ANALYSIS OF OPTIMAL CONDITIONS FOR OXIDATIVE PYROLYSIS OF ETHANE TO ETHYLENE IN A FLOW REACTOR WITH A LAMINAR FLOW REGIME

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Abstract: A numerical analysis was carried out to determine the optimal conditions for ethylene production via noncatalytic oxidative pyrolysis of ethane with oxygen in a flow reactor operating under laminar flow conditions. The study demonstrates the feasibility of implementing an autothermal oxidative pyrolysis process for ethane, achieving an ethylene yield of up to 55%, which is virtually comparable to the yield obtained in the energy-intensive thermal pyrolysis of ethane. Oxygen present in the system during oxidative pyrolysis acts as an effective inhibitor of soot formation. This makes it possible to reduce the volume of steam supplied during pyrolysis and, potentially, to eliminate steam injection altogether. The process also yields by-products: syngas with an $[H_2]/[CO]$ ratio of 1.75, which can be used in catalytic synthesis processes, and a substantial amount of heat — up to 4.4% of the total heat of ethane combustion.

Keywords: ethane; ethylene; oxidative pyrolysis; numerical analysis; flow reactor; laminar flow

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Figure Captions

Figure 1 Prescribed temperature profile of the reactor outer wall for all Φ values $T = T(x, r = 2.75\ \text{cm})$ (*1*), and the calculated gas temperature profile along the reactor axis, $T = T(x, 0)$, at $\Phi = 8.3$ (*2*)

Figure 2 Dependences of the ethane (C_2H_6) (*1*) and ethylene (C_2H_4) (*2*) mole fractions on the reactor axis ($r = 0$) (solid curves) and at the inner wall ($r = 2.5$ cm) (dashed curves) of the reactor on the x coordinate in the hot zone of the reactor calculated for the value $\Phi = 8.3$

Figure 3 Dependences of the conversion of C_2H_6 (*1*) and the yield of the main carbon-containing products C_2H_4 (*2*), CO (*3*), and CH_4 (*4*) on the equivalence ratio Φ

Figure 4 Dependence of the yields of H_2O (*1*) and H_2 (*2*) on the equivalence ratio Φ

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