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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 CO_2-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 CO_2 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), CO_2 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 CO_2 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 H_2 evolution trends demonstrated a slight positive deviation from linear additive behaviour, confirming possible synergetic effect, for all coal-coke blends.