

2D Computational Analysis of Fluid Flow and Heat Transfer in Rectangular Channels with Hierarchical Rib Turbulator Designs

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Abstract

This study presents a 2D CFD analysis (OpenFOAM, v2-f model) of turbulent flow and heat transfer in gas turbine cooling channels featuring novel hierarchical rib turbulators. Operating across Reynolds numbers of 20,000–80,000, a conventional uniform rib arrangement (PRA) is evaluated against three hierarchical designs (LIH, LDH, LDIH) to assess heat transfer (Nu), pressure drop (ΔP), and overall thermal performance. Validation against 3D experimental data shows the 2D approach accurately resolves centerline thermal physics (2.3% Nu error for LDH ribs) but overpredicts form drag (82.7% ΔP error). The results effectively isolate centerline aerodynamics to highlight fundamental performance differences among the geometries.

Keywords: blockMesh, RANS, turbulent flow, 2D domain, thermal performance, CFD

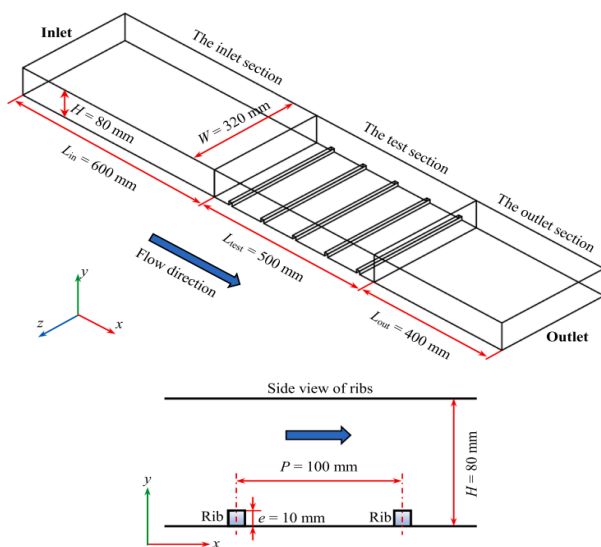


Figure 1: Schematic diagram of the computational domain in 3-D and 2-D, for our project, only the 2D domain is used.

Sr. no.	Geometry	Dimension
1.	Inlet	Length = 0.6 m, Height = 0.08 m
2.	Test section	Length = 0.5 m, Height = 0.08 m
3.	Outlet	Length = 0.4 m, Height = 0.08 m
4.	Rib (Square)	Side length = 0.01 m
5.	Rib pitch	0.1 m