

Review article

A review on performance of biogas and hydrogen on diesel engine in dual fuel mode

Chinmay Deheri, Saroj Kumar Acharya*, Dharendra Nath Thatoi, Ambica Prasad Mohanty

Dept. of Mechanical Engineering, ITER, SOA Deemed to be University, Odisha, India

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ABSTRACT

The growing concern of energy demand and environmental pollution using fossil fuel influences the requirement of alternative fuel for a clean and healthy environment. Numerous research works have been carried out to use alternative fuels in order to optimize the energy requirement. This review presents an in-depth analysis on the impact of alternative fuel in compression ignition (CI) engine in order to develop performance, emission and combustion characteristics. Deterioration in the performance parameters such as brake thermal efficiency (BTE) and exhaust gas temperature (EGT) has been found between 2 and 22% whereas a significant increase in brake specific fuel consumption (BSFC) was reported up to 36% by using gaseous fuel as an alternative source of energy in dual fuel engine. Further the analysis on combustion indicates increase in peak cylinder pressure and heat release rate up to 23% and 30% respectively. Emission analysis shows reduction in nitrogen oxides and smoke emission between 20 and 60%. However the dual fuel engine shows a significant increase in hydrocarbon (HC) and carbon monoxide (CO) emission up to 30% when compared with normal diesel engine.

1. Introduction

With the advancement in technologies and modern practices of increasing economy, though the economy and technology have increased but it has created a serious threat to the environment & have raised a big question mark towards developing a healthy & eco-friendly environment. The renewable energy sources such as biomass, geothermal, solar, wind & hydro-wave offers a wide range of attractive prospects. They are unlimited and are of economically viable as compared to other sources.

Energy is the basic need for sustainability and development of society. Fuel contains a large amount of energy that is being utilized for our daily life. Conservation of conventional fuel is increasing day by day which is a serious problem especially for a developing country like India and it is expected that a day will come when the requirement of fuel energy will be more than supply. With the increasing demand and growth of power sectors all over the world the conventional sources are decaying at an increasing rate [1]. This is one of the reasons that the researchers are focusing on alternative fuels. Another reason that the world is being tilting towards alternative fuels is environmental pollution. Air pollution and global warming are the major concern to go for alternative fuels. Main sources of air pollution and global warming are oxides of nitrogen, particulate matters, carbon dioxide etc [2]. These

polluting agents mainly resulted from the combustion of conventional fossil fuels.

A large percentage of engines in transportation as well as agricultural sectors are driven by the conventional fossil fuels. The outcomes of engines operated with fossil fuels are serious threat to the environment. This is why engines driven by renewable sources like biogas and hydrogen are getting more attention now a day. Conventional engines can be switched to be operated with biogas or hydrogen along with pilot diesel fuel with very less modification. Schematic diagram of the engines driven by biogas and hydrogen in dual fuel mode are shown in Figs. 1 and 2.

Alternative fuels are produced from renewable sources widely available in the environment itself. These are the fuels which can be used as replacement of conventional fossil fuels. These include biofuels, alcohol, natural gas, liquefied gas, biogas, hydrogen, etc [3]. These fuels exhibit a lot of positive impact towards the control of environmental pollution as well as global warming [4]. Sources of these alternative fuels include biological, agricultural, organic, inorganic, waste etc. These renewable sources being waste are used to produce alternative fuels which play a significant role in the environmental and economic growth of society [5].

Biomass is made up of about a large variety of sources which is available in enormous quantity and it is the leading contributor to the

* Corresponding author at: Dept. of Mechanical Engineering, ITER, SOA Deemed to be University, Bhubaneswar, Odisha 751030, India.

E-mail address: saroj.acharya76@gmail.com (S.K. Acharya).

Nomenclature

CI	Compression Ignition	HCCI	Homogeneous Charge Compression Ignition
EGT	Exhaust Gas temperature	BTE	Brake Thermal Efficiency
BSFC	Brake Specific Fuel Consumption	HC	Hydrocarbon
BP	Brake power	CO	Carbon Monoxide
BSEC	Brake Specific Energy Consumption	SFC	Specific Fuel Consumption
NOx	Nitrogen Oxide	CO ₂	Carbon Dioxide
VE	Volumetric Efficiency	NA	Naturally Aspirated
BGES	Biogas Energy Share	KME	Karanja Methyl Ester
RCCI	Reactivity Control Compression Ignition	DEE	Diethyl Ether
VCR	Variable Compression Ratio	DI	Direct Injection
CR	Compression Ratio	ID	Ignition Delay
PCCI	Premixed Charge Compression Ignition	NHRR	Net Heat Release Rate
IT	Injection Timing	PCP	Peak Cylinder Pressure
UHC	Unburned Hydrocarbon	THC	Total Hydrocarbon
CPP	Cylinder Peak Pressure	CH ₄	Methane
EGR	Exhaust Gas Recirculation	CD	Combustion Duration
HRR	Heat Release Rate	H ₂	Hydrogen
IMEP	Indicated Mean Effective Pressure	BTDC	Before Top Dead Center
CNG	Compressed Natural Gas	PM	Particulate Matter
MO	Maduca longifolia oil	DME	Dimethyl Ether
		ND	Neat diesel
		WI	Water injection

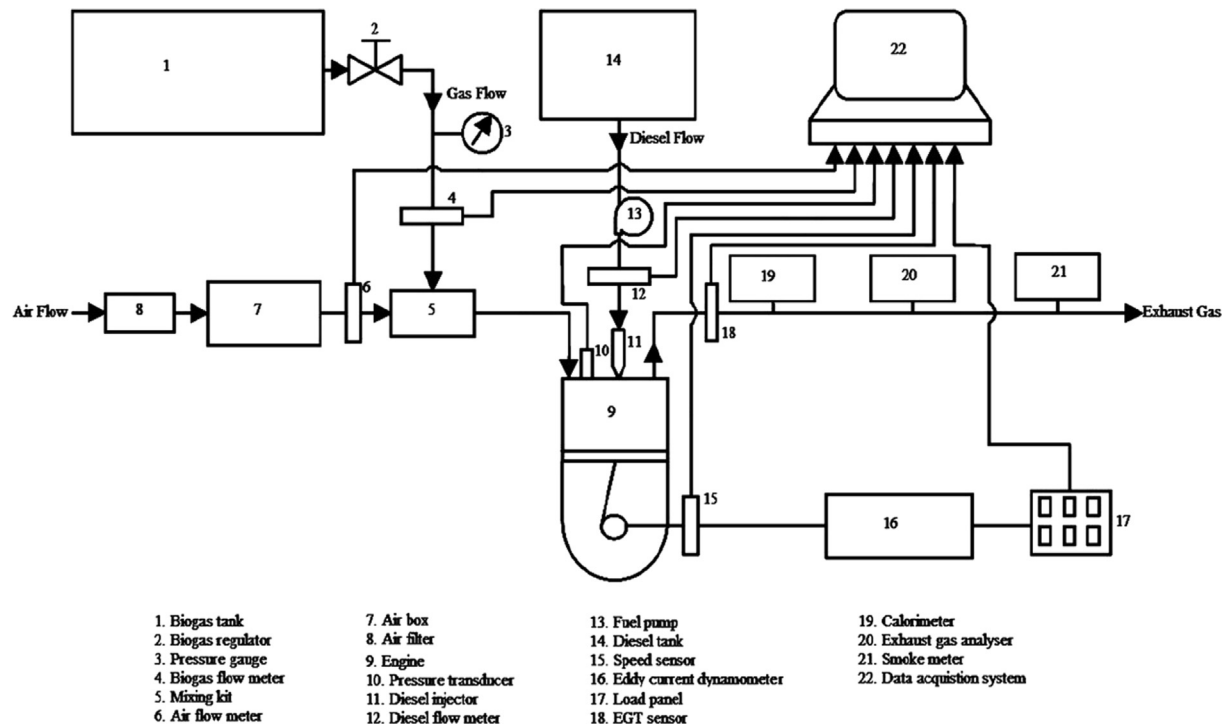


Fig. 1. Schematic diagram of biogas-diesel dual fuel engine.

renewable energy. The biomass is considered as a worldwide valuable and most effective alternative to fossil fuels.

Large quantities of cellulosic biomass, such as food wastes, rice husks, agricultural residues like straws, fruit shells, fodders & nut shells, leaves of green plants, and molasses are being disposed to the environment utilized. The various food wastes produced from different households, hotels and other sources also contribute a potential source for production of biogas.

The present review focuses on the utilization of biogas and hydrogen as alternative fuel in CI engine. Utilization includes the optimized performance and low emission characteristics of CI engines by the use of biogas and hydrogen as alternative fuels.

2. Performance analysis

Performance analysis of an engine includes the utilization of fuel energy to produce the required power. This chapter includes the analysis of various operating parameters such as brake thermal efficiency (BTE), brake power (BP), Specific fuel consumption (SFC), brake specific energy consumption (BSEC), Exhaust gas temperature (EGT). Characteristics of compression ignition engine observed by different researchers are presented in Table 1.

2.1. BTE

It is explained as the power produced from the engine by utilizing

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