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# INFLUENCE OF INJECTION PRESSURE ON PERFORMANCE PARAMETERS OF SEMI ADIABATIC DIESEL ENGINE WITH CRUDE VEGETABLE OIL WITH MAGNETIC INDUCTION

[1] D.S.Madhuri, [2] M.Ravi Chandra, [3] M.V.S. Murali Krishna

[1, 3] Department of Mechanical Engineering , Chaitanya Bharathi Institute of Technology, Hyderabad- 500 075, Telangana India.

[2] Mechanical Engineering Department, Gayatri Vidyaparishad College of Engineering, Madhuravada, Visakhapatnam- 530048 Andhra Pradesh, India,

**ABSTRACT:** Increase of injector opening pressure has a significance effect on performance and formation of pollutants inside the direct injection diesel engine combustion. Compression ignition (CI) engines are used to move major portion of the world's goods, power much of the world's equipment, and generate electricity more economically than any other device in their size range. Increasing industrialization of developing countries is resulting in increased demand for diesel worldwide. Substitution of this demand with straight vegetable oils (SVOs) is comparatively environmentally benign compared to diesel and biodiesel. However, drawbacks associated with crude vegetable oil of high viscosity and low volatility, which cause combustion problems, call for low heat rejection (LHR) engine or semi adiabatic diesel engine with its significant characteristics of maximum heat release and ability to handle the low calorific value fuel. LHR engine consisted of ceramic coated cylinder head. A hydrocarbon fuel was polarized by exposure to external force such as magnetism. The result of which is of course, more complete and rapid burning of the hydrocarbon fuel. Investigations were carried out to determine performance parameters of brake thermal efficiency, brake specific energy consumption, exhaust gas temperature, coolant load and volumetric efficiency with conventional engine (CE) and LHR engine with and without magnetic induction with vegetable oil operation with varied injector opening pressure. With vegetable oil with LHR engine with magnetic induction improved performance, when compared with CE.

**Keywords**: [Vegetable oils, Low heat rejection, Ceramic coating, Performance parameters, Injector opening pressure]

## 1. INTRODUCTION

Fossil fuels are limited resources; hence, search for renewable fuels is becoming more and more prominent for ensuring energy security and environmental protection. It has been found that the vegetable oils are promising substitute for diesel fuel, because of their properties are comparable to those of diesel fuel. They are renewable and can be easily produced. When Rudolph Diesel, first invented the diesel engine, about a century ago, he demonstrated the principle by employing peanut oil. He hinted that vegetable oil would be the future fuel in diesel engine [1]. Several researchers experimented the use of vegetable oils as fuel on conventional engines (CE) and reported that the performance was poor, citing the problems of high viscosity, low volatility and their polyunsaturated character. It caused the problems of piston ring sticking, injector and combustion chamber deposits, fuel system deposits, reduced power, reduced fuel economy and increased exhaust emissions [1–5]. Increased injector opening pressure may also result in efficient combustion in compression ignition engine [6-8]. Further increasing the injector opening pressure increases the nominal mean spray velocity resulting in better fuel-air mixing in the combustion chamber. Higher fuel injection pressures increase the degree of atomization. The fineness of atomization reduces the ignition lag, due to higher surface volume ratio. Smaller droplet size will have a low depth of penetration, due to less momentum of the droplet and less velocity relative to air, from where it has to find oxygen after evaporation. Because of this, air utilization will be reduced due to fuel spray being shorter. Also with smaller droplets, aggregate area of inflammation will increase after ignition, resulting high-pressure rise during second stage of combustion. Thus lower injection pressure giving larger droplet size may give lower pressure rise during the second stage of combustion and probably smoother running. However, poor performance at lower injector opening pressures indicates slow mixing probably because of insufficient spray penetration with consequent slow mixing during diffusion burning. Hence an optimum mean diameter of the droplet should be attempted as a compromise. The variation of injection opening pressure was done with nozzle-testing device. It has a significance effect on performance and formation of pollutants inside the direct injection diesel engine combustion. Experiments were conducted on engine with vegetable oil with increased injector opening pressure [6-8]. They reported that performance of the engine improved, particulate emissions reduced and $NO_x$ levels increased marginally with an increase of injector opening pressure.

The drawbacks associated with vegetable oils (high viscosity and low volatility) call for hot combustion chamber, provided by low heat rejection (LHR) combustion chamber. The concept of the engine with LHR combustion chamber is reduce heat loss to the coolant with provision of thermal resistance in the path of heat flow to the coolant. Three approaches that are being pursued to decrease heat rejection are

(1) Coating with low thermal conductivity materials on crown of the piston, inner portion of the liner and cylinder head (LHR–1 engine),

(2) air gap insulation where air gap is provided in the piston and other components with low-thermal conductivity materials like superni (an alloy of nickel),cast iron and mild steel (LHR–2 engine) and

(3).LHR –3 engine contains air gap insulation and ceramic coated components.

Experiments were conducted on LHR-1 engine with vegetable oil. [9-11]. They reported from their investigations, that LHR-1 engine at an optimum injection timing of $31^o$ bTDC with vegetable oil operation increased brake thermal efficiency by 5-6%, at full load operation–decreased particulate emissions by 25–30% and increased $NO_x$ levels, by 30–35% when compared with neat diesel operation on CE at $27^o$ bTDC.

Installation of magnets at the fuel circuit is an old art. Investigations were carried out on diesel engine and petrol engine on the effect of electromagnetic flux density on the ionization and the combustion of fuel[12].Number of experiments in which infl uence of magnetic field with 1000 Gauss to 9000 Gauss intensity on working of IC engine and exhaust emission was studied for analysis. They reported that a considerable reduction in the hydrocarbon constituent and particulate matter of the exhaust. Experiments were conducted on two stroke gasoline engine with providing magnets of different intensities (2000,4000, 6000 and 9000 Gauss) [[13]. The overall performance and exhaust emission tests showed a good result, where the rate of reduction in gasoline consumption ranged between (-1) %, and the higher the value of a reduction in the rate of 1% was obtained using field intensity 6000 Gauss as well as the intensity 9000 Gauss. It was found that the percentages of exhaust gas components (CO, HC) were decreased by 30%, 40% respectively, but CO2 percentage increased up to 10%.

Investigations were carried out on the study of magnetic fuel ionization method in four stroke diesel engines [14]. The results yielded from the experiments showed that thermal efficiency increased by 2% and emissions reduced to 5%.

Experimental work was carried out with magnetic fuel conditioner in internal combustion engine [15]. A permanent magnet was mounted in path of fuel lines. Mounting magnets in fuel line enhance fuel properties by aligning & orienting hydrocarbon molecules, better atomization of fuel (Proper mixing of air with fuel) etc. Use of such fuel conditioners improves mileage & better emission of vehicle. Finally this article also reviewed about new emerging technology i.e. fuel conditioners, developments done across the globe.

A study of the existing literature on LHR engine thus reveals inconclusive results. Little literature is available on comparative studies on performance parameters with LHR-1 engine with magnetic induction. The present work attempts to make comparative studies with two versions of engine i.e. the conventional and the one with thermally insulated combustion chamber, LHR–1, (ceramic coated cylinder head); with crude cottonseed oil with varied injector opening pressures. The comparison was made with and without magnetic fuel conditioner. Results were compared with CE and also diesel working on similar operating conditions.

## 2. MATERIALS AND METHODS

### 2.1. Fabrication of LHR-1 engine:

Partially stabilized zirconium (PSZ) of thickness 500 microns was coated on inside portion of cylinder head by means of plasma coating technique. Fig. 1 shows photographic view of LHR-1 engine with ceramic coated combustion chamber.

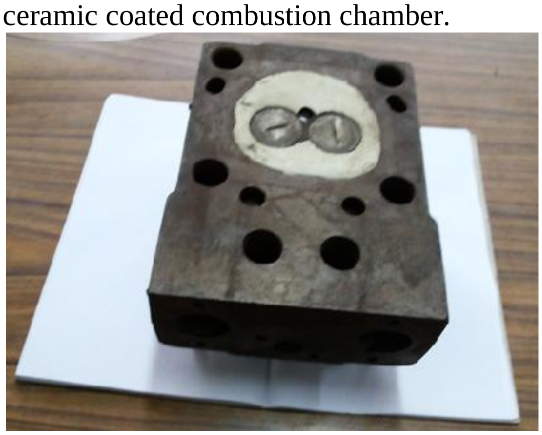
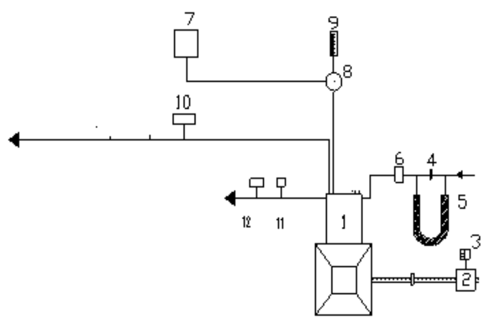


Fig.**1Photographic view of ceramic coated cylinder head**

### 2.2Experimental set-up

As mentioned earlier, this experiment uses two cylinder heads. The experimental set up used for investigations on engine with insulated combustion chambers with crude cotton seed oil is shown in Fig.2.The specifications of the experimental engine are given in Table1. The engine is connected to an electrical dynamometer (Kirloskar make) for measuring its Brake Power (BP).Dynamometer is loaded by loading rheostat. The combustion chamber consists of a direct injection type with no special arrangement for swirling motion of air. The fuel is measured by Burette method while air consumption of engine is measured by Air box method. The naturally aspirated engine is provided with water cooling system. Engine oil is provided with a pressure feed system. However, there is no measurement of temperature of lubricating oil. The Exhaust Gas Temperature and water flow outlet temperature are measured by means of thermocouples made of iron and iron-constantan attached to the temperature indicator.




1.Engine, 2.Electical Dynamometer, 3.Load Box, 4.Orifice flow meter, 5.U-tube water manometer, 6.Air box, 7.Fuel tank, 8, Pre-heater, 9.Burette, 10. Exhaust gas temperature indicator, 11.Outlet jacket water temperature indicator, 12. Outlet-jacket water flow meter, 13. Magnetic fuel conditioner.

**Table1:Specifications of Engine**

| Description | Specification |
|---|---|
| Engine make and mod | Kirloskar ( India) AV1 |
| Maximum power outp at a speed of 1500 rp | 3.68 kW |
| Number of cylinders ×cylinder position× stroke | One × Vertical position × four stroke |
| Bore × stroke | 80 mm × 110 mm |
| Method of cooling | Water cooled |
| Rated speed ( constan | 1500 rpm |
| Fuel injection systen | In-line and direct injection |
| Compression ratio | 16:1 |
| BMEP @ 1500 rpm | 5.31 bar |
| Manufacturer's recommended injectio timing and pressure | 27°bTDC × 190 bar |
| Dynamometer | Electrical dynamometer |
| Number of holes of injector and size | Three × 0.25 mm |
| Type of combustion chamber | Direct injection type |
| Fuel injection nozzle | Make: MICO-BOSCH No- 0431-202-120/HB |
| Fuel injection pump | Make: BOSCH: NO- 8085587 |

## 2.3.General description of cottonseed oil:

Odourless, dirty brown coloured liquid. Less dense than water and insoluble in water. Hence floats on water. Freezing point 32°F. Contains principally the glycerides of palmitic, oleic and linoleic acids. It is basically a triglyceride ester with a number of branched chains of 8-18 carbon atoms. Its chemical Formula is $C_{55}H_{100}O_6$, Molecular Weight is 857.38. Table.2 shows the Physio Chemical properties of diesel and cottonseed oil as per IICT :

| PROPERTY | DIESEL | COTTONSEED |
|---|---|---|
| Calorific Value | 44,800 kJ/kg | 39,648 kJ/kg |
| Fire Point | 68 ° C | 322° C |
| Flash point | 52-95 ° C | 316 ° C |
| Viscosity | 0.278 poise | 2.52 poise |
| Density | 0.916 kg/m$^3$ | 0.832 kg/m$^3$ |
| Cetane number | 50 | 41.8 |

**Table .2- Properties of Diesel and Cotton seed oil**

## 2.4 Provision of magnetic induction Specifications of Magnet

The permanent magnet has certain specifications like shape, size, gauss value, curie temperature.The shape of magnet is rectangular. The number of magnets provided is four. The magnetic intensity varied from 7000 - 9000 gauss. The dimensions of the magnet is 5cm× 2.5cm×1.25 cm

**Fig. 3 Installation of Magnetizer Set Up on the fuel line.**

The magnetizer is installed after the pneumatic governor and before the injector on inlet pipe or housing for maximum alignment and maximum effect. The magnets are placed in pairs (2 pairs), and are placed on the fuel pipe through a special arrangement fabricated with mild steel material. This enables the easy removal of the magnets from the fuel line.

## 2.5 Operating Conditions

Different configurations of the combustion chamber used in the experiment are conventional engine and LHR-1 engine. Various test fuels used in experiment are crude vegetable oil ( cotton seed oil) and diesel. The injection pressures were varied from 190 bar to 270 bar. Different operating conditions were with magnet induction and without magnetic induction.

## 3. RESULTS AND DISCUSSIONS

**Performance Parameters:** The various performance parameters determined were brake thermal efficiency, brake specific energy consumption, exhaust gas temperature and volumetric efficiency which varied with brake mean effective pressure**.**

Fig 4 shows variation of brake thermal efficiency (BTE) with brake mean effective pressure (BMEP) with different versions of the engine with diesel and vegetable oil operation without magnetic induction.

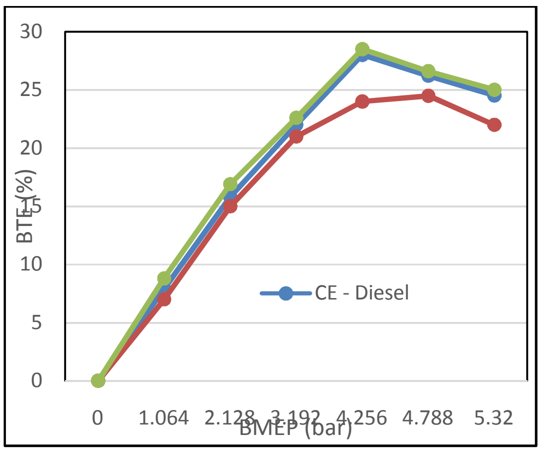



Fig. 4 Variation of brake thermal efficiency (BTE) with brake mean effective pressure (BMEP) of the engine without magnetic induction BTE increased up to 80% of the full load and beyond that load it decreased with test fuels with different versions of the engine. Increase of mechanical efficiency and fuel conversion efficiency might have increased BTE with test fuels up to 80% of the full load and beyond that load it decreased with test fuels with different versions of the engine. Decrease of mechanical efficiency, fuel conversion load and volumetric efficiency might have deteriorated the performance of the different versions of the engine. Conventional engine (CE) with vegetable oil operation showed deteriorated performance in comparison with CE with neat diesel operation. Low calorific value and high viscosity of vegetable oil might have showed deterioration in performance over diesel fuel on CE. LHR-1 engine with vegetable oil showed increased BTE over CE with diesel operation. Improved evaporation rate and reduced duration of combustion in hot environment provided by LHR-1 engine increased performance of the engine with vegetable oil operation.

Fig.5 shows the variation of brake thermal efficiency(BTE) with brake mean effective pressure(BMEP) with different versions of the engine with vegetable oil operation with magnetic induction(MI). Performance improved with magnetic induction with test fuels different version of the engine. A hydrocarbon fuel is polarized by exposure to external force such as magnetism. This state creates the condition for freer association of fuel particles. Under this condition, an alignment in the individual molecules occurs which then permits rapid bonding with the respective oxidizing media. The result of which is of course, more complete and rapid burning of the hydrocarbon fuel. Hydrocarbon molecules treated with a high magnetic field tends to de-cluster forming smaller associates with higher specific surface for the reaction with oxygen leading to improved combustion.

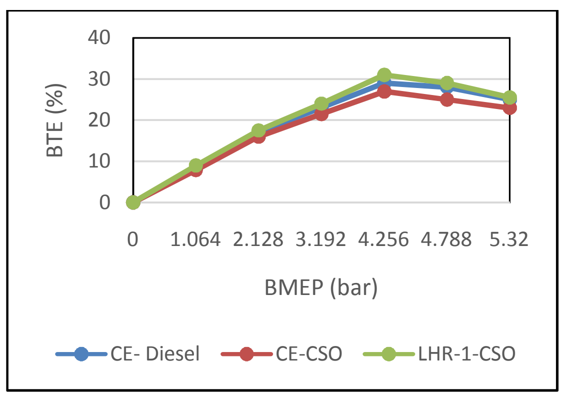



**Fig. 5 Variation of brake thermal efficiency (BTE) with brake mean effective pressure(BMEP) of the engine with magnetic induction**

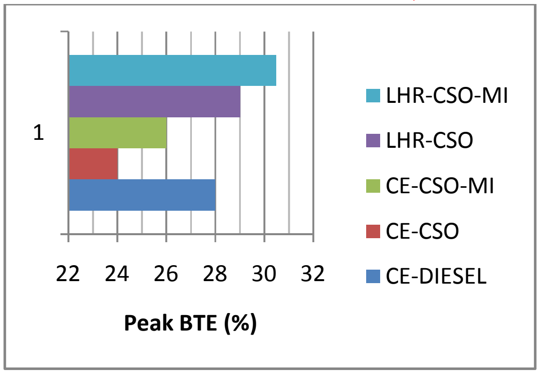



**Fig.6 Bar chart showing the variation of peak brake thermal efficiency (BTE) with different versions of the engine with test fuels with and without magnetic induction**

Different versions of the engine showed improved performance with magnetic induction with test fuels. Arrangement of the fuel particles in stream lined position might have improved the performance of the different versions of the engine with test fuels. CE with vegetable oil without magnetic induction decreased peak BTE by 14% when compared with CE with neat diesel operation. CE with vegetable oil with magnetic induction increased peak BTE by 8% when compared with CE with vegetable oil operation without magnetic induction. LHR-1 engine with vegetable oil operation showed comparable peak BTE in comparison with CE with neat diesel operation. Without magnetic induction, LHR-1 engine without with vegetable oil operation increased peak BTE by 21% in comparison with CE with vegetable oil operation.. With magnetic induction, with vegetable oil operation, LHR-1 engine increased peak BTE by 17% when compared with CE. This showed that LHR-1 engine with vegetable oil operation with magnetic induction showed improved performance in comparison with other versions of the engine. High heat release rate and alignment of fuel particles in streamline might have improved the performance of the engine with magnetic induction with LHR version of the engine. Table3 shows data of peak BTE varied with injector opening pressure for different versions of the engine with and without magnetic induction. From Table.3, it is observed, that peak BTE increased marginally with an increase of injector opening pressure with test fuels with different versions of the engine with and without magnetic induction.

| Engine Version | Test Fuel | Peak BTE (%) Injection Pressur (bar) | |
|---|---|---|---|
| | | 190 | 27( |
| CE | Diesel | 28 | 30 |
| CE | CSO | 24 | 26 |
| CE | CSO -MI | 26 | 28 |
| LHR | CSO | 29 | 31 |
| LHR | CSO - MI | 30.5 | 32 |

**Table.3-Data of peak brake thermal efficiency**

Improved spray characteristics of the fuel might have improved peak BTE with an increase of injector opening pressure. With magnetic induction, peak BTE increased with test fuels with different versions of the engine when compared with without magnetic induction.

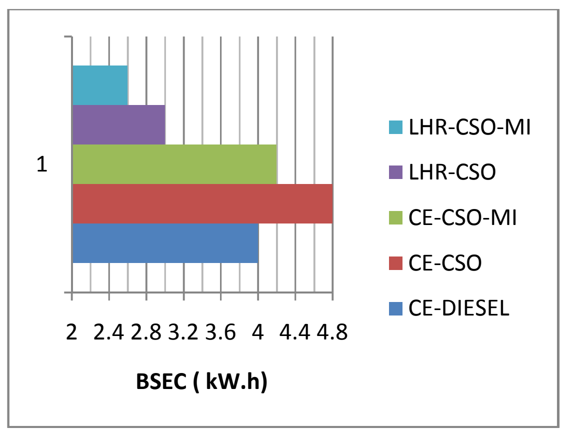



**Fig.7 Bar chart showing the variation of brake specific energy consumption (BSEC) at full load with different versions of the engine with test fuels with and without magnetic induction**

Cotton Seed oil with CE showed deteriorated performance in comparison with CE with diesel. Lower calorific value and higher viscosity of cottonseed oil might have increased BSEC at full load in comparison with CE with diesel operation. However, with magnetic induction with cottonseed oil with CE showed comparable performance with CE with diesel as fuel. This may be due to alignment of fluid flow lines under the action of magnets, which improved combustion effectively indicating lower or comparable BSEC at full load. With cottonseed oil, LHR-1 engine showed improved performance in comparison with CE. Faster rate of evaporation of fuel in the hot environment provided in the combustion chamber of LHR engine might have improved the performance. Hence, it is said that vegetable oil is suitable for LHR1 engine with provision of magnetic induction.Table4 shows data of BSEC at full load varied with injector opening pressure for different versions of the engine with and without magnetic induction.

| Engine Version | Test Fuel | Brake Specific Energ Consumption (kW h | |
|---|---|---|---|
| | | Injection Pressure (ba | |
| | | 190 | 270 |
| CE | Diesel | 4 | 3.2 |
| CE | CSO | 4.8 | 4.0 |
| CE | CSO -MI | 4.2 | 3.4 |
| LHR | CSO | 3.0 | 2.2 |
| LHR | CSO - MI | 2.6 | 1.8 |

**Table.4-Data of brake specific energy consumption at full load**

From Table4, it is noticed that BSEC at full load decreased marginally with an increase of injector opening pressure with different versions of the engine with and without magnetic induction with test fuels. Decrease of size of the fuel particle with an increase of injector opening pressure might have reduced BSEC at full load as less energy is required to combust the fuel. BSEC at full load decreased with magnetic induction with different versions of the engine with test fuels in comparison with without magnetic induction. Combustion improved with exposure of fuel particles with oxygen with magnetic induction and thus causing lower BSEC at full load. LHR engine reduced BSEC at full load with test fuels in comparison with CE with and without magnetic induction. Improved heat release rate might have lowered BSEC at full load with LHR engine.

Fig.8 presents bar charts showing the variation of exhaust gas temperature (EGT) at full load with different versions of the engine with test fuels with and without magnetic induction. Retarded combustion, higher duration of combustion, higher viscosity and un burnt fuel concentration at the walls of combustion chamber might have increased the EGT with cottonseed oil. LHR1 Engine with cottonseed oil showed higher EGT than cottonseed oil with conventional engine. This might be due to the fact that the combustion chamber was insulated to a greater extent. Heat was retained in combustion chamber leading to more rejection of heat causing increase in EGT.

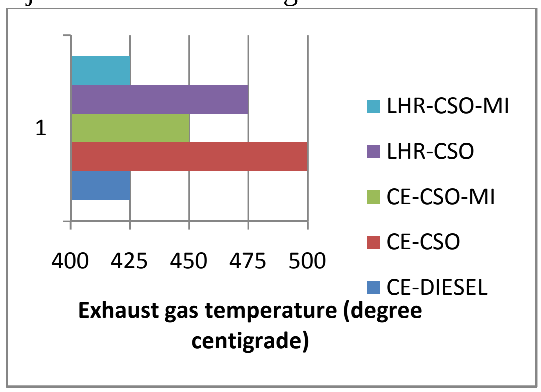



**Figure.8- Bar chart showing the variation of exhaust gas temperature at full load with different versions of the engine with test fuels with and without magnetic induction.**

Magnetic induction(MI) with different test fuels showed reduction of EGT in comparison with engine operating without magnetic induction. This indicates that combustion improved and there was less rejection of heat in the exhaust manifold.

Table5 shows data of EGT at full load varied with injector opening pressure for different versions of the engine with and without magnetic induction.

| Engine Version | Test Fuel | Exhaust Gas Temperature (° | |
|---|---|---|---|
| | | Injection Pressure (bar) | |
| | | 190 | 270 |
| CE | Diesel | 425 | 375 |
| CE | CSO | 500 | 450 |
| CE | CSO -MI | 450 | 400 |
| LHR | CSO | 475 | 425 |
| LHR | CSO - MI | 425 | 375 |

**Table.5- Data of exhaust gas temperature at full load**

From Table5, it is evident that EGT at full load decreased with an increase of injector opening pressure with different versions of the engine with test fuels with and without magnetic induction. Improved spray EGT at full load reduced with different versions of the engine thus confirming improved combustion with magnetic induction.

Fig.9 presents bar charts showing the variation of coolant load at full load with different versions of the engine with test fuels with and without magnetic induction. Coolant load was drastically higher with cotton seed oil with CE in comparison with CE operating with diesel. Un-burnt fuel combusted at the walls of combustion chamber might have increased coolant load. However, LHR1 with cottonseed oil drastically reduced coolant load. This may be due to provision of thermal insulation with LHR-1 engine with which thermal efficiency increased as there was proper distribution of heat. Cottonseed oil with magnetic induction decreased the coolant load effectively as fuel was not concentrated at the walls of the combustion chamber due to improved combustion. Similar trends were observed with LHR engine also. Coolant load reduced drastically with LHR-1 engine operating with cottonseed oil with magnetic induction when compared to the results when no magnets were put on the fuel line. Hence thermal efficiency was increased in case of LHR engine with the reduction of coolant load and exhaust gas temperatures.

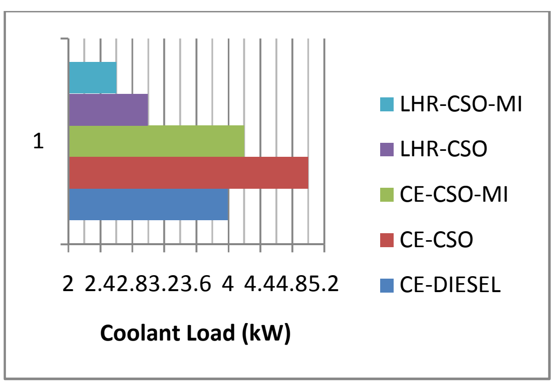



**Figure.9- Bar chart showing the variation of coolant load at full load with different versions of the engine with test fuels with and without magnetic induction**

Table 6 shows data of coolant load at full load varied with injector opening pressure for different versions of the engine with and without magnetic induction. From Table.6, it is observed that, coolant load at full load increased marginally with CE, while it decreased with LHR engine with test fuels with and without magnetic induction. In case of conventional engine, un-burnt fuel concentration reduced with effective utilization of energy, released from the combustion, coolant load increased marginally at full load due to increase of gas temperatures, when the injector opening pressure was increased.

| Engine Version | Fuel | Coolant Load (k W) | |
|---|---|---|---|
| | | Injection Pressure (ba | |
| | | 190 | 270 |
| CE | Diesel | 4.0 | 4.4 |
| CE | CSO | 5.0 | 5.4 |
| CE | CSO -MI | 4.2 | 4.6 |
| LHR | CSO | 3.0 | 2.6 |
| LHR | CSO - MI | 2.6 | 2.2 |

**Table.6 - Data of coolant load at full load**

However, with LHR engine combustion improved with improved oxygen-fuel ratios and spray characteristics of the fuel causing reduction of coolant load at full load. With magnetic induction, coolant load at full load decreased with both versions of the engine, in comparison with without magnetic induction. This showed that combustion improved with magnetic induction causing an increase of thermal efficiency. LHR engine reduced coolant load in comparison with CE with and without magnetic induction. Provision of thermal insulation and improved combustion might have lowered coolant load with magnetic induction.

Fig.10 presents bar charts showing the variation of volumetric efficiency at full load with different versions of the engine with test fuels with and without magnetic induction. Volumetric efficiency decreased marginally with cotton seed oil with conventional engine in comparison with conventional engine working with diesel as fuel. This might be due to increase of exhaust gas temperature with cottonseed oil with CE. The increase in EGT affects the rise in combustion wall temperature thereby affecting the volumetric efficiency. This might be also due to the increase of un-burnt fuel concentration with cottonseed oil as the vegetable oil was highly viscous and has high duration of temperature. LHR1 engine reduced volumetric efficiency drastically as the incoming air gets heated with the insulated component of LHR with which density reduced and hence the mass. The test fuels with magnetic induction(MI) showed improvement in volumetric efficiency when compared to the results yielded when there was no magnetic induction. This might be due to reduction of EGT and un-burnt concentration of fuel at the walls of the combustion chamber. This shows that combustion improved with additional supply of air with which thermal efficiency increased. Table7 shows data of volumetric efficiency at full load varied with injector opening pressure for different versions of the engine with and without magnetic induction. Volumetric efficiency at full load improved marginally with an injector opening pressure with test fuels with different versions of the engine with and without magnetic induction. Reduction of EGT at full load and reduction of un-fuel concentration at combustion chamber walls might have improved volumetric efficiency.

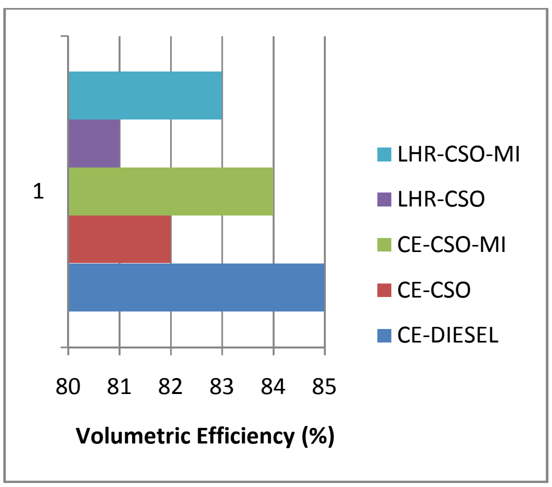



**Figure- 10 Bar chart showing the variation of volumetric efficiency at full load with different versions of the engine with test fuels with and without magnetic induction**

With magnetic induction, volumetric efficiency at full load increased marginally with different versions of the engine with test fuels in comparison with without magnetic induction. Improved oxygen–fuel ratios might have increased volumetric efficiency with magnetic induction.

| Engine Version | Test Fuel | Volumetric Efficiency (%) Injection Pressure (bar) | |
|---|---|---|---|
| | | 190 | 270 |
| CE | Diesel | 85 | 87 |
| CE | CSO | 82 | 84 |
| CE | CSO -MI | 84 | 86 |
| LHR | CSO | 81 | 83 |
| LHR | CSO - MI | 83 | 85 |

**Table.7- Data of volumetric efficiency at full load**

## CONCLUSIONS

Brake thermal efficiency was observed to be the higher with vegetable oil operation on LHR engine with magnetic induction.Brake specific energy Consumption was determined to be the lower with LHR engine with vegetable oil with magnetic induction.Cottonseed oil with magnetic induction on LHR engine showed an effective decrease in coolant load.The test fuels with magnetic induction showed improvement in volumetric efficiency when compared to the results yielded when there was no magnetic induction.The performance parameters were observed to be improved with an increase of an injector opening pressure.

## REFERENCES

[1]. S.K. Acharya, R.K. Swain and M.K. Mohanti, The use of rice bran oil as a fuel for a small horse-power diesel engine. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, vol.33, no.1, pp 80-88, 2009. [2]. B.K. Venkanna, C. Venkataramana Reddy, B. Swati and Wadawadagi, Performance, emission and combustion characteristics of direct injection diesel engine running on rice bran oil / diesel fuel blend. International Journal of Chemical and Biological Engineering, vol.2, no.3, pp131-137, 2009.

[3]. R.D. Misra and M.S. Murthy, Straight vegetable oils usage in a compression ignition engine—A review. Renewable and Sustainable Energy Reviews, vol. 14,pp 3005–3013, 2010.

[4]. No. Soo-Young, Inedible vegetable oils and their derivatives for alternative diesel fuels in CI engines: A review. Renew Sustain Energy Rev, vol.15, pp 131–149, 2011.

[5]. Avinash Kumar Agarwal and Atul Dhar, Experimental investigations of performance, emission and combustion characteristics of Karanja oil blends fuelled DICI engine, Renewable Energy, vol. 52, pp 283–291, 2013.

[6]. S. Jindal, B.P. Nandwana, N.S. Rathore, and V. Vashistha, Experimental investigation of the effect of compression ratio and injector opening pressure in a direct injection diesel engine running on Jatropha methyl ester, Applied Thermal Engineering, **30**, 442–448,2010.

[7]. B.K. Venkanna, and R.C. Venkataramana, Influence of fuel injection rate on the performance, emission and combustion characteristics of DI diesel engine running on calophyllum inophyllum linn oil (honne oil)/diesel fuel blend, SAE Technical Paper No. 2010-01-1961, 2010.

[8]. Avinash Kumar Agarwal, Dhananjay Kumar Srivastava, Atul Dhar, et al. Effect of fuel injection timing and pressure on combustion, emissions and performance characteristics of a single cylinder diesel engine. Fuel, 111: 374–83, 2013.

[9]. M.V.S. Murali Krishna, R.P. Chowdary, T.Kishen Kumar Reddy and P.V.K, Murthy, Performance evaluation of waste fried vegetable oil in a low grade low heat rejection diesel engine, Int Res Mech Eng Technol 2(2), 35-43, 2012.

[10]. T. Ratna Reddy, M.V.S. Murali Krishna, Ch. Kesava Reddy and P.V.K. Murthy, Comparative performance of ceramic coated diesel engine with mohr oil in crude and biodiesel form. Int J Eng Advanced Technol 2(3), 588-596, 2012.

[11]. Ch. Kesava Reddy, M.V.S. Murali Krishna, P.V.K. Murthy and T. Ratna Reddy, Performance evaluation of a low grade low heat rejection diesel engine with crude Pongamia oil, Int Scholarly Res Network Renew Energy 2012, Article ID 489605, 1-10.

[12]. Engr Okoronkwo et al. The Effect of Electromagnetic Flux Density on the Ionization and Combustion of Fuel (An Economy Design Project), American Journal of Scientific and Industrial Research, 528-531,2010..

[13]. Shweta Jain et al.), "Experimental investigation of Magnetic Fuel Conditioner (MFC) in I.C. engine, IOSR Journal of Engineering, 2, 27-31, 2012.

[14]. Ali S Farisa et al. Effects of Magnetic Field on Fuel Consumption and Exhaust Emissions in Two-Stroke Engine, Science Direct Energy Procede ,Vol. 18, pp. 327-338, 2012.

[15]. P.V.Kumar et al. Experimental study of a novel Magnetic Fuel ionization method in four stroke diesel engines, IJMERR, 3, 1, January, 2014