INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

In the cycle of waste generation and management, the recovery of energy from solid wastes through highly efficient and low pollutant technology is a promising way. Hence, the current study focuses on clean syngas production via plasma gasification of solid waste termed as refused derived fuel (RDF), computer keyboard plastic waste (CKPW) and electrical switch waste (ESW). On a laboratory scale, several experiments are conducted to assess the impact of feed mass flow rate, feed CO_2 gas flow rate and plasma torch power on the syngas concentration and yield. A 3-E analyses comprising cold gas efficiency (CGE), exergy efficiency and levelized cost of syngas (LCOS) is performed, considering all the feeds. Further, two newly emerging technologies, (a) molten carbonate fuel cell (MCFC) and (b) chemical looping reforming (CLR), are integrated with plasma gasification for hydrogen and electricity production. The simulation of the plants is performed using Aspen plus and consequently, 4-E (3-E and environmental) analyses are executed. A high-quality syngas with H_2 (32.23 vol.%), CO (51.98 vol.%) content, possessing a calorific value of 16.46 MJ/m^3 and CGE of 39.04% is obtained for CKPW at the plasma power of 2 kW. However, with parameters of 30 g/10 min, 0.4 lpm and 0.75 kW, a higher CGE of 49.90% and exergy efficiency of 48.30% are achieved using RDF feed. While the lowest LCOS value of 23.40 INR/kWh is estimated for CKPW feed. The proximate and ultimate analysis of oil obtained from CKPW feed showed properties similar to diesel, with high C (90.8 wt.%), H (6.8 wt.%) and LHV (39.13 MJ/kg), and low O (0.46 wt.%) content. Whereas, the residue of RDF has high ash content of 13.95 wt.%. Ash contains a good amount of Ti, Ba, Ca, Si, Al, etc., which can find applications in healthcare, paints, dye-casting and the cement industry after enrichment.

The simulation results from MCFC plant utilizing RDF estimates the highest energy and exergy efficiencies of 54.12% and 52.02% for the system of Syngas:CH_4 [PSA: MCFC], respectively. Moreover, the cost of electricity (COE) ranges between 77.48 and 107.93 $/MWh, while the levelized cost of hydrogen (LCOH) is between 1.01 and 3.94 $/kg. On the other hand, utilizing CKPW and ESW in the CLR system resulted in even higher energy efficiency of 72.35% for CKPW feed. Plasma gasification contributes a large portion of exergy destruction. In addition, the COE for all cases of CKPW feed remains below 76 $/MWh and the LCOH between 0.8-1.7 $/kg. Besides, all the plants assure higher sustainability from the ecological point of view based on the carbon emissions.