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ABSTRACT

Induction Heating for Plastic Waste Treatment

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Many industrial processes rely on endothermic reactions that require significant energy input to maintain optimal reaction temperatures. However, conventional heating methods, such as resistive or convective heating, often result in substantial energy losses due to inefficient heat transfer, thermal gradients, and dissipation to the surroundings. These inefficiencies are particularly critical in high-temperature processes, such as plastic or biomass pyrolysis, where uniform and rapid heating is essential for maximizing energy efficiency and reaction performance.
To address these limitations, this study explores the use of induction heating as an alternative approach, leveraging 3D-printed metallic lattice structures (MLS) to enhance heat transfer efficiency. By generating heat directly within the material through electromagnetic induction, this method minimizes external heat losses and improves thermal control, making it a promising solution for various endothermic chemical processes, including pyrolysis.
Additive manufacturing enables the creation of complex MLS geometries, unlocking new possibilities for advanced heating applications. In this work, we propose an innovative approach using 3D-printed MLS subjected to an aleternating high-frequency electromagnetic field as an inductive heating system for plastic pyrolysis. This technique enhances energy efficiency by positioning the heat source inside the reactor, thereby reducing heat loss and supporting environmental circularity (figure 1).

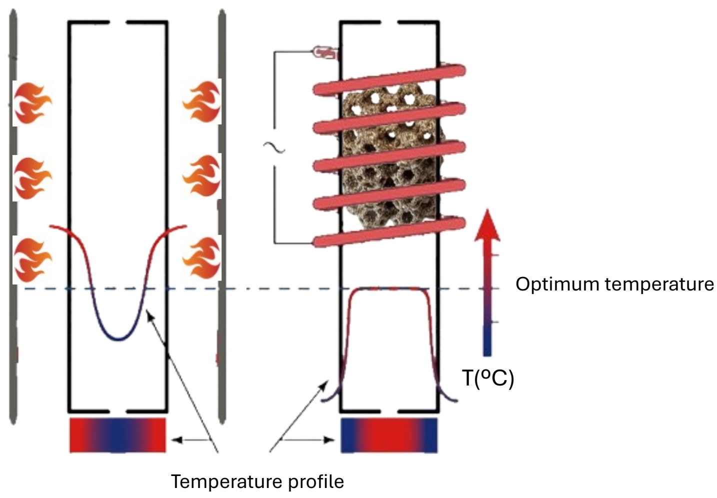

Figure 1. Comparison between traditional and the innovative heating system proposed. (Figure adapted from a related work (18) (Mortensen M et al., doi: 10.1021/acs.iecr.7b02331)

The research includes a comprehensive characterization of the electromagnetic field within a coil connected to an alternating high-frequency induction equipment and examines the effects of a constant electromagnetic field, generated by a Helmholtz coil, on the induction heating of 3D-printed stainless steel structures. The Joule effect serves as the primary heat transfer mechanism, with the maximum achievable temperature determined by the electrical properties of the MLS. Additionally, a study of thermal properties establishes the relationship between temperature and the electromagnetic parameters governing the heating process in simple 3D-printed metallic structures (rings and hexagons).

The findings provide valuable insights into optimizing induction heating in 3D-printed MLS for use as reactor cores in endothermic industrial processes. This method enables localized and rapid reactor heating, where energy is transferred from an external power source via electromagnetic induction to the MLS, which then converts it into thermal energy.

References

[1] S.L. Wong, S. Armenise, B.B. Nyakuma, A. Bogush, S. Towers, C.H. Lee, K.Y.Wong, T.H. Lee, E. Rebrov, M. Muñoz. Journal of Analytical ad Applied Pyrolysis. 169; (2023).