Students Win Using Simulation-Driven Design

Affiliation with ANSYS helps the University of Waterloo Formula Motorsports team win an award for an innovative air intake design at the Formula SAE Michigan 2009 competition.

By Anish Ganesh, Intake System Designer, University of Waterloo Formula Motorsports, Canada

The University of Waterloo (UW) Formula Motorsports team is a student-operated organization, based in Canada, that designs and builds an open-wheel race car to compete in the annual Formula SAE competition. Organized by SAE International (formerly the Society of Automotive Engineers), the annual competition challenges student teams from around the globe to design, fabricate, market and race a formula-style autocross vehicle. The competition is divided into two main categories: static and dynamic events. The static events consist of engineering design competition, marketing presentation, cost report and technical inspection. The dynamic events include acceleration, skid pad, autocross, fuel economy and a 22-kilometer endurance test.

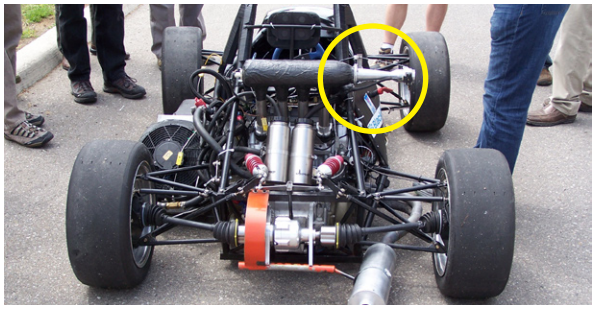
The University of Waterloo Formula Motorsports team has made great progress in the design of their 2010 car. One of the most significant changes for the upcoming season is the transition to the second-generation Honda CBR 600 RR powerplant, which is lighter, smaller and more powerful than its incumbent, the Honda CBR 600 F4i. This transition requires many components to be redesigned. FSAE race car competition rules limit engine power by restricting all air for engine combustion to pass through a 20-milimeter hole. Therefore, optimizing the flow of air through the intake geometry is crucial in providing the desired engine performance. The UW team saw this rule as an opportunity for innovation, and it set out to modify the wall geometry approaching and departing this air flow restrictor to obtain maximum flow of air into the engine.

Using ANSYS CFX software for a three-dimensional computational fluid dynamics (CFD) analysis, the team achieved an optimal design of the intake restrictor for the engine with considerable reduction in development time and cost. The goal was to maximize the pressure recovery through the restrictor. At the maximum operating condition of the engine, the optimized design improves the pressure recovery of the restrictor by 4 percent, while the overall length of the design is increased by only 5 percent.

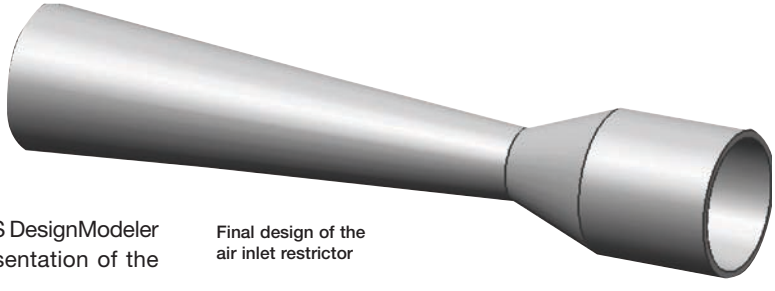
The intake system designer used ANSYS DesignModeler software to generate a parametric representation of the restrictor geometry. The fluid volume and face meshes required for all the geometries were created in the ANSYS Meshing application and were imported into ANSYS CFX software, in which the fluid properties and physics were defined and the fluid flow simulations were performed. The student analyzed simulation results using the ANSYS CFD-Post post-processing tool.

The UW team considered a number of restrictor geometry concepts. The ANSYS CFD-Post tool was used to calculate pressure recovery and to detect flow

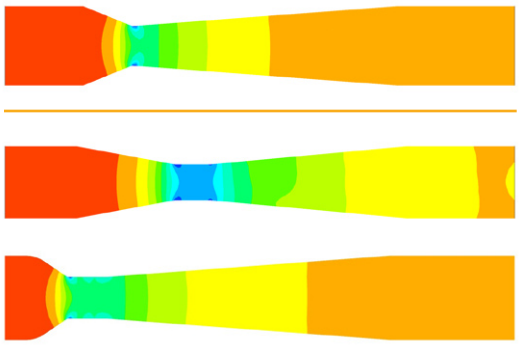
2009 University of Waterloo Formula Motorsports car



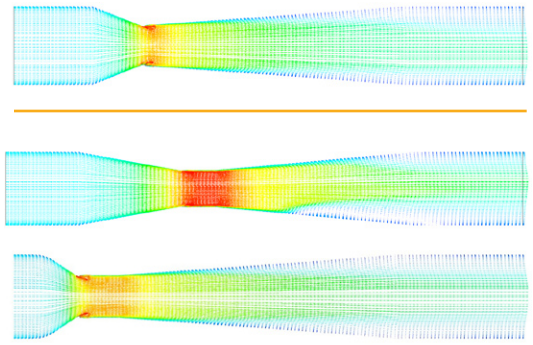
2009 car showing the air inlet that was redesigned



Final design of the air inlet restrictor



Pressure contours for the air inlet on the original design (top) and two alternatives (below)



Velocity vectors on the original design (top) and two alternatives (below)

separation due to viscous effects and adverse pressure gradients for each of the geometries. Due to the presence of flow separation, several design concepts including the original were discarded.

As to the remaining design concepts, the team selected the one that demonstrated the best pressure recovery for further refinement using the goal-driven optimization tool in ANSYS DesignXplorer software within the ANSYS Workbench environment. This tool implements a design of experiments procedure that recognizes the parameters set in the geometry-creation stage. The tool varies the parameters to defined ranges, modifies the geometry and mesh, and obtains solutions for all the ranges automatically. Based on the results required, ANSYS DesignXplorer identified the three optimum candidates that fulfilled the design requirements. In this case, the final optimized design was selected based on this optimization process. The optimized restrictor design helps to improve the overall performance of the engine by boosting the flow of air into the engine, therefore increasing combustion efficiency while reducing emissions.

Fluid flow simulation is a vital tool for engine system developers. The ability to improve pressure recovery and minimize flow separation in the restrictor design has allowed the team to maximize the performance and efficiency of the new powerplant. Formula Motorsport teams extensively use CFD simulation to quickly and cost effectively evaluate the performance of their intake system designs and to investigate the impact of design changes on overall vehicle performance. This process eliminates the need for multiple prototype cycles in which full-size restrictors are constructed for physical flow-bench testing.

The University of Waterloo Motorsports team won the 2009 Formula SAE CFdesign Computational Fluid Dynamics Award presented during the 2009 Formula SAE competition held in May 2009 at the Michigan International Speedway. The UW team received the honor for their use of CFD to optimize the air flow through the restrictor for their 2010 intake system.

The author has worked at ANSYS, Inc. as a technical writer for four co-operative work terms. ANSYS CFX developers assisted him on various aspects of the restrictor design. The Formula Motorsports team at the University of Waterloo thanks ANSYS for their continual support in developing a winning car.

To the Finish Line

Today's undergraduate students are tomorrow's engineers and researchers. Formula SAE is designed to promote careers and excellence in engineering, and, as a partner to the program, ANSYS provides its engineering simulation software to student participants. Currently, nearly 50 university teams use ANSYS to design their formula cars, many with outstanding results.

"ANSYS is committed to working with universities in many ways," said Paul Lethbridge, ANSYS academic product strategy and planning manager. "This exciting project takes students out of the classroom and allows them to apply textbook theories to real work experiences. Formula SAE gives them a great foundation in using Smart Engineering Simulation tools that they will employ throughout their careers."

University of Waterloo Formula Motorsports team in 2009