IMPACT ANALYSIS OF VARIOUS DESIGN AND PERFORMANCE PARAMETERS ON ENGINE PERFORMANCE- A REVIEW PAPER

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Abstract
Energy is the prime requirement for economic development. Every economic sector including agriculture, industries and domestic requires input of energy. As a result of economic development energy consumption in all forms has been steadily rising all over the country. This growing consumption of energy resulted in rising prices of oil and gas and potential shortage in future. In view of this performance enhancement is the basic requirement for the any system to achieve energy conservation. The performance enhancement of conventional stationary diesel engine specifically used in agriculture sector will leads to the overall growth and development of agricultural industries in India. Considering this, the various methods used by different investigators for performance enhancement and emission improvement are studied and their impact on performance and emission are analyzed.
Keywords: Internal combustion engine, Biodiesel, Brake specific fuel consumption, Brake thermal efficiency.

1. Introduction

a) General concept of diesel engine

In internal combustion engine (ICE) the chemical energy of fuel is converted into heat energy through combustion. Via thermodynamic cycle, some heat energy is converted into effective work to drive the engine. The remaining energy is released into the environment in the form of waste heat generated from cooling water and exhaust gas. Owing to their excellent drivability and fuel economy, diesel engines are the most common ICE which is widely used in various sectors such as agriculture, transportation and industry. Due to the rising prices of oil and gas the performance of engine has become the most important factor to achieve economic growth. Further due to their diffusive combustion diesel engines are the main emitters of respiratory suspended particles which have serious effect on environment and could lead to human disease. Therefore the performance and emission are the key issues which require serious attention. Diesel engine with high performance and low emission has become the trend of diesel engine development in the recent time due to the growing concerns of energy conservation and public health. The various methods of achieving performance enhancement and emission improvement in the diesel engine have been studied and analyzed in this paper.

b) Present situation of diesel engine industry and problem identification

Rajkot is one of the leading center and hub for manufacturing and assembling of various automobile parts and all types of diesel engines which are used for various applications in the field of irrigation, small capacity generator set and agriculture. Engines assembled by local manufacturers are tested as per IS:11170:1985 which is the Indian standard for performance aspects of diesel engine used in the agriculture field with rated brake power less than 19kW, however this standard is not covering any requirements related to emission aspects. Therefore, engines manufactured and assembled by local manufacturers contains high amount of

visible smoke in the exhaust which may lead to low overall efficiency and high emission. Considering this limitation and due to the recent export policy framed by Indian government this industry is facing the strong competition in the international market from cost and performance aspects. Therefore, this review is done to help the industry to find out the various methods which can be adopted for improving performance and emission characteristics of the engine.

2. Literature Review

Performance and emission improvement in the diesel engine is not a new concept as lot of work has been done in this direction. Various authors have studied and suggested different methods for achieving this objective. Liang Y U et al. [1] evaluated the impact of various parameters like pressure, timing and duration of combustion on the performance of the diesel engine fueled with Jatropha curcas oil. On the basis of the results he concluded that higher combustion pressure, longer duration of combustion and advancement in timing was desirable for the better engine performance.

P.K.Devan and N.V. Mahalakshmi [2] studied the performance, emission and combustion characteristics of C.I. engine by completely replacing diesel with blends of fuel namely methyl ester of paradise oil and eucalyptus oil. Reduction of smoke by 49%, reduction in HC emission by34.5%, reduction in CO emission by 37% and reduction in NO_X by 2.7% were achieved in this experiment. Baljinder Singh et al. [3] conducted the performance test on engine using various blends of biodiesel produced from mustard oil with commercial diesel. The effect of various blends of biodiesel on parameters such as speed of engine, fuel consumption, brake power, specific fuel consumption and thermal efficiency were measured. The results indicated that 8% blend of above biodiesel with diesel resulted in very good performance without any further modification in engine.

M. Talbi and B.Agnew [4] utilized the energy of exhaust gases from diesel engine for performance enhancement. It was demonstrated that a pre and intercooled turbocharger engine configuration cycle offers considerable benefits in terms of SFC, efficiency and output which are significant in diesel engine performance. Magong He et al. [5] increased the recovery of waste heat from internal combustion engine using combined thermodynamic cycle which consists of two cycles: the organic Ranking cycle for recovering the waste heat of lubricant and high temperature exhaust gas, and Kalina cycle for recovering the waste heat of low-temperature cooling water.

M.Shyam et al.[6] evaluated the performance of the low H.P diesel engine using blend of rapeseed oil with conventional diesel. He observed that emission increases with use of rapeseed oil as a biodiesel however it can be brought to normal by decarburizing of manifold and fuel injector tip. Wearing of critical components because of higher fuel consumption and higher exhaust gas temperature were observed with this biodiesel however it was not abnormal. O.Armas et al. [7] studied the effect of water oil emulsions on performance and emission of light duty diesel engine and investigated that brake thermal efficiency increased while NOx, HC and particulate matter emission decreased by using water oil emulsions. S.Saravanan et al.[8] studied the combined effect of fuel injection timing, EGR percentage and fuel injection pressure in controlling the NO_X emission. It was investigated from the experiment that higher fuel injection pressure (FIP), higher fuel injection timing (FIT) and higher % of EGR (by volume) were resulted in lower NO_X emission.

B.S. Chauhan et al. [9] studied the effect of various factors responsible for higher CO and NO_X emission. This study indicated that at higher load the amount of air remains same and fuel quantity increased which resulted into higher CO emission therefore CO emission increase linearly with the load. At the same time NO_X emission also increased linearly with the load, due to the higher combustion temperature at higher load which is the most important factor for the emission of NO_X. Md. Narun Nabi et al.[10] compared the exhaust emission with neat diesel and diesel biodiesel blends chemically known as mono-alkyl fatty acid ester. The results indicated that CO emission and smoke emission were lower for engine with diesel biodiesel blends. The NO_X emission was higher for engine with diesel bio diesel blends however it can be reduced by applying EGR.

T. Hejwowski and A.Weronski [11] conducted the experiment for studying the effects of thin

thermal barrier coatings on performance of a diesel engine. The results indicated that ceramic coating did not produce observable knock in the engine, further no significant wear of piston skirts or cylinder liner was found and performance of the modified engine was also found satisfactory. Cherng-Yuan Lin and Kuo-Hua Wang[12] investigated the performance and emission characteristics using multi-phase O/W/O (oil in water in oil) test fuels for diesel engine. The results indicated that O/W/O emulsions resulted in lower exhaust gas temperatures and lower NO_X, CO emission and smoke opacity.

Ekrem Buyukkaya [13] conducted the experiment on diesel engine to compare the performance, emission and combustion characteristics of a diesel engine fuelled with pure diesel and using different blends of neat rapeseed oil from 5% to 100%. The results indicated that lower smoke opacity and higher brake specific fuel consumption were resulted with biodiesel. The measured CO emission of B5 and B100 fuels were found to be 9% and 32% lower than that of the diesel fuel, respectively. The combustion analysis indicated that ignition delay was shorter for neat rapeseed oil and its blends as compared to diesel. Gvidonas Labeckas and Stasys Slavinskas [14] examined the effects of inclusion of different blends of rapeseed oil methyl ester in diesel on BSFC, brake thermal efficiency, emission composition and smoke opacity. The results indicated that due to the cost effectiveness and the real advantages in terms of performance, efficiency and emissions, up to 10% bio-fuel blends could be regarded for full scale usage in unmodified diesel engine.

Yackup Incingur and Duran Altiparmak [15] evaluated the effect of fuel cetane no and injection pressure on diesel engine performance and emission. He observed that engine torque and power at maximum torque speed were increased by 5% and 4% respectively with increasing cetane no from 46 to 54.5. However further increase was not resulted in significant change in performance. NO_X emission was reduced by 10% with increase in cetane no from 46 to 61. Cenk Sayin and Mustafa Canakci [16] studied the influence of injection timing on the performance and exhaust emissions when single cylinder diesel engine fuelled with ethanol blended diesel ranging from 0% to 15% with an increment of 5%. The results indicated that for retarded injection timing NO_X and CO_2 emission increased and unburned HC and CO emission decreased for all test conditions. However, with the advanced injection timing decreasing HC and CO emission diminished while NO_X and CO_2 emission boosted. Performance parameters like BSFC and BTE for retarded and advanced injection timing were giving negative effect as compared to the original injection timing for all engine speeds and loads.

Yu Shi and Rolf D Reitz [17] carried out the test to find out optimal injection strategies for a heavy duty C.I. engine fueled with diesel and gasoline like fuels operated under mid and high load conditions using CFD tool. The test results indicated that with an optimized injection system gasoline-like fuels are promising for heavy-duty CI engines due their lower NO_X and soot emissions and higher fuel economy compared to conventional diesel fuels. Oguzhan Dogan [18] aimed to evaluate the influence of n-butanol/diesel fuel blends on engine performance and exhaust emissions in a small diesel engine using 5 test fuels i.e. B5, B10, B15, B20 and neat diesel fuel. The test results showed that smoke opacity, nitrogen oxide and carbon monoxide emissions reduced while hydrocarbon emissions increased with the increasing n-butanol content in the fuel blends however there was increase in the brake specific fuel consumption with increasing n-butanol content in fuel blends.

H.Song et al.[19] studied the impact of variation in fuel properties of biodiesel and petroleum diesel on various engine parameters. He conducted the experiment to verify the effect on nitric oxide emission and smoke concentrations from a diesel engine fuelled with 20% v blend of biodiesel in petroleum diesel. The results indicated that on average biodiesels fuels tend to emit higher NO emissions however the statistical probability of the averages being different is low however in some unique cases biodiesel fuels emit substantially lower NO emission when exhaust gas recirculation is used. Smoke concentration in this study was generally lower with the biodiesel fuels as compared to conventional diesel. A.Agarwal et al.[20] conducted the experiment on single cylinder engine to evaluate the effects of fuel injection

strategies and injection timings on engine combustion, performance and emission characteristics. The results indicated that brake thermal efficiency (BTE) along with exhaust gas temperature and brake mean effective pressure (BMEP) increased up to fuel injection pressure of 500 bars, after which they reduced slightly. For advanced injection timings, BMEP and BTE increased, while brake specific fuel consumption (BSFC) and exhaust gas temperature reduced significantly. Carbon dioxide (CO_2) and HC emissions decreased significantly while NO_X emission increased with advanced injection timings.

Magin Lapuerta et al. [21] conducted the analysis of various work done on biodiesel to study the effect of biodiesel fuel on various performance and emission parameters. He observed that decrease in output power, increase in BSFC and unchanged thermal efficiency were resulted in most of the experiments. While considering the emission aspects, NO_X emission increased with biodiesel because of advanced injection process, however sharp reduction in particulate emissions because of reduced soot formation and enhanced soot oxidation. CO and HC emission decreased considerably with biodiesel because of complete combustion caused by the increased oxygen content in the flame. K.Muralidharan et al.[22] carried out the experiment to estimate the performance, emission and combustion characteristics of a single cylinder four stroke variable compression ratio multi engine fuelled with waste cooking oil methyl ester and its blends with standard diesel. Comparing the results of experiment with that of standard diesel confirmed that there was a considerable improvement in the performance parameters as well as exhaust emissions. It was also found that the combustion characteristics of waste cooking **oil** methyl ester and its diesel blends closely followed those of conventional diesel.

Mustafa Canakci et al. [23] studied the effect of speed on various engine parameters and claimed that speed is one of the important parameter for performance enhancement because it positively affects the turbulence level of air entering into the cylinder, volumetric efficiency and engine friction. Y.He and Y.D. Bao[24] conducted an experiment with an aim to raise the thermal efficiency of an engine fuelled with a mixture of rapeseed oil and conventional diesel oil. The experimental results obtained showed that a mixing ratio of 30% rapeseed oil and 70% diesel oil was practically optimal in ensuring relatively high thermal efficiency of engine as well as homogeneity and stability of oil mixture. Further quadratic regressive orthogonal design test method was adopted to examine the dependence of specific fuel consumption on four adjustable working parameters when the above mentioned fuel was used. It was identified from the analysis that the predominant factor affecting the specific fuel consumption was fuel delivering angle, which in this specific study was 2 to 3 degrees advance as compared to engine fueled with pure diesel oil.

D.descieux and M. Feidt[25] analyzed the thermodynamic performance of an air standard diesel engine with heat transfer and friction losses. It was evident from the analysis that the speed is a predominant factor for enhancing the performance, further there is an existence of two optimal engine speeds one relative to maximum power and the second to maximum efficiency. Murat Karabekats et al. [26] studied the effects of preheated cottonseed oil methyl ester (COME) on the performance and emission of a diesel engine. It was investigated that preheated COME up to 90 Degree leads to favorable effect on thermal efficiency, brake power and CO emission but adversely affects the NO_X emission, however further increase in temperature resulted in adverse effect on the brake power because of fuel leakage caused by decreased fuel viscosity. The results suggested that COME preheated up to 90 degree can be used as an alternative fuel without any significant modification at the expense of NO_X emission.

Cenk Sayin and Metin Gumus[27] investigated the influence of compression ratio(CR) and injection parameters like injection timing(IT) and injection pressure(IP) on the performance and emission of diesel engine using combination of different blends of biodiesel-diesel fuel. Tests were carried out using different combination of CR, IT and IP at 20 N m engine load and 2200 rpm. The results suggested that increased CR, increased IP but original IT are desirable for the best results because for all the tested combination of fuels it leaded to decrease in the smoke opacity, CO and HC emissions however negatively affects the NO_X emission.

Satishkumar et al. [28] analyzed the effects of diesel-alcohol blends on the combustion, performance and emission of diesel engines. It was examined from the study that blending of alcohols along with some CN improver in diesel fuels can reduce diesel engine emissions without adversely affecting performance. It was also revealed that butanol is a better alternative for diesel fuel due to its superior fuel properties than those of methanol and ethanol.

A.Siva Kumar et al. [29] carried out the performance test of a diesel engine with neat diesel fuel and cottonseed oil (CSO) made from transesterification process. The experimental results indicated that exhaust emission including carbon monoxide(CO),particulate matter(PM) and smoke emission were reduced for all biodiesel mixture, however adverse effect was observed on NO_X emission. N .Ravikumar et al.[30] studied the effect of compression ratio and EGR on performance, combustion and emission characteristics of diesel engine. The tests were conducted at different compression ratios with different loads and for different EGR rates. The results indicated that the increase in compression ratio resulted in higher brake thermal efficiency. With increase in EGR percentage the brake thermal efficiency increased by 13.5% and NO_X emission reduced by 11%.

Rafidah Rahim et al.[31] studied the effect of temperature on diesel engine performance when blended with 5% biodiesel using one dimensional numerical analysis of GT-power software for simulation. The simulations are conducted at full load condition where the temperature alters between 300K and 500K. The simulation results indicated that the brake power and brake torque were reduced by 1.39% maximum and 1.13% maximum respectively for the engine operating with fuel blend at different temperatures. The decrease in the lower heating value caused an increase in the brake specific fuel consumption thus reduces the brake thermal efficiency of engine performance at full load. S. Semin et al.[32] investigated the effect of fuel injection pressure (FIP) on performance of diesel engine at fixed load with various speeds. The experimental results obtained in this article showed that, increasing the fuel injection pressure resulted in higher value of IHP and BHP with higher speed. However, the value of SFC decreased with increase in the FIP from 180 bar to 200 bar only when the speed of the engine was higher than1000rpm.

R. Baker and Chang Sik Lee [33] investigated the influence of various factors on the output performance and exhaust emission in the direct injection type diesel engine. The results of this study indicated that combustion parameters have influence on the combustion processes and the nitric oxide emission in the direct injection type diesel engine. The nitric oxide concentration decreased with the increase of engine speed and the advance of injection timing. S. Jindal [34] investigated the effects of the engine operating parameters like compression ratio, fuel injection pressure, injection timing and engine speed on the emission of NO_X and found that higher compression ratio, injection pressure and speed were resulted in lower emission of NO_X for pure diesel as well as diesel blended with biodiesel. CR. Laguitton[35] studied the effect of CR on the emission of diesel engine. The results of a study indicated that, although there was a small CO and HC penalty, either reducing the CR or decreasing the IT greatly reduced OP and NO_X emission. Based on the above literature a comprehensive review of work done by various researchers on engine performance and emission using various methods are analyzed in Table-1 and the impact of different methods on various engine performance and emission parameters are summarized in Table-2.

Table-1- Summarized work by different researchers in the field of performance enhancement and emission improvement.

Author	Method used	Concept	Parameters Affected/Modified	Result/Conclusion
[2]	Diesel engine fueled with Jetropha curcas oil preheated to 150˚C	Finding of ideal combustion pressure, timing of combustion, and duration of	Combustion pressure	Higher than diesel
			Timing of combustion	Earlier than diesel

		combustion for jetropha curcas.	Duration of combustion	Longer than diesel
[3]	C.I. engine fuelled with methyl ester of paradise oil-evcalyptus oil blends replacing diesel engine completely.	Evaluating Performance and Emission characteristics with alternative fuel.	Brake thermal efficiency increased by 2.4% Smoke emission reduced by 49%, HC by 34.5%, CO by 37% . Increase in NO_X emission by 2.7%	Blend of 50% methyl ester paradise oil and 50% eucalyptus oil can be used as an alternative suitable fuel in diesel engine.
[4]	Diesel engine fuelled with biodiesel produced from used mustard oil used in Diesel engine.	Performance test conducted on engine using various blending ratio of biodiesel with commercial Diesel	Speed of engine, SFC, Torque, BP & thermal efficiency	Out of different blending ratios 8% blend of biodiesel with diesel resulted in higher performance without making significant modification in engine.
[5]	Utilization of exhaust gas energy for performance enhancement.	Performance prediction of four different configurations of a turbocharger diesel engine and absorption refrigeration unit combination using SPICE simulation software.	Performance parameters like thermal efficiency, fuel consumption and power output.	Diesel absorption combined cycle with pre-intercooling will have higher output and thermal efficiency however lower overall efficiency
[6]	Use of combined thermodynamic cycle for increasing waste heat recovery.	Use of organic rankine cycle for recovering the waste heat of lubricant and Kalina cycle for recovering the waste heat of cooling water.	Fuel utilization efficiency and performance parameters of engine.	Compared with traditional cycle configuration, more waste heat can be recovered by the combined cycle which ultimately results in to higher performance.
[9]	Stationary diesel engine with different fuel injection timing, fuel injection pressure and percentage of EGR using Taguchi's parametric design.	Combined effect of fuel injection timing, fuel injection pressure and EGR on performance and emission.	NOx emission, smoke concentration and brake fuel conversion efficiency	Retarded injection timing without EGR with standard injection pressure is optimum combination for the reduction in NOx emission with lesser effect on smoke concentration and brake fuel conversion efficiency

[11]	Small Capacity engine experimented with fumigation of ethanol.	Identification of various factors responsible for emission of CO and NO_X emission.	CO and NO_X by increasing load	Higher load increased the CO emission linearly because of increased fuel quantity for same air. It will also increase NO_X emission linearly because of higher combustion temperature.
[13]	Effect of thin ceramic thermal barrier coating on diesel engine performance.	Effect on various performance parameters were analyzed for conventional and modified engine.	Fuel consumption	Lower for modified engine considerably
			Specific fuel consumption	Lower for modified engine by 15-20%
			Power	Higher for modified engine by 8%
			Temperature of cooling water	Few degree higher for modified engine.
[17]	Effect of fuel cetane number and injection pressure on diesel engine performance and emission	The fuel with 46,51,54.5 and 61.5 CN were tested for each injection pressures of 100,150 and 250 bar	NOx Emission	Reduced by 15% when fuel CN number is increased for the standard injection pressure. It increased slightly for injection pressure of 250 bar.
			Smoke Emission	Increased when injection pressure is reduced to 100 bar however decreased when injection pressure is increased to 250 bar.
			Engine torque and power output	Increase in engine torque by 5% and power output by 4%with increase in CN from 46 to 54.5 however no significant increase beyond 54.5
[19]	Investigation of original injection strategies for a heavy duty C.I. engine fuelled with diesel and	A non dominated sorting genetic algorithm-II was coupled with CFD tool	NO_X and soot emission	In optimized injection system, gasoline like fuels are promising for

	gasoline like fuels operated under mid and high load condition with CFD tool.	to seek optimal combinations of injection system variables.		heavy duty CI engines due to their lower NO_X and soot emission compared to conventional diesel.
[22]	Determine the effect of fuel injection strategies and fuel injection timing on engine combustion, performance and emission characteristics.	Single cylinder engine was run at constant speed of 2500 rpm with 2 FIP i.e. 500 and 1000 bar at different injection timings (SOI).	BTE	Increased with increase in FIP
			BMEP, BSFC & EGT	BMEP increased up to 500 bar than reduced slightly while BSFC and EGT reduced significantly for advanced SOI.
			Emission	CO2 and HC emission decreased however NOx emission increased with increase in FIP. Lower CO2 and HC emission while higher NOX emission was observed with advanced injection timing.
[25]	Prediction of engine performance and exhaust emission for 5 different neural networks to define how the input affect the outputs using different biodiesel blends of waste frying palm oil.	Using artificial neural network (ANN) model, the performance and exhaust emission of a diesel engine have been predicted for biodiesel blends.	Fifth network was found sufficient for all outputs from performance and emission aspects.	Fuel properties, engine speed and environmental conditions were taken as input. So they can be considered as important parameters for performance and emission aspects.
[27]	The thermodynamic performance of air standard diesel engine with heat transfer and friction loss is analyzed.	Generic methodology was used to simulate the static response of an IC engine to determine the various factors affecting power and efficiency.	Cylinder volume, stroke bore ratio, compression ratio, air fuel ratio, speed and wall temperature.	Existence of two optimal parameters for each case one relative to maximum power and second to maximum efficiency.

[32]	VCR engine run at different compression ratio and at different load with different EGR rates.	Attempt is made to study the effects of cooled exhaust gas recirculation on performance, combustion & emission of VCR Diesel engine	Performance Parameters.	With increase in CR the brake thermal efficiency increases and SFC decreases.
			Emission parameters.	It is found that with raise in % EGR the NOX emission was gradually decreases by 11% to 85% at different CR . Smoke opacity gradually decreases at all CR.
			Duration of combustion.	The combustion duration was decreases by 2 to 3 Deg. With increase in CR due to less ignition delay.
[33]	4 cylinder 2 stroke engine run at Fixed load and various engine speed and then at fixed speed and different engine load.	Diesel engine power, performance and fuel consumption values are investigated based on load variation, engine speed with increasing fuel injection pressure.	IP, IHP, BP.BHP, Bmep were investigated for various speed fixed load and fixed speed and various load with increasing injection pressure.	Effect of increasing injection pressure, increases fuel consumption in both fixed load-variations in engine speeds and fixed engine speed-variation in loads
[34]	The 4 stroke single cylinder diesel engine was run with the different speed and different injection timing.	It presents the investigation of influence factors on emission in D.I. Diesel engine.	Speed and injection timing are dominant factors for emission of Nitric Oxide	The nitric oxide emission decrease with the increase of engine speed and advance of injection timing. Increase in the engine speed at given injection timing reduces the Nitric oxide concentration.
[35]	The Diesel engine run with the Jetropha Bio Diesel to investigate the effect of various engine parameters on NO_X emission	It targets the investigating effects of engine operating parameters such as CR, FIP, FIT and engine speed on emission of Nox. .	Compression ratio	NO_X emission increases with compression ratio.
			Engine speed	NO_X emission increases with decrease in speed.
			Injection pressure	NO_X emission decreases with increase in injection pressure.

.**Table-2- Impact of various methods on performance and enhancement**

Sr No	Method Implemented	Performance Parameters			Emission parameters			
		BSFC	ηBth	Output Power	CO	HC	NO_X	Smoke
1	Different blends of Jetropha curcas oil with diesel	Decrease	Increase	-----	Decrease	Decrease	Increase	Increase
2	Blends of methyl ester made of paradise oil-eucalyptus oil with diesel	----	Increase	-----	Decrease	Decrease	Increase	Decrease
3	Blends of mustard oil with diesel	----	No Change	No Change	------	----	----	----
4	Utilization of energy of exhaust gases of diesel engine	Increase	Increase	Increase	---	----	---	-----
5	Use of combined thermodynamic cycle for increasing recovery of waste heat from diesel engine.	Increase	Increase	Increase	----	----	----	----
6	Blends of rapeseed oil with conventional diesel (Decarburizing exhaust manifold and fuel injector tip after every 100 hrs)	No Change	No Change	No Change	----	----	---	----
7	Water oil emulsion in conventional diesel	----	Increase	-----	-----	Decrease	Decrease	Decrease
8	Increasing FIT, FIP & % of EGR in diesel engine.	----	----	----	----	----	Decrease	Decrease
9	Blends of Pamolin biodiesel in diesel	----	----	----	----	----	Increase	Decrease
10	Increase in % of load of diesel engine	----	----	-----	Increase	----	Increase	------
11	Blends of mono alkyl fatty acid ester in diesel	---	---	------	Decrease	-----	Increase	Decrease
12	Thin thermal barrier ceramic coating in diesel engine	Decrease	Increase	Increase	----	----	----	-----
13	Use of multiphase O/W/O for diesel engine	----	-----	-----	Decrease	-----	Decrease	Decrease
14	Use of different blends of rapeseed oil with diesel	Increase	----	----	Decrease	----	----	Decrease
15	Use of various blends of rapeseed oil methyl ester with diesel	Increase	No Change	-----	Decrease	Decrease	Increase	Decrease
16	Effect of increasing cetane no(CN) and fuel injection pressure(FIP) in diesel engine.	---	-----	Increase	---	----	Decrease	Increase

17	Blends of ethanol biodiesel in diesel with advancement of fuel injection timing(FIT) in	Decrease	Decrease	----	Decrease	Decrease	Increase	-----
18	Effect of advancement of injection timing in diesel engine.	---	---	----	----	---	Decrease	Decrease
19	Effect of various blends of n butanol biodiesel with diesel	Increase	Increase	-----	Decrease	Increase	Decrease	Decrease
20	Effect of differences in the fuel properties of biodiesel compared to diesel	---	----	----	----	----	Increase	Decrease
21	Advancement of injection timing (FIT) in diesel engine.	Decrease	Increase	----	----	Decrease	Increase	-----
22	Effect of various blends of waste cooling oil methyl ester in diesel	Decrease	Increase	----	Decrease	Decrease	Increase	------
23	Increase in speed of diesel engine	Decrease	Increase	Increase	---	----	Decrease	---
24	30% rapeseed oil blends with commercial diesel .	---	Increase	Increase	---	---	---	----
25	Preheated(up to 90°C)cotton seed oil methyl ester with diesel	----	Increase	Increase	Decrease	----	Increase	-----
26	Increase in compression ratio(CR) and Injection pressure(FIP)	---	---	----	Decrease	Decrease	Increase	Decrease
27	Alcohol blends along with CN improver in diesel	---	----	-----	Decrease	Decrease	Decrease	Decrease
28	Blends of cotton seed oil made from transesterification process.	---	----	----	Decrease	-----	Increase	Decrease
29	Increase in compression ratio(CR) and % of EGR	---	Increase	----	------	-----	Decrease	------
30	Increase in temperature using 5% biodiesel blend in diesel	Increase	Decrease	Decrease	---	----	----	----
31	Increase in FIP with fixed load and various speeds	Decrease	-----	Increase	-----	------	------	----
32 `	Increase in CR, FIP and speed together	----	-----	-----	----	-----	Decrease	---
33 `	Decrease in CR	---	----	-----	Increase	Increase	Decrease	Decrease

3. Conclusion

This above review indicated that in recent years, the most preferred method for achieving performance and emission improvement is part replacement component of petroleum diesel with biodiesel. The reason for this is obvious as most countries of the world are exploring alternate energy sources which are environment friendly and are from renewable source. Some other work has been done direction of modifying either various design parameters like compression ratio, fuel injection pressure, fuel Injection timing or operating parameters like cetane no, load, speed and weight of the engine for improvement in performance and emission parameters. For enhancing competitiveness in the field of agriculture along with performance the mobility and convenience are also important factors, therefore weight reduction possibilities can be applied in this case for achieving these objectives.

REFERENCES

1. Liang Yu, Zhou Li-ying, Wang Zi-yu, Guo Jian, Luo Fu-qiang. (n.d.). Experimental Investigation on the combustion characterstics of a Diesel Engine fueled with Jetropha Curcas Oil.

2. Devan P.K., Mahalakshmi N.V. . (2009). A Study of the performance, emission and combustion characterstics of a compression ignition engine using methyl ester of paradise oil- eucalyptus oil blends. *Applied Energy(86)* , 675-680.

3. Baljinder Singh, Jagdeep Kaur, Kashmir Singh. (2010). Production of Biodiesel from used mustard oil and its performance analysis in Internal Combustion engine. *Journal of energy resources technology* .

4. Talbi M, Agnew. B. (2002). Energy recovery from diesel engine exhaust gases for performance enhancement and Air conditioning. *Applied Thermal Engineering(22)* , 693-702.

5. Maogang He, Xinxin Zhang, Ke Zeng, Ke Gao. (2011 , 6821-6829). A combined thermodynamic cycle used for wate heat recovery of internal combustion engine. *Energy 36* .

6. Shyam M., Verma S.R., Pathak B.S. (1987). Performance of Low Horsepower Diesel engine with a blend of Rapseed Oil and Conventional Diesel fuel. *Energy in agriculture,6* , 231-243.

7. Armas. O, Ballesteros R. Martos F.J., Agudelo J.R. (2005). Characterization of light duty Diesel engine pollutant emissions using water emulsified fuel. *Fuel(84)* , 1011-1018.

8. Saravanan S., Nagarajan G., Sampath S. (2010). Multi response optimization of NOx emission of stationary diesel engine. *Fuel(89)* , 3235-3240.

9. Chauhan Bhupendra Singh, Naveen Kumar, Shyam Sunder Pal, Yong Du Jun. (2011). Experimental studies on fumigation of ethanol in small capacity Diesel Engine. *Energy36* , 1030-1038.

10. Md. Nurun Nabi, Md. Shamim Akhter, Md. Zaglul Shahadat. (2006). Improvement of engine emissions with conventional diesel fuel and diesel-biodiesel blends. *Bioresource Technology 97* , 372-378.

11. Hejwowski, T., Weronski A. (2002). The effect of thermal barrier coatings on diesel engine performance. *Vacuum 65* , 427-432.

12. Lin Cherang-Yuan, Kuo Hua Wang. (2004). Diesel engine performance and emission characteristics using 3 phase emulsions as fuel. *Fuel 83* , 537-545.

13. Buyukkaya, E. (2010). Effects of biodiesel on a DI diesel engine performance emission and combustion characteristics. *Fuel 89* , 3099-3105.

14. Labeckas Gvidonas, Stasys Slavinskas. (2006). The effect of rapeseed oil methyl ester on direct injection Diesel engine performance and exhaust emissions. *Energy Conversion and Management 47* , 1954-1967.

15. Icingur Yakup, Duran Altiparmak. (2003). Effect of fuel cetane number and injection pressure on a DI Diesel engine performance and emissions. *Energy*

Conversion and Management 44 , 389-397.

16. Cenk Sayin, Mustafa Canakci. (2009). Effects of Injection timing on the engine performance and exhaust emissions of a dual fuel diesel engine. *energy conservation and management 50* , 203-213.

17. Yu Shi, Rolf D. Reitz. (2010). Optimization of a heavy duty compression ignition engine fueled with diesel and gasoline like fuels. *Fuel 89* , 3416-3430.

18. Dogan Oguzhan. (2011). The influence of n-butanol/diesel fuel blends utlization on a small diesel engine performance and emissions. *Fuel 90* , 2467-2472.

19. H.Song, B.T.Tompkins, J.A.Bittle, T.J.Jacobs. (2012). Comparisions of NO emissions and soot concentrations from biodiesel-fuelled diesel engine. *Fuel 96* , 445-453.

20. Avinash Kumar Agarwal, Dhananjay Kumar Srivastava, Atul Dhar, Rakeshkumar Maurya, Praveshchandra Shukla, Akhilendra Pratap Singh. (2013). Effect of fuel injection timing and pressure on combustion, emissions and performance characteristics of a single cylinder diesel engine. *Fuel111* , 374-383.

21. Lapuerta Magin, Octavio Armas, Jose Rodriguez Fernandez. (2008). Effect of biodiesel fuels on diesel engine emissions. *Progress in Energy and combustion science 34* , 198-223.

22. Muralidharan K., Vasudevan D., Sheeba K.N. (2011). Performance, emission and combustion characteristics of biodiesel fuelled variable compression ratio engine. *Energy 36* , 5385-5393.

23. Canakci Mustafa, Ahmet Necati Ozsezen, Erol Arcaklioglu, Ahmet Erdil. (2009). Prediction of performance and exhaust emissions of a diesel engine fueled with biodiesel produced from waste frying palm oil. *Expert Systems with Applications 36* , 9268-3280.

24. He Y., Bao Y.D. (2003). Study on rapeseed oil as alternative fuel for a single cylinder diesel engine. *Renewable Energy 28* , 1447-1453.

25. D.Descieux, M.Feidt. (2007, 1457-1466). One zone thermodynamic model simulation of an ignition compression engine. *Applied Thermal Engineering 27* .

26. Karabektas Murat, Gokhan Ergen, Murat Hosoz. (2008). The effects of preheated cottonseed oil methyl easter on the performance and ehaust emissions of a diesel engine. *Applied Thermal Engineering 28* , 2136-2143.

27. Sayin Cenk, Metin Gumus. (2011). Impact of compression ratio and injection parameters on the performance and emissions of a DI diesel engine fueled with biodiesel-blended diesel fuel. *Applied Thermal Engineering 31* , 3182-3188.

28. Satish Kumar, Jae Hyun Cho, Jaedeuk Park, II Moon. (2013). Advances in diesel-alcohol blends and their effects on the performance and emissions of diesel engines. *Renewable and Sustainable energy Reviews 22* , 46-72.

29. Sivakumar A., Maheswar D., Vijaya Kumar Reddy K. (2009). Comparision of Diesel engine performance and emissions from Neat and Transesterified cotton seed oil. *Journal of Mechanical and Industrial Engineering* , 190-197.

30. N. Ravi Kumar, Y.M.C Sekhar, S.Adinarayana. (2013). effects of compression Ratio and EGR on Performance Combustion and Emissions of DI Injection Diesel Engine. *International Journal of Applied Science and Engineering* , 41-49.

31. Rahim Rafidah, Rizalman Mamat, Mohd Yusof Taib, Abdul Adam Abdullah. (2012). Influence of Fuel Temperature on a Diesel Engine Performance Operating with Biodiesel Blended. *Internationa Journal of Advanced Science and Technology* .

32. Semin S., R.Abu Bakar, A.R. Ismail, I.Ali. (2008). An experimental investigation of

diesel engine fuel injection pressure effect on power, performance and fuel consumption. *Archieve of SID* .

33. Rosil Abu Bakar, Chang Sik Lee. (1997). the effect of Combustion Parameters on the Nitric Oxide Emission in direct Injection type Diesel engine. *KSME Internationa Journal Vol 11* , 672-680.

34. Jindal, S. (2010). effect of engine parameters on NOx Emissions with Jatropha biodiesel as fuel. *International Journal of energy and Environment* , 343-350.

35. Laguitton, O. (n.d.). The effect of compression ratio on exhaust emission from a PCCI diesel engine. *Energy Conversion and Management 48(2007) 2918-2924* .