1. Property Correlations, Surface Area & Resistance of Matrix Elements

Table 8.1: User inputs and correlations for various properties based on regenerator type. Correlations from (Gedeon, SAGE users manual [35]).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Regenerator Type | | | |
|  | Woven Screen | Random Fiber | Packed Sphere | Stacked Foil |
| Inputs | Porosity ()  Wire Diameter () | Porosity ()  Wire Diameter () | Porosity ()  Sphere Diameter () | Gap Width ()  Thickness ()  Roughness () |
| Hydraulic Diameter ( |  |  |  |  |
| Laminar Friction Factor ( |  |  |  |  |
| Laminar Nusselt Number () |  |  |  |  |
| Laminar Conduction Enhancement Factor () |  |  |  |  |
| Turbulent Friction Factor ( | --- | --- | --- |  |
| Turbulent Nusselt Number () | --- | --- | --- |  |
| Turbulent Conduction Enhancement Factor () | --- | --- | --- |  |
| Extra Equations: |  |  |  |  |

Woven Screen & Random Fiber Regenerators

For a long cylindrical element

|  |  |
| --- | --- |
| Surface Area = |  |
| Volume = |  |
| Average Radius = |  |
| Resistance from Surface to Average Radius = |  |
| Surface Area per unit Volume = |  |
| Resistance times Area = |  |

Packed Sphere Regenerators

For spherical elements

|  |  |
| --- | --- |
| Surface Area = |  |
| Volume = |  |
| Average Radius = |  |
| Resistance from Surface to Average Radius = |  |
| Surface Area per unit Volume = |  |
| Resistance times Area = |  |

Stacked Foil Regenerators

For Planar Elements

|  |  |
| --- | --- |
| Surface Area = |  |
| Volume = |  |
| Average Radius = |  |
| Resistance from Surface to Average Radius = |  |
| Surface Area per unit Volume = |  |
| Resistance times Area = |  |

Table 8.2: User inputs and correlations for various properties based on heat exchanger type: Fin Enhanced Surface, Fin Connected Channels. Correlations from [35] unless otherwise indicated.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Heat Exchanger Type | | |
|  | Fin Enhanced Surface | Fin Connected Channels (Rectangular) | Fin Connected Channels (Triangular) |
| Inputs | Fin Separation ()  Fin Thickness ()  Roughness ()  Surface to build off of | Gas space between source channels ()  Source channel width ()  Source channel wall thickness ()  Surface roughness ()  Base Width / Fin Separation ()  Fin Thickness () | |
| Porosity () |  |  |  |
| Hydraulic Diameter () |  | check definition | \* |
| Laminar Friction Factor () | \*  Analytical: 14 (alpha=1) to 24 (alpha inf) [Kays compact HX] | | \* |
| Laminar Nusselt Number () | 8.23 is for inf. Aspect ratio channel / parallel plates!  Analytical: 2.89 (alpha=1) to 7.54 (alpha inf) [Kays compact HX] (const. wall temp)  [Cengel p.491] | | \*\* |
| Lam. Cond. Enhancement Factor () | 1 | | |
| Turbulent Friction Factor ( | \* | | \* |
| Turbulent Nusselt Number () | Is Aprx like Colburn equation [Cengel p496]  Only for Re>10,000!  Alternative, from Sage manual, Rect fins: | | \*\*\* |
| Turbulent Conduction Enhancement Factor () |  | | |
| Extra Equations: | Depending on the orientation of the fin, Fin Length () is |  |  |
| \*Polynomial Fit to Table Data of weights [71] multiplied onto equation for circular pipe [35]  \*\*Constant Wall Temperature inflow and peripheral directions [72]  \*\*\*Gnielinski correlation [73]  Correct (Idehik) | | | |

Table 8.3: User inputs and correlations for various properties based on heat exchanger type: Tube and Plate Heat Exchangers.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Continuously Finned | |  |
|  | Staggered – always turbulent | |  |
| Inputs | Spacing Perpendicular to Flow ()  Spacing Parallel to Flow ()  Fin Thickness ()  Fin Separation ()  Tube Outer Diameter ()  Tube Inner Diameter () | |  |
| Porosity () |  | |  |
| Hydraulic Diameter () |  | |  |
| Friction Factor () | \* | |  |
| Nusselt Number () | If  \*  Else  \* | |  |
| Conduction Enhancement Factor () | 1 | |  |
| Extra Equations: |  | \*\* |  |
| \* [74]  \*\* Combined formula of [74], with component representing pressure drop of bare staggered tube banks derived from data of [75]. | | |  |

Table 8.4: User inputs and correlations for various properties based on heat exchanger type: Individually Finned Tube Heat Exchangers.

|  |  |
| --- | --- |
|  | Individually Finned |
|  | Staggered |
| Inputs | Fin Length () |
| Porosity () |  |
| Hydraulic Diameter () |  |
| Laminar Friction Factor () | Assumed to be always turbulent |
| Laminar Nusselt Number () | Assumed to be always turbulent |
| Laminar Conduction Enhancement Factor () |  |
| Turbulent Friction Factor () | If (Low Finned Tubes)  \*  Else (High Finned Tubes) |
| Turbulent Nusselt Number () | If (Low Finned Tubes)  \*\*\*  Else (High Finned Tubes)  \*\* |
| Turbulent Conduction Enhancement Factor () | 1 |
| \* Chai [76]  \*\* Webb [74]  \*\*\* Ganguli & Yilmaz [77] | |

Table 8.5: User inputs and correlations for various properties based on heat exchanger type: Bare Tube Banks (internal). Correlations from [35] unless otherwise indicated.

|  |  |
| --- | --- |
|  | Bare Tube Banks (internal) |
|  | Staggered |
| Inputs | Tube Spacing () (Circle Packed Arrangement)  Tube Outer Diameter ()  Tube Inner Diameter () |
| Porosity () |  |
| Hydraulic Diameter () |  |
| Laminar Friction Factor () |  |
| Laminar Nusselt Number () | 6.0 |
| Laminar Conduction Enhancement Factor () | 1 |
| Turbulent Friction Factor () |  |
| Turbulent Nusselt Number () |  |
| Turbulent Conduction Enhancement Factor () |  |