46th AIAA Aerospace Sciences Meeting and Exhibit
7 - 10 January 2008, Reno, Nevada

AIAA 2008-749

Lattice Boltzmann Simulations of the DLR-F4, DLR-F6 and Variants

Anthony Keating[1], Jeremy Beedy[2] and Richard Shock[3]
Exa Corporation, Burlington, MA, 01803, USA

The DLR-F4 and DLR-F6 are simplified wing and fuselage geometries which have been used in the past for validation of computational fluid dynamics (CFD) codes at three AIAA sponsored Drag Prediction Workshops. The objectives of these workshops were to evaluate the use of state-of-the-art computational methods in predicting aircraft forces and moments. The first workshop, held in 2001 used the DLR-F4 geometry, while the second and third workshops used the DLR-F6 geometry and included variants of the DLR-F6 with nacelles and an additional wing-body fairing (the FX2B fairing) to remove the separation at the wing-body junction. In this paper, lattice Boltzmann simulations of these geometries are performed using the commercially available CFD code, PowerFLOW 4.0. We compare overall lift and drag values, deltas between geometry variants, and surface pressure coefficients to the detailed sets of experimental data. Predicted flow structures are compared to experimental surface oil flows at the wing-body junction to show the effectiveness of the FX2B fairing.

Nomenclature

b	= wing length
C_d	= drag coefficient
C_l	= lift coefficient
C_m	= pitching moment coefficient
C_p	= coefficient of pressure
c	= wing chord length
c_i	= lattice Boltzmann discrete velocity vector
f_i	= lattice Boltzmann particle distribution function
f_i^{eq}	= lattice Boltzmann equilibrium distribution function
k	= turbulent kinetic energy
LES	= large eddy simulation
Ma	= Mach number
T	= temperature
u	= velocity
u_τ	= friction velocity
VLES	= very large eddy simulation
VR	= variable resolution
WB	= wing-body only
WBPN	= wing-body, pylon and nacelle
y^+	= dimensionless distance, $y\ u_\tau / \nu$
ε	= turbulence dissipation
τ	= lattice Boltzmann relaxation time
ρ	= density
ν	= kinematic viscosity

[1] Senior Validation Engineer, Exa Corporation, 3 Burlington Woods Dr, Burlington, MA, 01803.
[2] Application Engineer, Exa Corporation, 3 Burlington Woods Dr, Burlington, MA, 01803.
[3] Director, Physics Validation and Support, Exa Corporation, 3 Burlington Woods Dr, Burlington, MA, 01803.