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When cooling jackets and internal cooling coils do not give enough heat transfer area, a circulating cooling system is sometimes used. Process fluid from the reactor is pumped through an external heat exchanger and back into the reactor. Cooling water is added to the shell side of the heat exchanger at a rate ***F, as*** set by the temperature controller. The circulation rate through the heat exchanger is constant.

Assume that the shell side of the exchanger can be represented by two perfectly mixed “lumps” in series and that the process fluid flows countercurrent to the water flow, also through two perfectly mixed stages.

The reaction is irreversible and fist-order in reactant A:



The contents of the tank are perfectly mixed. Neglect reactor and heat-exchanger metal.

Derive a dynamic mathematical model of this system.

