Gaspar García, CFD portfolio

Compared

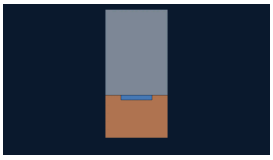
Updated 2026-11-14

Micro-channel heat sink: the model reads 0.95 to 2.09 °C hot at all four thermocouples

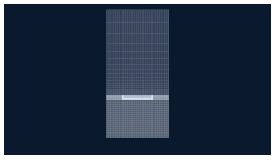
Objective. Predict the copper temperature at four thermocouples in a water-cooled micro-channel heat sink with a steady laminar conjugate model of one channel, and compare with measurements.

Parameters

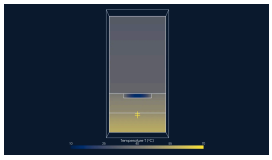
Reynolds number (inlet properties, hydraulic diameter)	890
Effective heat flux (planform)	100 W/cm^2, 21.3333 W per channel
Inlet velocity	2.904014677 m/s
Inlet water temperature	288.15 K (15 °C)
Hydraulic diameter	348.947 µm
Solver	OpenFOAM v2412, chtMultiRegionSimpleFoam, steady
Turbulence model	None: laminar
Cells	11,660 to 268,522 (four grids)



1 Geometry



2 Mesh

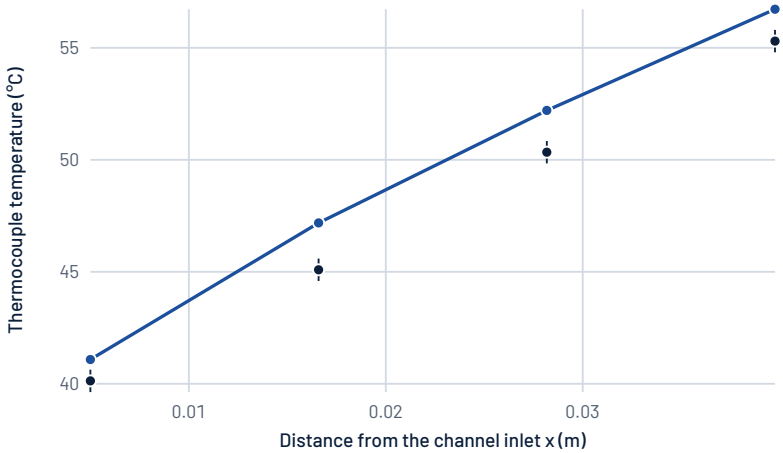


3 Results

Comparison with experiment

Quantity	Experiment	Simulation, finest grid	Signed difference (°C)
TC1, x 5 mm	40.13 °C	41.08 °C	+0.95 °C
TC2, x 16.588 mm	45.09 °C	47.18 °C	+2.09 °C
TC3, x 28.176 mm	50.34 °C	52.21 °C	+1.87 °C
TC4, x 39.764 mm	55.30 °C	56.72 °C	+1.42 °C

Thermocouple temperature (°C) against Distance from the channel inlet x (m)



- Measured, digitised (bar: digitising estimate)
- Measured, same points (bar: thermocouple uncertainty, paper)
- Simulation, finest of four grids

Verdict

On the finest of four grids the model reads 0.95 to 2.09 °C above the four digitised thermocouple temperatures. Only TC1 has a numerical band (about 0.5 K, this scheme only). A comparison, not a validation.

Limits

- Measured values digitised from a figure (±0.5 °C); one operating point has a grid ladder.
- No band at TC2 to TC4; the energy-scheme sensitivity exceeds the TC1 band.
- Unit cell: no plenum maldistribution; air-pocket geometry read from drawings.

1. W. Qu and I. Mudawar (2002), "Experimental and numerical study of pressure drop and heat transfer in a single-phase micro-channel heat sink", International Journal of Heat and Mass Transfer 45, 2549-2565. DOI 10.1016/S0017-9310(01)00337-4. Fig. 7 thermocouple temperatures, digitised by me.
2. L. Eça and M. Hoekstra (2014), "A procedure for the estimation of the numerical uncertainty of CFD calculations based on grid refinement studies", Journal of Computational Physics 262, 104-130. DOI 10.1016/j.jcp.2014.01.006.
3. IAPWS-97 liquid-water properties, as fitted by my water-property script (no further citation in the local files).

Full page with sources, mesh and numerical accuracy: /cases/cht-qu-mudawar/. Every number is checked against its source file.