

Abstract

Increasing energy requirements worldwide have significantly prompted energy generation migration through alternate resources. Humankind dependency on fossil fuels cannot be continued due to its non-sustainability issues in energy, environment, and economic practice. It is proclaimed that the global energy demand will increase around 25% in 2040, where the electric power consumption will double by 2060. As per the present scenario, due to the fast depletion of energy sources and reserves-to-production (R/P) ratio, there will be atrocious growth in energy demand. So, to the large extent, optimum and efficient use of the present resource will be a significant support to sustain the energy, economic and environmental demands.

Regarding these issues and daunting challenges, it is mandatory to opt replacement of fossil fuel carriers with sustainable alternate fuel resources. As far as a renewable energy source is concerned, biomass-derived energy carriers could be one of the promising solutions. Biomass is primarily derived from the forest, and worldwide forests cover around 30% of the land base, which possesses approximately 384 billion m³ as total forestry inventory. To convert biomass to higher-value products, the primary routes followed to convert biomass into energy-rich are combustion, thermochemical processes, and biochemical processes.

Among this, researchers posit that thermochemical conversion-based gasification technology is more suitable for biomass conversion due to their self-sufficient auto thermic process and more energy recovery and heat capacity in compared to combustion and pyrolysis. Furthermore, the gasification process is appealing since it offers many benefits, such as biomass adaptability and waste type, use of entire feedstock, high-temperature range, and high conversion rate. Gasification comprises the thermochemical transformation of solid feedstock (coal, biomass, etc.) into gaseous fuel through partial oxidation with the gasifying agents like air, steam, oxygen,

or their mixtures. However, the gasification significantly depends on the type of gasification and feedstock, air or steam/feedstock, gasification temperature, particle size, and feed rate.

In regard to the previous work, mostly the research work has been done in the area of biomass gasification with limited operating conditions. In addition to this, there is very little work has been attempted in the literature that specially studied the Waste Biomass and low-grade coal gasified producer gas (PG) and integration with diesel-fuelled CI engine, and to analyze engine performance and emission characteristics experimental as well as numerically. Also, there is no author that has concluded the cumulative effect of engine input variable for an optimum response of performance and emission together.

Hence, there is essential to study low-grade coal and biomass gasified PG coupled with an internal combustion engine and provide the optimum engine input parameters for improved engine performance and operation. Because, if the blended form of chemical energy is available for power generation in an engine and its operating variables are not optimized, there will be a reduction in power and increment in fuel consumption and emission. Concerning these aspects, in the present study, we have attempted to resolve this obvious gap.

In light of the above discussions, the present work by the author presents an experimental and numerical study to optimize the operating parameters of diesel engines fuelled by biomass or coal based producer gas blended with diesel fuel in terms of optimal performance and exhaust emissions by integrating advanced multi-objective optimization technique Response surface Methodology. A comprehensive thermochemical equilibrium based model of downdraft gasifier was developed by minimizing Gibbs free energy using Aspen Plus software. In the experiment, a total of 48 number of the experimental matrix wherein downdraft gasifier integrated with dual

fuel diesel engine fuelled with multiple biomass and coal were executed to perform RSM optimization and ANOVA sensitivity test.

The results of these stimulated model and experimental analysis shall not only be helpful in designing a optimized biomass fixed bed gasifier, but shall also be useful to obtain the optimum performance and emission analysis of dual fuel diesel engine fuelled with Producer gas and diesel. The complete work has been segregated into five chapters.

The present work, comprising five chapters, has been made with this motivation to emphasize on various issues related to the possibilities, problems, and prospects of utilizing gasification technique in better way so that the infrastructural problems of fuel oil scarcity and environment degradation could be squarely met.