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Plasma Gasification for Municipal Solid Waste Treatment

Addressing the growing challenges in municipal solid waste (MSW) management and the limitations of conventional treatment technologies, plasma-based thermal treatment has emerged as a promising solution. This study conducts a comprehensive investigation, combining both lab-scale and pilot-scale plasma gasification systems to evaluate and optimize the performance of plasma-based waste processing. Initially, a lab-scale plasma gasification setup was developed to conduct detailed optimization studies focused on the preheating chamber's temperature and electrode consumption, which are crucial for improving long-term operational efficiency. The experiments aimed to achieve a consistent preheating temperature of more than 850 ℃ using various carrier gases, including argon, nitrogen, air, and mixtures. At 250 A and 300 A currents with a 25-35 V range, temperature profiles were monitored over one hour to evaluate thermal performance and power consumption. Among the tested configurations, argon plasma (15 LPM, 300 A) reached the target temperature in 16 minutes with the lowest power consumption of 1.95 kW, followed by air plasma (15 LPM, 300 A) in 20 minutes at 2.33 kW, and argon-air plasma (10 LPM & 5 LPM, 300 A) in 20 minutes at 2.23 kW. Electrode consumption was also studied to assess operational sustainability. Argon-nitrogen plasma exhibited the lowest electrode wear (9 g/h for anode, 3 g/h for cathode), whereas argon-air plasma showed the highest rates (66 g/h anode, 48 g/h cathode) [1]. Recently, it has been shown that CO2 plasma also produces high temperatures and increases CO concentration [2]. Building on these lab-scale findings, a pilot-scale plasma chamber with a 50 kg/h installed capacity was assessed for its energy efficiency, gas composition, byproduct characterization, and environmental compliance. The system processed the combustible fraction of MSW at approximately 1000 ℃, achieving a total energy consumption of 0.586 kWh/kg of waste after implementing a temperature shoot control strategy, resulting in a ˜15% reduction in energy use. Mass and energy balances were performed to quantify heat losses and material flows. Gas analysis revealed that CO and H2 were the dominant gaseous products, accounting for nearly 30% of the total output, with a lower heating value (LHV) of 4.7 MJ/Nm3 and cold gas efficiency between 44-53%. The solid residue (ash) was analyzed using EDX and ICP-MS techniques and found carbonless and non-toxic. Furthermore, wastewater from the gas cleaning system was found to have a neutral pH with total dissolved solids (TDS) between 1200-1500 mg/L, supporting the system's environmental safety and viability for sustainable waste management [3]. This study underscores plasma-based system's technical feasibility and optimization potential for environmentally sound and energy-efficient MSW treatment, with crucial insights into gas quality, energy dynamics, and material durability.
KEYWORDS: Plasma Gasification; Graphite electrode; Preheating; MSW;

REFERENCES

[1] T. Rana and S. Kar, Journal of the Energy Institute 120, 102122, 2025. https://doi.org/10.1016/j.joei.2025.102122

[2] Tejashwi Rana, Aishik Basu Mallick, Satyananda Kar, Energy Conversion and Management 350, 120972 (2026). https://doi.org/10.1016/j.enconman.2025.120972

[3] T. Rana and S. Kar, Journal of the Energy Institute 114, 101617, 2024. https://doi.org/10.1016/j.joei.2024.101617

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