بسم الله الرحمن الرحيم

(إنَّ فِي خَلْقِ السَّمَوَاتِ والأرضِ واختلافِ اللَّيْلِ والنَّهَارِ لآيَاتٍ لأولِي الألباب الَّذين يَذْكُرُونَ اللَّهَ قياماً وقعوداً وعلى جَنْوِهِم وِي تَفْكِرُونَ فِي خَلْقِ السَّمَوَاتِ والأرْضِ) رَبّنا مَا خَلَفْتَ هَذَا بَاطِلًا سَبِحَاتَكَ فَقَنَا عَذَابَ النَّارِ)

آل عمران
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Nomenclature

A       Limiting reactant
$A_b$   Cross sectional area of bubble phase ($m^2$)
$A_r$   Dimensionless argon concentration
$a$     Catalyst surface area per unit volume of the reactor ($\frac{m^2}{m^3}$)
$Bi$    Biot number
$C_{pg}$ Heat capacity of bulk gas ($\frac{J}{kg.K}$)
$C_{pf}$ Average heat capacity of gas ($\frac{J}{kg.K}$)
$C_{pc}$ Heat capacity of the coolant ($\frac{J}{kg.K}$)
$C_{pm}$ Heat capacity of the metal ($\frac{J}{kg.K}$)
$C_{ps}$ Heat capacity of catalyst ($\frac{J}{kg.K}$)
$C_j$   Bulk Concentration of component j in the gas phase ($\frac{mol}{m^3}$)
$C_{s,j}$ Surface Concentration of component j ($\frac{mol}{m^3}$)
$D_a$   Axial dispersion coefficient ($\frac{m^2}{sec}$)
$d_b$   Bubble diameter (m)
$D_r$   Radial dispersion coefficient ($\frac{m^2}{sec}$)
$D_e$   Effective diffusivity ($\frac{m^2}{sec}$)
$D_p$   Equivalent diameter of catalyst particle (m)
$dp$    Catalyst diameter (m)
$d_r$   Diameter of reactor (m)
$d_i$   Inside diameter of tube (m)
$d_o$   Outside diameter of tube (m)
\[ E \quad \text{Activation energy (} \frac{J}{mol} \text{)} \]

\[ f_j \quad \text{Fugacity of component } j \text{ (atm)} \]

\[ g \quad \text{Gravitational acceleration (m/sec}^2\text{)} \]

\[ H \quad \text{Expanded bed height (m)} \]

\[ h \quad \text{Time (hour)} \]

\[ (H_{bd})_b \quad \text{Interphase heat transfer coefficient between bubble and dense phase} \]
\[ (j/m^3 \text{ sec K}) \]

\[ (K_{bd})_{jb} \quad \text{Interphase mass transfer coefficient between bubble and dense phase} \]
\[ (\text{sec}^{-1}) \]

\[ N_j \quad \text{Molar flow rate of component } j \text{ leaving reactor (Kmoles/sec)} \]

\[ N_{jb} \quad \text{Molar flow rate of component } j \text{ in the bubble phase (Kmoles/sec)} \]

\[ N_{jd} \quad \text{Molar flow rate of component } j \text{ in the dense phase (Kmoles/sec)} \]

\[ N_{jF} \quad \text{Molar flow rate of component } j \text{ in the fresh feed to fluidized bed reactor (Kmoles/sec)} \]

\[ P \quad \text{Reactor pressure (bar)} \]

\[ Q_F \quad \text{Volumetric flow rate of total feed reactor (m}^3\text{/sec)} \]

\[ Q_b \quad \text{Volumetric flow rate of bubble phase gas (m}^3\text{/sec)} \]

\[ Q_d \quad \text{Volumetric flow rate of exit dense phase gas (m}^3\text{/sec)} \]

\[ Q_{dF} \quad \text{Volumetric flow rate of inlet dense phase gas (m}^3\text{/sec)} \]

\[ R \quad \text{The gas constant (m}^3\text{pa/gmol.K)} \]

\[ r_{NH_3} \quad \text{Ammonia rate of reaction (kgmol of NH}_3\text{/h.m}^3\text{ of catalyst bed)} \]

\[ T_b \quad \text{Bubble phase temperature (K)} \]

\[ T_d \quad \text{Dense phase temperature (K)} \]

\[ T_{exit} \quad \text{Fluidized bed exit temperature (K)} \]

\[ T_F \quad \text{Feed gas temperature (K)} \]

\[ u_b \quad \text{Superficial gas velocity of bubble phase gas (m/sec)} \]
\( u_0 \)  Superficial gas velocity of fresh feed gas (m/sec)

\( u_{mf} \)  Superficial gas velocity of fresh feed gas at minimum fluidization (m/sec)

\( V \)  Volume of overall reactor (m\(^3\))

\( x_{jF} \)  Mole fraction of component j in fresh feed (dimensionless)

\( Z \)  Distance along bed height (m)

\( \delta \)  Bubble phase volume as a fraction of total bed volume (dimensionless)

\( \varphi_j \)  Fugacity coefficient of component

\( \Delta H_r \)  Heat of reaction (J/gmol)

\( \rho_g \)  Density of gas (kg/m\(^3\))

\( \rho_g \)  Density of solid particles (kg/m\(^3\))

\( \varepsilon_{mf} \)  Dense phase voidage at minimum fluidization conditions (dimensionless)

\( \mu \)  Viscosity (kg/m.sec)