Energy 234 (2021) 121225

Contents lists available at ScienceDirect

Energy

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

Response Surface Methodology to predict the performance and emission characteristics of gas-diesel engine working on producer gases of non-uniform calorific values

G. Arun Prasad [a], P.C. Murugan [d, *], W. Beno Wincy [b], S. Joseph Sekhar [c]

[a] Department of Mechanical Engineering, Kongu Engineering College, Erode, 638060, India
[b] Department of Mechanical Engineering, National Engineering College, Kovilpatti, India
[c] Department of Mechanical Engineering, University of Technology and Applied Sciences-Shinas, PC-324, Oman
[d] Department of Automobile Engineering, Kongu Engineering College, Erode, 638060, India

ARTICLE INFO

Article history:
Received 4 May 2021
Received in revised form
8 June 2021
Accepted 12 June 2021
Available online 17 June 2021

Keywords:
Producer gas
Dual-fuel
Engine performance
Response surface methodology
Emission

ABSTRACT

Energy generation through gasification technology has received significant attention from policy makers and researchers. To promote government policies on biomass and utilize energy source that are abundantly available in rural areas, suitable technologies must be developed with a focus on popular applications in a place. The biomass in rural areas differs from place to place and they may not generate uniform calorific value (CV) of producer gas (PG). The quality of PG is essential to run engines of power generators with required performance. Hence, in this study, a mathematical investigation was performed on a dual-fuel diesel engine for CV of PG from 3.4 to 6.6 MJ/Nm^3. The major objective was to find the impact of the variation in CV of PG from coir pith, rice husk, rubber wood, coconut shell and rubber seed kernel shell on the performance of the engine. Response Surface methodology with suitable tools had been used for developing the model. The model predicted the optimum thermal efficiency, specific energy consumption and diesel replacement rate as 25.8%, 13.95 MJ/kWh and 59.04% respectively while calorific value of PG was 6.57 MJ/Nm^3. However, CO and NO_x emissions were found increasing with the increase in calorific value of PG.

1. Introduction

Electrification of villages worldwide can provide a huge impact on rural development and poverty alleviation in any nation. Globally, it is estimated that 675 million people may not have access to electricity in 2030 [1]. In India, 72.2% of the people live in rural areas [2]; moreover, the country has a huge biomass potential of 665 MT per year [3] which is abundantly available in rural areas [4]. One of the solutions to provide energy to rural areas is implementation of small-scale decentralized power generating units [5,6]. Biomass is a clean and eco-friendly renewable energy source, and it could dramatically improve the economy and provide energy security. Many studies showed that the thermochemical route is eco-friendly and economically viable [7]. Moreover, it was suggested that thermochemical conversion method could be a good eco-friendly alternative for conventional power generation [8,9]. In previous studies, experimental investigations were focussed on the feedstock available in rural areas such as tamarind shell [10], cocoa pod husk [11], coconut shell [12] and so on. The observations showed that the generated producer gas (PG) had the higher heating value from 4 to 6 MJ/Nm^3. The impact of moisture in biomass, optimum equivalence ratio, gas yield, and efficiency of gasifier are elaborately discussed in the above literature.

Throughout the world, several studies were conducted on the use of dual-fuel blends (diesel, biodiesel + producer gas) in engines. The studies were focussed to investigate possible replacements for conventional fuels such as diesel (D) [13]. The PG with calorific value (CV) 4.17 MJ/Nm^3 from babul wood, and the biodiesel extracted from Karanja seed were tested in a compression ignition (CI) engine. The brake thermal efficiency (BTE) of 20% was found in dual-fuel (D and PG) mode [14]. The gas with CV 3.5 MJ/Nm^3, obtained from silver oak wood and biodiesel from vegetable oil was tested in a 3.7 kW engine at the compression ratio (CR) 20. The results suggests that the diesel fuel consumption is influenced by

* Corresponding author.
E-mail address: pcmurugan@ymail.com (P.C. Murugan).

https://doi.org/10.1016/j.energy.2021.121225
0360-5442/