**NOMENCLATURE**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argn</td>
<td>Regenerator cross-section area, m²</td>
</tr>
<tr>
<td>Aris</td>
<td>Riser cross-sectional area, m²</td>
</tr>
<tr>
<td>Cₜh</td>
<td>Weight fraction of hydrogen in coke, (kg H₂)/(kg coke)</td>
</tr>
<tr>
<td>Cₜc</td>
<td>Coke on catalyst, kg coke/kg catalyst</td>
</tr>
<tr>
<td>Cₜi</td>
<td>Concentration of ith component, kmol/m³</td>
</tr>
<tr>
<td>Cₜpc</td>
<td>Catalyst heat capacity, kJ/kgK</td>
</tr>
<tr>
<td>Cₜpco</td>
<td>Mean heat capacity of CO, kJ/kgK</td>
</tr>
<tr>
<td>Cₜpco₂</td>
<td>Mean heat capacity of CO₂, kJ/kgK</td>
</tr>
<tr>
<td>Cₜpf₁</td>
<td>Liquid feed heat capacity, kJ/kgK</td>
</tr>
<tr>
<td>Cₜpfᵥ</td>
<td>Vapor feed heat capacity, kJ/kgK</td>
</tr>
<tr>
<td>Cₜph₂₀</td>
<td>Mean heat capacity of water, kJ/kgK</td>
</tr>
<tr>
<td>CₜPN₂</td>
<td>Mean heat capacity of N₂, kJ/kgK</td>
</tr>
<tr>
<td>CₜPO₂</td>
<td>Mean heat capacity of O₂, kJ/kgK</td>
</tr>
<tr>
<td>Cₜrgc</td>
<td>Coke on regenerator catalyst, (kg coke)/kg cat</td>
</tr>
<tr>
<td>Cₜsc</td>
<td>Coke on spent catalyst, (kg coke)/kg cat</td>
</tr>
<tr>
<td>Eₜβ</td>
<td>Activation energy for CO/CO₂ at the catalyst surface</td>
</tr>
<tr>
<td>Eₜj</td>
<td>Activation energy of ith cracking reaction in the riser</td>
</tr>
<tr>
<td>Eₜ1₃c</td>
<td>Activation energy for homogeneous CO combustion</td>
</tr>
<tr>
<td>Eₜ1₃h</td>
<td>Activation energy for heterogeneous CO combustion</td>
</tr>
<tr>
<td>fₜc</td>
<td>Molar flow rate of carbon in the regenerator, kmol/sec</td>
</tr>
<tr>
<td>fₜco</td>
<td>CO molar flow rate in the regenerator, kmol/sec</td>
</tr>
<tr>
<td>fₜc₀₂</td>
<td>CO molar flow rate in the regenerator, kmol/sec</td>
</tr>
<tr>
<td>fₜh₂₀</td>
<td>H₂O molar flow rate in the regenerator, kmol/sec</td>
</tr>
<tr>
<td>fₜN₂</td>
<td>N₂ molar flow rate in the regenerator, kmol/sec</td>
</tr>
<tr>
<td>fₜO₂</td>
<td>O₂ molar flow rate in the regenerator, kmol/sec</td>
</tr>
<tr>
<td>fₜtot</td>
<td>Total gas molar flow rate in the regenerator, kmol/sec</td>
</tr>
<tr>
<td>Fₜair</td>
<td>Air flow rate to the regenerator, kmol/sec</td>
</tr>
<tr>
<td>Fₜent</td>
<td>Entrained catalyst flow rate kg/sec</td>
</tr>
<tr>
<td>Fₜj</td>
<td>Molar flow rate of jth lump, kmol/sec</td>
</tr>
<tr>
<td>Fₜrgc</td>
<td>Catalyst Circulation Rate (CCR), kg/sec</td>
</tr>
<tr>
<td>Fₜsc</td>
<td>Spent catalyst flow rate, kg/sec</td>
</tr>
</tbody>
</table>
\(F_{\text{feed}}\)  
Oil feed flow rate, kg/sec

\(h\)  
Dimensionless riser height

\(H_{\text{ris}}\)  
Riser height, m

\(\Delta H_{\text{evp}}\)  
Heat of vaporization of oil feed, kJ/kg

\(H_{\text{co}}\)  
Heat of Formation of oil feed, kJ/kmol

\(H_{\text{co2}}\)  
Heat of formation of CO\(_2\), kJ/kmol

\(H_{\text{H2O}}\)  
Heat of formation of H\(_2\)O, kJ/kmol

\(\Delta H_i\)  
Heat of cracking of \(i\)th lump, kJ/kmol

\(i\)  
total no. of reactions in the reactor

\(j\)  
Total no. of kinetic lumps

\(k_{0,i}\)  
Frequency factor for \(i\)th reaction in the riser

\(k_{\text{co}}\)  
Frequency factor for coke combustion, 1/(atm)(s)

\(k_{13c}\)  
Frequency factor in heterogeneous CO combustion expression, 
kmol CO/(m\(^3\))(atm\(^2\))(s)

\(k_{13h}\)  
Frequency factor in homogeneous CO combustion expression, 
kmol CO/(m\(^3\))(atm\(^2\))(s)

\(MW_j\)  
Molecular weight of \(j\)th lump, kg/kmol

\(MW_c\)  
Molecular weight of coke, kg/kmol

\(MW_g\)  
Average molecular weight of gas oil feed, kg/kmol

\(MW_H\)  
Molecular weight of hydrogen

\(P_{\text{ris}}\)  
Riser pressure, atm

\(P_{\text{rgn}}\)  
Regenerator pressure, atm

\(P_{O2}\)  
Average mean oxygen partial pressure, atm

\(Q_{\text{air}}\)  
Heat flow rate with air, kJ/sec

\(Q_C\)  
Heat released by the carbon combustion, kJ/sec

\(Q_{\text{ent}}\)  
Heat input to the dense bed from entrained catalyst returning from 
cyclone, kJ/sec

\(T_{\text{feed}}\)  
Gas oil feed temperature, K

\(T_{\text{rgn}}\)  
Regenerator dense bed temperature/Regenerated catalyst temperature, K

\(T_{sc}\)  
Temperature of spent catalyst, K

\(\Delta T_{st}\)  
Stripper temperature drop (~10 \(^0\)C)

\(W\)  
Catalyst inventory in the regenerator, kg

\(X_{pt}\)  
Relative catalytic CO combustion rate

\(X_j\)  
Mole fraction of \(j\)th component
Z  Axial height from the entrance of the riser or regenerator, m
Z_{bed}  Regenerator dilute bed height
Z_{dil}  Regenerator dilute phase height, m
Z_{rgn}  Regenerator height, m
Q_{loss, rgn}  Heat losses from the regenerator, kj/sec
Q_{loss, ris}  Heat losses from the riser base, kj/sec
r_i  Rate of the ith reaction (kmol/kg.cat.s)
R  Universal gas constant
ROT  Riser outlet temperature (K)
T  Riser temperature at any axial height, K
T_{air}  Temperature of the air to the regenerator
T_{base}  Base temperature for heat balance calculations, K (866.6 K)
Q_{rgc}  Heat flow with regenerated catalyst, kj/sec
Q_{sc}  Heat flow rate with spent catalyst, kj/sec
Q_{sg}  Heat flow rate with gases from the regenerator dense bed, kj/sec
Q_H  Heat released by the hydrogen combustion, kj/sec

Greek Letters
\alpha_{ij}  Stoichiometric coefficient of jth species in ith reaction
\beta_c  CO/CO2 ratio at the surface in the regenerator
\beta_{c0}  Frequency factor in \beta_c expression
\epsilon  Riser or regenerator void fraction
\rho_c  Catalyst density, kg/m^3
\rho_{den}  Catalyst density in the regenerator dense bed, kg/m^3
\rho_{dil}  Catalyst density in the dilute phase of the regenerator, kg/m^3
\rho_g  Molar gas density in the regenerator, kmol/m3
\rho_v  Oil vapor density, kg/m^3
\phi  Catalyst activity
\Theta  Catalyst residence time, sec