Journal of
Materials Engineering and Applications

Abstract

Performance enhancement of lignite downdraft gasification system by using steam and catalyst

Upadhyay Darshit S
Nirma University, India

Abstract:
Gasification of lignite in the presence of MgCO3 as a catalyst was carried out in 10 kWe pilot scale (atmospheric pressure) downdraft gasifier. The main disadvantage with lignite is the clinker formation at high temperature. To overcome this problem, MgCO3 lumps were used as a catalyst with lignite (22-25 mm). The experiments were carried out with four different catalysts to lignite (C/L) ratios (wt%) viz. 0%, 3%, 5% and 7%. The performance of the gasifier was evaluated on various parameters such as specific fuel consumption (SFC), gas yield, producer gas composition, producer gas heating value (LHV), cold gas efficiency (CGE), tar and particulate matter (PM). The Energy balance, mass balance, and exergy analysis were also carried out for different C/L ratios. The studies reveals with an increase in the C/L ratio, clinker formation reduced and became almost negligent with 7% C/L ratio. Furthermore, the gas yield, H2/CO ratio, LHV, CGE and exergy efficiency also increased by 2.52%, 9.94%, 22.22%, 20.24%, and 29.04%, respectively with the same ratio. Whereas, SFC, tar and PM concentration were reduced by 16.48%, 41.61%, and 33.09%, respectively.

This work also aims to identify the optimum Steam to Lignite ratio, wt% (SLR) to achieve higher H2 yield and lower tar yield in the producer gas. Six different SLRs (0, 0.06, 0.14, 0.18, 0.24, 0.30 and 0.48) was used for this study. The producer gas Lower Heating Value (LHV) and Cold Gas Efficiency (CGE) were found in the range of 4.96 MJ Nm-3–5.62 MJ Nm-3 and 70.6% -81%, respectively for different SLR. The optimal SLR was identified to be 0.24, having lower specific fuel consumption (1.437 kg kWh-1), lower tar content (112.28 mg Nm-3), lower Particulate Matter (PM) (27.34 mg Nm-3), higher LHV (5.62 MJ Nm-3) and higher CGE (81%). H2 yield and H2/CO ratio improved by 34.7% and 52%, respectively whereas tar yield reduced by 78.31% at 0.24 SLR compared to air gasification. The mass balance, exergy analysis, heat loss analysis were also carried out for this study. The study concludes that the 7% loading of MgCO3 with lignite and 0.24 SLR (individually) offered the best results amongst most of the reported feedstock.

Biography:

Dr Darshit S Upadhyay is working as Assistant Professor in Mechanical Engineering Department since 2012. He has completed MTech in Thermal Engineering and PhD from Nirma University in 2012 and 2020, respectively. He has 6 SCI-indexed journal publications and presented more than 15 conference

papers in the area of gasification, biomass cookstove, etc. He has received different project grants as PI/Co-PI from Nirma University and Gujarat Council on Science and Technology (GUJCOST) in the area of Renewable Energy. Dr Upadhyay has guided 11 postgraduate dissertations

Recent Publications:

1. Updhyay D S, Panchal K, Sakhiya AK, Patel R N, "Air-Steam gasification of lignite in a fixed bed gasifier: Influence of steam to lignite ratio on performance of downdraft gasifier", Energy, Volume 211, November, 2020, Article No. 118187
2. Updhyay D S, Khosla A, Chaudhari A, Patel R N, "Effect of catalyst to lignite ratio on the performance of a pilot scale fixed bed gasifier", Energy, Volume 189, December, 2019, Article No. 116229
3. Upadhyay D S, Panchal K, Sakhiya AK, Patel A H, Patel R N, "Effect of Equivalence Ratio on the Performance of the Downdraft Gasifier - An Experimental and Modelling Approach", Energy, Volume 168, 2019, February, 2019, Pages 833-846
4. Upadhyay D S, Makwana H, Patel R N, "Performance Evaluation of 10 kWe Pilot Scale Downdraft Gasifier with Different Feedstock", Journal of Energy Institute, Volume 92, Issue 4, August, 2019, Pages 913-922
5. Patel V, Upadhyay D S, Patel R N," Gasification of lignite in a fixed bed reactor: Influence of particle size on performance of down draft gasifier", Energy, Volume 78, December, 2014, Pages 323-332

Citation: Upadhyay Darshit S, Performance enhancement of lignite downdraft gasification system by using steam and catalyst, Green Energy and Material Science, September 24, Dubai, UAE