14. Industrial chemical reactors

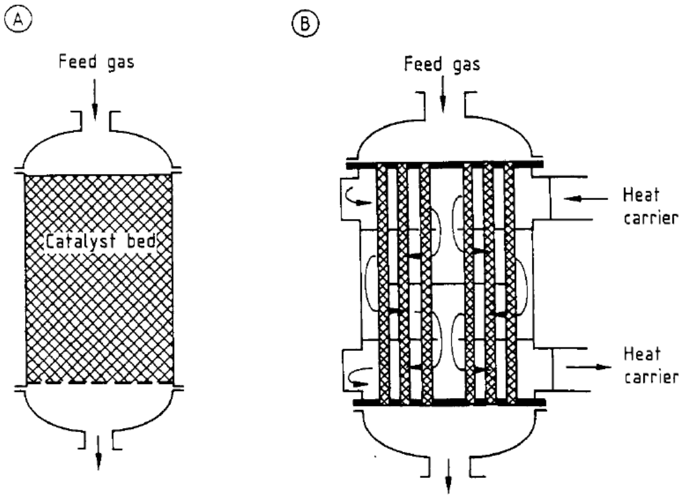


Figure 1. Basic types of catalytic fixed-bed reactors. A) Adiabatic fixed-bed reactor; B) Multitubular fixed-bed reactor.

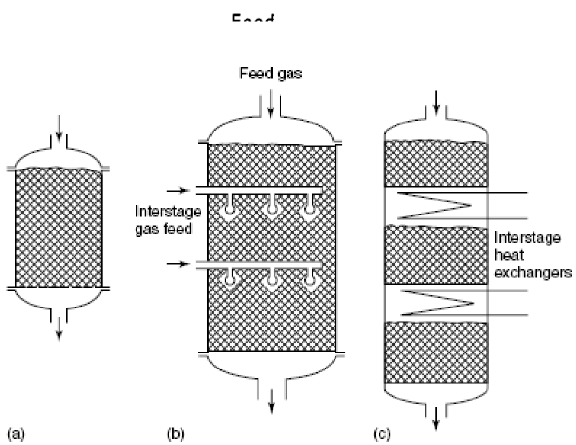


Fig. 12 Development of fixed-bed reactors. (a) Single-bed adiabatic packed-bed reactor; (b) adiabatic reactor with interstage gas feed (ICI concept); (c) multi-bed adiabatic fixed-bed reactor with interstage heat exchange.

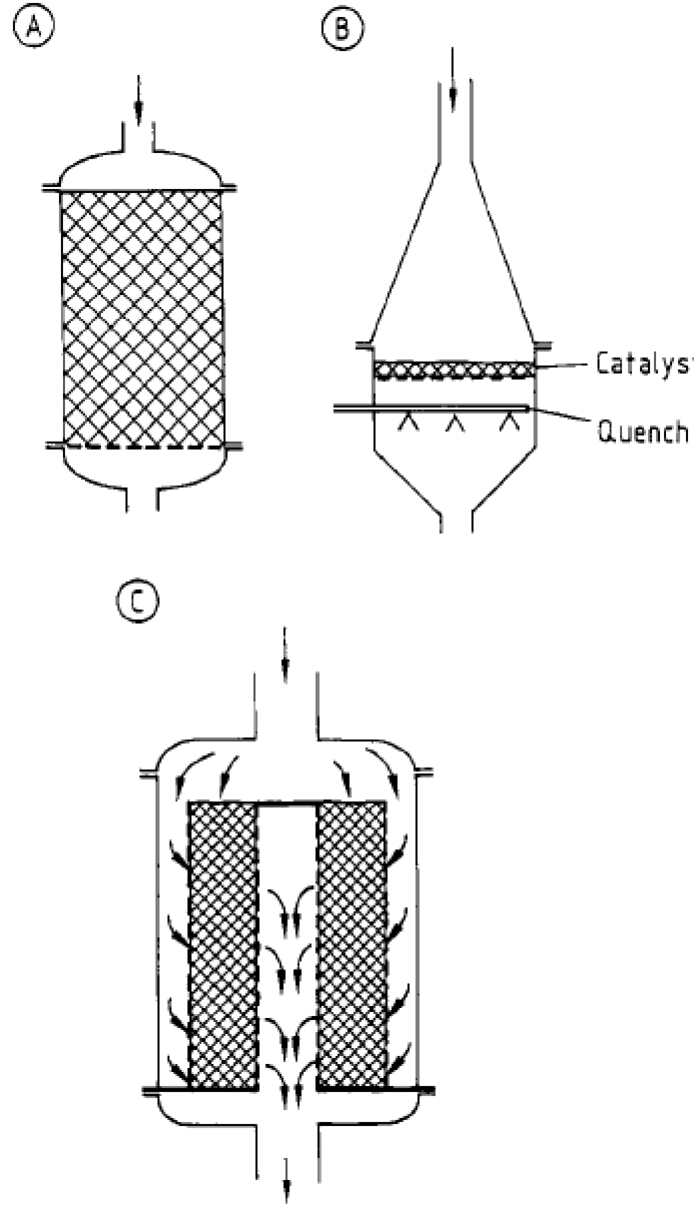


Figure 9. Main design concepts for adiabatic reactors. A) Adiabatic packed-bed reactor; B) Disk reactor; C) Radial-flow reactor.

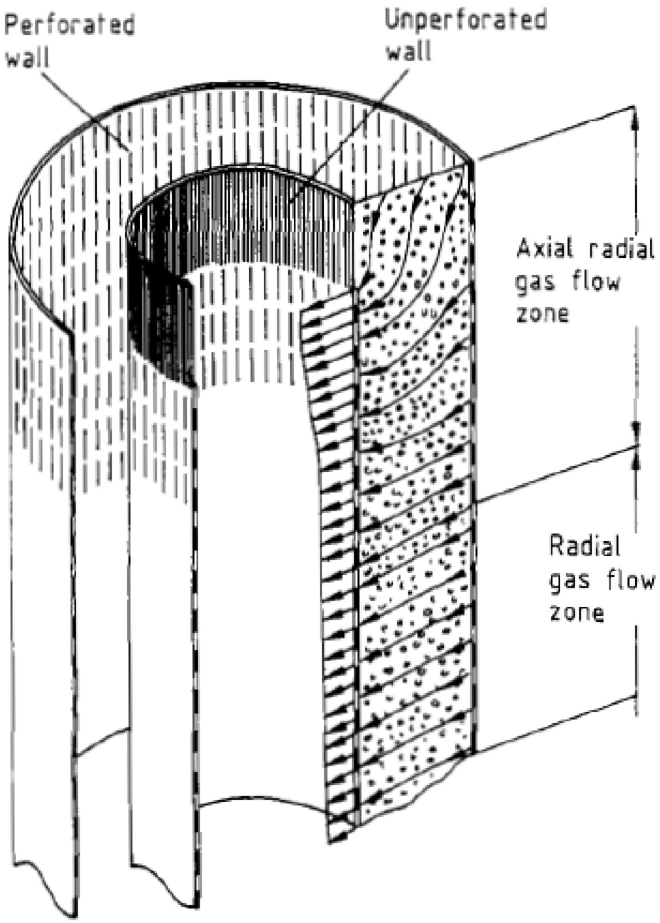


Figure 10. Upper bed closure in a radial-flow reactor [22].

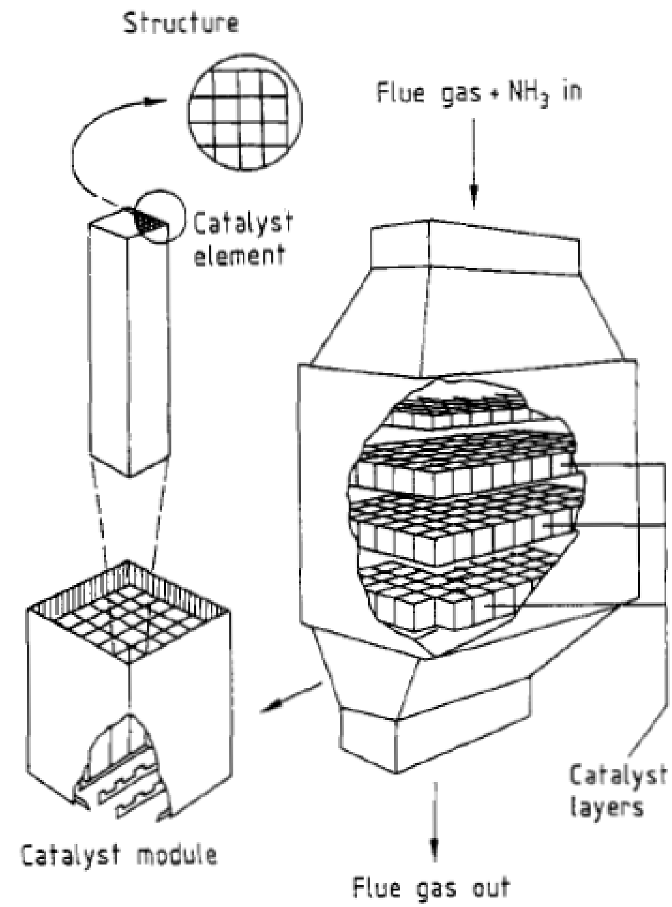


Figure 11. Reaction chamber for removal of nitrogen oxides from power station flue gases [23].

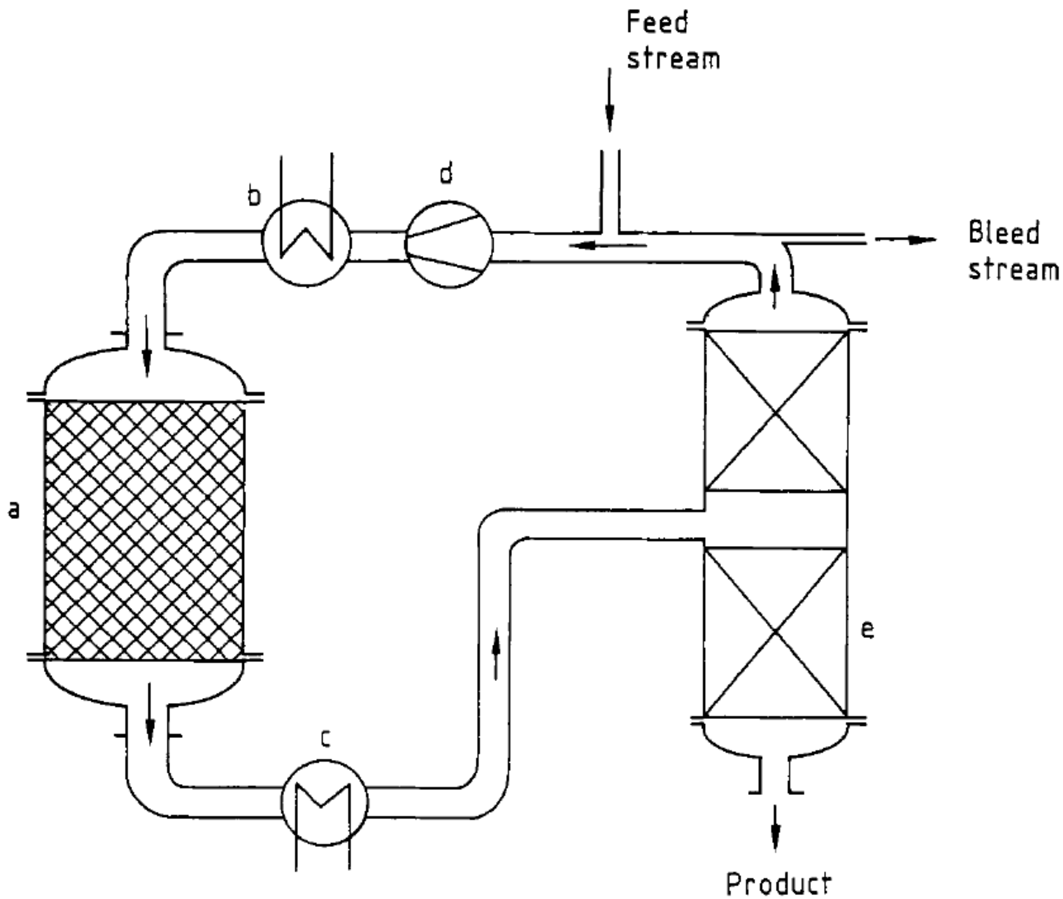


Figure 2. Reaction cycle for synthesis reactions with incomplete conversion. a) Fixed-bed reactor; b) Feed Preheater; c) Exit cooler; d) Recirculation compressor; e) Separation device.

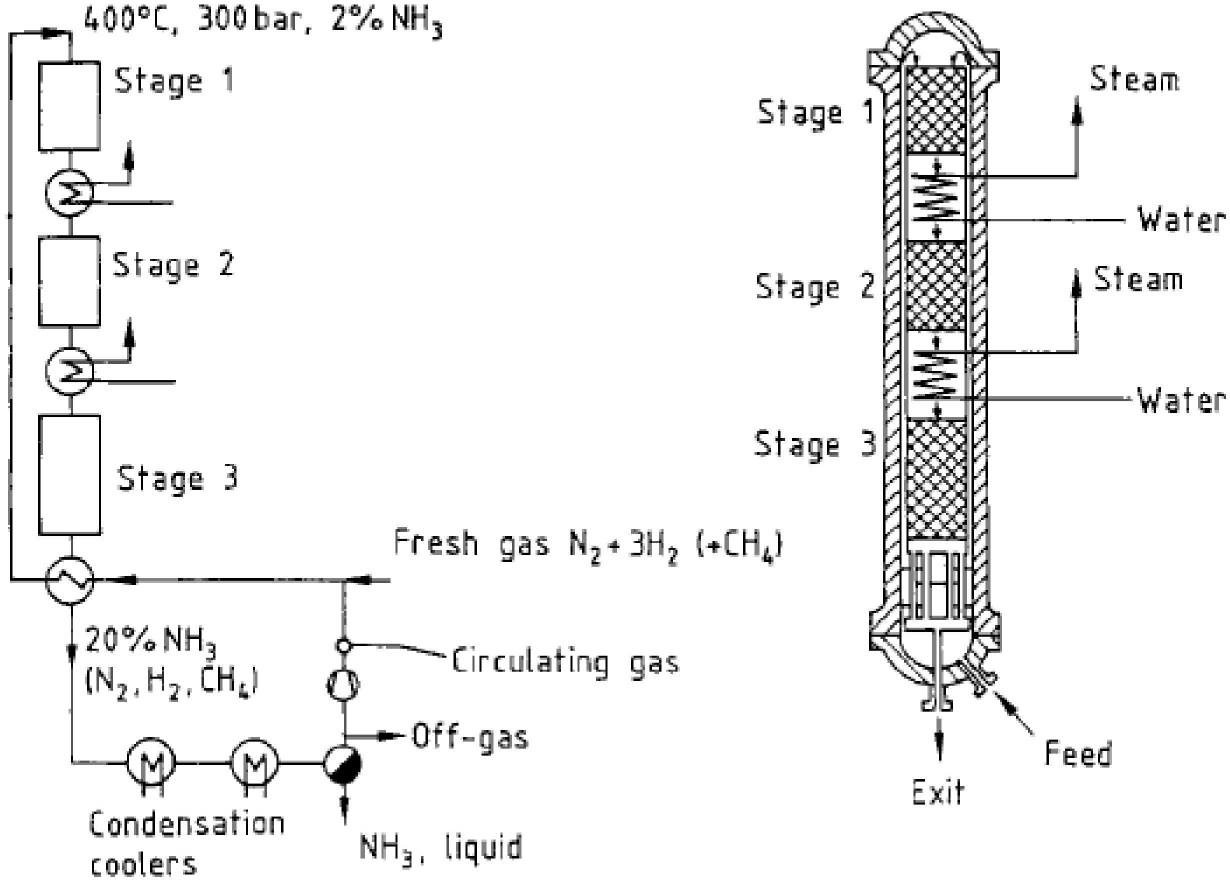


Figure 15. Schematic of a multistage reactor for ammonia synthesis.

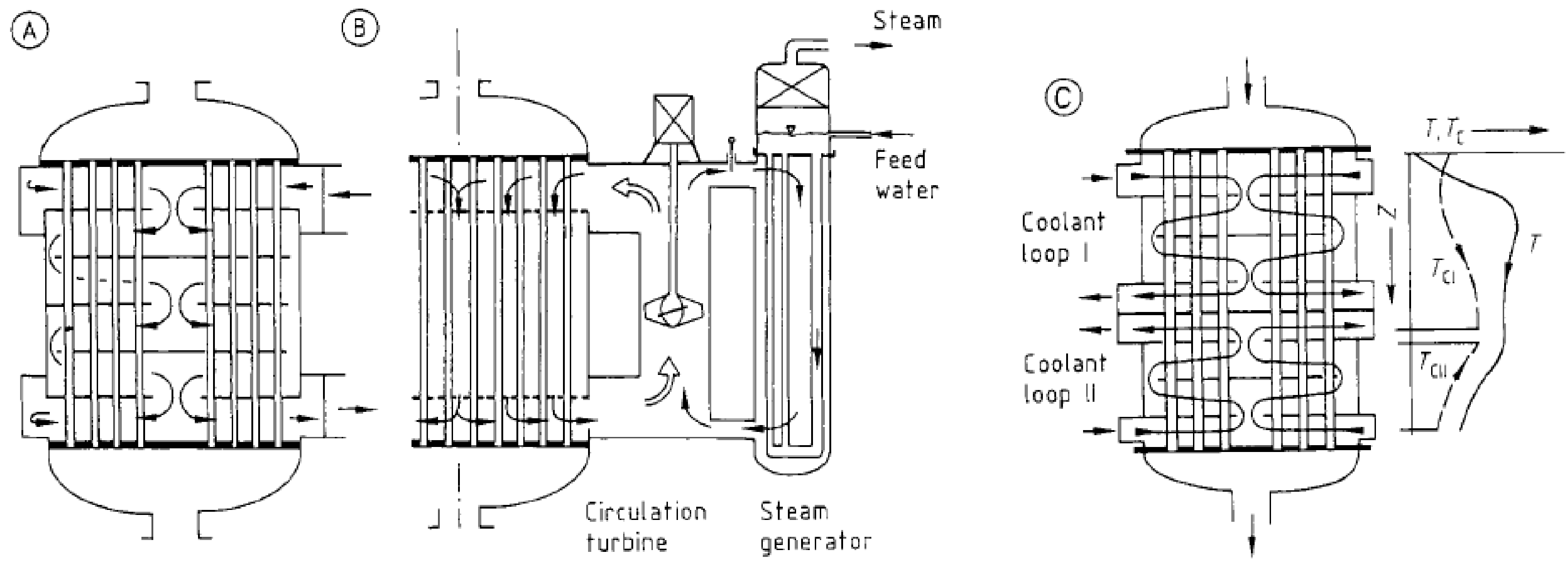


Figure 16. Heat transfer medium control in tube-bundle fixed-bed reactors. A) Cross flow; B) Parallel flow; C) Multiple cooling sections.

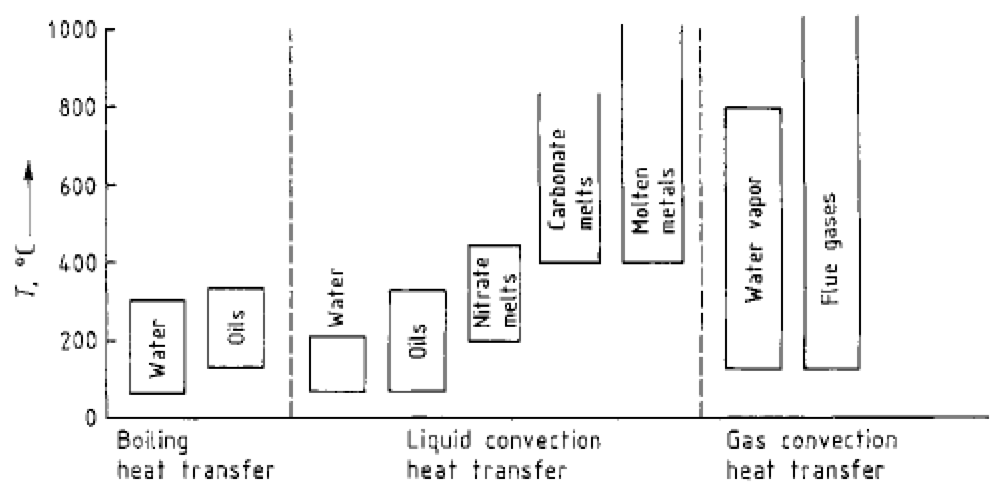
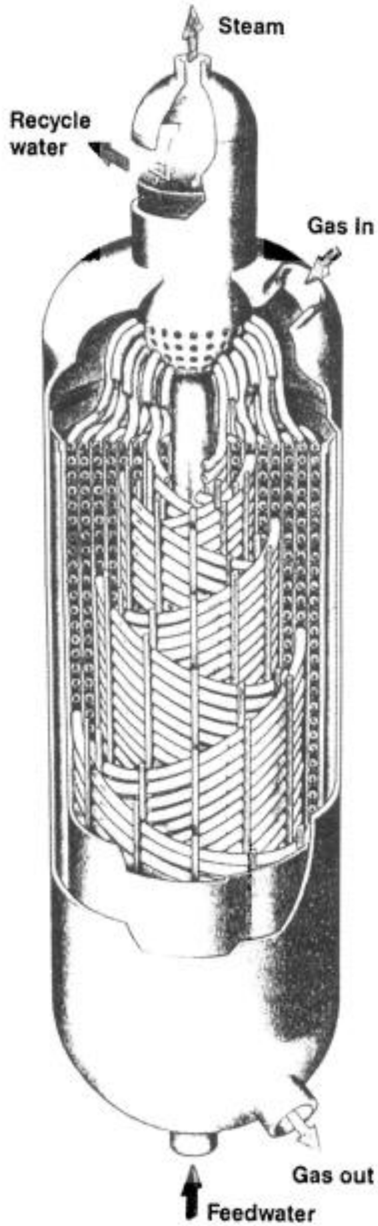


Figure 17. Application ranges for common heat transfer media.

A)



B)

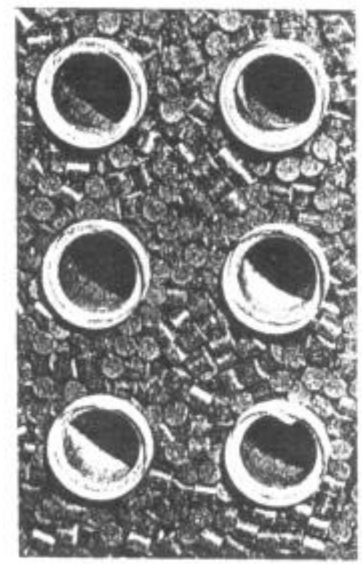


Figure 19. A) Design concept of the Linde isothermal reactor for methanol synthesis; B) Cut through the tube bundle surrounded by catalyst pellets (from [26]).

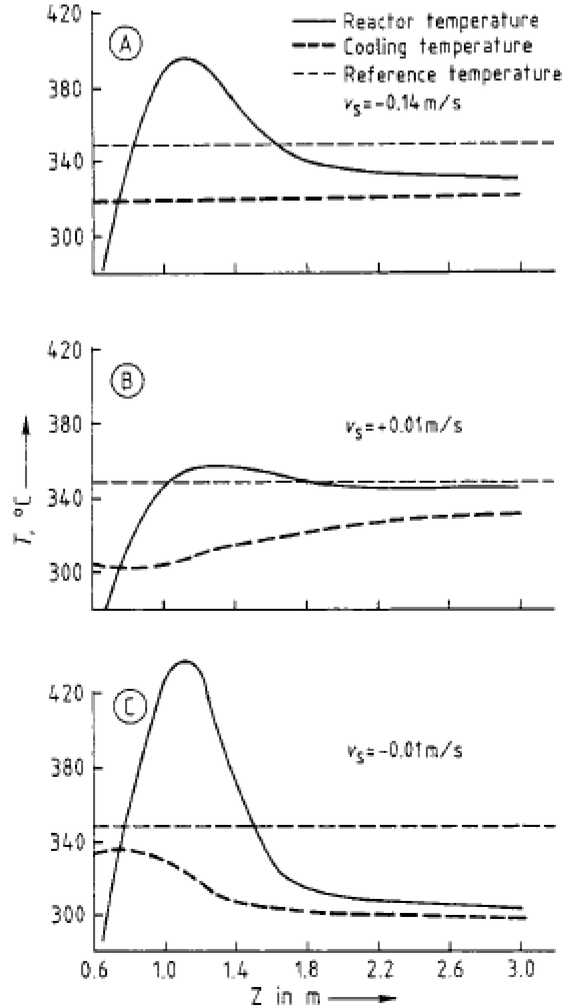


Figure 20. Influence of the coolant flow direction and flow velocity v_s on the reaction temperature profile. A) Isothermal, B) Cocurrent flow; C) Countercurrent flow.

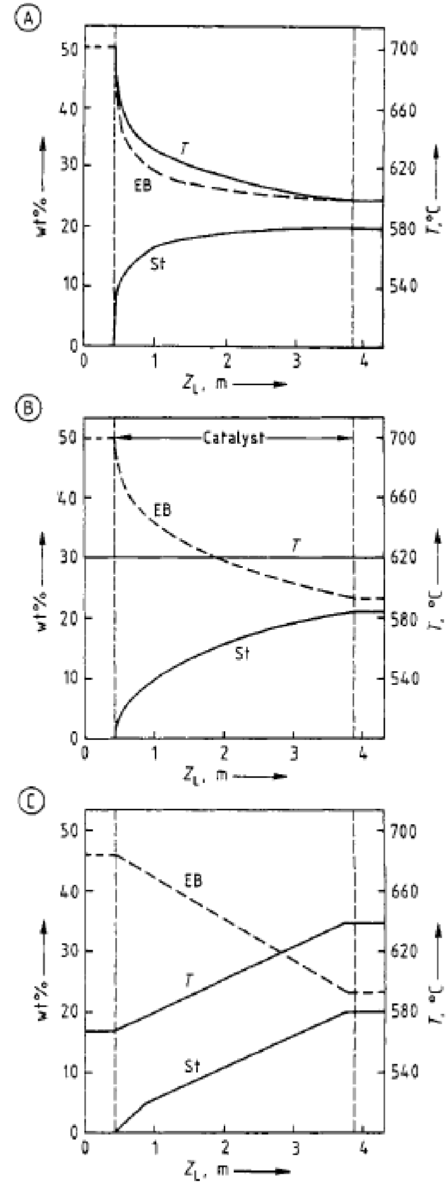


Figure 21. Influence of the heating strategy on the temperature and concentration profiles in styrene synthesis. A) Adiabatic; B) Isothermal; C) Countercurrent heating. EB = ethylbenzene; St = styrene.

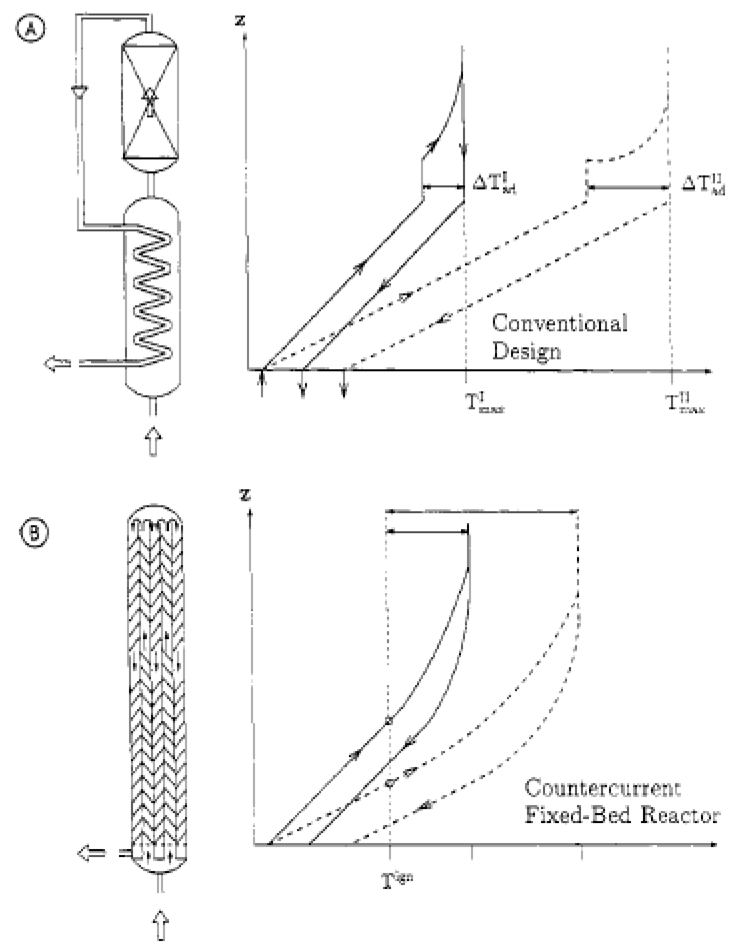


Figure 23. Autothermal fixed-bed reactors with recuperative heat exchange. Basic design and typical temperature profiles. A) Conventional design with separate heat exchanger; B) Countercurrent fixed-bed reactor.

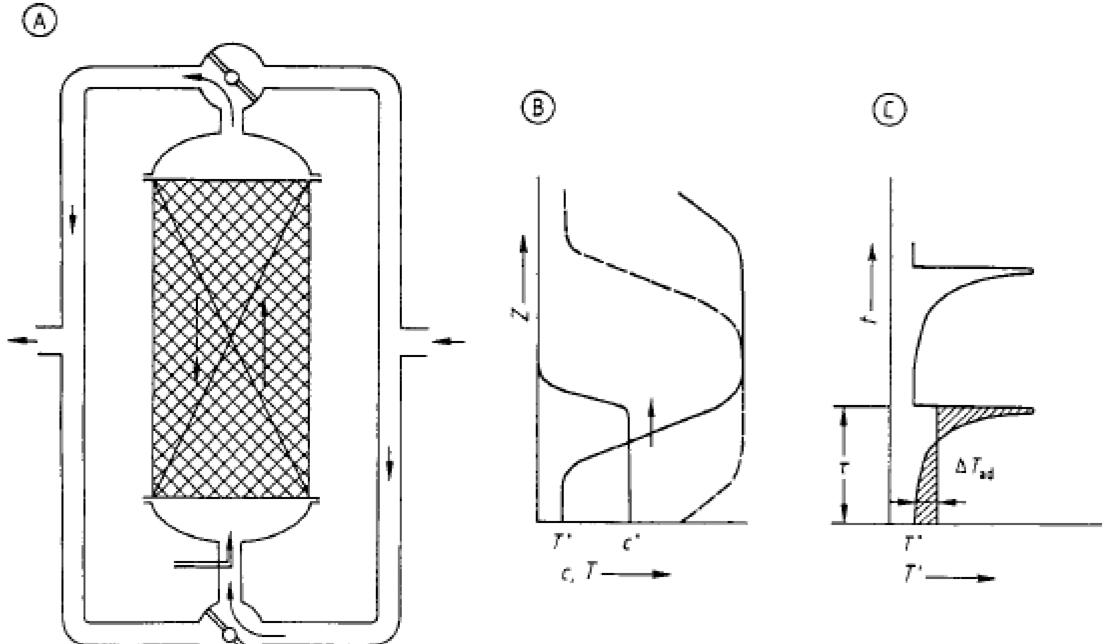


Figure 24. Autothermal reaction control with direct (regenerative) heat exchange for an irreversible reaction [14]. **A**) Basic arrangement; **B**) Local concentration and temperature profiles prior to flow reversal in steady state; **C**) Variation of outlet temperature with time in steady state.

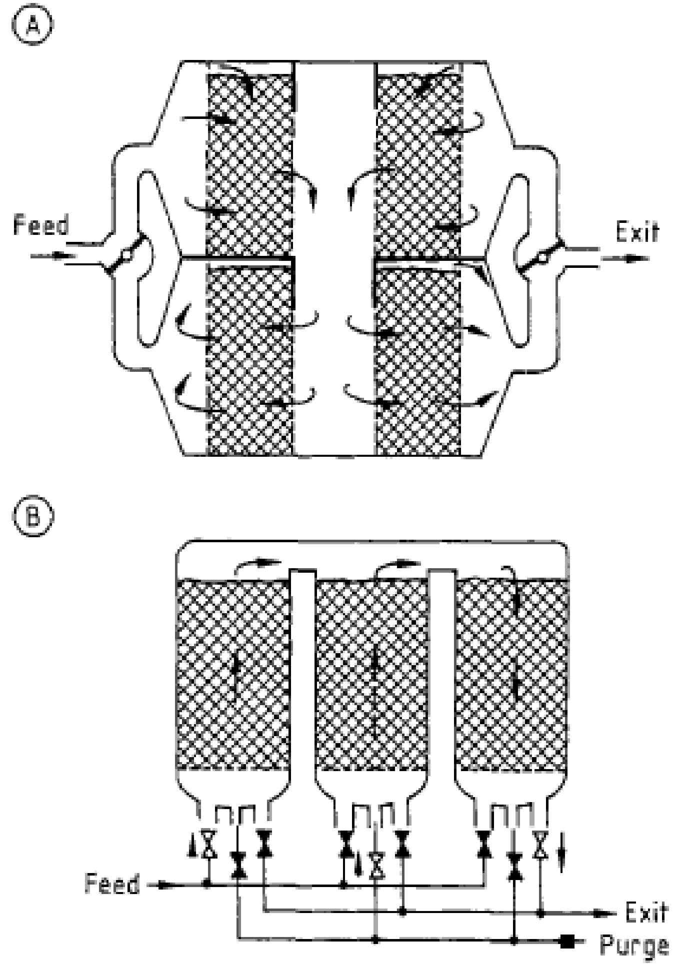


Figure 26. Alternative arrangements for autothermal reactor design with periodic flow reversal. A) Radial-flow concept; B) Multiple-bed arrangement.

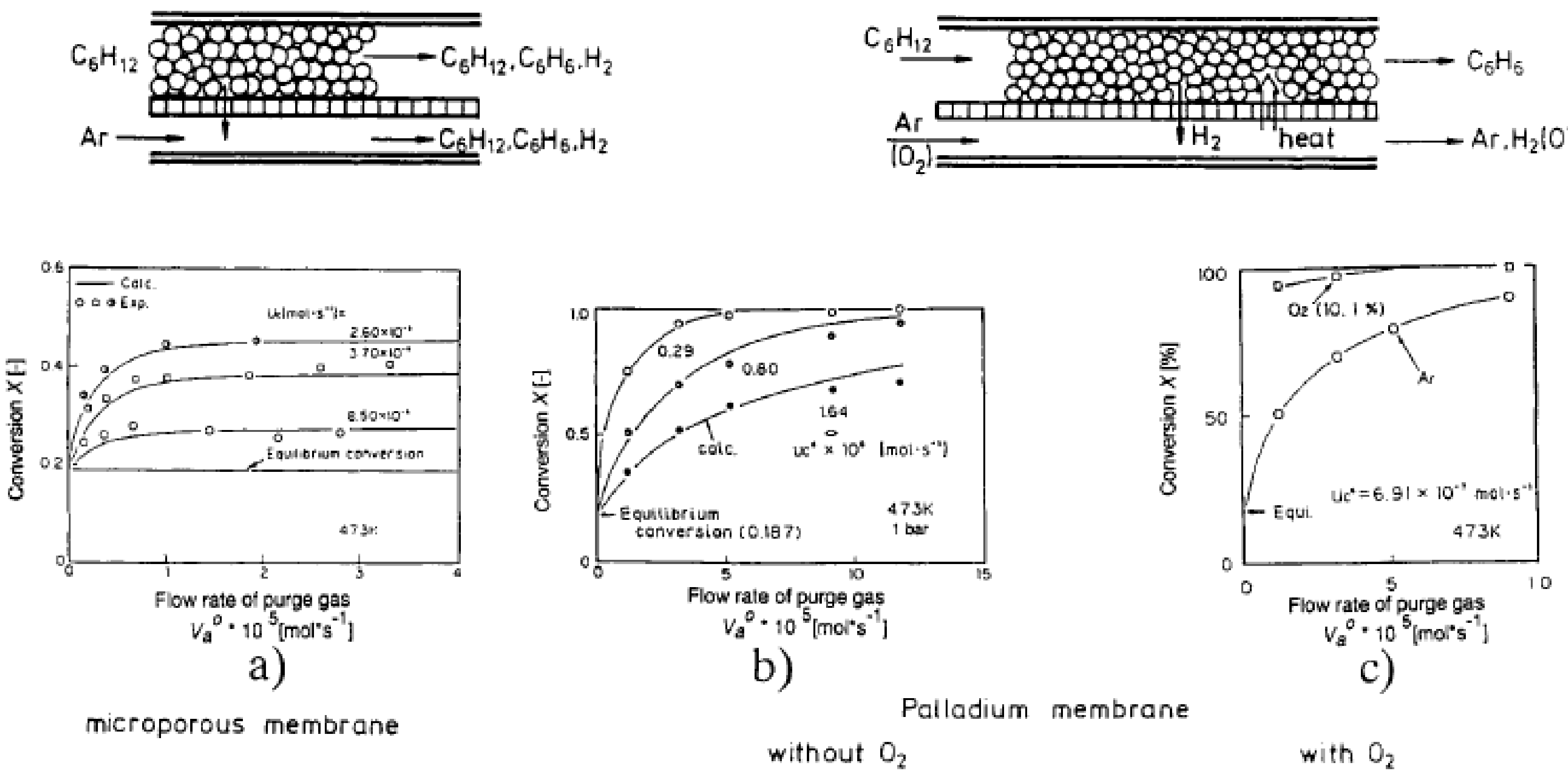


Figure 28. Cyclohexane dehydrogenation in different membrane reactors, adopted from Itoh [55], a) microporous inert membrane; b) H_2-selective Pd membrane; c) H_2-selective Pd membrane with combustion on the permeate side (from [56]).

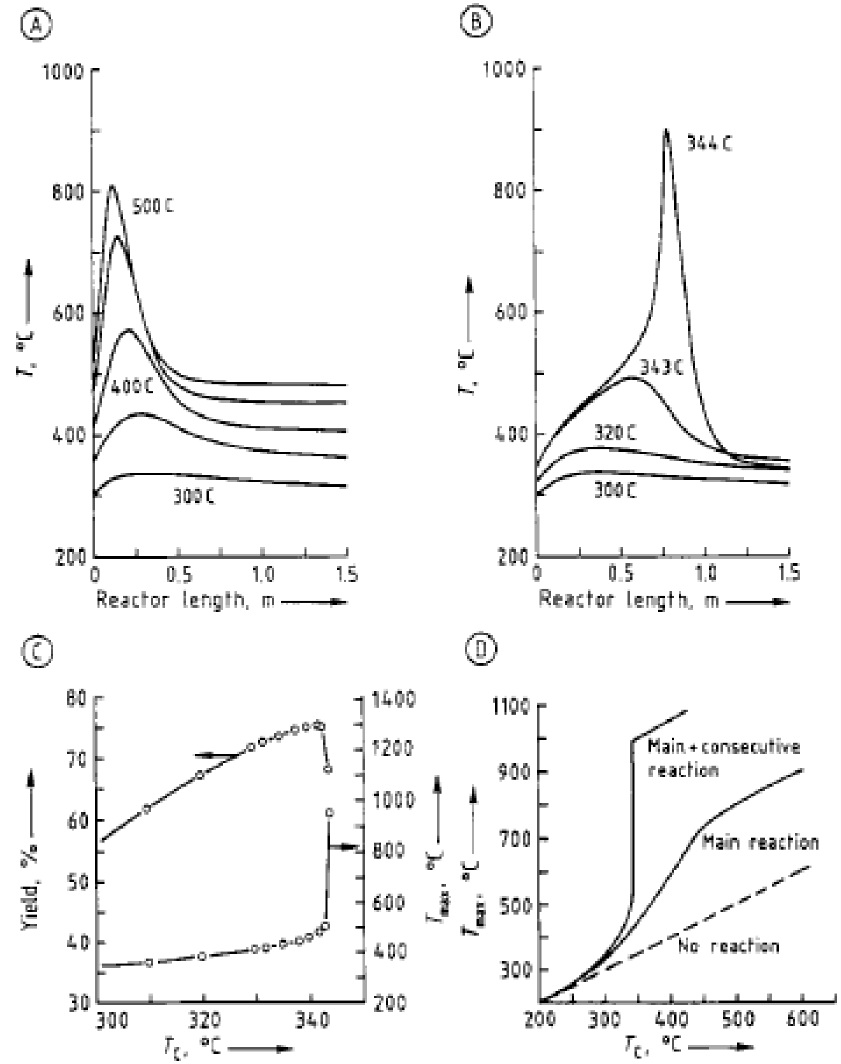


Figure 31. Parametric sensitivity of a partial oxidation reaction in a fixed-bed reactor of typical dimensions as a function of the coolant temperature T_c with $T(z = 0) = T_c$. A) Temperature profile over reaction length (main reaction only); B) Temperature profile including total oxidation as side reaction; C) Maximum temperature T_{max} and yields as a function of coolant temperature T_c in case B; D) T_{max} as a function of T_c for both cases.

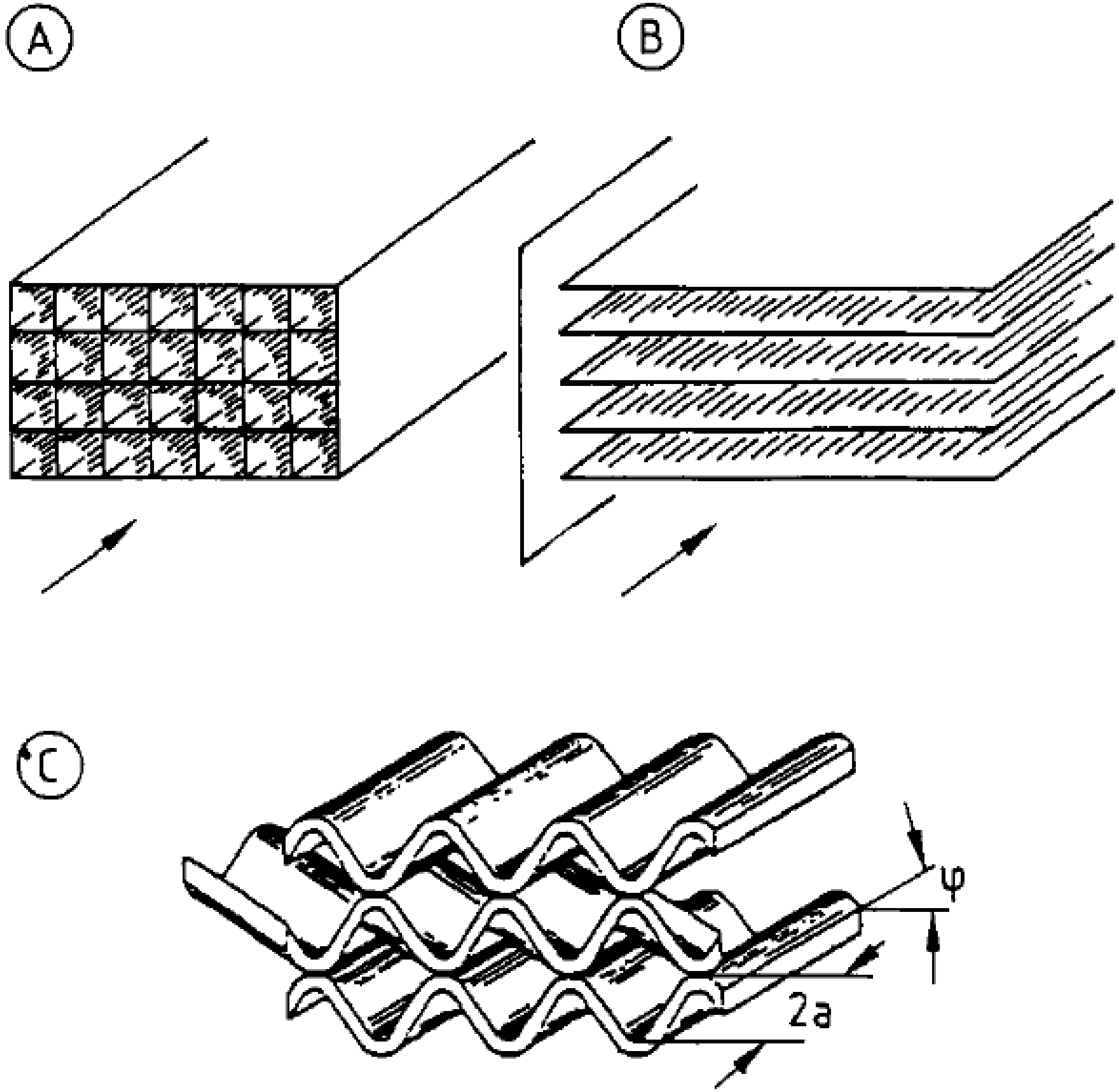


Figure 3. Usual shapes of monolith catalysts. A) Square-channel monolith; B) Parallel-plate monolith; C) Corrugated-plate packing.

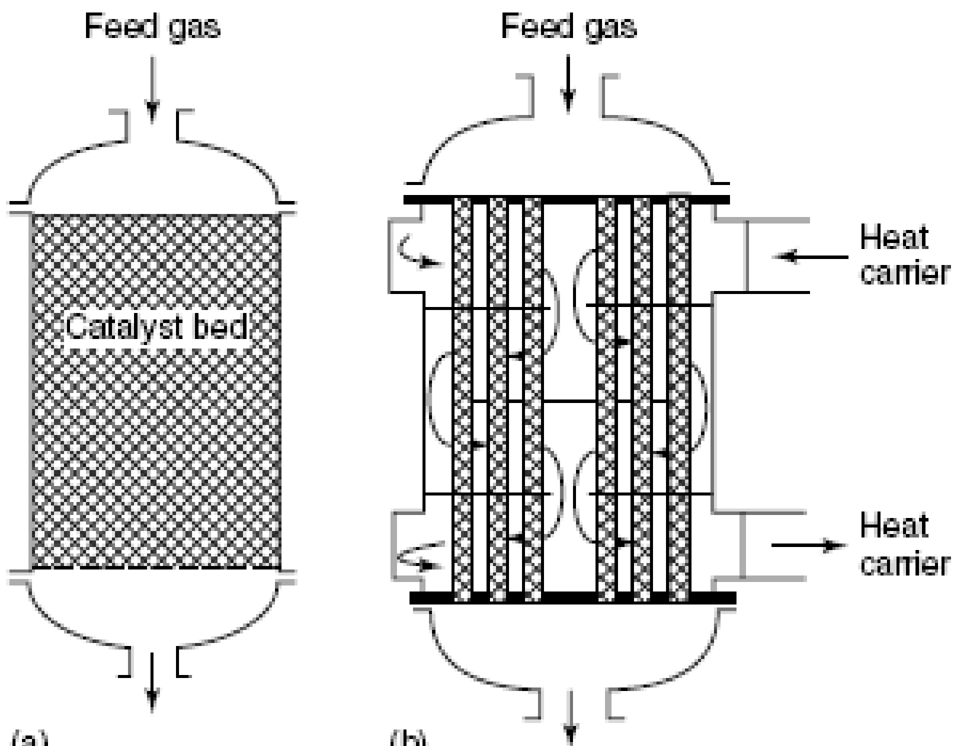


Fig. 1 Basic types of catalytic fixed-bed reactors. (a) Adiabatic fixed-bed reactor; (b) multitubular fixed-bed reactor.

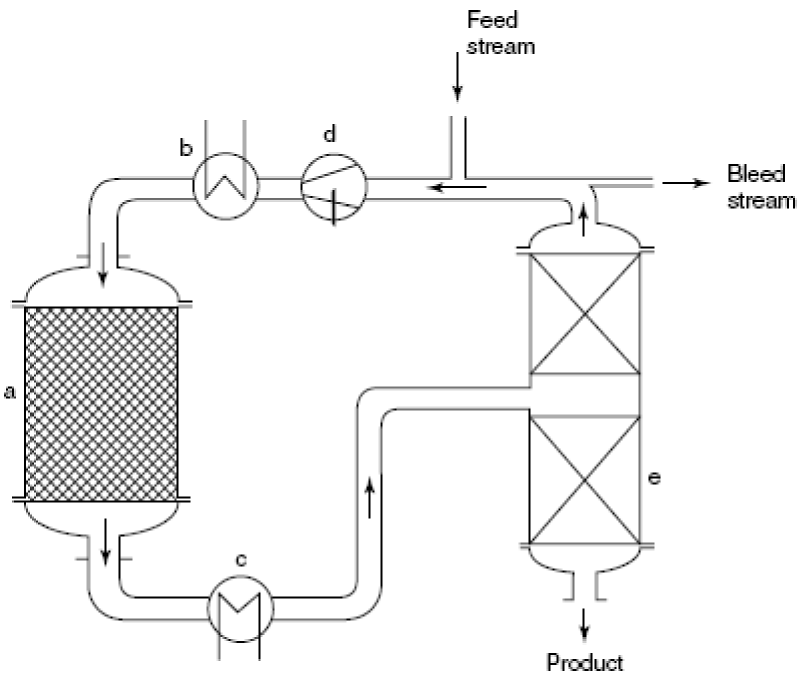


Fig. 2 Reaction cycle for synthesis reactions with incomplete conversion. (a) Fixed-bed reactor; (b) feed preheater; (c) exit cooler; (d) recirculation compressor; (e) separation device.

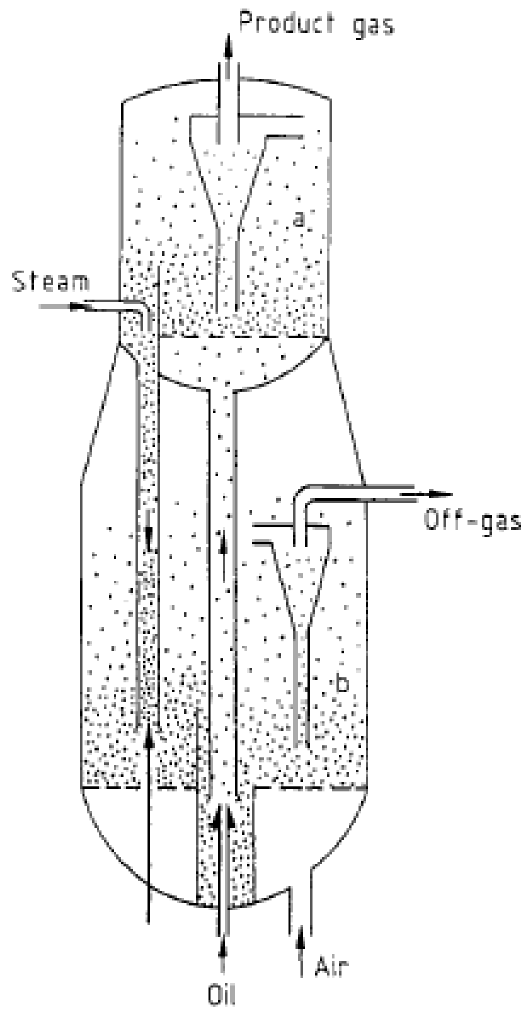


Figure 15. Fluid catalytic cracking process (Kellogg–Orthoflow system; according to Refs 74 and 75: (a) reactor; (b) regenerator.

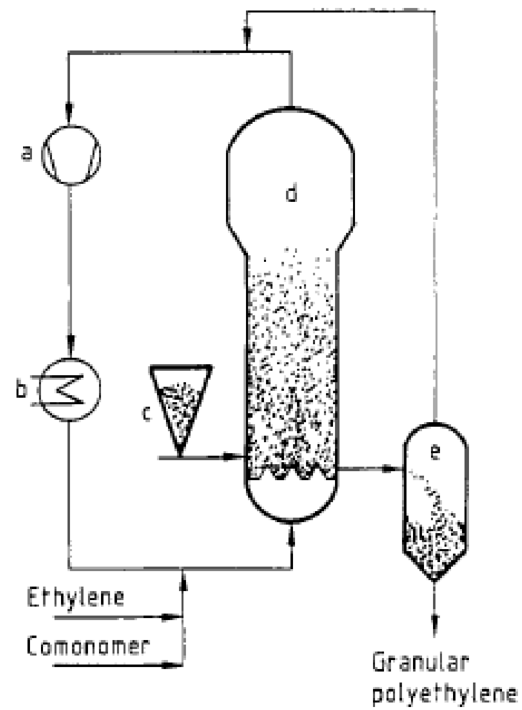


Figure 19. Gas-phase polymerization of ethylene (Unipol process) [2]: (a) compressor; (b) cooler; (c) catalyst feed hopper; (d) reactor; (e) separator.

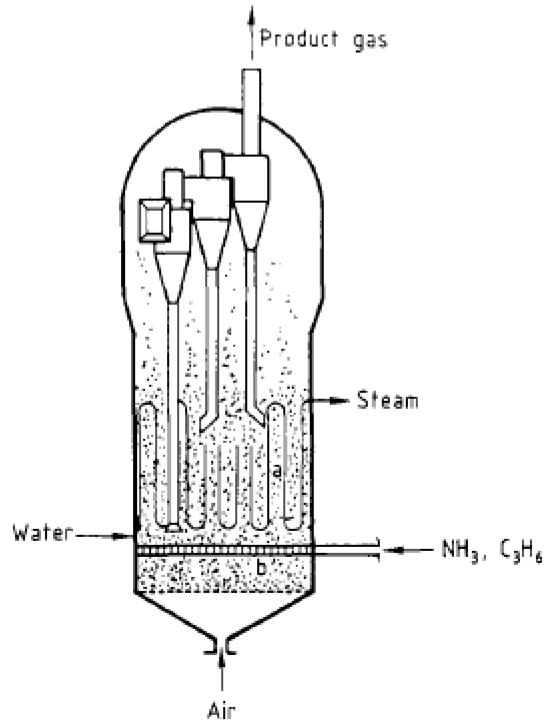


Figure 17. Synthesis of acrylonitrile (Sohio process) [2]: (a) cooler with internals; (b) distributor.

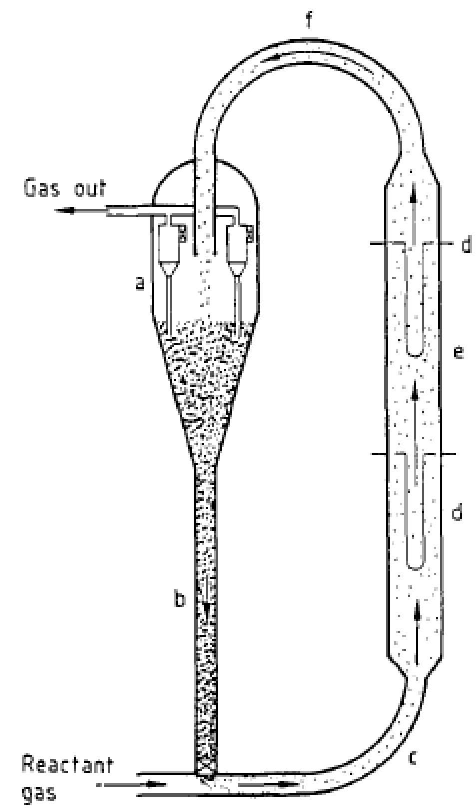


Figure 18. Fischer–Tropsch synthesis in the Synthol reactor [2, 78]: (a) hopper; (b) standpipe; (c) riser; (d) cooler (*coil*); (e) reactor; (f) gooseneck.

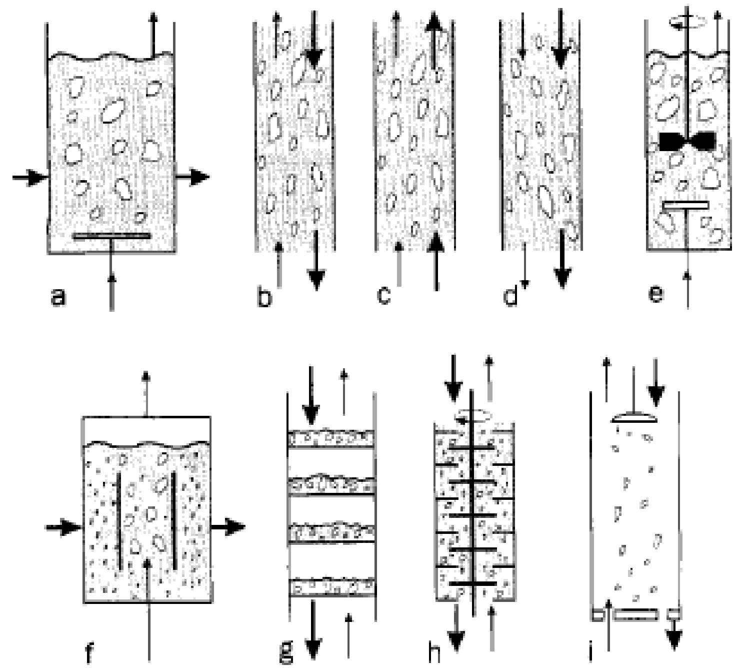


Figure 1. Slurry reactors classified by the contacting pattern and mechanical devices: (a) slurry (bubble) column; (b) countercurrent column; (c) co-current upflow; (d) co-current downflow; (e) stirred vessel; (f) draft tube reactor; (g) tray column; (h) rotating disc or multi-agitated column reactor; (i) three-phase spray column; → liquid flow; → gas flow.

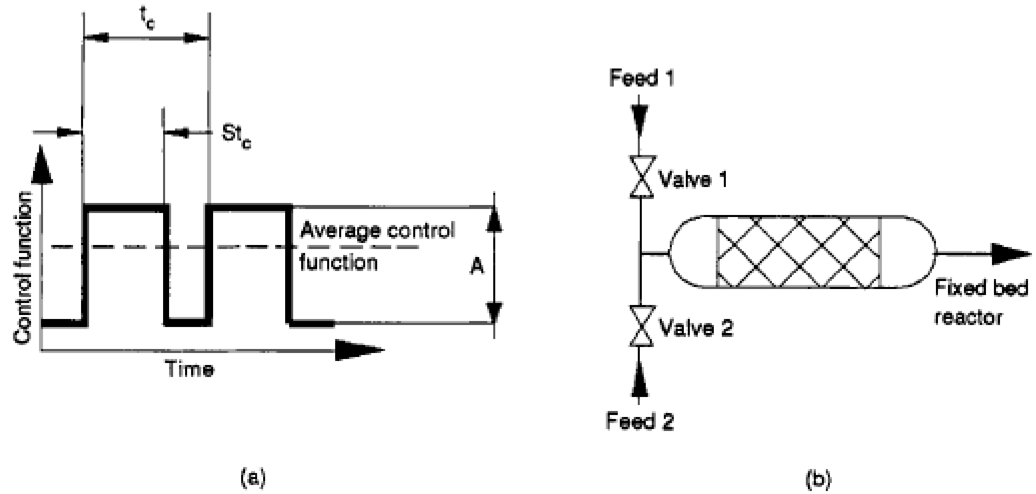


Figure 1. (a) Step-wise function of inlet parameters change. (b) Fixed-bed reactor operated at periodic switching between two different feeds that provide for step-wise control.

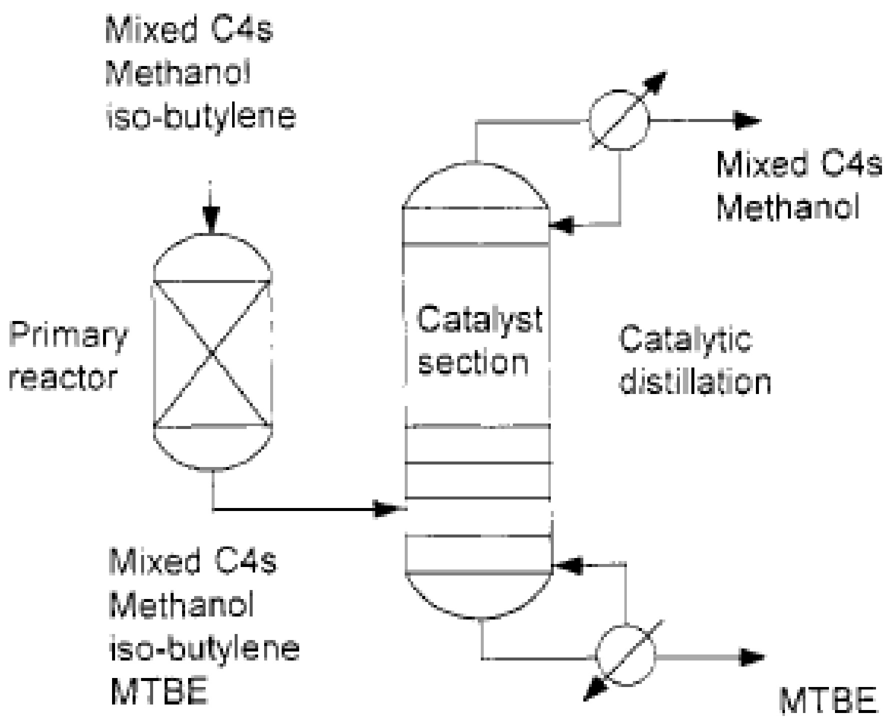


Figure 5. The CR&L catalytic distillation process for MTBE.