Property change of mixing in a Fischer-Tropsch process

【Module Learning Objectives】

- The ideal-gas mixture model and property changes due to mixing

【Associated Sections in Selected Textbooks】

- Introduction to Chemical Engineering Thermodynamics[1] Sec. 11.4

【Associated Web Modules】

- Fischer-Tropsch process: http://biofuelsacademy.org/web-modules/process/fischer-tropsch-process/

【Process Background and Problem】

Fischer-Tropsch (FT) process is the process where synthesis gas (H_2 and CO) is converted into a mixture of hydrocarbons, oxygenates, water and carbon dioxide. The essential step, known as the Fischer-Tropsch (FT) reaction, can be written as

$$nCO + (2n+1)H_2 \rightarrow C_nH_{(2n+2)} + nH_2O$$

where $C_nH_{(2n+2)}$ represents a range of hydrocarbons, ranging from low-molecular-weight gases (n=1, methane), by way of gasoline (n=5-12), diesel fuel (n=13-17), and as far as solid waxes (n>17). The FT reaction is usually a catalytic reaction at high temperatures (180-350^{o}C) and high pressure for realistic rates to be achieved, and the typical catalysts used are based on iron or cobalt. The hydrocarbons produced by FT process can be refined and used in place of more conventional liquid fuels derived from crude oil[2].

For a Fischer-Tropsch process where H_2 and CO enter a continuously operating reactor, if the stream of hydrogen flowing at the rate of 0.5 kg s^{-1} and the stream of carbon monoxide flowing at the rate of 3 kg s^{-1} mix adiabatically in this steady-flow process, what is the rate of entropy increase as a result mixing? Assume the gases exhibit ideal gas behavior.

Bibliography

[1] J. M. Smith, H. C. Van Ness, and M. M. Abbott, *Introduction to chemical engineering thermodynamics*. McGraw-Hill, 2005.

[2] A. de Klerk and E. Furimsky, “Catalysis in the refining of Fischer–Tropsch syncrude,” *Q. J. Res. Sci. Technol. Platin. Group Met. Dev. their Appl. Ind.*, vol. 55, pp. 263–267, 2011.