/9.5/75.5, 200 degree-20/10/70, 190 degree-10/22/68, 190 degree-15/25/60, 190 degree-20/29/51, 180 degree-10/35/55, 180 degree-15/39/46, 180 degree-20/40/40, 170 degree-10/43/47, 170 degree-15/45/40 and 170 degree-20/50/30. Where as they selected six ethanol-ethyl acetate-diesel such as 200 degree-10/9/81, 200 degree-15/9.5/75.5, 200 degree-20/10/70, 190 degree-10/22/68, 190 degree-15/25/60 and 190 degree-20/29/51. BTE (Brake Thermal Efficiency) at low load is low and at high load is high, CO (carbon monoxide) emission is reduced 1.4% to 44.4%, unburnt hydrocarbons was found in higher rate, the emission rate of nitric oxide is reduced to 24% found on 190 degree -20/29/51. But the exhaust gas temperature is found high on the blends. It will be reduced by using 190-degree proof aqueous ethanol blend. [14]

Zdzisław Chłopek et. al. done an experiments on compression ignition (CI) engine and the fuels are diesel oil and rape methyl esters (RME). When diesel oil used effective power and output torque is highest. For summer biofuel both effective power and output torque rather lower and for winter biofuel they were reduced. Emission of carbon monoxide is reduced (up to 30%) when the methyl esters of rape oil (RME) is used. Hydrocarbons, nitrogenous oxide are also reduced but the difference between them was about 10% and a reduction in the specific brake emission for the summer (S) biofuel and an increase in the emission for the winter (W) biofuel. Temperature of exhaust gas if much higher of diesel oil and to some degree lower for methyl esters of rape oil (RME). Effective efficiency is similar for diesel oil and summer biofuel and much lower for winter biofuel. [15]

Balachandar.K et. al. carried out experiment on a single cylinder four stroke engine and fuel injector is set at four different loads like o. 1.2.3. 4kw.In this experiment the blend is prepared by using cashew nut shell liquid and volume ratio is b10 and b20. The engine speed is fixed at 1500rpm and the engine start at 0 load to attain the rated speed and steady condition. And then added load to note changes in fuel consumption. Rpm. Power output were measured and display in the monitor. In this experiment it is

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 02, February-2021

obtained that the engine efficiency decrease at full load for fuel injection. The brake specific consumption of fuel with increase at various loads. the break thermal efficiency increase slightly by increasing specific fuel consumption. [16]

E. Ramjee et. al. used a single cylinder four stroke water cooled diesel engine is with rated power of 3. 7kw for experimentation. This experiment is done with different inject pressure like 180, 210, 240 bar and hydraulic dynamometer is used for loading the engine for loading. Pilot fuel quantity, Fuel, Injection and Speed are the parameters selected for Parameters. The engine is running at 1500 rpm. The engine is operated at dual mode and at different injection pressure. The amount of diesel pilot fuel is kept constant and speed is increased by supplying pilot fuel to engine to attain desired speed. It is obtained that exhaust gas temperature increased by increasing brake power. increasing or decreasing brake power the specific fuel consumption of dual fuel and diesel increased or decreased. increasing brake power Brake thermal efficiency increase with dual fuel and diesel. [17]

Jilin Lei et. al. done experimentation on direct injection turbo charged diesel engine with 3.298L. This experiment consists of ac electric dynamometer. Exhaust analyzer, fuel consumption meter and smoke meter and atmospheric pressure is maintained at 81kpa. The inlet of turbo charge compressor connected to the output of engine condition system. Temperature sensor and pressure sensor. Preparation of blend A hydraulic vibration emulsification device is used installed on high pressure pump. The blend and diesel is delivered to emulsification device by two fuel delivery system. Then emulsified ethanol blend is injected to the cylinder by pump and injectors. This device provides different proportion of blend without modifying and stopping the engine. It is obtained that The smoke emission drops with increasing ATM pressure and increasing ATM pressure specific fuel consumption of both mixtures. [18]

George Elias Zacharakis-Jutz et. al. was investigated performance characteristics of ammonia engines using direct injection strategies. The first strategy tested liquid direct injection in a compression-ignition (diesel) engine utilizing highly advanced injection timings. Ammonia was used with dimethyl ether (DME) in a duel fuel combustion strategy. Three ammonia-DME ratios were tested: 100%DME, 60%DME-40%NH3, and 40%DME-60%NH3. At a 1900rpm and 2500rpm engine speed. The second strategy tested gaseous direct injection of ammonia in a sparkignition (gasoline) engine. In first case is Results show that engine speed and load decreases as ammonia concentration in the fuel mixture increases. Significant cycle-to-cycle variations are observed when 40%DME-60%NH3 is used. In second case Results show that using gasoline-ammonia little improvement of BSEC or CO2 is observed. It was also observed that that there was a significant increase in both NOx HC. [19]

Dinh Xuan Thanh et. al. used waste cooking oil synthetic is made from waste cooking oil for experimentations. And this blend was used and compared with conventional diesel fuel when they are run on IC Engine. The engine used in this experiment is a single cylinder four stroke water cooled direct injection diesel engine. In this study 40kw regenerative dynamometer is used. To attain specific speed, the engine is run at different speeds. The cylinder pressure were recorded by high speed data acquisition system including 2 high accuracy piezoelectric pressure transducer, a crank angle encoder and a combustion analyzer. The fuel consumption is measured by advanced fuel measurement device. Thermocouple is used to measure exhaust gas engine oil coolant inlet and outlet. The engine running torque decreases from 1.9 Nm to 5.4 Nm at all speeds when using waste cooking oil synthetic diesel as compared to CD. Engine using WCOSD has higher speed than CD. The BTEs of the engine fuelled with WCOSD are higher at almost engine speed. [20]

CONCLUSION: -

From the above literure review following conclusions can be made-

- In most of the cases we can use ethanol-diesel blend up to the 5% to 10% by volume ratio
- The compression ignition diesel engine is used without any modifications.
- The BSFC increases with increase in ethanol percentage.
- The Brake Thermal Efficiency is lesser than pure diesel fuel.

Finally, the review revels that Ethanol is beneficial for environment and it is made from renewable resources.

REFERENCE: -

[1] Nilesh Mohite, Sujit Kumbhar, Vinay Kale, Tausif Mulla, “Study of Performance Characteristics of Variable Compression Ratio Diesel Engine Using Ethanol Blends with Diesel” International Journal of Engineering Science and Technology (IJEST), Vol. 4 No.06 June 2012.
[2] Ho Young Kim, Jun Cong Ge and Nag Jung Choi “Effects of Ethanol–Diesel on the Combustion and Emissions from a Diesel Engine at a Low Idle Speed” Appl. Sci. 2020, 10, 4153; doi:10.3390/app10124153
[3] Tarkan Sandalc J, Yasin Karagöz, Emre Orak, and Levent Yüksek, “An Experimental Investigation of Ethanol-Diesel Blends on Performance and Exhaust Emissions of Diesel Engines” Hindawi Publishing Corporation Advances in Mechanical Engineering Volume 2014, Article ID 409739.
[4] İsmet Celikten, “The Effect of Biodiesel, Ethanol and Diesel Fuel Blends on The Performance and Exhaust Emissions in A DI Diesel Engine” GU J Sci., 24(2):341-346 (2011).
[5] K Rajesh, Ganesh D.B “Assessment of Ethanol as Fuel Additive to Diesel-Biodiesel Blends on Combustion and Performance Characteristics in CI Engine” Blue Eyes Intelligence Engineering & Sciences Publication. DOI: 10.35940/ijitee. I1121.0789S219.
[6] Mehmet Çelik, İlker Örs, Cihan Bayindirli and Mehmet Demiralp, “Experimental investigation of impact of addition of bioethanol in different biodiesels, on performance, combustion and emission characteristics” Journal of Mechanical Science and Technology 31 (11) (2017) 5581~5592
[7] Praveen A. Harar “Experimental investigation on the performance and emission characteristics of compression ignition engine fueled with various blends of water melon biodiesel” Int. Res. Adv., 2017, 4(1), 18-23.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 02, February-2021

[8] Naresh Muddineni, B Anitha Reddy, Dhrubjyoti Baruah, "Preparation and Performance Aaalysis of Biofuels on CI Engine" International Journal of Mechanical Engineering and Technology (IJMET) Volume 8, Issue 12, December 2017, pp. 447–455, Article ID: IJMET_08_12_045.
[9] Nambaya Charyulu Tatikonda, "Comparative Analysis of Performance Characteristics of A Compression Ignition Engine Fuelled with Cymbopogon Oil Methyl Ester and Diesel Blends with Base Engine and Coated Engine" International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181, Vol. 9 Issue 05, May-2020
[10] Ranjan Kumar Mishra, "Engine Performance Characteristics of 4-Stroke Compression Ignition Engine Fuelled with Blends of Biodiesel Extracted from Waste Cooking Oil", Journal of Emerging Technologies and Innovative Research (JETIR), Nov 2014 (Volume 1 Issue 6), JETIR (ISSN-2349-5162).
[11] Thanh Viet Nguyen, Khanh Duc Nguyen, Nang Xuan Ho, Vinh Duy Nguyen, "Engine performance and combustion characteristics of a direct injection compression ignition engine fueled waste cooking oil synthetic diesel", Int J Coal Sci Technol (2020) 7(3):560–570, https://doi.org/10.1007/s40789-020-00328-x.
[12] Vaneet Bhardwaj, Varun Singla, Pradeep Gaikwad and Gomish Sharma, "Study of Performance Characteristics of Compression Ignition Engine Fuelled with Blends of Biodiesel from Used Cottonseed Oil" International Review of Applied Engineering Research.ISSN 2248-9967 Volume 4, Number 3 (2014), pp. 289-296.
[13] Y.H. Teoh, K.H. Yu, H.G. How and H.-T. Nguyen, "Experimental Investigation of Performance, Emission and Combustion Characteristics of a Common-Rail Diesel Engine Fuelled with Bioethanol as a Fuel Additive in Coconut Oil Biodiesel Blends" Energies 2019, 12, 1954.
[14] T. K. Bhattacharya, Ram Chandra and T. N. Mishra, "Performance Characteristics of a Stationary Constant Speed Compression Ignition Engine on Alcohol-Diesel Microemulsions". Agricultural Engineering International: the CIGR Ejournal. Manuscript EE 04 002. Vol.VIII. June, 2006.
[15] Zdzisław Chłopek, Sebastian Jagiełło, Sebastian Juwa, Tomasz Skrzek, "Comparative Examination of Performance Characteristics of an IC Engine Fueled with Diesel Oil and Rape Methyl Esters" The Archives of Automotive Engineering – Archiwum Motoryzacji Vol. 74, No. 4, 2016.
[16] Balachandar.K, Shantharaman.P.P, "Performance and Characteristics of Biodiesel by Using Compression Ignition Engine" International Journal Of Core Engineering & Management (IJCEM), Volume 2, Issue 1, April 2015.
[17] E. Ramjee, K. Vijaya Kumar Reddy and J. Suresh Kumar, "Performance and emission characteristics of compression ignition (CI) engine with dual fuel operation (diesel + compressed natural gas (CNG))" journal of Petroleum Technology and Alternative Fuels Vol. 4(2), pp. 24-29, February 2013.
[18] Jilin Lei, Yuhua Bi, and Lizhong Shen, "Performance and Emission Characteristics of Diesel Engine Fueled with Ethanol-Diesel Blends in Different Altitude Regions" Hindawi Publishing Corporation Journal of Biomedicine and Biotechnology,Volume 2011, Article ID 417421, 10 pages doi:10.1155/2011/417421
[19] George Elias Zacharakis-Jutz, "Performance characteristics of ammonia engines using direct injection strategies" (2013). Graduate Theses and Dissertations. 13032.
[20] Dinh Xuan Thanh, Thanh Viet Nguyen, Dien Vu Minh, Khanh Duc Nguyen,Vinh Nguyen Duy, "Engine Performance Characteristics of a Compression Ignition Engine Fuelled by Traditional Diesel and Waste Cooking Oil" IOP Conf. Series: Materials Science and Engineering 739 (2020) 012011 doi:10.1088/1757-899X/739/1/012011