Renewable and Sustainable Energy Reviews 30 (2014) 961–986

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

Engine combustion, performance and emission characteristics of gas to liquid (GTL) fuels and its blends with diesel and bio-diesel

H. Sajjad*, H.H. Masjuki, M. Varman, M.A. Kalam, M.I. Arbab, S. Imtenan, S.M. Ashrafur Rahman

Center for Energy Sciences, Department of Mechanical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia

A R T I C L E I N F O

Article history:
Received 27 March 2013
Received in revised form
30 August 2013
Accepted 18 November 2013
Available online 8 December 2013

Keywords:
Gas to liquids (GTL)
Fuel properties
Combustion
Engine performance
Exhaust emission

A B S T R A C T

Crude oil price hikes, energy security concerns and environmental drivers have turned the focus to alternative fuels. Gas to liquid (GTL) diesel is regarded as a promising alternative diesel fuel, considering the adeptness to use directly as a diesel fuel or in blends with petroleum-derived diesel or bio-diesel. GTL fuel derived from Fischer–Tropsch synthesis is of distinctly different characteristics than fossil diesel fuel due to its paraffinic nature, virtually zero sulfur, low aromatic contents and very high cetane number. GTL fuel is referred to as a “clean fuel” for its inherent ability to reduce engine exhaust emission even with blends of diesel and bio-diesel.

This paper illustrates feasibility of GTL fuel in context of comparative fuel properties with conventional diesel and bio-diesels. This review also describes the technical attributes of GTL and its blends with diesel and bio-diesel focusing their impact on engine performance and emission characteristics on the basis of the previous research works. It can introduce an efficacious guideline to devise several blends of alternative fuels, further the development of engine performance and constrain exhaust emission to cope with the relentless efforts to manufacture efficient and environment friendly powertrains.

Contents

* Corresponding author. Tel.: +60 146 981 838; fax: +60 379 675 317.
E-mail address: h.sajjad013@gmail.com (H. Sajjad).

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http://dx.doi.org/10.1016/j.rser.2013.11.039

1. Introduction

Since the evolution of civilization the motive of fuel was only to move the engines. The gradual advancement of civilization associated with growth of transport sector has influenced the excessive usage of fossil fuels initiating a confrontation of dual exigency between abrupt depletion of fossil fuel and environmental degradation [1–6]. The single motive of fuel usage has now been diversified to other issues like improved engine performance with exhaust emission constraint in future emission legislations. The projections up to 2020 demonstrate the increased demand of fossil fuels up to three times that will boost the pollution levels in terms of airborne pathogens (i.e. infections, particles and chemicals), greenhouse effect in context of local, territorial and global spectrum.

According to the viewpoint of curbing global warming and strict emission legislation, the introduction of powertrains with low exhaust emission has been desired. Diesel engines have been expected to be a promising candidate because of higher thermal efficiency and CO_2 reduction over gasoline engines [7]. The diesel-fueled engine has recently been besieged with concerns over its contributions to the atmospheric emissions inventory due to less emission reduction specially failing to decrease NO_x and PM emission simultaneously [8,9].

In these consequences a strong worldwide drive towards alternative liquid fuels for transportation, mainly driven by emissions reduction, energy security concerns, volatility in the fuel price and the search for renewable fuels to compliment the dwindling world fuel supplies. Moreover, goals of improving air quality and diversifying energy resources have intensified research into identifying suitable alternative fuels for internal combustion engines [7,10–12]. Gas to liquid fuels synthesized from natural gas by means of Fischer–Tropsch process [13–15] can play a promising role as a clean alternative fuel [16]. GTL fuels have several distinguished beneficial properties as an alternative clean diesel fuel compared to conventional fossil diesel including virtually zero sulfur, negligible amounts of aromatics and hetero atomic species like sulfur and nitrogen. Higher cetane number and the absence of PAH content, which are the principal properties of GTL fuels, have potential to reduce particulate matter (PM) emissions [9,17–24]. This distinguishing characteristic has a potential to reduce NO_x emissions [8,17,20,24–28] by increasing the exhaust gas recirculation (EGR) ratio without significant smoke penalty [9,23,25,26,29] up to a certain level. Significant reduction in desulfurization process frequency associated with tremendous development of after-treatment catalyst results improved fuel efficiency. Higher cetane number leads towards improved combustion that yields lower CO emission [9,17,18,20–22,25,26,30] and HC emission [18–21,23,25,26,30,31]. For the above mentioned reasons, GTL fuels have been expected to have a potential to achieve low emissions without any major engine modifications [29,32–35] and insignificant loss in efficiency [8,9,17–20]. GTL fuels can be blended with conventional petroleum-derived diesel fuels [36–40] and biodiesels [41–45] and due to their excellent properties, they may significantly upgrade the properties of these fuel blends.