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Effect of H_2:CO ratio in syngas on the performance of a dual fuel diesel engine operation

Bibhuti B. Sahoo [a], Niranjan Sahoo [b], Ujjwal K. Saha [b,*]

[a] Centre for Energy, Indian Institute of Technology Guwahati, Guwahati 781 039, India
[b] Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Guwahati 781 039, India

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ABSTRACT

Syngas, an environment friendly alternative gaseous fuel for internal combustion engine operations, consists mainly of carbon monoxide and hydrogen. In this paper, at different loads, the effect of syngas on the performance, combustion and emission characteristics of a diesel engine was studied. For this purpose, three different volumetric compositions of syngas fuels were examined in the diesel engine under dual fuel modes. The syngas with 100% H_2 compositions showed an improved engine performance, but, at the expense of higher NO_x emissions for an increase in load. The NO_x emissions reduced when 25% and 50% CO were added in the 100% H_2 composition syngas. At the best efficiency loading point of 80%, the maximum diesel replacement was found as 72.3% for 100% H_2 syngas mode. At same engine load, the thermal efficiency was found to be 16.1% for 50% H_2 syngas. It increased to 18.3% and 19.8% when H_2 content was increased to 75% and 100%, respectively. At higher loads, the 50% and 75% H_2 content syngas modes showed a good competitive performance to that of 100% H_2 mode. The higher CO and HC emission levels were recorded for 25 and 50% CO fraction syngas fuels due to their CO content in the fuel compositions. At part-loads (20% and 40% loads), all the tested ranges of syngas modes resulted in a poor performance including higher emission levels.

1. Introduction

One of the most effective means of reducing diesel engine emissions is the use of alternative gaseous fuels in place of fossil diesel. This is because, combustion of gaseous fuel produces almost no oxides of sulfur (SO_x) and relatively little oxides of nitrogen (NO_x), the main constituents of acid rain, and substantially less carbon dioxide (CO_2), a key culprit in the greenhouse debate, than most oil products and coal [1]. The most commonly used alternative gaseous fuels for compression ignition (CI) engines that can substitute diesel are: natural gas, liquefied petroleum gas, hydrogen (H_2), biogas, landfill gas, sewage gas, digester gas, syngas etc. In its simplest form, syngas is composed of two diatomic molecules, carbon monoxide (CO) and H_2 that provide the building blocks upon which an entire field of fuel science and technology is based. Over the years, the gaseous mixture of CO and H_2 has had many names depending on how it was formed; producer gas, town gas, blue water gas, synthesis gas, and syngas, to name a few. In principle, syngas can be produced from any hydrocarbon feedstock. These include: natural gas, naphtha, residual oil, petroleum coke, coal, and biomass [2].

Mixtures of H_2 and CO could serve as an alternative spark ignition (SI) fuel due to their high anti-knock behavior [3,4]. However, addition of H_2 to CO tends to increase combustion temperatures and hence increases nitric oxide (NO) emissions under stoichiometric SI combustion [5]. As reported by Boehman and Corre [6], the use of H_2 and CO mixtures is more appropriate in lean burn conditions where combustion temperatures are moderated by excess air like in a CI diesel engine. Also, these mixtures could serve in ‘dual fuel’ mode that operates under CI using a pilot injection of diesel fuel. Again, in their published work, Garnier et al. [7] have suggested the use of syngas in diesel engines with dual fuel mode for mechanical and electrical applications. They have defined dual fuel engine as an ideal multi-fuel engine that operates effectively on a wide range of fuels including the flexibility of operating as a conventional diesel engine. During dual fuel operation, a carbureted mixture of air and high octane index gaseous fuel is sucked and compressed like in a conventional diesel engine. The compressed mixture of air and fuel-gas does not auto-ignite due to poor ignition quality of the gaseous fuel. Hence, it is fired by a small liquid fuel injection, known as pilot, which ignites spontaneously at the end of compression phase [8].

* Corresponding author. Tel.: +91 361 2582663; fax: +91 361 2690762.
E-mail addresses: bbs.iitg@gmail.com (B.B. Sahoo), shock@iitg.ernet.in (N. Sahoo), saha@iitg.ernet.in (U.K. Saha).

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