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Effect of heat transfer on synthesis gas production in catalytic reactors

Abdullah Al-Musa[1], S Shabunya[2], V Martynenko[2], V Kalinin[2], M Al-Saleh[1] and **A Al-Zahrani[1]**
[1]King Abdulaziz City for Science and Technology, KSA
[2]A.V. Luikov Heat and Mass Transfer Institute of the National Academy of Sciences of Belarus, Belarus

Synthesis gas is a starting material for various chemical processes of industrial application. Industrial catalytic reactors are designed under the impact of various technical conditions, the traditions accepted in the industry and taking into account the various restrictions of economic sense. Characteristic temperature regime of industrial installations for synthesis gas production is 700-1000 oC. At such temperatures, catalytic processes associated with the partial oxidation of hydrocarbons take place rapidly, so the composition of synthesis gas becomes close to the equilibrium for the residence time about the tens of milliseconds. This means that the resulting composition depends on the temperature and pressure of implemented process. The residence time is about some seconds in industrial plants producing synthesis gas, i.e., it is ten times higher than the characteristic time of catalytic processes. This means that in customary reactor design the rate of implemented processes are rather controlled by diffusion limitations than kinetic properties of catalysts in use. Optimization of heat and mass transfer implemented in catalytic reactor can reduce the catalyst volume. We have developed a coaxial catalytic reactor with controlled preheating of inlet mixture and heating of reactor jacket. Designed reactor shown in figure is used in the experiments to produce synthesis gas featured by low content of CO_2<0.1% and CH4<0.5% that is typical for protective atmosphere. We tested four types of granular catalyst using Ni, Pt, Rh and Pd to produce such synthesis gas by catalytic partial oxidation of natural gas. In all cases the composition of produced synthesis gas are consistent with the characteristics of the products produced by industrial generators of protective atmosphere. Our experimental plant with a maximum syngas capacity 12.5 n.m^3/hr uses 0.45 liter of catalyst, while industrial generators of similar performance use several tens of liters of catalyst. The results of conducted experiments suggest the possibility to reduce the volume of used catalyst and thereby the size of analyzed industrial plant by several times.

aalmusa@kacst.edu.sa