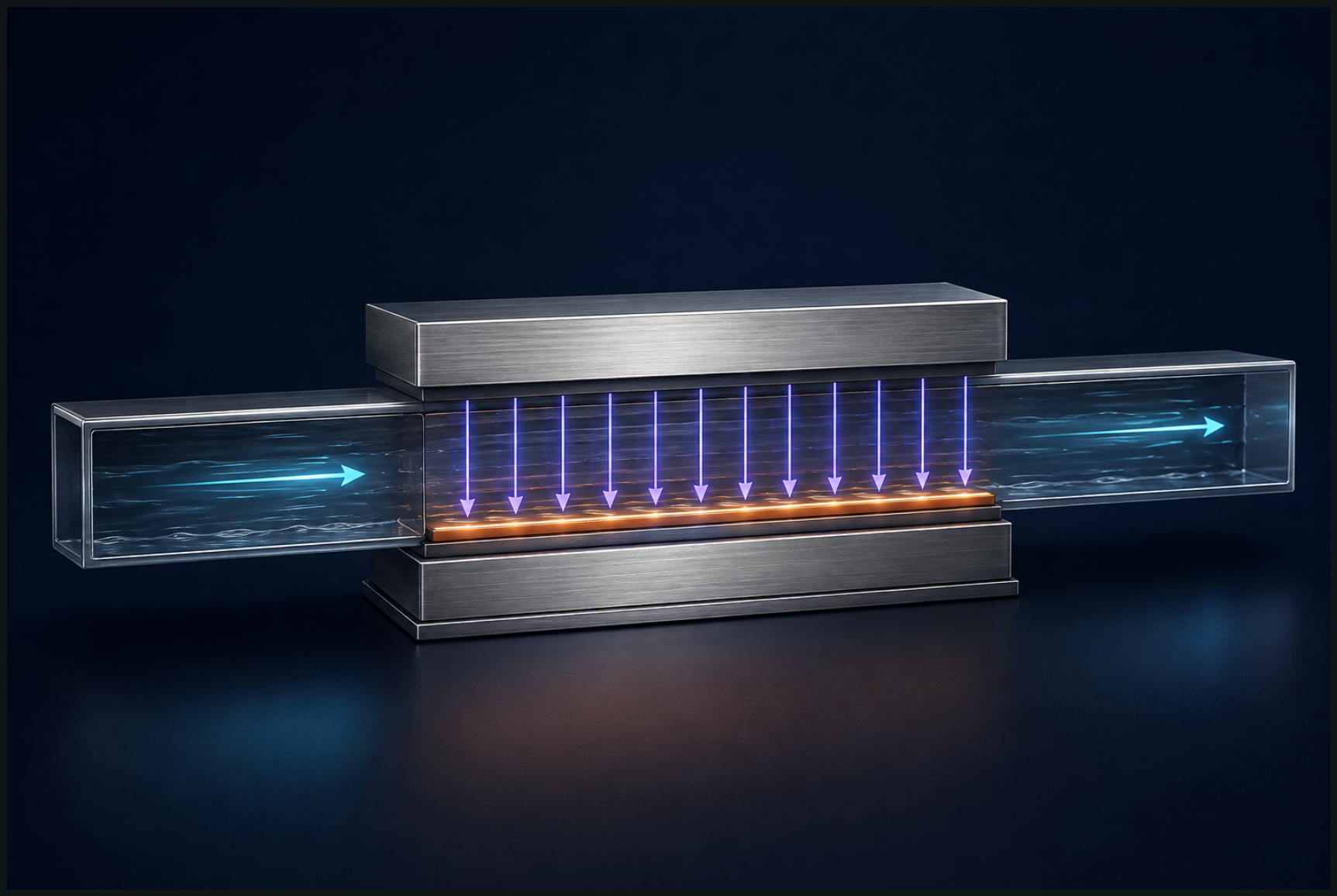
PORTFOLIO REPORT

MHD channel: flow and thermal response



Conceptual illustration of the liquid-metal channel and applied magnetic field.

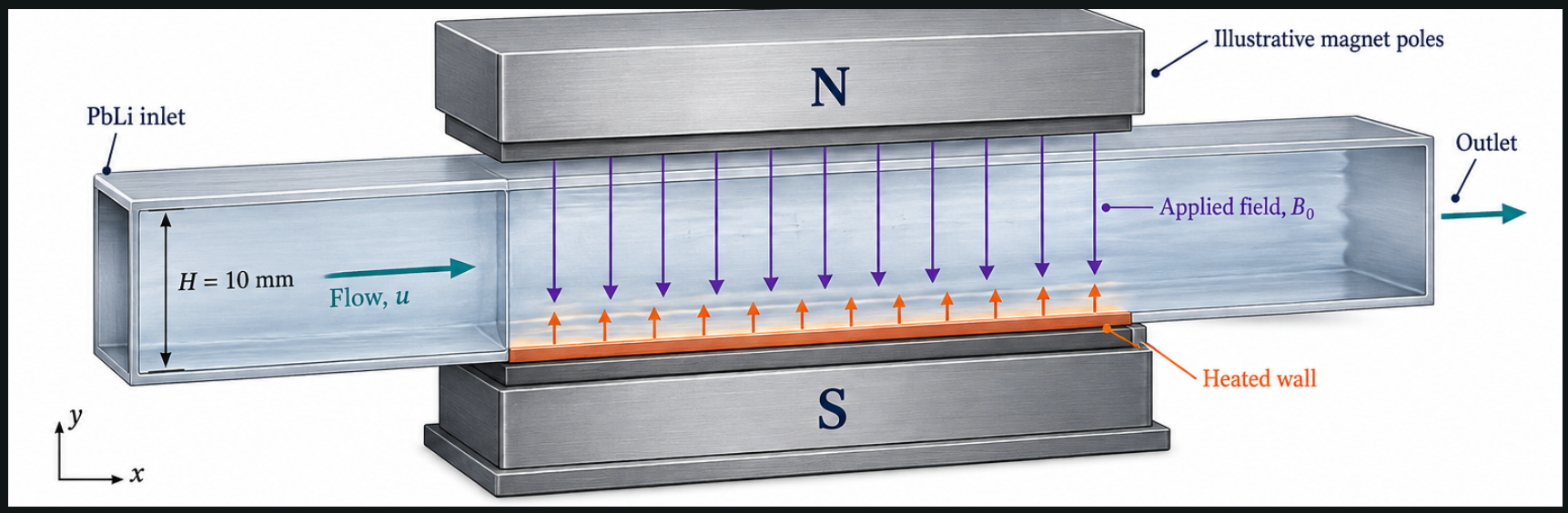
20	23.5-25.9%	0.78-0.81 K
CFD cases	Lower sampled peak speed	Lower axial-mean wall temperature

Re = 250, 500, 750, 1000 | Ha = 0, 2.5, 5, 7.5, 10. Changes compare Ha = 10 with Ha = 0 at the same Re. The sampled speed profile changes strongly; the wall-temperature response is modest.

01 / MODEL AND METHOD

A heated liquid-metal channel

Native case reports and saved sampling locations define the model and the quantities used in this report.



Conceptual schematic. Magnet hardware and depth are illustrative; not to scale.

Native model: 300 × 10 mm; field at x = 50-250 mm, directed -y; 600 K inlet. The full bottom wall is heated at 100 kW/m^2; the upper wall is adiabatic; outlet gauge pressure is 0 Pa.

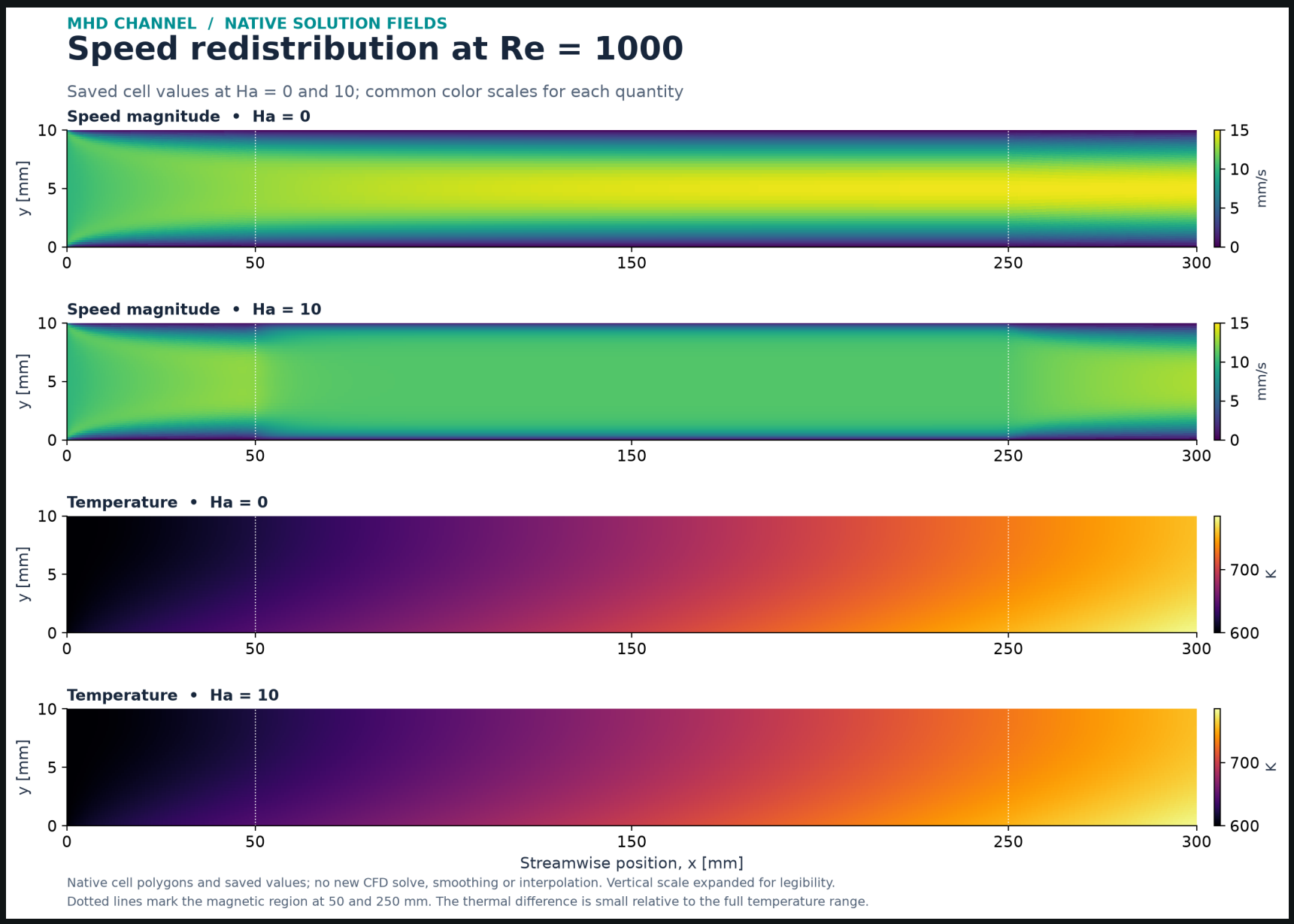
Fluid	PbLi; density 9806 kg/m^3; viscosity 0.00193 Pa s; thermal conductivity 20.93 W/(m K). Constant properties.
Flow solver	ANSYS Fluent 25.2; 2D, steady, laminar, pressure-based; double precision.
Discretization	Coupled pressure-velocity scheme; second-order pressure, momentum and energy; first-order electrical potential.
Mesh	37,500 quadrilateral cells and 38,301 nodes in each of the 20 native cases.
Field	Ha uses half-height a = 5 mm; Ha = |B| a sqrt(sigma / mu). Electrical conductivity is 782,000 S/m; Ha = 10 gives |B| = 0.09936 T.

Sampling: Line 1 at y = 0; Line 2 at y = 5 mm; Line 3 at x = 150 mm. Re uses Dh = 20 mm. Mesh sensitivity and physical validation remain open.

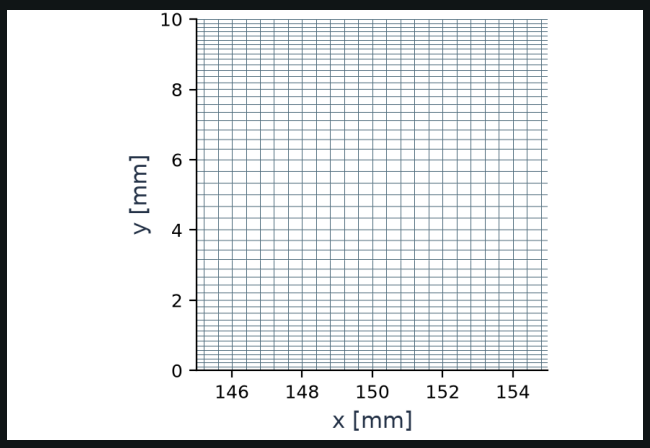
02 / NATIVE MESH AND FIELDS

The spatial response in the saved solutions

Native cell polygons and saved field values at Re = 1000, reconstructed without a new CFD solve.



ACTUAL MESH DETAIL



37,500 quadrilateral cells

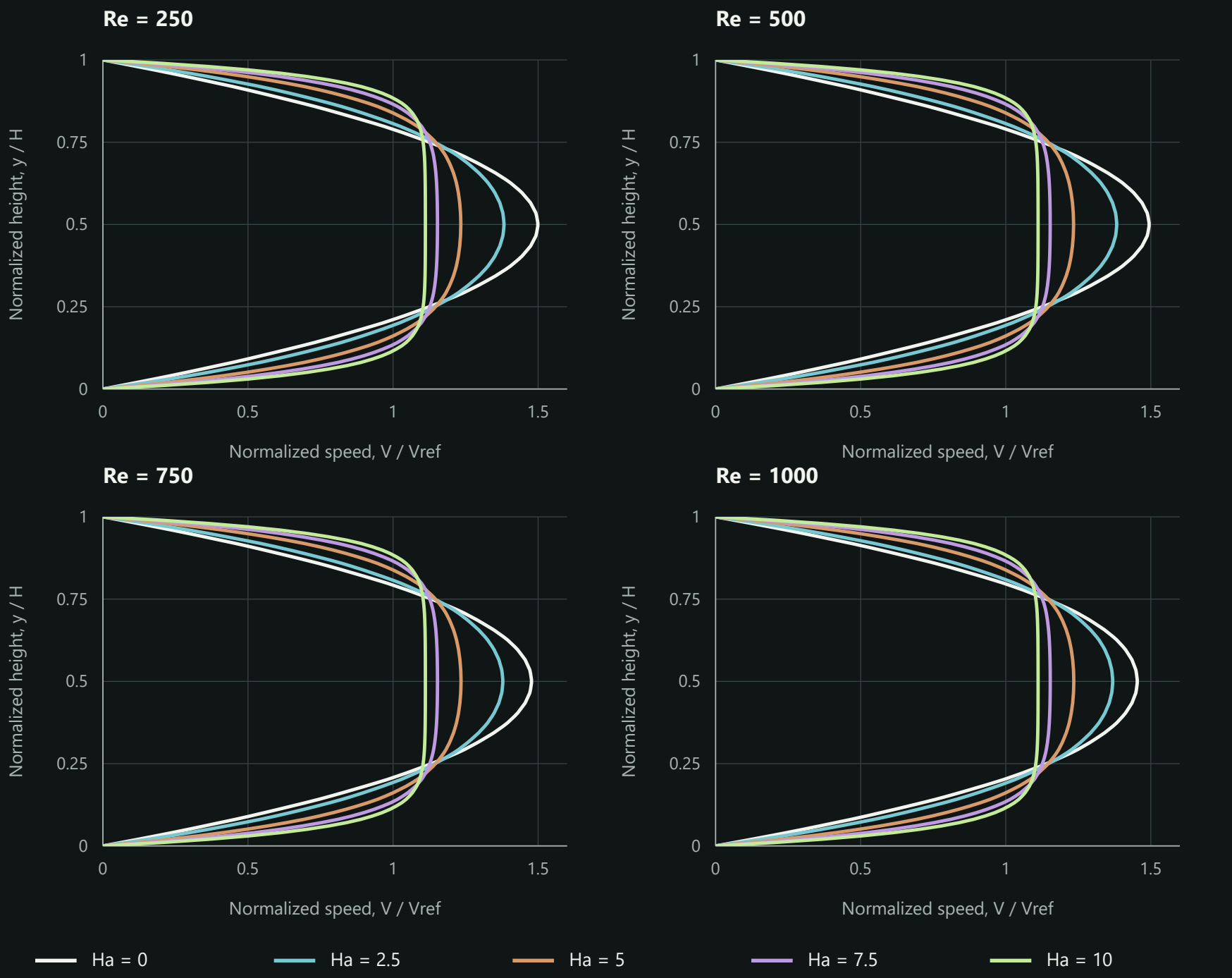
Native face connectivity shows the near-wall grading. The detail spans x = 145-155 mm and the full 10 mm channel height.

Common color scales are used for each quantity. The field is localized between x = 50 and 250 mm. Vertical scales are expanded for legibility.

03 / VELOCITY REDISTRIBUTION

The sampled core becomes flatter

Each Reynolds number uses its own zero-field height-mean reference speed, shared by all five Ha curves.



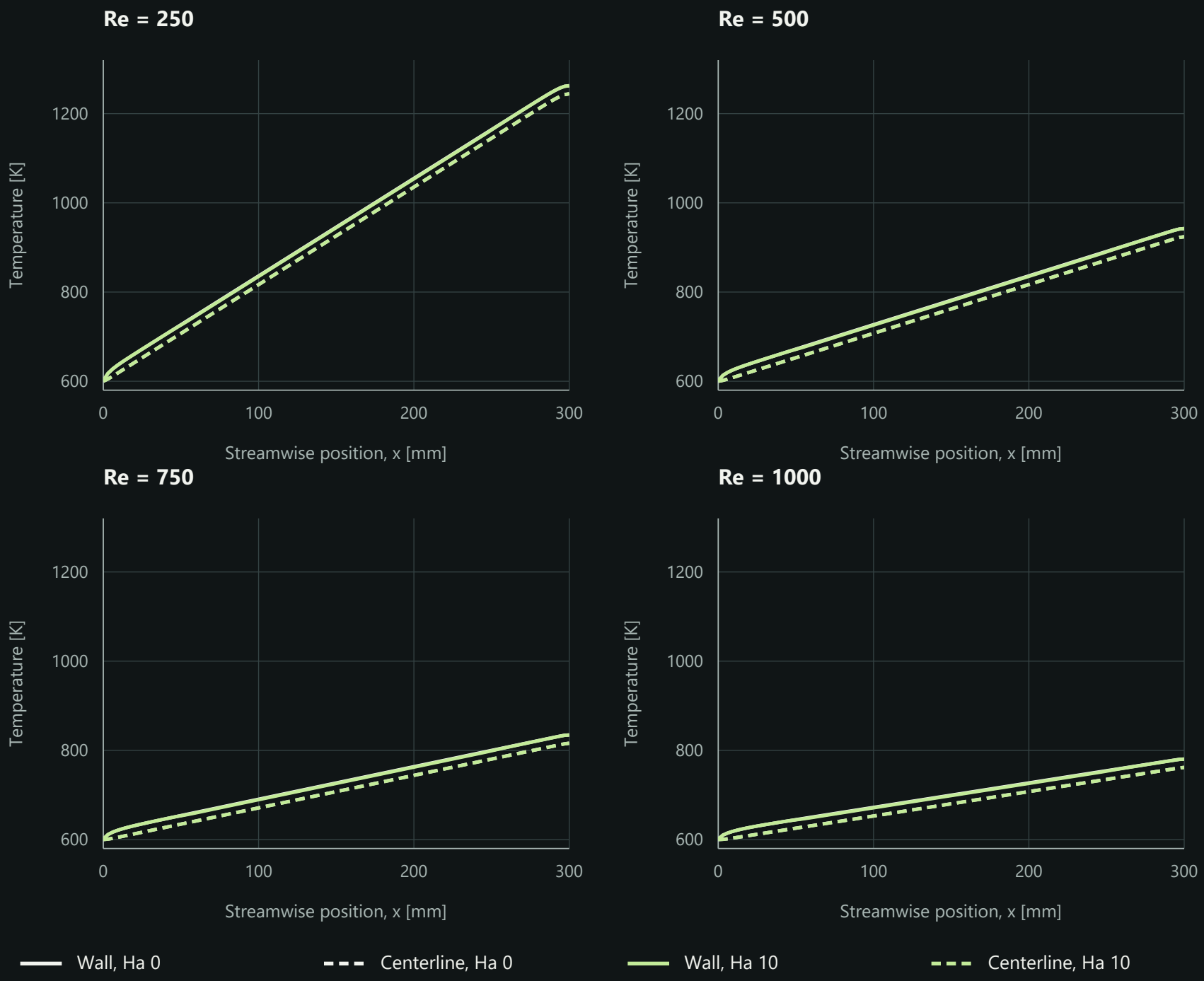
23.5-25.9% lower peak speed at Ha = 10. The integrated height-mean speed changes by less than 0.084%. V is the exported speed magnitude; this line integral is not a signed mass-flow check.

All 100 samples per case are connected directly. No smoothing or individual peak normalization is applied.

04 / TEMPERATURE LEVELS

Keep the absolute temperature in view

Wall and centerline temperatures at Ha = 0 and 10 nearly overlap at this scale. All panels use the same axes.



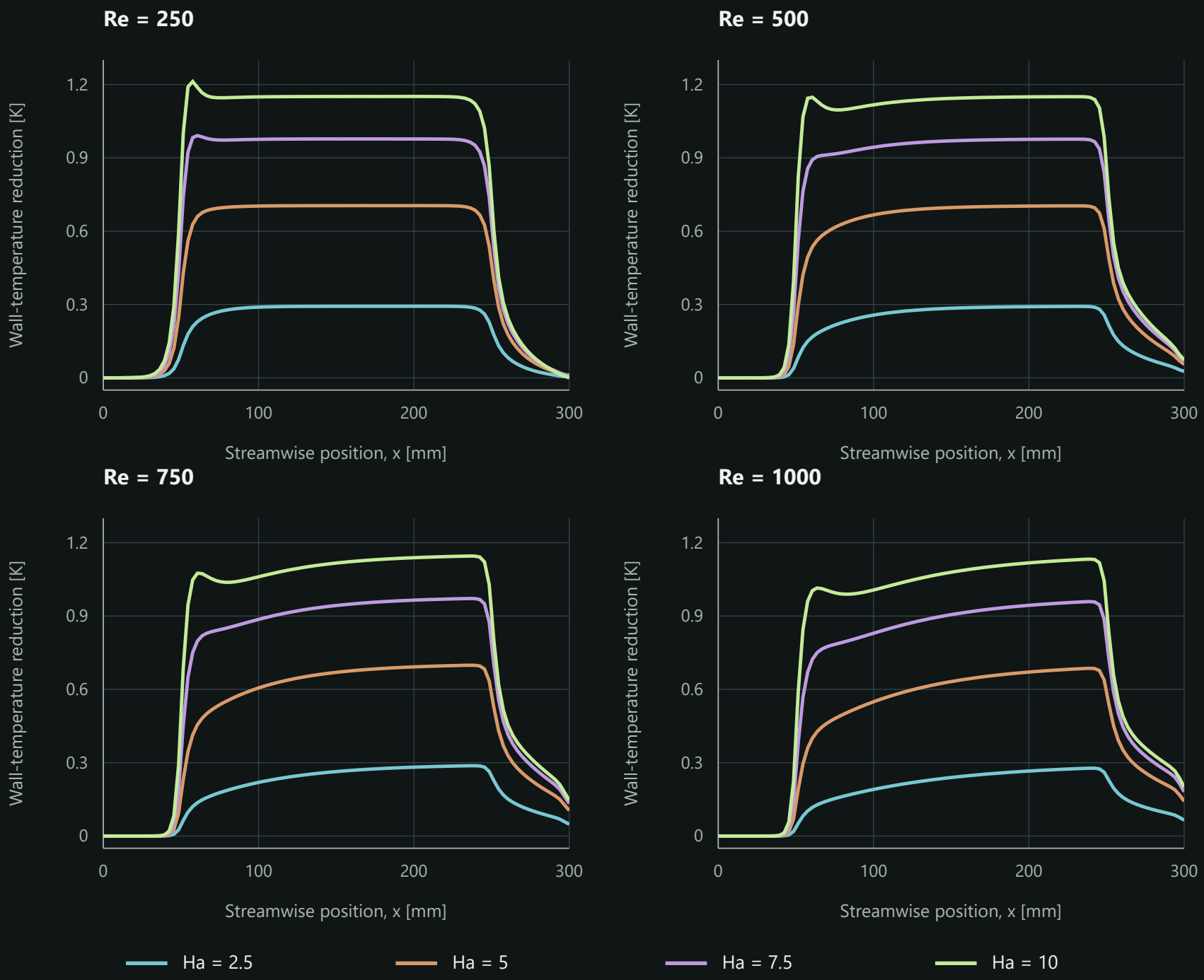
At Ha = 10, maximum sampled wall temperature is 1262.62 K at Re = 250 and 780.33 K at Re = 1000. Constant-property predictions at these levels require material and operating-feasibility checks.

Line 2 is centerline temperature. It is not a mass-flow-averaged cross-sectional bulk temperature.

05 / WALL-TEMPERATURE RESPONSE

A small reduction across much of the wall

Reduction = Tw at Ha = 0 minus Tw at the plotted Ha, evaluated at the same x and Re. Positive values indicate cooling.



0.78-0.81 K lower axial-mean wall temperature at Ha = 10. The largest local reduction is about 1.21 K. The reduction of the maximum sampled wall temperature is much smaller: about 0.0001-0.200 K.

These are three different measures. A local reduction cannot be reported as the change in maximum temperature.

06 / COMPARISON AND DEFINITIONS

Separate the direct results from the index

All values below compare Ha = 10 with Ha = 0 at the same Reynolds number. Means include the full exported span.

Re	Peak speed decrease [%]	Axial-mean wall decrease [K]	Maximum wall decrease [K]	Mean Nu_ref increase [%]
250	25.85	0.7991	0.00012	3.37
500	25.61	0.8051	0.07361	3.34
750	24.76	0.7943	0.14648	3.25
1000	23.52	0.7755	0.19977	3.14

CENTERLINE-REFERENCED THERMAL INDEX

$$h_{ref}(x) = q'' / [T_w(x) - T_c(x)]$$

$$Nu_{ref}(x) = h_{ref}(x)\, D_h / k$$

Tc is the centerline temperature. Dh = 0.020 m; k = 20.93 W/(m K); q" = 100,000 W/m².

WHAT THE 3.14-3.37% CHANGE MEANS

The mean Nu_ref increase summarizes the changed wall-to-centerline temperature difference under the prescribed heat flux. It is not a conventional bulk-temperature Nusselt number. h_ref and Nu_ref differ by the constant factor Dh/k.

AVERAGING AND ENDPOINT SENSITIVITY

Axial means use trapezoidal integration over 0.299999803 m, including both endpoints. The first-point Nu_ref is about 69-98. Omitting the first interval lowers the absolute mean by roughly 6-9% and changes the Ha = 10 gain to about 3.48-3.65%.

The report retains the full span and does not silently remove the inlet. Sample density and endpoint sensitivity need further testing.

07 / INTERPRETATION AND SOURCE TRAIL

What the current evidence supports

A preliminary 20-case comparison of field strength at matched Reynolds numbers, based on native line exports.

FLOW REDISTRIBUTION IS THE CLEARER SIGNAL

The sampled speed profiles flatten as Ha increases. The direct wall-temperature response is modest. Neither the thermal index nor the speed profiles establish a pumping-power or overall-efficiency benefit.

Mesh and solution	Saved ratios support flow (<1e-4) and energy (<1e-10) convergence. Electrical-potential ratios are unavailable (0/0 scales). Grid independence is not established.
Thermal validity	Test material-property sensitivity and operating feasibility over the modeled temperatures; compare with independent physical or benchmark evidence.
Thermal metric	Export matched mass-flow-averaged cross-sectional temperatures before reporting standard h or Nu. Check local heat flux and inlet sampling sensitivity.
Hydraulic comparison	Use matched pressure-drop and signed flow data from the same solutions before comparing pumping effort or net performance.

SOURCE RECORD AND REPRODUCTION

Raw data: Wall Temperature.csv (Line 1), Bulk Temperature.csv (Line 2) and the original velocity-profile CSV (Line 3), from MHD Fusion/New_Result. Each contains 20 cases with 100 samples per case.

Native setup: Fluent reports, settings, case/data files and CFD-Post Results.cst from Sep_05_MHD_Final Result_files. Saved residual records, cell fields and face connectivity support the numerical context.

The accompanying generator, copied inputs, recomputed metrics and SHA256 source manifest preserve the report. Charts are rebuilt from CSV values; no existing report pages are embedded.