Effect of Cylindrical Combustion Chamber Shape, on the Performance of Home Oil Biodiesel Fueled Diesel Engine.

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***Abstract*: An experimental investigation is done on a single cylinder four stroke direct injection diesel engine operated on honge oil as a biodiesel. This experimental study mainly focused on investigation of the performance of diesel engine using Honge oil (Pongemia)**

The performance and emission characteristics were analyzed with cylindrical combustion chamber shape, nozzle geometry, injection pressure and EGR.

Engine tests are carried on the single cylinder four stroke diesel engine. This study is to investigate effect of change in the combustion chamber shape on the performance of biodiesel operated diesel engine.Due to the biodiesel in the diesel engine it is found that the engine performance is decreasing this is happening due to improper mixing of air and fuel. The performance of the engine can be made good by altering the shape of the piston. The performance and emission characteristics will be studied for various piston geometries of engine(HCC , CCC) and for the given diesel engine the piston geometry which gives better performance is selected Using the design of experiments

Keywords: Cylindrical combustion chamber; Biodiesel (HOME); Design of experiments by Taguchi analysis; Exhaust gas recirculation.

1. INTRODUCTION

These days, all the light vehicles and the heavy duty vehicles are being run using diesel fuel. In India, diesel used for 1 day is approximately 4 million barrels per day of oil (calculated in the year 2017), if this is the condition then there is no longer availability of the fuel in future(1). Diesel extraction countries like Iran, Iraq, Kuwait etc, as per their calculation there wont be any longer availability of the fuel after 60- 70 years.In order to overcome these difficulties there is a research on the use of biodiesels as a fuel in diesel engine(2).

Lot of research work was done on using solar energy to run the vehicles but unfortunately that doesent work(3).Therefore the left option is using biodiesel, in Malaysia around 70% of the car are run using POME oil biodiesel as well as in the countries like India, buses are being run on biodiesel blends.But there is still research going on, on using 100% biodiesel to run the vehicles.

In this study the experimental investigation was carried out on the single cylinder four stroke diesel engine using 100% biodiesel and for the better results of the engine in order to make higher efficiency we are altering the parameters like Cylindrical combustion chamber, Injection pressure, EGR (exhaust gas recirculation).

1.1 EGR (Exhaust Gas Recirculation)

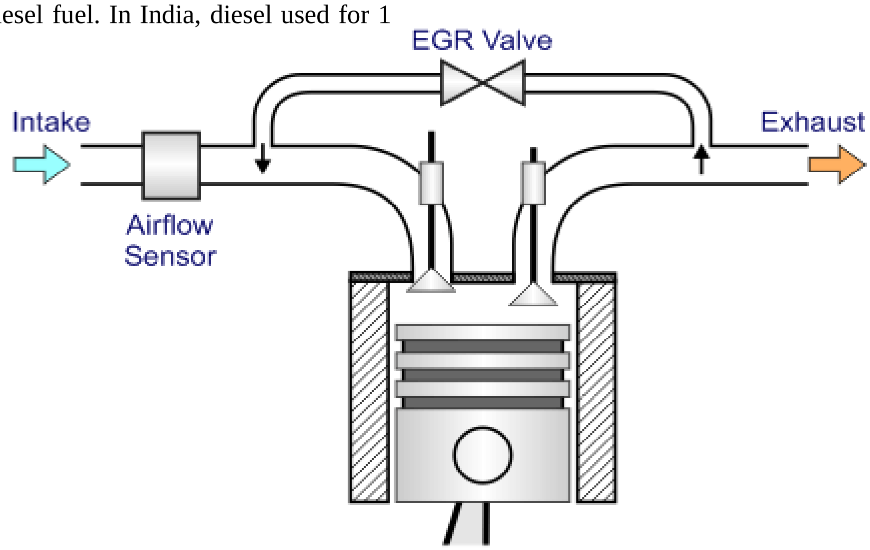


Fig a. Exhaust Gas Recirculation Set-up.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 01, January-2019

In order to reduce the NO_x emissions exhaust gas recirculation is used. This helps in recirculating the small amount of exhaust gas to the engine intake as a intake air and helps in the proper mixing of air fuel mixtures.

This system mainy has exhaust gas inlet and gas outlet and as well as cold water inlet and hot water oullet it contains a large number of tubings inside the system through which the water is circulating, the hot exhaust gases temperature from the engine is about 300 to 400^0C this temperature is suitable to supply it to engine inlet therefore the temperature of the gas is cooled down by EGR(4). EGR has given with a ball valve which controls thegas inlet to the EGR systemthe valve can be adjusted to 5%, 10% 15% etc. cold water is circulated into the system and when the hot gases enter the chamber heat exchange takes place between water and the hot gases water gains the temperature of the hot gases and converts it around 40^0 to 45^0C so that it can be recirculated to the engine. When engine takes normal air that is around 27^0 to 30^0C therefore the mixing of air-fuel mixture doesent happen properly if the air-fuel mixture isn't proper then it affects the efficiency of the engine so exhaust gas recirculation is used.

1.2 PROPERTIES OF FUEL USED

Fig.1 HONGE TREE Fig.2 HONGE SEEDS Fig.3 HONGE OIL

The properties of fuel were calculated under laboratory conditions in energy conversation laboratory of the college

Table.1 Properties of diesel fuel and biodiesel (Honge)

Property	**Honge biodiesel**	Diesel
Flash point (^{0}C)68	142	68
Fire point (^{0}C)	195	66
Calorific value (MJ/kg)	37.15	42.00
Viscosity at 40^0 C (mm^2/sec)	4.7	2.28
Density at 15^0 C (kg/m^3)	894	830
Acid number (mg KOH/g)	0.45	0.34
Water content (mg/kg)		102
Ash content (%)	0.01	0.01

From the table it is clear that the calorific value of the biodiesel is 37MJ.The viscosity and the density of the biodiesel is more compared to diesel fuel.Similarly the flash point and fire point for Diesel is lesser comapred to Biodiesel

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 01, January-2019

2. EXPERIMENTAL METHOD

Fig 4. shows Experimental Test Engine

Table 2 - Engine Specifications

Engine	Four stroke single cylinder
Make	Kirloskar
BHP	5HP
RPM	1500
Fuel	Diesel
Bore	80mm
Stroke length	110mm
Cooling method	water cooled
Ignition method	Compression ignition
Compression ratio	1:17.5

An experimental investigation is done on a single cylinder four stroke direct injection diesel engine operated on honge oil as a biodiesel and is a four stroke water cooled. Initially the engine is operated at a constant speed of 1500 rpm engine can withstand higher pressure, water is used as a medium of cooling, water required for the engine cooling was forced by a water pumpthrough the water jacket. The engine specifications are showen in the above table.

Initially selection of biodiesel is based on availability of biodiesel. The biodiesel used in this work is HOME(honge) (This experiment is conducted on pure biodiesel i,e: 100% biodiesel without any blends)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 01, January-2019

2.1 Installing modified cylindrical piston

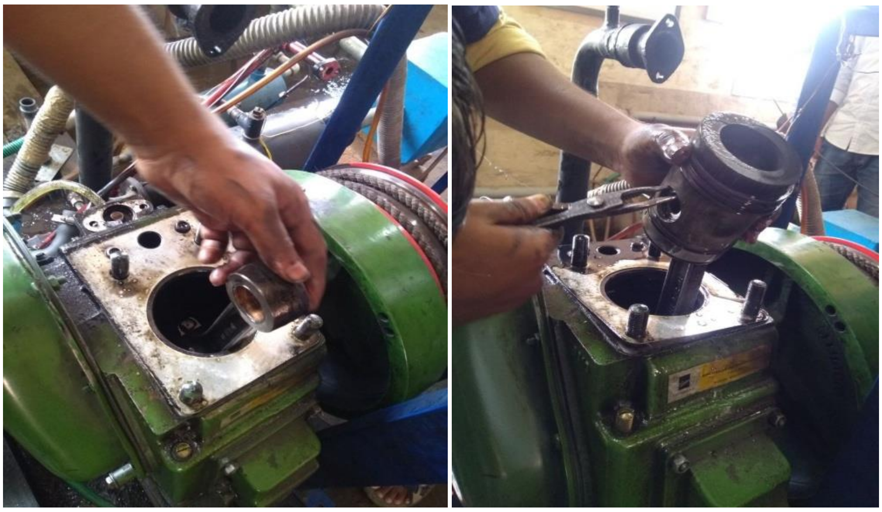


Fig 5. Installing Cylindrical Piston , (Hemispherical piston is removed and modified cylindrical piston fitted on to the connecting rod)

2.2 Design of Hemispherical piston geometry

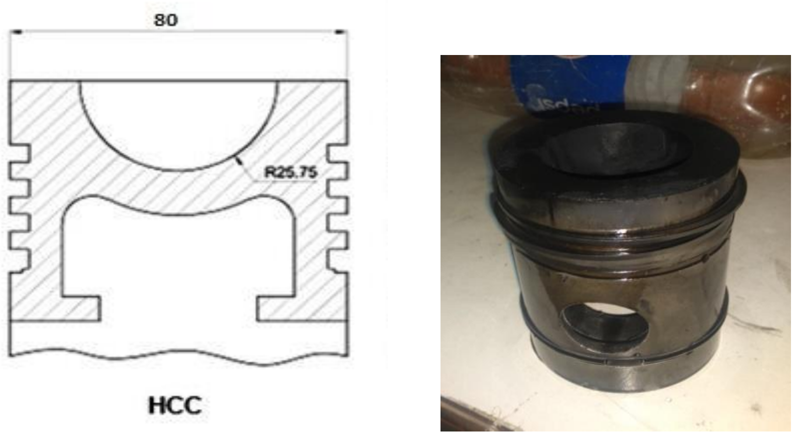


Fig 6. shows the hemispherical combustion chamber shape and having the 80mm bore diameter with 25mm radius.

2.3 Design of Cylindrical piston geometry

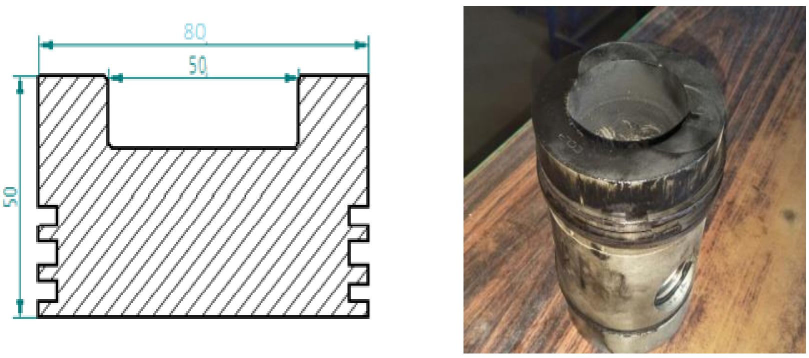
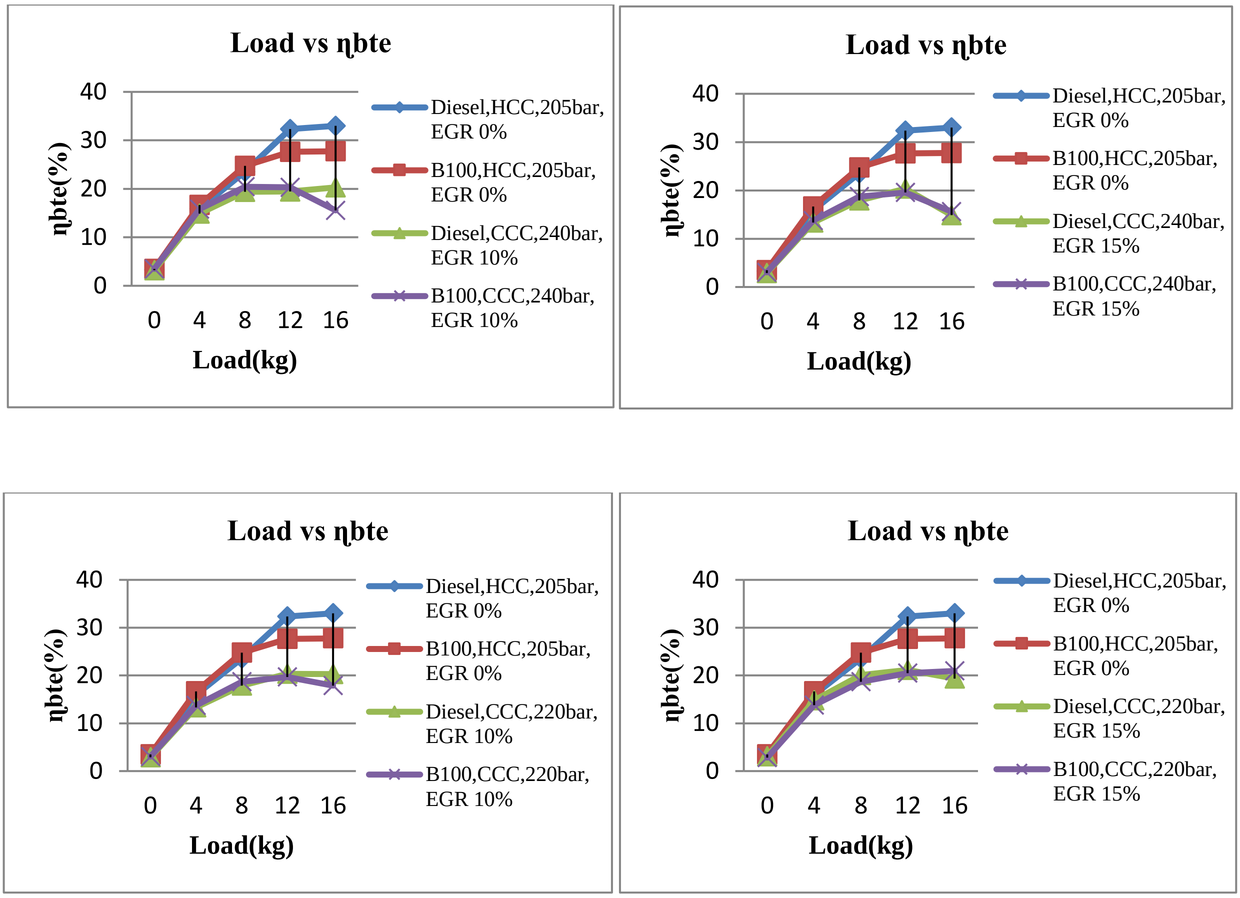


Fig 7.Cylindrical combustion chamber shape.

3. RESULTS AND DISCUSSION

3.1 Brake thermal efficiency:



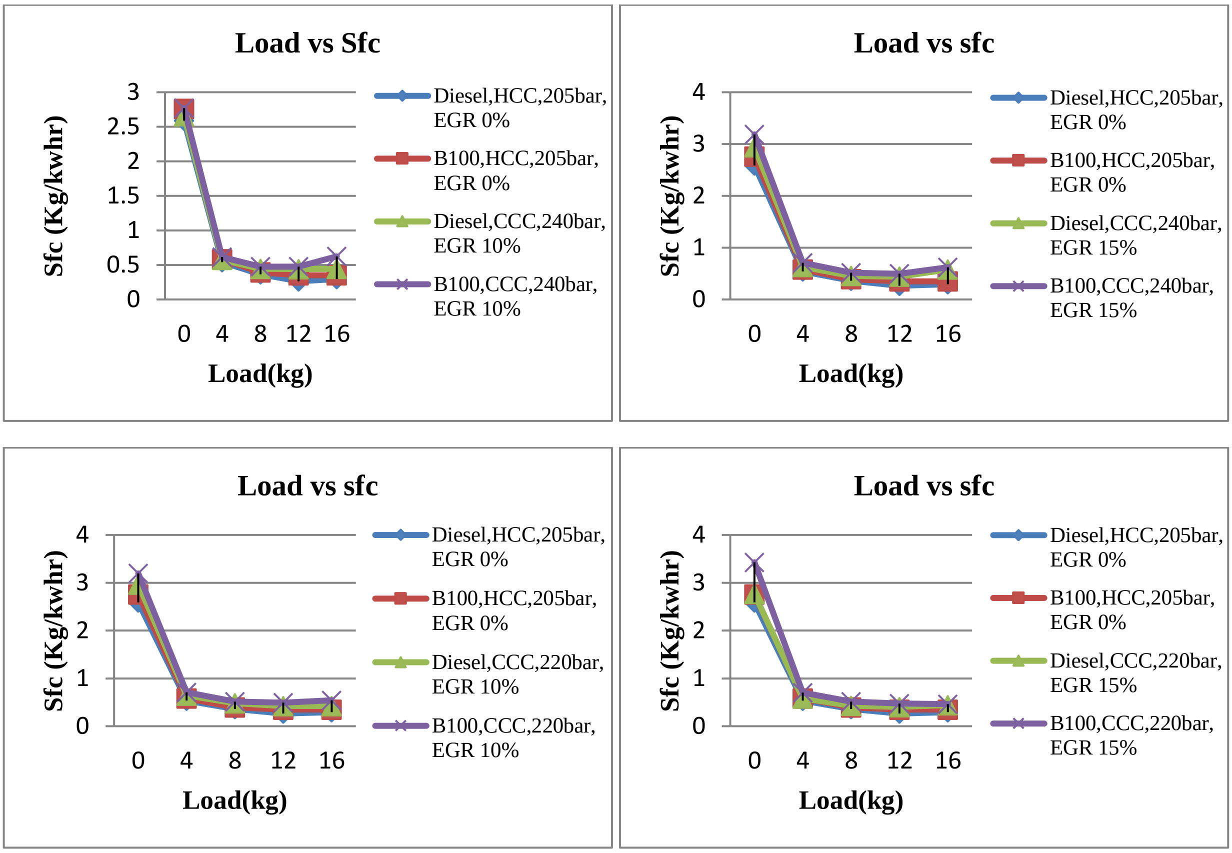
Graphs: Load vs Brake thermal efficiency

The above graph shows the variation of Load vs brake thermal efficiency. Load increases with brake thermal efficiency increses. In HCC shape with EGR(10 %) and without EGR diesel gives higher brake thermal efficiency for all loads. Brake thermal efficiency has improved with increase in load for both parameters and it is observed that diesel for HCC shape and B100 for CCC shape gives more efficiency.

From the graph and validation by taguchi method the result for diesel,brake thermal efficiency is more at injection pressure 220bar and EGR 10% with 4 holes nozzle geometry, similarly for B100 brake thermal efficiency is more at injection pressure 220bar and EGR 15%4 holes nozzle geometry .

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 01, January-2019

3.2 Specific fuel consumption:

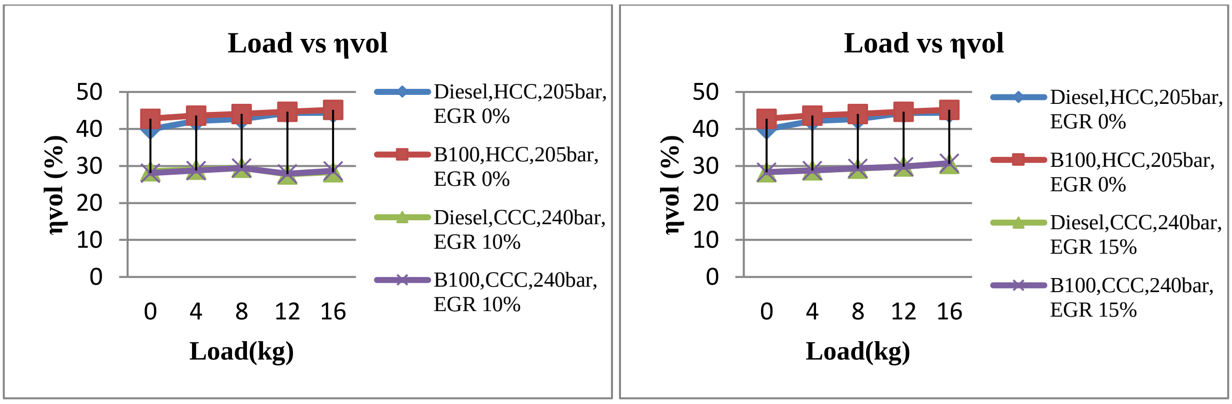


Graphs: Load vs Specific fuel consumption

The above graph shows the variation of Load vs Sfc. It is observed that the Sfc is less in HCC with EGR compared to without EGR. The specific fuel consumption is less in CCC with EGR (10 %) for B100 blend compared to CCC shape without EGR. Specific fuel consumption in cylindrical combustion chamber is more compared to hemispherical combustion chamber due to poor combustion.

From the graph and validation by taguchi method the result for diesel, Specific fuel consumption is less at injection pressure 220bar and EGR 10% with 4 holes nozzle geometry, similarly for B100 Specific fuel consumption is less at injection pressure 220bar and EGR 15% 4 holes nozzle geometry.

3.3 Volumetric efficiency:



International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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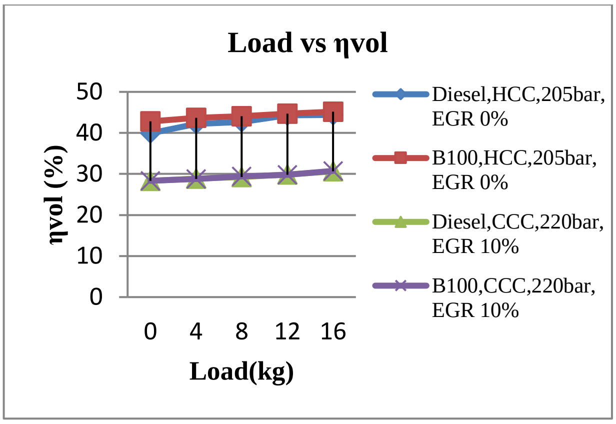

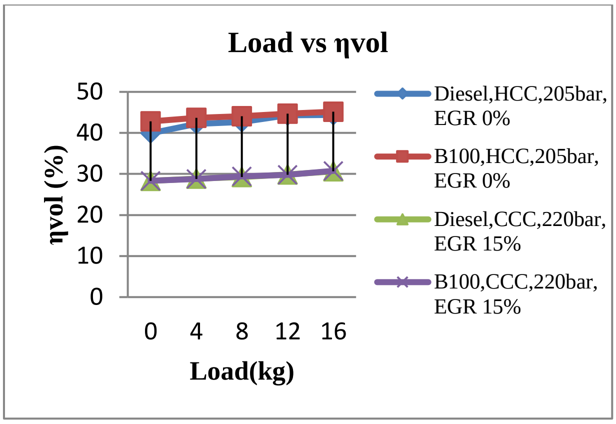

Graphs: Load vs Volumetric efficiency

The above graph shows the variations of Load vs volumetric efficiency. It is observed that Volumetric efficiency In cylindrical combustion chamber with EGR 15 % and injection pressure 220bar,using fuel as B100 is more than volumetric efficiency of HCC without EGR.

From the graph and validation by taguchi method the result for diesel,volumetric efficiency is more at injection pressure 220bar and EGR 10% with 4 holes nozzle geometry, similarly for B100 volumetric efficiency is more at injection pressure 220bar and EGR 15%4 holes nozzle geometry.

4. VALIDATION BY TAGUCHI METHOD:

4.1 For Diesel Fuel:

1. Generate L4 array by minitab software using Taguchi Method.

↓	C1	C2
	IP	EGR
1	220	10
2	220	15
3	240	10
4	240	15

2. Enter the brake thermal efficiency of experimental result in the C3 column of L4 array as shown below

↓	C1	C2	C3
	IP	EGR	BTE
1	220	10	20.31
2	220	15	19.36
3	240	10	20.30
4	240	15	14.87

International Journal of Engineering Research & Technology (IJERT)
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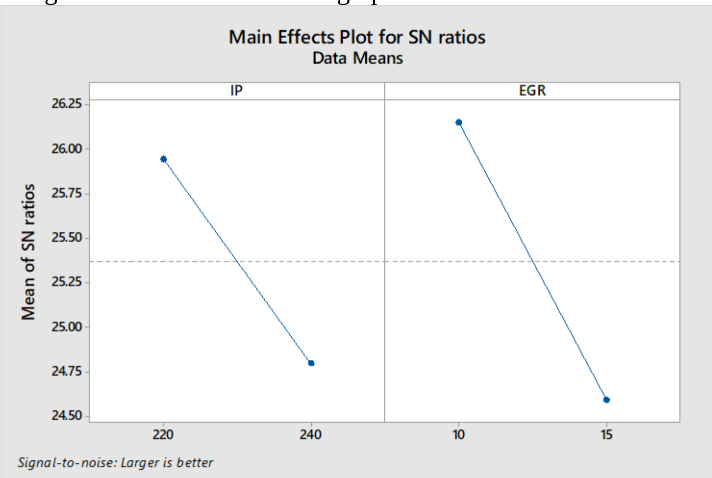
3. Analyze the above taguchi design so that SN ratio and SN graph is obtained.



(Note:- Larger is better)

From above graph it is clear that the nominal operating parameters are 220 Bar pressure and 10% EGR

4.1.1 Response table for signal to noise ratio:

Level	IP	EGR
1	25.95	26.15
2	24.8	24.59
Delta	1.15	1.56
Rank	2	1

- From the set of experiments it is clear that Primary cause for increase in efficiency is EGR 10%, secondary cause is Iinjection pressure 220bar.

4.1.2 Analysis of variance:

Source	DF	Adj SS	Adj MS	F-value	P-value	%
IP	1	5.062	5.062	1.01	0.499	24.99%
EGR	1	10.176	10.176	2.03	0.390	50.23%
Error	1	5.018	5.018			24.77%
Total	3	20.256				99.99%

4.1.3 Regression Equation:

BTE = 52.6 - 0.638 EGR - 0.112 IP

SR.NO	IP	EGR	BTE_{exp}	BTE_{the}
1	220	10	20.31	21.58
2	220	15	19.36	18.39
3	240	10	20.30	21.58
4	240	15	14.87	16.15

4.2 For Honge(B100):

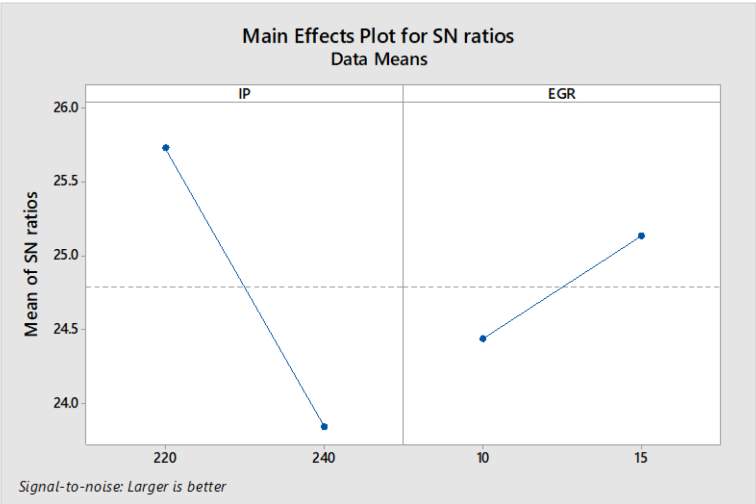
1. Generate L4 array by minitab software using Taguchi Method.

↓	C1	C2
	IP	EGR
1	220	10
2	220	15
3	240	10
4	240	15

2. Enter the brake thermal efficiency in the C3 column of L4 array as shown below.

↓	C1	C2	C3
	IP	EGR	BTE
1	220	10	17.88
2	220	15	20.94
3	240	10	15.54
4	240	15	15.57

3. Analyze the above taguchi design so that SN ratio and SN graph is obtained.



From above graph the optimize value injection pressure 220 bar and EGR 10% shows highest brake thermal efficiency.

4.2.1 Response table for signal to noise ratio.

Level	IP	EGR
1	24.44	25.73
2	25.13	23.84
Delta	0.69	1.90
Rank	2	1

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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Primary cause for increase in efficiency is EGR 10%,secondary cause for increase in efficiency is Iinjection pressure 220bar.

4.2.2 Analysis of variance:

Source	DF	Adj SS	Adj MS	F-value	P-value	%
IP	1	14.861	14.861	6.47	0.238	76.04%
EGR	1	2.387	2.387	1.04	0.494	12.21%
Error	1	2.295	2.295			11.74%
Total	3	19.543				99.99%

4.2.3 Regression Equation:

BTE = 58.0 - 0.1928 IP + 0.309 EGR

SR.NO	IP	EGR	BTE_{exp}	BTE_{the}
1	220	10	17.88	18.674
2	220	15	20.94	20.219
3	240	10	15.54	14.818
4	240	15	15.57	16.363

4. CONCLUSIONS

1. Biodiesel can be used as alternative fuel for diesel engine by some modification of engine because of its higher viscosity.
2. Mass of fuel consumption decreases in HCC with EGR compared to without EGR. Mass of fuel consumption is less in CCC with EGR for blend B100 at lower loads.
3. Specific fuel consumption in cylindrical combustion chamber shape is more compared to hemispherical combustion chamber due to poor combustion.
4. Brake thermal efficiency for diesel is higher in CCC without EGR as compared to B100 blend gives higher brake thermal efficiency in CCC shape with EGR 15 % and 220bar IP.
5. Volumetric efficiency is higher for HCC without EGR compared to with EGR due to higher inlet temperature and diluting the mixture.
6. In both HCC and CCC with EGR gives higher mechanical efficiency compared to without EGR. In the condition the B100 gives higher mechanical efficiency compared to with EGR and without EGR.
7. By attaching the EGR set up along with slight modification of combustion chamber and nozzle geometry, there is a enhances the performance parameters by using the biodiesel as fuel in the diesel engine.
8. By the comparison, the experimental values are very close to theoretical values, by using, taguchi method. The optimized parameters in diesel engine for diesel fuel at 220 bar, 4 holes nozzle geometry and 10 % EGR optimized in CCC shape. Similarly, the optimized parameters in diesel engine for HOME fuel at 220 bar, 4 holes nozzle geometry and 15 % EGR optimized for HOME fuel in CCC shape.

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