COMBUSTION ANALYSIS OF CI ENGINE FUELED BY PONGAMIA PINNATA BIODIESEL AND HYDROGEN AS A SECONDARY FUEL

VIGNESH RAVI[1], J.DHIYANESWARAN[2], P.KARTHICK[3], V.VIJAY VARSHIDH[4]

[1]PreFinal Year Student, Mechanical Engineering
[2]Assitant Professor, Mechanical Engineering
[3]PreFinal Year Student, Mechanical Engineering
[4]PreFinal Year Student, Mechanical Engineering
Chettinad College of Engineering & Technology, Karur-639 1144

***

Abstract - *The use of alternate fuels is much needed one in the near future. The depleting stage of the fossil fuels and the pollution caused by it are the main reasons for the need of alternate fuels. Hydrogen is expected to be one of the most important fuels in the near future to meet the fuel scarcity and stringent emission norms. On the other hand, pongamia pinnata biodiesel is also one of the most important alternative fuels because of its easy availability and nature of growth. In this experimental investigation, combustion analysis is done on CI engine fueled by pongamia pinnata biodiesel with hydrogen induction. The combustion parameters such as heat release rate, peak pressure and ignition delay are computed. It is observed that the hydrogen induction of 10 LPM with biodiesel shows that heat release rate and cylinder pressure are about 4% and 8% respectively higher when compared to diesel which results in reduced emissions. From the result it is inferred that, the ideal value of hydrogen induction with the biodiesel is found to be 10 LPM and further increase in hydrogen induction leads to knocking inside the cylinder.*

Key Words: CI Engine, Pongamia Pinnata Bio Diesel, Secondary Fuel Hydrogen.

1. INTRODUCTION

Energy is a physical quantity that is much needed for the growth of the world. The increase in population and strenuous growth of industrialization has made some disturbances in the ecosystem of the earth. The increase in population and economic development results in the need for energy. Energy demand for each sector is increasing rapidly. The residential and commercial energy demand is about to rise about 30% by 2040. This vast need for energy is due to the urbanization where more people are moving from rural areas to cities. The people's way of living is changed which results in the use of modern fuels apart from those wood and agricultural waste which were used as a fuel earlier. As there is an considerable increase in transportation market over the past few years ,the demand of energy increases due to the increase in commercial vehicles such as planes, trucks, trains, cars. It is estimated to rise about 40 percent from 2010 to 2040. Industry is the initiator of the global market. As there is an increase in population, the need for daily products rises for which leads to the establishment of the companies and factories. Industry also sustains the growth in the economy by creating job opportunities and services. Overall the need for energy increases day by day.

1.1 DEPLETION OF FOSSIL FUELS

Energy is of three forms: fossil, renewable and fissile. At present, most of the energy comes from fossil fuels like petroleum, coal and natural gas. Nearly 80% of energy comes from the use of fossil fuel as a source. Fossils fuels are consumed at a rapid rate so that it is depleting slowly and within two decades it will be completely exhausted. The present energy situation is that most of oil and gas reserves present in gulf countries are in their peak production levels which will slowly decrease as the days goes on. The main reasons for the depletion of resources are due to the rapid growth of urbanization and industrialization. Oil reserves accounts for about 63% of the global reserves which is in its peak production from 2015-2040 and the danger of running out. The natural gas forms the primary source of energy production and its use is growing rapidly and it accounts for about 25% of energy production. It will in peak production from 2020-2050. Coal is evenly spread across the world and it accounts for 23% of global energy production and eventually 37% of is used for the production of electricity. Finally, the fossil fuel is not renewable and its use is increasing fastly which lead to depletion of the resources.

1.2 PROPERTIES OF FUELS

The use of biodiesel as an alternate fuel is mainly because of its reduced emissions and increased engine efficiency. Addition of hydrogen with biodiesel however will further reduce the emissions and lead to higher engine performance. From the past experimental analysis it is found that for all load conditions, hydrogen injection led to reductions in total PM mass concentration ranging from 10 to 50 %. Pure biodiesel shows 10 to 25% increase in NOx emissions over neat diesel fuel as pointed out by Anil Singh Bika et al (2008). To conclude NOx emissions show little to no change with hydrogen input however other emissions (CO, CO_2, and HC) are reduced considerably. The Table 1.1 lists the properties of diesel, pongamia pinnata biodiesel and hydrogen which has been adopted in the literatures Saravanan et al (2008) and Savita Sangwan et al (2010).

Properties of Diesel, Pongamia Pinnata biodiesel and hydrogen

Properties	**Diesel**	**Pongamia Pinnata**	**Hydrogen**
Formula	$C_nH_{1.8n}C_8$-C_{20}	-	H_2
Auto ignition temperature (K)	530	-	858
Flammability limits (volume % in air)	0.7-5	-	4-75
Density at 160 C and 1.01 bar (kg/m^3)	833-881	-	0.0838
Flame velocity (cm/s)	30	-	265-325
Quenching gap in NTP air (cm)	-	-	0.064
Diffusivity in air (cm^2/s)	-	-	0.63
Octane number	30	-	130
Cetane number	40-55	51	-
Boiling point (K)	436-672	-	20.27
Viscosity at 15.5°C, centipoises	2.6-4.1	5.51	-
Vapour pressure at 38°C (kPa)	Negligible	-	-
Specific gravity	0.83	0.917	0.091

Important properties of diesel, biodiesel and hydrogen

Parameters	**Diesel**	**Pongamia Pinnata**	**Hydrogen**
Calorific value (MJ/kg)	44.32	41.3	121
Flash point (°C)	90	158	-
Fire point (°C)	110	185	-

2. EXPERIMENTAL SETUP

The experiment is done by running the engine at constant speed at no load condition and it is sufficiently warmed at each load conditions and coolant water temperature is maintained as per the engine specification. The important thing to notice is before taking the readings the engine should be sufficiently warmed up with respective test fuels.

At first, the engine is made to run at no load condition for about 15 minutes to achieve steady state condition. Then, the 10 cc of fuel consumption time, exhaust gas temperature, cylinder pressure, mass flow rate of air and mass flow rate of hydrogen readings are taken for different load conditions from (0%, 20%, 40%, 60%, 80% and 100%) respectively for different LPM's of hydrogen. The other readings like speed, mean effective pressure are noted from the data acquisition software 'Engine Soft'. The Figure 4.4 shows the block diagram of the experimental setup with data acquisition system. The Figure 4.5 shows the photographic view of the experimental setup.

Table -1: Combustion parameters of test fuels at peak load (80%)

Fuel	Crank Angle (deg)	Peak HRR (J/deg)	Crank Angle (deg)	Peak Pressure (bar)
Diesel	361	100.45	369	63.74
Biodiesel	357	83.76	369	62.27
Biodiesel + hydrogen 10 LPM	357	105.56	367	70.03

it is clear that the peak pressure and heat release rate for pongamia pinnata biodiesel along with 10 LPM of hydrogen occurs at a crank angle of 357° and 367° respectively, while for pure pongamia pinnata biodiesel it occurs at a crank angle of 357° and 369° respectively and finally for pure diesel it occurs at a crank angle of 361° and 369° respectively. From this, it is evident that the ignition delay for pongamia pinnata biodiesel along with 10 LPM of hydrogen induction is considerably lesser when compared to pure diesel and pongamia pinnata biodiesel. This is because of the combustion property of hydrogen which induces faster combustion inside the cylinder.

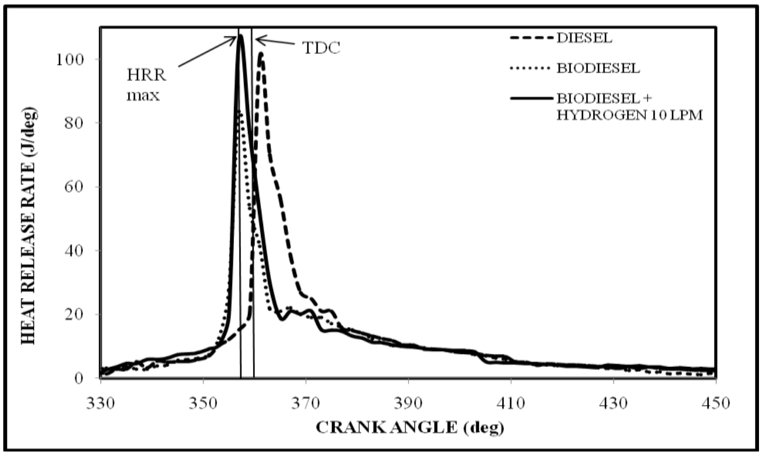


Chart-1: Crank Angle Vs HRR for different fuel at 80% load

The Chart-1 shows the comparative analysis of the graph between crank angle and heat release rate for diesel, pongamia pinnata biodiesel and pongamia pinnata biodiesel along with 10 LPM of hydrogen as fuel intake. The HRR is measured with one degree crank angle accuracy. It is noted that the heat release rate is around 4% to 5% higher that of diesel. Normally, with pure pongamia pinnata biodiesel as a primary fuel the heat release rate at this condition is said to be minimum because as the ignition delay is shorter, the premix combustion phase for biodiesel is less intense. However, with addition of hydrogen the heat release rate is increased above diesel. This indicates that the combustion inside the cylinder occurs fully with minimum unburnt fuel molecules when compared with diesel and biodiesel. This increase is mainly due to the higher calorific value of hydrogen

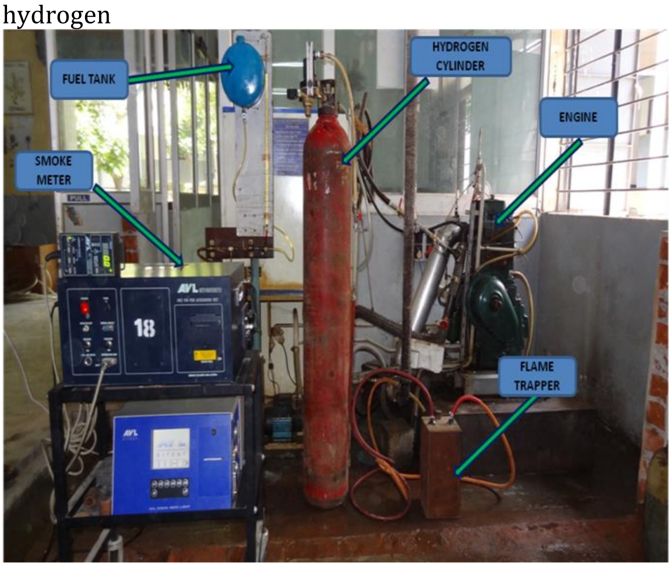
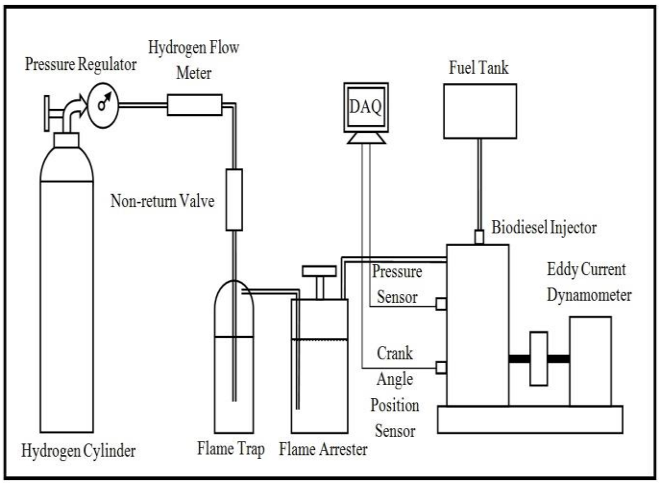


Fig -1: Photographic view of the experimental setup



3. CONCLUSIONS

Experiments are conducted for different LPM's of hydrogen along with the pongamia pinnata biodiesel as an ignition source at different load conditions. The significant condition is found to be at 10 LPM of hydrogen induction along with the pongamia pinnata biodiesel at 80% load condition. Further increase in hydrogen induction above 10 LPM with the pongamia pinnata biodiesel leads to knocking inside the cylinder. The following results are drawn from the present experimentation:

- The heat release rate found to be maximum at 10 LPM of hydrogen induction along with the pongamia biodiesel at 80% load condition and it is around 4% to 5% higher that of diesel
- The peak pressure of 70.03 bar occurring at 7 ° CA after TDC for biodiesel with 10 LPM of hydrogen induction at 80% load shows that the peak pressure is around 8% higher compared to diesel
- The ignition takes place a little earlier when compared to pure diesel because of the faster combustion of hydrogen

Based on the above results, it can be concluded that due to higher heat release rate, cylinder pressure and shorter ignition delay, the complete combustion takes place inside the cylinder and therefore, the emissions are considerably reduced when compared to diesel.

REFERENCES

[1] Anil Singh Bika, Luke M. Franklin and David B. Kittelson (2008), 'Emissions Effects of Hydrogen as a supplement Fuel with Diesel and Biodiesel', SAE Paper 2008-01-0648.

[2] Avinash Kumar Agarwal*, Atul Dhar (2013), 'Experimental investigations of performance, emission and combustion characteristics of karanja oil blends fuelled DICI engine', Renewable Energy 52 283-291.

[3] Ayhan Demirbas (2008), 'Biodiesel'-A realistic fuel alternative for diesel engine,.

[4] Fayaz H. Saidur R. Razali N. Anuar F.S. Saleman A.R. Islam M.R (2012), 'An overview of hydrogen as a vehicle fuel', Renewable and Sustainable Energy Reviews, Volume 16, Issue 8, Pages 5511-5528.

[5] Heywood J B (2008), 'Internal combustion engine fundamentals', McGraw-Hill series in mechanical engineering.
.