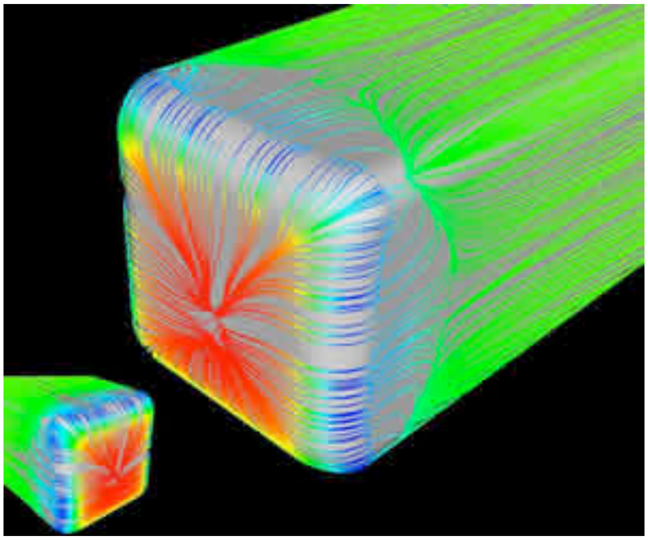
Chalmers University Uses Advanced CFD to Help
Volvo Cars Build More Aerodynamic Vehicles

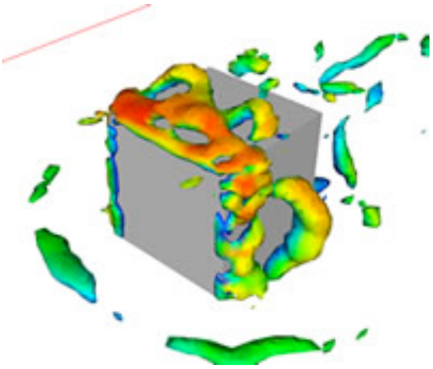


Aerodynamics plays a crucial role in a passenger car's fuel economy, emissions and stability. But aerodynamic design is still a mystery in some ways, particularly when trying to determine how to reduce wakes, the unsteady airflow at the back of a vehicle.

Researchers at Chalmers University of Technology in Gothenburg, Sweden, are working with Volvo Cars to formulate better ways to study the effects of aerodynamics on cars. Using a combination of computational fluid dynamics (CFD), high-end computer systems, and advanced visualization software, the university is close to finding a way to effectively predict flow around cars.

Windy Conditions

According to Sinisa Krajnovic, a researcher in CFD at Chalmers, there are several ways in which aerodynamics can affect cars:

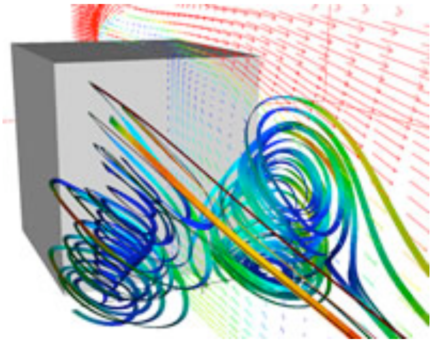


- *Drag:* This is the largest aerodynamic force a car must overcome. A car with low drag will have better fuel economy and lower emissions.
- *Stability:* The flow around a car not only leads to drag but also to other aerodynamic forces. These forces affect driving stability and can influence comfort and safety.
- *Wind noise:* The airflow interacts with the surface of the car body to generate wind noise, which can be annoying to drivers and passengers.
- *Dirt and water:* These can accumulate on a vehicle with unsteady flow.

Volvo Cars asked Chalmers researchers to find better ways to study these conditions. The project is part of a larger investment by Volvo Cars and Chalmers in external aerodynamics and aero-acoustics.

"Our project is meant to give a deeper understanding of the flow around cars to optimize aerodynamics and help Volvo Cars design them better," Krajnovic says.

Transient Simulations for Unsteady Flows



One of the more difficult aerodynamic forces to predict is drag, because it is mainly caused by wakes. Wakes cannot be predicted with the Reynolds Average Navier-Stokes (RANS) equation, which is typically used to simulate other aerodynamic forces.

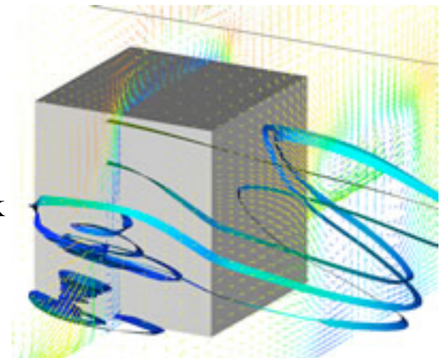
So Chalmers scientists study wakes using the Large Eddy Simulation (LES), which has had greater success in predicting the pressure at the rear of bluff bodies (objects that produce large wake regions) such as cylinders and

cubes. The LES is a computational fluid dynamics method that results in a three-dimensional, time-dependent solution.

"To make a prediction of the wake behind a car or wind noise using computer simulation, researchers must use some transient simulation such as LES," Krajnovic says. "The RANS CFD method can only provide us with information about the steady-state flow, but not data about unsteady flow such as the flow behind a car."

From Cubes to Cars

Chalmers researchers limited their initial LES studies to airflow around a three-dimensional cube, since the simulation of a real-life car requires a large amount of computational memory and time.



"The cube was the best-documented experimental work on this flow and the geometry was simple. We could concentrate only on LES and how to make it computationally cheap," Krajnovic says.

The group used ICEM CFD software for preprocessing and an in-house solver. The solver was run using SGI ORIGIN2000 R1000 processors for calculation and Digital Equipment Corp. systems for pre- and postprocessing. CEI's EnSight Gold software was then used to visualize flow features such as streamlines, velocity vector planes, isosurfaces of pressure, and particle traces around the cube.

Flow-feature extraction in EnSight allows engineers and scientists to automatically visualize complex computational fluid dynamics interactions. The software provides automatic detection and display of major flow features such as vortex cores, boundary layer separation and reattachment lines, surface flow topology, and boundary layer characteristics.

"Vortex core extraction would be difficult to do without EnSight," Krajnovic says. "It is very important in LES to be able to study instantaneous flow. EnSight also makes it possible to make high-quality movies that allow us to study instantaneous flow in detail."

EnSight's ability to handle large amounts of data on high-end computers is also a plus, Krajnovic says. The models being visualized can be as large as four million nodes. EnSight Gold has visualized models as large as 11.5 billion nodes.

After success using LES with the surface-mounted cube, Chalmers researchers ran simulations using a simplified bus model. These tests were also successful. Krajnovic says they are now ready to use the process on a simplified passenger car model.

An Air of Confidence

With the new approach to studying wakes, researchers at Chalmers have found a way to simulate real-life aerodynamic occurrences without having to sacrifice too much computer power and memory.

"With increases in storage resources and computational power, this technique will be used more frequently and for more computationally demanding flows in the future," Krajnovic says. "It will eventually help Volvo Cars design a safer, more comfortable and more fuel-efficient vehicle, which could have a huge impact on the way vehicles are designed for everyone."

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The research discussed in this article is being conducted by Sinisa Krajnovic and Lars Davidson at the Department of Thermo and Fluid Dynamics at Chalmers University. More information can be found at http://www.tfd.chalmers.se/~lada/projects/sinisa/proright.html