Design and Manufacturing Research for a Lean World Workshop

Analytical Models as Design Tools for Electronics Cooling Applications

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Outline

- Web-based and spreadsheet design tools based on analytical analyses
- Physically-based, minimal input, meaningful output
- Web tools: www.mhtlab.uwaterloo.ca\tools.html
- Spreadsheet tools: rix@mhtlab.uwaterloo.ca
Thermophysical Properties of Liquids & Gases

- Function of temperature
- Gases: air, argon, nitrogen, carbon dioxide
- Liquids: water, ethylene glycol, mixtures

Fluid Properties Calculator

<table>
<thead>
<tr>
<th>Input Values</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid: Ethylene Glycol 30%</td>
<td>Density: 1.0376E+3 (kg/m^3)</td>
</tr>
<tr>
<td>Temperature: 20 (degrees C)</td>
<td>Dynamic Viscosity: 2.1671E-3 (kg/m.s)</td>
</tr>
<tr>
<td>Digits: 5</td>
<td>Kinematic Viscosity: 2.0885E-6 (m^2/s)</td>
</tr>
<tr>
<td></td>
<td>Specific Heat: 3.7141E+3 (J/kg.K)</td>
</tr>
<tr>
<td></td>
<td>Conductivity: 0.48418 (W/m.K)</td>
</tr>
<tr>
<td></td>
<td>Prandtl number: 16.623</td>
</tr>
<tr>
<td></td>
<td>Thermal Diffusivity: 1.2564E-7 (m^2/s)</td>
</tr>
</tbody>
</table>
Natural Convection Models for Heat Sinks

- Plate fin and radial fin configurations
- Solves for source temperature or heat flow rate
Effective Conductivity of Multilayered Substrates

- Effective conductivity calculator based on Fourier series analysis
- Up to 20 layers, pre-programmed material properties available
- Calculated $k$ effective based on relative source size, position and edge conditions
Spreading Resistance Calculators

- Circular and rectangular substrates
  - Single and two layers
  - Finite, semi-infinite (flux tube) and infinite
- Circular, strip and rectangular sources
  - Isoflux
  - Parabolic
  - Equivalent Isothermal
- Edge cooling calculators are available
Thermal Contact Resistance for Non-conforming Rough Surfaces

- Excel - VBA implementation of analytical model
- Calculation based on readily available surface parameters, such as
  - surface slope
  - hardness
  - out-of-flatness