Inductively Heated Moving-Bed Reactors for Methane Pyrolysis

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The electrification of energy-intensive chemical processes requires flexible and efficient heating concepts beyond conventional fossil-fired systems. Inductive heating enables direct heat generation within the reaction zone, thereby minimizing heat transfer limitations and enabling rapid and targeted thermal control [1,2]. Methane pyrolysis represents a particularly promising application due to its potential for CO_2-free hydrogen production [3].

A major challenge of methane pyrolysis is the formation of solid carbon deposits on reactor walls and heating elements, resulting in reactor blockage and operational instability [4,5]. In this work, an inductively heated moving-bed reactor concept is presented in which a carbon precursor acts simultaneously as susceptor material, heat carrier, and transport medium for solid carbon products. The precursor particles are heated directly within an alternating magnetic field while methane is introduced in counter-current flow to the moving bed. Carbon formed during methane decomposition deposits on the moving particles rather than on reactor internals, while gaseous products leave the reactor in upward flow. The counter-current configuration additionally enables internal heat integration.

Experimental investigations at the BFI technical centre demonstrate methane conversions of up to 95% (Figure 1) [6,7]. The conditioned carbon co-product from methane pyrolysis can be reused as precursor material, enabling a cyclic process concept and providing opportunities for the generation of value-added carbon materials [8].

Beyond methane pyrolysis, the reactor concept shows potential for further electrified high-temperature processes such as Fischer–Tropsch synthesis and methanation reactions. Catalyst carriers or coated susceptors may additionally combine catalytic functionality with inductive heat generation. Overall, inductively heated moving-bed reactors provide a promising platform for integrating renewable electricity into high-temperature chemical processes while improving heat-transfer efficiency and operational flexibility.

References

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Figure 1: Inductively heated moving-bed reactor for methane pyrolysis during operation.