Optimization Under Uncertainty of Manifold Microchannel Heat Sinks

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**Motivation**
- Enhanced performance over microchannels due to manifolds
- Inherent geometric uncertainties affect optimized design

**Approach: Computational Domain**
- **Unit Cell Model**
  - Modeling Tool: CUBIT 13.0
  - Solver: Ansys FLUENT 13.0
- **Porous Medium Model**
  - Solid domain: Silicon
  - Coolant fluid: Water

**Objective**

**Input Variables**
- Channel Width ($W_c$)
- Channel Depth ($D_c$)
- Inlet Length ($L_{in}$)
- Outlet Length ($L_{out}$)
- Manifold Length ($L_m$)
- Manifold Depth ($D_m$)

**Output Parameters**
- Pressure Drop ($\Delta P$)
- Heat Transfer Coefficient ($h$)

**Optimization Results**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Deterministic (Unit Cell)</th>
<th>Probabilistic (Unit Cell)</th>
<th>Probabilistic (Porous Medium)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$u = 0.03$ m/s</td>
<td>$W_c$ ($\mu$m)</td>
<td>$L_{in}$ ($\mu$m)</td>
<td>$W_c$ ($\mu$m)</td>
</tr>
<tr>
<td>$0.7(h/h_{max}) + 0.3(-\Delta P/\Delta P_{max})$</td>
<td>28</td>
<td>245</td>
<td>24</td>
</tr>
<tr>
<td>$0.5(h/h_{max}) + 0.5(-\Delta P/\Delta P_{max})$</td>
<td>33</td>
<td>234</td>
<td>27</td>
</tr>
</tbody>
</table>

- Heat transfer coefficient decreases with increase in $W_c$
- Heat transfer coefficient reaches a maximum at $r \sim 3$.
- Probabilistic optimization predicts different optimal geometry, more robust than deterministic
- Results from porous medium model match unit cell model within specified uncertainties