

Alternative gaseous fuels in port fuel injection spark ignition engines

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This paper investigates the use of alternative gaseous fuels in port fuel injection spark ignition engines via the Lotus engine simulation program. To this end, the engine model for a port fuel injection spark ignition engine was designed, and engine performance was determined separately for gasoline and alternative gaseous fuels, i.e. compressed natural gas and liquefied petroleum gas. According to the results, brake thermal efficiency increases while engine performance and fuel consumption decrease with methane and propane when compared to gasoline under the same conditions. While a slight increase in the fuel/air equivalence ratio of gaseous fuels improves the engine performance, fuel consumption remains almost stable. Another factor that enhances engine performance is the increasing compression ratio for methane and propane. In this manner, performance values that are closer/equal to gasoline are achieved. Under these conditions, fuel consumption decreases notably, while significant increases are observed in brake thermal efficiency.

Keywords: Alternative fuels, Port fuel injection, Spark ignition engine, Engine performance, Fuel consumption

List of symbols

A	area, m^2
AFR	air/fuel ratio
$bmeep$	brake mean effective pressure, kPa
b_{spc}	brake specific fuel consumption, $g\ kW^{-1}\ h^{-1}$
b_{te}	brake thermal efficiency, %
B	bore, m
CAD	crank angle degree
CR	compression ratio
ER	equivalence ratio
f_{meep}	friction mean effective pressure, kPa
i_{meep}	indicated mean effective pressure, kPa
L_{cr}	connecting rod length, m
\dot{m}	mass flowrate, $g\ h^{-1}$
MBT	maximum brake torque
N	engine speed, $rev\ min^{-1}$
p	pressure, kPa
P	power, kW
Q_{LHV}	lower heating (calorific) value of fuel, $MJ\ kg^{-1}$
Q_w	total heat transfer to the cylinder walls, kJ
R	gas constant, $J\ kg^{-1}\ K^{-1}$
Re	Reynolds number
S	stroke, m
ST	spark timing
T	temperature, K
U_{piston}	mean piston speed, $m\ s^{-1}$
V_d	cylinder displacement volume, m^3
W	work, kJ

x_b	mass fraction burned
Z	cylinder number
$\Delta\theta_b$	burn duration, CAD
η	efficiency, %
θ	crank angle, CAD
θ_{st}	ST crank angle, CAD
ρ	density, $kg\ m^{-3}$
τ	torque, N m
ω	angular speed, $rad\ s^{-1}$

Subscripts

c	cycle
d	displacement
e	effective (brake)
f	fuel
in	inlet air
r	revolution
s	stoichiometric
st	spark timing
vol	volumetric
w	wall

Introduction

A combination of several concerns emerging following the oil crises of 1970s, such as an increasing awareness towards environmental issues, energy security and fuel conservation goals, has drawn attention to alternative fuels.¹⁻³ Some recent events, including the high pump prices of gasoline and diesel fuel and the continuous stringent emission regulations, have also intensified such concerns. The term 'alternative fuel' is commonly used for energy sources that are non-petroleum based and whose combustion generates lower emissions compared

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The novel begins with Richard Papen, a bright but troubled young man, arriving at Hampden College. Richard is immediately drawn to the group of students who call themselves the Classics Club. The club is led by Henry Winter, a brilliant and charismatic young man. Henry is obsessed with Greek mythology and philosophy, and he quickly draws Richard into his world. The other members of the Classics Club are equally as fascinating. Bunny Corcoran is a wealthy and spoiled young man who is always looking for a good time. Charles Tavis is a quiet and reserved young man who is deeply in love with Henry. Camilla Macaulay is a beautiful and intelligent young woman who is drawn to the power and danger of the Classics Club. The students are all deeply in love with Morrow, and they are willing to do anything to please him. Morrow is a complex and mysterious figure, and he seems to be manipulating the students for his own purposes. As the students become more involved with Morrow, they begin to commit increasingly dangerous acts.

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