Predicting Mold Corner Temperature Based on Angled Water Slot Geometry
2D Narrow Face

Typical Dimensions

- \( d_{ml} = 25 \text{ mm} \)
- \( d_{ch} = 11 \text{ mm} \)
- \( w_{ch} = 5 \text{ mm} \)
- \( d_m = 13 \text{ mm} \)
- \( L_c = 13.5 \text{ mm} \)
- \( L_{ch} = 16 \text{ mm} \)
- \( A = 60^\circ \)
2D Narrow Face Boundary Conditions

**Hot Face**

q = constant

**Cold Face**

q = 0

q = h_w(T - T_w)
Water slot - Fin Analogy

\[
h_{\text{fin}} = \frac{h_w w_{ch}}{L_{ch}} + \sqrt{2h_w k_m (L_{ch} - w_{ch})} \tanh \frac{2h_w d_{ch}^2}{k_m (L_{ch} - w_{ch})}
\]
Heat Flux and $L_c$ Influence
Corner Temperature

Distance to Corner from Angled Water Slot, $L_c$ [m]

- $q=0.5$ MW/m$^2$
- $q=2$ MW/m$^2$
- $q=3$ MW/m$^2$
- $q=5$ MW/m$^2$
- $q=10$ MW/m$^2$
Corner Temperature Normalized by Heat Flux

\[
T^* = \frac{k(T_c - T_{water})}{qL_{eff}}
\]

\[
L_{eff} = \frac{k_m}{h_{fin}} + d_m
\]

Distance to Corner from Angled Water Slot, \( L_c \) [m]

- \( q = 0.5 \) MW/m²
- \( q = 2 \) MW/m²
- \( q = 3 \) MW/m²
- \( q = 5 \) MW/m²
- \( q = 10 \) MW/m²
Mold Thickness Effects $T_c$

\[ T^* = \frac{k(T_c - T_{\text{water}})}{qL_{\text{eff}}} \]

\[ L_{\text{eff}} = \frac{k_m}{h_{\text{fin}}} + d_m \]
Corner Temperature Prediction

\[ L^* = \frac{L_c}{d_m} \]

\[ T^* = \frac{k(T_c - T_{\text{water}})}{qL_{\text{eff}}} \]

\[ T^* = 0.65L^* + 0.42 \]

"Nondimensional Length", \( L^* = \frac{L_c}{d_m} \)
Typical design
A = 75 °C
L_c = 22 mm
q = 2.5 MW/m²

Optimized design
A = 45 °C
L_c = 11 mm
q = 2.5 MW/m²
Calculating $T_c$

\begin{align*}
L^* &= \frac{L_c}{d_m} \quad (1) \\
T^* &= \frac{k(T_c - T_{\text{water}})}{qL_{\text{eff}}} \quad (2) \\
L_{\text{eff}} &= \frac{k_m}{h_{\text{fin}}} + d_m \quad (3) \\
T^* &= 0.65L^* + 0.42 \quad (4) \\
T_c &= \left( 0.65 \frac{L_c}{d_m} + 0.42 \right) q \left( \frac{k_m}{h_{\text{fin}}} + d_m \right) + T_w \quad (5)
\end{align*}
Adding Three Dimensional Accuracy to CON1D
$q = 2.5 \text{ MW/m}^2$

- **hot face**
  - $307 \, ^\circ\text{C}$
  - $280$
  - $240$
  - $200$
  - $159$
  - $130$
  - $100$
  - $71$

- **cold face**
  - $70 \, ^\circ\text{C}$
  - $70$
  - $70$
  - $70$
  - $70$
  - $70$
  - $70$
  - $70$

- **water slot**
  - $162.2 \, ^\circ\text{C}$

- **thermocouple**
  - $313 \, ^\circ\text{C}$

- **&**
  - $h = 54 \text{ kW/m}^2\text{K}$
  - $T_w = 25 \, ^\circ\text{C}$

- **&**
  - $k = 315 \text{ W/mK}$
3D accuracy in CON1D using an offset

3D ANSYS

$T_{\text{hot}} = 313.1 \, ^{\circ}\text{C}$

$T_{\text{therm}} = 162.2 \, ^{\circ}\text{C}$

$T_{\text{cold}} = 70 \, ^{\circ}\text{C}$

CON1D prediction

$T_{\text{hot}} = 306.8 \, ^{\circ}\text{C}$

$T_{\text{offset}} = 162.2 \, ^{\circ}\text{C}$

$T_{\text{therm}} = 116.3 \, ^{\circ}\text{C}$

$T_{\text{cold}} = 68.7 \, ^{\circ}\text{C}$

offset distance 5.6 mm