

Gasification Characteristics of Indian high-ash Coal, Petcoke, and their blends in an Entrained-flow Reactor

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Indian coals have an average ash content of 45%. Fluidized-bed gasifiers are widely acknowledged to be most suitable for high-ash coals; however, suffer from poor carbon conversion and operational issues such as agglomeration and defluidization, arising from low-temperature eutectics that are a product of complex mineral matter interactions. In this regard, the fuel flexible entrained-flow gasifiers which recover ash in the form of slag—a valuable by-product precursor to metals recovery and thus for improved profit margins—emerge as attractive choice in view of the heterogeneity of mineral composition and the resulting uncertainty associated with agglomerate formation.

Nonetheless, entrained-flow gasification of high-ash coals is economically challenging as more heat is taken away by the melting slag, in turn, consuming more carbon and oxygen to maintain heat balance in the gasifier. Co-utilization of petcoke, with its low ash content and superior fuel properties, is a potential solution to optimize ash content and to improve the slag rheological behaviour.

This work, in an ongoing effort to facilitate efficient utilization of indigenous Indian high-ash coals, the first time reports the direct CO₂-based co-gasification studies of Indian high-ash coal, petcoke, and their blends in a custom-built dry-feed atmospheric entrained-flow gasifier. Additionally, thermodynamic and exergy analysis of a 500 MW Indian high-ash coal “Oxygen-blown IGCC system with CO₂ recycle and low-temperature flash for CCS” is presented.

A typical feed flow rate of 1 g/min was maintained in all experiments. The effect of key operating parameters such as temperature (1000–1400 °C), CO₂ concentration (20–80 vol%), and coal-coke blend composition was investigated on the quality of fuel gas, carbon conversion, evolution of N- and S-derived pollutants, and on possible synergetic effect. Further, in order to assess the mineralogical and morphological transformations, complementary X-ray Powder Diffraction (XRD) and Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy (SEM/EDX) tests were also conducted.

Carbon conversion and the yield of fuel gas, in particular of CO, increased with increasing temperature and CO₂ concentration for all the tested fuels. Near complete conversion for coal at 1300 °C and conversions up to 35% with petcoke at 1400 °C, were observed. CO and H₂ evolution trends demonstrated a slight positive deviation from linear additive behaviour, confirming possible synergetic effect, for all coal-coke blends.