Abstract for Case 1.2

Ringleb Flow

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1. Code description

- We employ the CPR-DG formulation [1-4] for space discretization
- A GMRES solver with a LU-SGS as a preconditioner [5]. Only the block diagonal matrices are stored.
- The standard p4 meshes are used in the simulation with p = 1 to 5
- The code was run in a serial mode
- Post-processing was done using tecplot

2. Case summary

- The simulation started from the analytical solution. We were able to converge density residual to 10 orders for most cases.
- 30 search directions employed in GMRES.
- Time step 1.0E20.
- Taubench ran in 9.83 seconds.

3. Meshes

- Standard posted p4 quadrilateral meshes were used
- The curved walls were represented with p-4 polynomials

4. Results

Two types of boundary conditions were used for the walls. One is the wall boundary condition, and the other is to fix the solution at the walls to the exact solution.

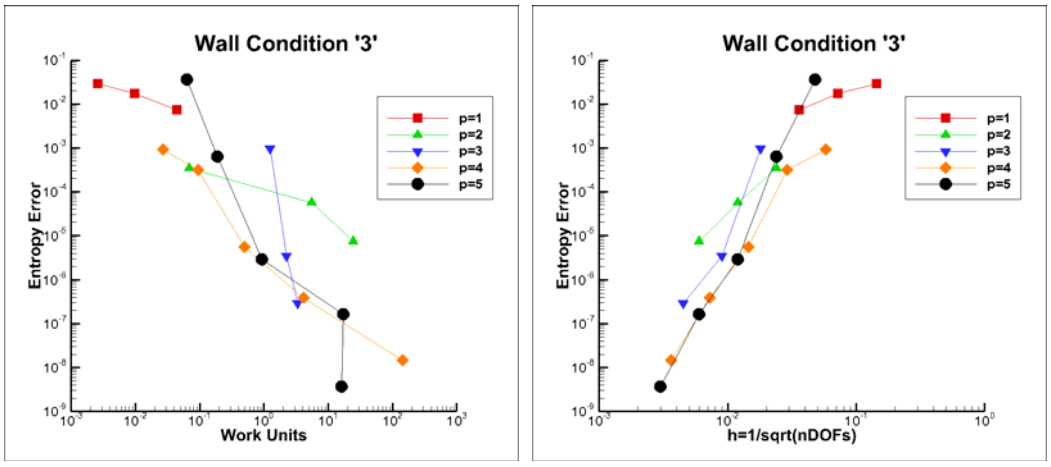

Figure 1. Errors vs. Work Units and Length Scale with the Wall Boundary Condition

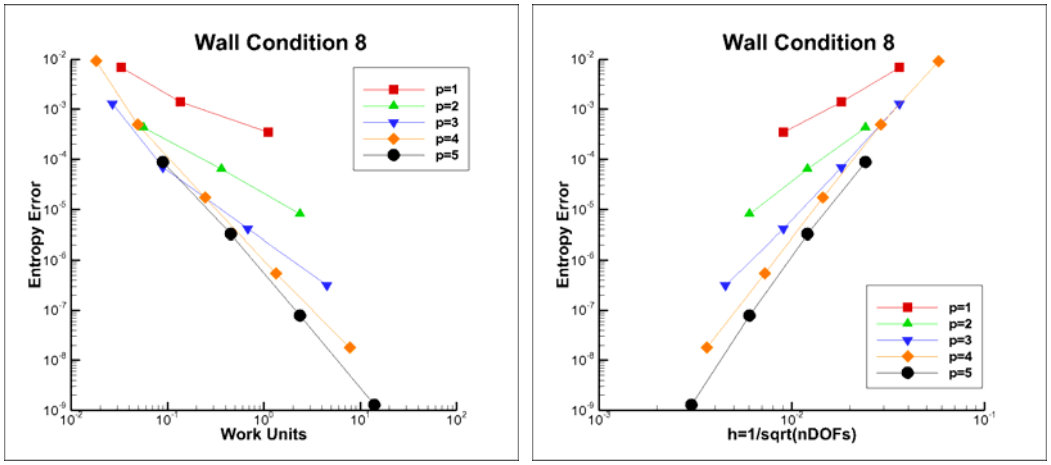

Figure 2. Errors vs. Work Units and Length Scale with the "Exact" Boundary Condition at the Walls

Interestingly, the work units to complete the residual evaluation 100 times with 250,000 DOFs differ quite significantly on two computers, old (5 years) and new (2 years). The TauBench times are 17.4 and 9.44 respectively.

p	1	2	3	4	5
work units (new)	1.29	1.06	1.00	0.94	0.90
Work units (old)	1.04	0.84	0.76	0.70	0.67

5. References

[1] H.T. Huynh, A flux reconstruction approach to high-order schemes including discontinuous Galerkin methods, AIAA Paper 2007-4079.

[2] Z.J. Wang and Haiyang Gao, "A unifying lifting collocation penalty formulation including the discontinuous Galerkin, spectral volume/difference methods for conservation laws on mixed grids," Journal of Computational Physics 228 (2009) 8161－8186.

[3] Z.J. Wang, H. Gao and T. Haga, "A Unifying Discontinuous Formulation for Hybrid Meshes," Adaptive High-Order Methods in Computational Fluid Dynamics, Edited by Z.J. Wang, World Scientific Publishing, 2011.

[4] H. Gao, Z.J. Wang and H.T. Huynh, "Differential Formulation of Discontinuous Galerkin and Related Methods for the Navier-Stokes Equations", Communications in Computational Physics, accepted.

[5] Y. Sun, Z.J. Wang and Y. Liu, "Efficient Implicit Non-linear LU-SGS Approach for Compressible Flow Computation Using High-Order Spectral Difference Method", Communications in Computational Physics, Vol. 5, No. 2-4, pp. 760-778 (2009).