Parallel CFD of a prototype car with OpenFOAM

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Abstract

The Alérion Supermileage team at Laval University is a group of mechanical engineering students who design and build a prototype car with the intent of making it the most fuel efficient as possible. A great factor that determines fuel efficiency of a ground vehicle is its aerodynamic drag. The team was interested in determining which improvements could be made to the current shell design to reduce the drag even more.

To that end, the OpenFOAM toolbox was compiled on a 300 processor shared cluster located at McGill University for the purpose of modeling the aerodynamics of the car. The compilation was done in order to link the code with the precompiled cluster OpenMPI librairies that have InfiniBand support. A quasi-linear relationship between the number of processors used and the computation time was observed. It was possible to attain a very small turnover time for the calculations and this indicates that the software is an attractive option for industry players that have access to a cluster; not to mention that OpenFOAM is more flexible than commercial alternatives. The k-omega-SST model was used for all of the simulations. Preliminary results show that the model correctly predicts the drag coefficient and flow characteristics.

The simulations were done using a three-dimensional mesh. Different mesh sizes ranging from 1 to 5 million cells were analyzed. Meshing of the domain was done with Gmsh for some of the simulations and with snappyHexMesh for others. The mesh was decomposed for parallel computations with the help of the metis algorithm implemented in OpenFOAM.

Simulations were also done to study the effect of side-winds on the shell and thus predict the drag that occurs when the car is turning. Other parts of the study involved many shell shapes with slightly different features, such as camber in the wheel covers, different curvatures of the main body, different lengths and angles of attack, etc.

Drag coefficients in the range of 0.08 to 0.12 were found, depending on the mesh and parameters used. The effect of relying on structural boundary layer cells next to the wall in comparison to unstructured cells was also studied.

Key words: Automotive, Fuel Economy, Streamlined, Cluster, OpenFOAM

References

[1] To be determined.