EngOpt2018 - 6th International Conference on Engineering Optimization
Instituto Superior Técnico, Lisbon Portugal • 17-19 September, 2018
Editors: H.C. Rodrigues, J. Herskovits, C.M. Mota Soares, et al.

Abstract ID 1055

THE ADAPTATION OF THE "EXPRESS-3D" CODE FOR THE HYPERSONIC FLOWS SIMULATION

Evgeny Shilnikov

Keldysh Institute of Applied Mathematics RAS, Russian Federation
evvlash@mail.ru

Keywords: Hypersonic flows,Quasi gas dynamic equations,Separated flows,Shock wave/boundary layer interaction,Non-orthogonal grid

Abstract: The paper presents the experience of using the parallel program complex "Express-3D", which implements an explicit finite-difference scheme, based on the quasi-gas-dynamic (QGD) equations system, for modeling hypersonic gas flows. The last version of the code uses multi-block non-orthogonal hexahedral grids [1]. Modeling of high-speed gas flows has some peculiarities. The modeling of hypersonic flows around compression corners for different values of both the angle itself and the angle of attack, showed that in the case of a continuous flow the calculation can be carried out with the same parameters of the method as for the flows with moderate velocities. However, the artificial viscosity, which allows calculations in the presence of strong shock waves (high Mach numbers), can significantly distort the flow field in the subsonic region. To obtain the correct size of the separation zone, it is necessary to modify the regularizers in the QGD system. Calculations showed that the desired result can be achieved by optimizing the relationship between regularizers, analogous to shear and bulk viscosities. In addition, at least at the beginning of calculations, it is preferable to use the flux relaxation approach [2]. As a result, the algorithm allows to simulate gas flows in a wide range of Mach numbers. Some results of using this code for the problems of the hypersonic flow / boundary layer interaction are presented. The simulation results are discussed and compared with the known experimental data. Parallel programs are realized for both the standard x86 architecture, and the architecture of the CUDA graphics processors. A parallel implementation uses MPI, shmem and CUDA libraries. The efficiency of parallel implementation is investigated. The accelerations obtained on different types of GPU are compared. Calculations showed that the increased volume of exchanges in the case of non-orthogonal grids in comparison with rectangular grids leads to a significant drop in acceleration on GPU's of the Tesla C20xx type. However, modern calculators with Kepler architecture allow to achieve good acceleration without changes in the program code.

References

(1) *Alexander Davydov and Evgeny Shilnikov. Program Complex for Fluid Dynamic Problems Simulation on GPU-Based Computer Systems. Proceedings of ICNAAM 2014, 4 p., AIP Conference Proceedings, 2015, T. 1648, № 1, 850071, DOI: 10.1063/1.4913126.*

(2) *Boris Chetverushkin and Evgeny Shilnikov. Flux Relaxation as an Approach to the Stability Improvement for Explicit Finite Difference Schemes. CD proceedings of the II International conference on Engineering Optimization (EngOpt-2010), Lisbon, Portugal, September 2010.*