Gaspar García, CFD portfolio

Compared

Updated 2026-11-14

Tall-cavity natural convection: mean Nusselt number 20 % below the quoted experiment, and refining the grid does not close the gap

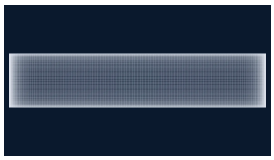
Objective. Predict buoyancy-driven heat transfer in a tall air cavity heated on one side and cooled on the other, with a measured numerical uncertainty, and compare it with the Betts and Bokhari experiment.

Parameters

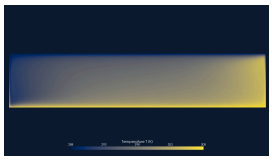
Rayleigh number (cavity width)	0.86×10^6
Height, width, depth	2.18 m, 0.076 m, 0.52 m
Wall temperatures	307.75 K and 288.15 K (19.6 K)
Fluid	Air, Pr 0.705
Solver	OpenFOAM v2412, buoyantSimpleFoam
Turbulence model	k-omega SST, wall-resolved
Wall y+ max	0.097 finest, 0.26 coarsest
Cells	8,000 to 64,410



1 Geometry



2 Mesh

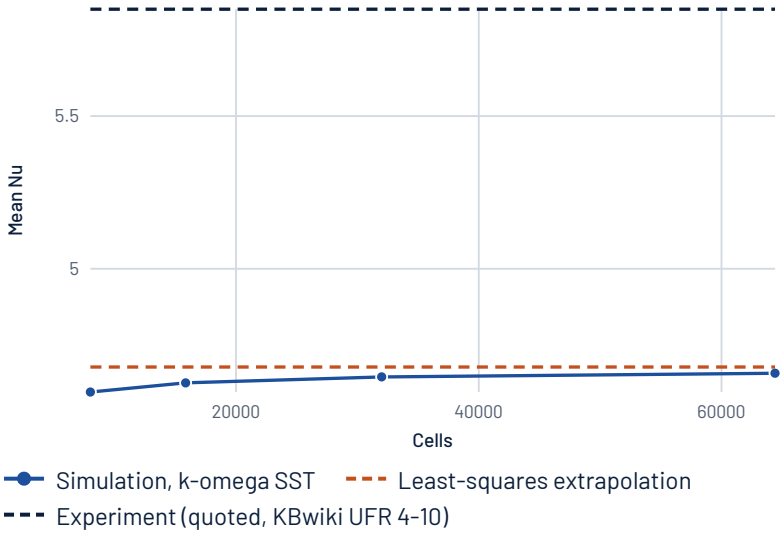


3 Results

Comparison with experiment

Quantity	Experiment	Simulation, finest grid	Signed difference
Mean Nusselt number	5.85	4.658	**−20.4 %**
Peak upward velocity at y/H 0.5	0.140 m/s	0.1664 m/s	**+19 %**
Mean temperature, RMS difference across the cavity, 9 heights	–	–	**0.41–1.45 K**
Temperature normal to floor / roof at x 38.1 mm, RMS difference	–	–	**0.31 K / 0.85 K**

Mean Nu against Cells



Verdict

Wall-resolved k-omega SST on four grids gives mean Nu 4.658 ±0.025, −20.4 % from the 5.85 quoted for the experiment; the extrapolated 4.678 shows the gap is not a grid effect. Its cause (model, inputs, measurement or Nu definition) cannot be separated with the data on hand.

Limits

- The experimental Nu is second-hand, with unknown definition and uncertainty: a comparison, not a validation.
- 2-D slice of a 3-D rig; top and bottom wall temperatures imposed from the experiment.
- The wall-layer explanation is a 3-point-gradient inference; the too-laminar hypothesis is untested.

1. Betts, P.L., Bokhari, I.H. (2000). Experiments on turbulent natural convection in an enclosed tall cavity. Int. J. Heat and Fluid Flow, Vol. 21, pp. 675-683. (Cited from the ERCOFTAC page; closed access, not read.)
2. ERCOFTAC Classic Collection, case 079: turbulent natural convection in an enclosed tall cavity (University of Manchester). Data CC BY-NC-SA 4.0.
3. ERCOFTAC KBwiki, UFR 4-10: natural convection in simple closed cavity, N. Waterson (Mott MacDonald Ltd), ERCOFTAC 2004. Source of the quoted mean Nusselt number.
4. Eça and Hoekstra (2014): the least-squares numerical-uncertainty procedure, as implemented in the project's gci.py.

Full page with sources, mesh and numerical accuracy: /cases/betts-bokhari-cavity/. Every number is checked against its source file.