MAE 210B – Turbulence Research Project Lit Study

J. A. Schetz\* and A. K. Jakubowski, Experimental Studies of the Turbulent Wake behind Self-Propelled Slender Bodies

* Wind tunnel test of axisymmetric body
  + Sampled turbulent wake data with hot wire anemometers
  + Multiple sample locations downstream
* Axial Velocity Plot – Fig 3
  + u/V vs r/R (one plot for each x-location)
  + Shows x-direction velocity profile at various stream-wise stations
  + Momentum deficient diminishes with increasing distance downstream of body
* Axial Turbulence Intensity plot – Fig 4
  + (u’^2)^0.5 vs. r/R (one plot for each x-location)
  + Corrected with freestream turbulence intensity, assuming superposition valid
  + Varied behavior in location of peak intensity
* Reynolds Shear Stress plot – Fig 5
  + Overbar(u’v’) vs. r/R
* Maximum Axial turbulence intensity decay plot – Fig 13
  + Max((u’^2)^0.5) vs. x/D
  + Get max turbulence intensity at each axial location
  + Plot demonstrates turbulence decreases as wake diminishes
* Maximum Reynolds Stress decay – Fig 14
  + Max(Overbar(u’v’)) vs. x/D
  + Same as previous, but with stress
* Velocity profile similarity plot – Fig 15
  + (U – u) / (U – uc) vs r/R (uc is centerline)
  + Non-dimensionalize velocity profiles to show self-similarity at each x-location
  + All velocity profiles overlap

R. Röhrig ⇑, S. Jakirlic ́ 1, C. Tropea, Comparative computational study of turbulent flow in a 90° pipe elbow

* Turbulent flow through a 90 pipe elbow in a range of moderately high Reynolds numbers
  + Simulate with LES and RANS and compare differences
* Computational methodology
  + Large Eddy Simulation
    - Explicitly solve large scale, use approximation for small (less compute)
    - Navier-Stokes equation has to be spatially filtered
  + Reynolds Averaged Navier Stokes
    - Near-wall second-moment closure model
  + All simulations in OpenFOAM
* Numerical Validation
  + Straight, turbulent pipe flow for calibration
  + U is mean velocity, u is turbulent velocity
  + Non-dimensional turbulent intensities – Fig 4
    - Eddy viscosity models (like SST) can’t compute turbulent intensity because they create an isotropic result
    - Reynolds stress models are higher order and can
* Other good stuff in this paper, but RSM not relevant to my SST runs

Ravindra G. Devi, Joseph Mathew, Peeush K. Bishnoi, Computations of turbulent near wakes of axisymmetric bodies

* Comparison of turbulence models over ellipsoid and sphere
  + K-epsilon, k-omega, Reynolds stress model
  + Before and after separation
  + Compare to experimental data
  + Previous studies have concerned LES and DNS
    - But RANS is an industry standard, it need its own studies
    - This paper provides that
* Solutions using CFX-5 finite volume solver
  + Grid made with unigraphics and ICEMCFD, unstructured
* Table 1 – compare global properties: drag coefficient, separation location, etc
* Turbulent intensity – Fig 4-6
  + No explanation of how calculated or which model used (probably RSM)

PietroCatalanoa, MengWangb, GianlucaIaccarinob, ParvizMoin, Numerical simulation of the flow around a circular cylinder at high Reynolds numbers

* Simulate flow around circular cylinder
  + Show LES is better than URANS
* Qualitative results
  + Compare wake contours
* Quantitative results
  + Compare mean flow velocities
  + Compare force coefficient time histories
* No turbulent parameter analysis

Sowjanya Vijiapurapu, Jie Cui, Performance of turbulence models for flows through rough pipes

* Solve rough, circular pipe flow with RANS and LES
  + “RANS/LES perform equally well in predicting time-averaged flow statistics”
  + “no instantaneous information can be obtained from RANS”

H.F. Lam\*, H.Y. Peng, Study of wake characteristics of a vertical axis wind turbine by two- and three-dimensional computational fluid dynamics simulations

* Simulate flow past vertical axis wind turbine (entire structure, not just blades)
  + Transition SST (4-eqn) and DES
  + Validate with PIV data
* Previous work
  + Ferreria: PIV of real wind turbine
  + McLaren: 2-D Unsteady Reynolds Averaged Navier Stokes (URANS) with Shear Stress Transport (SST) turbulence closure on turbine blades
* Computational modeling
  + Mach < 0.3, use incompressible URANS
  + Use SST for resolving turbulent flow
    - Blends k-omega in close-wall with k-epsilon in far field
    - Transition SST: improved 4 eqn model
      * Accurately predict separated flow transition
  + Use Improved delayed DES (IDDES) to verify sensitivity to turb. Model
    - Based on SST, but also DES
  + SIMPLEC pressure-velocity coupling scheme
  + Sensitivity studies performed
    - 1st then 2nd order schemes
    - time step study
    - grid sensitivity study
    - Use wake stream velocity to check convergence – fig 6
    - Validate convergence by comparison to PIV
  + Wake profiles of SST and IDDES were identical
    - Not sensitive to turbulence model
    - Use SST for further analyses
* 3D SST Results
  + presented turbulence intensities are average of intensities in all 3 directions
  + Plot mean velocities and average turbulent intensities of 2D/3D cases
    - Plot profiles along different horizontal and vertical lines (HLs and VLs)
      * Note the orientation of the axes so that horizontal/vertical are intuitive
    - Horizontal line mean flow (fig 8, 9) and turb. Intensity (fig 10)
    - vertical line mean flow (fig 11, 12) and turb. Intensity (fig 13)