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Fuel Conversion Benefit of Producer Gas Over Gasoline – An Experimental Analysis

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Abstract

Growing energy targets, depletion of fossil fuels and environmental concerns have paved the way to explore alternative (renewable) fuels. In this paper, the performance and in-cylinder analysis of a four stroke modified spark ignition engine fueled with bottled Producer gas is addressed. The nature of energy conversion of a producer gas (a multi component fuel) as compared to straight-run Gasoline was analyzed and discussed. Study shows that, Producer gas engines can yield a saving of approximately over 70 % on fuel consumption over Gasoline powered engines. Analysis of fuel conversion indicated a scope of reduced energy consumption with producer gas engine to the tune of 5 %.

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Keywords: Producer gas, Biomass gasification, Specific fuel consumption, Down draft gasifier;

Abbreviations

PG	Producer gas
BTDC	Before top dead centre
BSFC	Brake specific fuel consumption (kg-gas/ kW-hr)
BSEC	Brake specific energy consumption (MJ/kW-hr)

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1. Introduction

Internal combustion engines have been a major source for power generation worldwide over many decades. The utility of engines powering the generator sets (gensets) has been a tremendous benefit to society, but at the cost of degradation to environment primarily due to harmful emissions. In this context, to mitigate the climate change and to reduce dependency on fossil fuels, major research is focused on (i) improving the existing engine design, (ii) improving the combustion process (iii) after treatment of exhaust gases and (iv) adoption of renewable fuels. Producer gas (PG) is one such renewable and eco-friendly fuel [1,2], having a potential to meet the twin requirement of improving the in-cylinder combustion process and also an ability to undergo a cleaner combustion resulting in lower emission levels.

1.1. Producer gas and its utility for power generation

Present work is addressed in a thermo-chemical energy conversion view point, where the biomass is considered to undergo a gasification process (air as gasification agent) in a reactor unit called gasifier, giving rise to a multi component fuel called Producer gas. PG is a mixture of three combustibles and two non-combustible gases namely, hydrogen, methane, carbon monoxide and carbon-di-oxide, nitrogen respectively [3]. The composition and calorific value of PG varies widely depending upon the type of feed stock used and gasifier design [4].

PG derived from biomass gasification process is extensively used for power generation application. The total installed biomass power capacity in India as on 2014 is 11.88 % of 147615 MW total reserve [5]. As per Energy Alternatives India (EAI), estimates suggest that India has a potential to generate 30000 MW from crop waste alone. Few studies indicate that 15 to 50 % of global energy utilization could come from biomass by 2050 [6]. Among the reactor units, down draft gasifiers are most suitable for engine application due to their ability to break down higher hydrocarbons like tar [7]

For commercial utility, small power level gasoline powered gensets are commonly used in India. Pursuing PG as a potential candidate over Gasoline fuel, the present study was motivated to study and to bring out the in-cylinder aspects of both fuels for technological development. Since biomass gasification derived PG is susceptible to vary in composition [8], authors have considered a fixed set of PG composition (bottled gas). According to literature, SI engines have a tendency to undergo instabilities in combustion process and can cause torque fluctuations [9]. For a fuel like PG, significant instabilities in combustion can be expected and therefore optimal spark time is to be selected.

2. Material and its properties

To study the engine performance, in the present work a fixed set of calibrated producer gas composition of H_2 (16%), CO (18%), CH_4 (1%), CO_2 (12%) and N_2 (53%) on volume basis was considered and the calculated combustion properties are listed in Table 1. Spark Ignition (SI) engine was operated with two fuels namely, (i) Producer gas, and (ii) Gasoline.

Table 1. Combustion properties

Properties	Producer gas	Gasoline [13]	Natural Gas [14]
Chemical formula	H_2, CH_4, CO and Inerts	C_8H_{18}	CH_4
Lower heating value (MJ/kg)	3.91	44.4	50.2
(A/F) stoichiometry (kg/kg)	1.04	14.7	17.2
Mixture heating value (MJ/kg)	1.91	2.82	2.75
Flame speed (m/sec) at phi = 1	--	0.41	0.35