Renewable and Sustainable Energy Reviews xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Impact of modified parameters on diesel engine characteristics using biodiesel: A review

Varun Goel*, Naresh Kumar, Paramvir Singh

Department of Mechanical Engineering, National Institute of Technology Hamirpur (H.P), 177005, India

ARTICLE INFO

Keywords:
Biodiesel
Compression ratio
Injection timing
Injection pressure
Modification

ABSTRACT

Today in every nation's agenda, the utmost priority is given to reduce the impact of pollution (emissions related to air and water) that is created through different sources. This pollution is highly impacting our life on the daily basis. The best way is to reduce the pollution by encouraging usage of environment friendly activities. Moreover, the rate by which our conventional (non-renewable) sources of fuel depleting is really alarming and might perish in long run. The only way for the sustainable development is by adopting eco-friendly and renewable sources of fuel. Oxygenated fuel is an alternative fuel for the diesel engine because it is reversible in nature and its emissions are low. This paper has focused on the impact of different modification made in CI (compression ignition) engines in order to work at their optimum level in terms of combustion, emission and performance. The modification in engine had carried out by varying injection pressure (IP), injection timing (IT),compression ratio (CR), combustion chamber geometry etc. Results show that at high value of CR, IP and retardation or advancement of IT shows the improvement in the combustion, performance and emissions characteristics of CI engines. At modified conditions brake specific fuel consumption, unburned hydrocarbon, smoke opacity and carbon monoxide emission decreases and brake thermal efficiency and nitrogen oxide emission increases as compared to without modified ones. The result also shows that retarded injection timing as compared to original injection timing, emission of nitrogen oxide decreases.

1. Introduction

Fluctuation is considered to be disadvantageous either in terms of heart rate or in the prices of crude oil because for the long run both leading move towards the declined phase of its life. In today's world, diesel engine is widely used in the transportation sector and fuel prices are growing as the effect of its esclating demand and lower availability. The transportation sector among all is the second largest consumer of energy which is playing an important role in the projections of energy demand [1,2]. The annual energy outlook (2016) has reported that fuel consumption of heavy and medium duty vehicles in the transportation sector is 28% of total energy consumption and 60% of the total liquid fuel consumption in 2015 which will increase to 72% in 2035 [3]. Diesel fuel is highly viable because it can provide good capacity along with fuel conversion efficiency to the engine. But, consumption of petroleum product produces harmful gases which are highly toxic and affects human life and eventually contributing to the global warming and other environmental issues [4–7]. So, there is an emergent need to focus on two major issues for the large applicability of compression ignition (CI) engine. One is to search cost effective fuel and other is efficient alternative fuel.

Many researchers had introduced a variety of options such as an alternative to fossil fuels like ethanol, compressed natural gas (CNG), hydrogen, compressed air, etc [8–12]. But all the alternatives discussed were having limitations like low combustion rate, lower heating value, higher viscosity, less efficiency etc which affects the efficiency of engine and adversely affected the life of moving engine parts. Along with this, alternate fuels are even costly than the fossil fuels. So, it is necessary to find out an alternative which is not only cost effective but also yields more or same energy as petroleum products and have low emission profile.

Diesel engine emits two type of emissions i.e. regulated emissions (CO_2, NO_x, HC, CO, smoke etc.) and unregulated emissions (carbonyl compounds, aldehydes) [13–15]. In regulated emission CO, HC w produced due to incomplete combustion of fuel because of less oxygen content present in the diesel while NO_x emitted due to higher combustion temperature. According to the WHO-16 report in 2012, around 12.6 million people died because of deleterious environment all over the world [16]. Many organizations and agencies were established all over the world and worked to hold off the pollution and climate change

* Corresponding author.
E-mail address: varun7go@gmail.com (V. Goel).

http://dx.doi.org/10.1016/j.rser.2017.09.112
Received 27 December 2016; Received in revised form 22 August 2017; Accepted 26 September 2017

Nomenclature

A-F	Air-Fuel Ratio
AOME	Adelfa oil methyl ester
aTDC	After top dead centre
BD	Biodiesel
BTE	Brake thermal efficiency
bTDC	Before top dead centre
BSFC	Brake specific fuel consumption
BSEC	Brake specific energy consumption
CBWD	Carbon black water diesel
COME	Canola oil methyl ester
CI	Compression ignition
CO	Carbon monoxide
CR	Compression ratio
DI	Direct injection
DMDF	Diesel-methanol dual fuel
EGT	Exhaust gas temperature
EGR	Exhaust gas recirculation
HRR	Heat release rate
HOME	Honne oil methyl ester
IP	Injection pressure
IT	Injection timing
JME	Jatropha methyl ester
KOME	Karanja oil methyl ester
LOME	Linolenic linseed oil methyl ester
MBT	Maximum brake torque
MRPP	Maximum rate of pressure rise
MHRR	Maximum heat release rate
METPSO	Thevetiaperuviana seed oil methyl ester
NO_x	Nitrogen oxide
OSPD	Orange skin powder diesel solution
PPM	Parts per million
POME	Pongamia oil methyl ester
PSME	Palm stearin methyl ester
SO	Smoke opacity
UHC	Unburnt hydrocarbon
UTO	Used transformer oil
WCO	Waste cooking oil
WPO	Waste plastic oil

in terms of reduction in emission levels along with an increase in its efficiency. The automobile industries are facing large pressure to meet the CI engine emissions within the approved level. Modification of engine parameters, recirculation of exhaust, adding lubricants, additives, alternative fuels etc. were tried to use for an increase in the efficiency in CI engine. Using oxygenated fuels, biodiesel (BD) is an alternative to use in CI engine because it has some valuable properties like higher oxygen contents; fewer sulphur contents etc. [17–20]. So, biofuels which are produced mainly from animal waste and livestock can be a good option to replace our traditional method. Many types of methyl ester of vegetable oil like cottonseed (*Gossypium hirsutum*), rapeseed (*Brassica napus*), sunflower seed (*Helianthus annuus* L.), palm (*Theobroma cacao*), soybean, coconut (*Cocos nucifera*), linseed (*Linum usitatissimum*) etc. and its blends with diesel have been used as fuel in CI engine with and without modification in engine. Several challenges like higher viscosity, low calorific value, carbon deposition and higher NO_x emission, etc were faced by using BD and its blends used in place of diesel [21–25,156]. Some excellent reviews on the performance, combustion, emission and tribological characteristics of biodiesel and its blends has been carried out by various investigators [26–30] The BD has a higher viscosity than diesel, which leads to the poor atomization of air-fuel mixture by which soot particles and carbon monoxide emissions increases. Also for the same rotation of crank shaft, more amount of fuel entered because of high density of biodiesel thereby increases the BSFC. As BD has higher oxygen content which helps in better combustion in the combustion chamber due to which increase in the temperature of cylinder takes place and availability of oxygen increase the NO_x emissions [31–35]. Diesel fuel properties depend upon the number of hydrocarbon present in the mixture while due to the higher oxygen atom present in the BD and it is accepted as oxidized hydrocarbon. BD has low calorific value than diesel fuel; so for obtaining same power, BD consumption is more in comparison with diesel fuel. Many researchers have reported that the reduction in toxic emissions for BD along with alike performance with diesel fuel [36–40].

Fundamentally, there are two options to improve the efficiency and reduce emissions in a diesel engine. First is the mechanical and indicated efficiency by reducing the losses (like heat loss from the cylinder, wall, cooling water and friction losses) and other is to use an alternative compatible fuel in the engine [41–46]. BD is having different but nearly same chemical and physical properties as compared to diesel so the engine parameters i.e., compression ratio (CR), injection timing (IT), injection pressure (IP) etc. may not be optimal for the usage of BD and its blends because the engine had manufactured for diesel fuel [47–49]. IP and CR mainly affect the exhaust emissions and combustion rate while IT effects mainly particulate emissions. With varying IP and CR, many researchers were found enhanced results for performance parameters in the engine [50,51]. Advanced IT [52] or retarded IT [53,54] also affects the performance of diesel engine. Emissions also deteriorated at these modified parameters [55–57]. So, they have a significant effect on the performance of CI engine.

1.1. Objective of the study

For the existence in the world, modification is needed in every field either it is human lifestyle or machine. The earth is moving in a stage of turn down non-renewable energy resources, although energy need is continuously increasing. So, modification in the engine is need of time to balance 'the law of supply and demand'. The modification is an amendment or changes made to establish something which results towards betterment. Many researchers had worked on a modification of engine like a change in combustion chamber geometry, cooling system, coating on engine parts (piston etc.), compression ratio, injection timing, injection pressure etc. [58–64]. The affect of these parameters on performance, emission and combustion characteristics of the engine. The engine characteristics are also influenced by various parameters like engine design, properties of fuel (density, calorific value, flash point, etc.). Also, air-fuel (A-F) mixture which effects the combustion rate and hence characteristics of the engine depends on the shape and size of the engine [65–67].

The main objective of this paper is to investigate the modification done in the CI engines in the form of CR, IP and IT and its effect on the performance and emissions of CI engine.

1.2. Importance of significant parameter

Due to some favourable properties of biodiesel, it shows favourable results in terms of emission but negative impact on BTE and BSFC as compared to diesel in CI engine. So, it is imperative to increase the performance of biodiesel in CI engines by modifying the parameters (CR, IP and IT).

With the increase in IP, BTE and BSFC undergo positive impact. Because at a high injection pressure, the droplet size decreases and its surface area increases. So, mixing of air-fuel become better during ignition delay which results in an increase in BTE and decrease in BSFC. But after a particular limit, it affects the penetration of fuel inside the combustion chamber. So, a mixture of air-fuel may not be homogeneous