

Visitor Research Report

Visitor Name: Mr. Patrick Greene
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Area of Research: Modeling of Unsteady Flow Phenomena

Period of Visit: July 7, 2008 – July 18, 2008

Goal:

Study the effects of surface roughness and isolated roughness elements on the stability of hypersonic flow.

Strategy:

This goal will be accomplished through the use of direct numerical simulations of hypersonic flow with surface roughness and isolated roughness elements. The compressible Navier-Stokes equations are solved using a fifth-order WENO scheme and a third-order Runge-Kutta scheme for time advancement. The simulations currently use a body fitted grid over the roughness element, but in the future the immersed boundary method will be used. The current geometry being investigated is the Boeing/AFOSR Mach 6 quiet wind tunnel at Purdue University. Experimental runs with an isolated roughness have already been performed at Purdue University. Since we are performing simulations of the same geometry, we can compare our results to the experimental results for validation. However, the wind tunnel at Purdue utilizes a bleed to restart the boundary layer just before the throat. The bleed is modeled in our simulations by applying different boundary conditions along the wall. Before the bleed, slip boundary conditions are applied. While after the bleed, no slip boundary conditions are used.

Accomplishments:

Numerical simulations of flow in the Purdue wind tunnel without a roughness element were performed and compared to results obtained from experiments and previous computations. The results agree well with the experiments and previous computations. These simulations were performed to verify that the modeling of the bleed in our simulations does not have a large effect on the flow in the test section of the wind tunnel.

Progress has also been made in generating a body fitted grid of the Purdue wind tunnel with a smooth roughness element. Since a body fitted grid is being used, a smooth roughness element must be used. Our current grids have a roughness element in the shape of a Gaussian.

Future Work:

Work is still being done on the body fitted grid of the Purdue wind tunnel with a smooth roughness element. Also, a three-dimensional WENO code is still being developed. Once both are completed, simulations can be performed for flow in the Purdue wind tunnel with a smooth roughness element. Eventually, the body fitted grid will be replaced with the immersed boundary method.

Pending Publications:

Greene, P. T., Eldredge, J. D., Zhong, X., and Kim, J., "A Numerical Study of Purdue's Mach 6 Tunnel with a Roughness Element," AIAA Paper, January 2009

Seminar Presented:

No seminar presented.