Cold Plate Solver — Summary and User Guide

1. Purpose

This interactive HTML/JavaScript tool models a liquid-cooled cold plate with embedded parallel or serpentine tubes. It computes heat transfer, fluid pressure drop, and temperature distribution for different tube spacings. The tool includes a graphical interface for geometry definition, heat source placement, and automated case studies.

2. Solution Method

The solver uses a finite-difference approach to calculate the 2D temperature distribution in the plate, accounting for:
• Conduction through the plate thickness and plane.
• Convection between the coolant and the plate along tube locations.
• Volumetric heat generation from defined heat-source regions.

Two flow configurations are supported:
1. Parallel flow — flow divides equally among tubes, each with independent inlet temperature.
2. Serpentine flow — a single continuous tube path, with fluid heating progressively along its length.

The solver iteratively updates the plate and fluid temperatures until steady-state convergence. Convective coefficients and pressure drops are determined using correlations for laminar and turbulent internal flow, scaled by user-specified Friction Factor and Nu Factor inputs to account for turbulence promoters or coils.

3. Interface Overview

• Setup Panel: define plate geometry, materials, coolant properties, and flow conditions.
• Solve Panel: specify tube spacing range, add heat sources, and execute grid and parametric studies.
• View Panel: displays temperature field, tube layout, and flow arrows.
• End View Panel: cross-sectional view showing tube placement across plate thickness.
• Results Panels: plot of maximum plate temperature and pressure drop versus spacing; case table listing key metrics.

4. How to Use

1. Enter plate geometry (Length, Width, Thickness) and select material and coolant.
2. Define coolant inlet temperature, tube diameter, flowrate, and turbulence factors.
3. Add heat sources by clicking 'Add Heat Source' and dragging on the grid. Assign loads in watts.
4. Set minimum and maximum tube spacings in millimeters.
5. Click 'Run Cases' to evaluate five equally spaced conditions between Min and Max

spacings.
6. View Max T and ΔP vs spacing in the results chart.
7. Click a point on the chart to show the corresponding temperature field on the grid.
8. Use 'Add Tubing' to view the end cross-section.
9. The case table lists spacing, tube count, Re, h, Max T, and ΔP.

5. Suggested Values

• Plate thickness: 5–12 mm typical.
• Tube diameter: 4–8 mm.
• Coolant flowrate: 3–10 L/min.
• Friction factor: 1.0 for smooth tubes, 1.2–2.0 for turbulators.
• Nu factor: 1.0 baseline, up to 2.0 for enhanced heat transfer.
• Tube spacing: typically 1–2× tube diameter.

6. Limitations

• Plate is assumed isothermal through its thickness (thin-plate approximation).
• Heat transfer coefficients are uniform along tube length.
• Laminar/turbulent correlations apply to straight circular tubes only.
• Fluid properties are constant (no temperature-dependent viscosity or density).
• Radiation and external convection are neglected.
• Edge boundary conditions are adiabatic.
• Solver uses a simplified steady-state model without transient effects.

7. Outputs

• Temperature field (°C) plotted over plate surface with color legend.
• Outlet temperature estimate.
• Pressure drop (kPa) and maximum plate temperature (°C) vs tube spacing.
• Case table listing key flow and thermal data.

8. Documentation and References

1. Incropera, F. P., and DeWitt, D. P. *Fundamentals of Heat and Mass Transfer*.
2. Mills, A. F. *Heat Transfer*.
3. Holman, J. P. *Heat Transfer*, McGraw-Hill.
4. Shah, R. K., and London, A. L. *Laminar Flow Forced Convection in Ducts*.
5. Gnielinski, V., 'New Equations for Heat and Mass Transfer in Turbulent Pipe and Channel Flow,' *Int. Chem. Eng.*, 16(2), 1976.