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Sedan Performance/Economy Rear Diffuser

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Abstract

This project consists of designing in SolidWorks a model of the performance/fuel economy diffuser. The design is modeled with an Ahmed body (recommended shape for CFD testing vehicles) and the diffuser will be applied to the bottom of the rear bumper of the car. After this is done the model will be imported into ANSYS for CFD testing. Testing entails importing the model, then creating a mesh around the model, and then setting up the program to run analysis for calculating the coefficient of drag. Then building this SolidWorks model as a full working prototype for actual road-testing purposes. With the results from road testing, theoretical calculations can be compared with actual results.

Project Goals

1. Utilize ANSYS fluent for obtaining the coefficient of drag for an Ahmed body with similar dimensions to a 2013 Toyota Corolla.
2. Create a diffuser to be placed on the Ahmed body for ANSYS fluent testing.
3. Run physical tests on an actual 2013 Toyota Corolla before and then after placing an actual diffuser on the vehicle.

Introduction or Background

- Reducing drag is important for reducing the drag force through out the vehicle which can increase fuel economy and increasing the overall performance on a vehicle

- Computation Fluid Dynamics (CFD) utilizes many different disciplines needed to solve complex flow problems

- Utilizing acceleration equations for road testing vehicles for Drag Coefficients, these drag coefficients can be compared to the CFD analysis results

Road Testing

- The road test is a simple setup Utilizing a vehicle with an accurate speedometer and a timer

- The vehicle would begin above 55 MPH and then be put into neutral, as the vehicle decelerates on the flat road the timer would begin once speedometer hit 55 MPH and then be stopped at 45 MPH

- With the Velocities, time, frontal area, density of air, and the mass of the vehicle, the coefficient of drag can be found through acceleration equations, drag force equations, and coefficient of drag equations.

CFD Setup

- Simulation was created by the combining the setups from Marco Lanfrit's *Best Practice Guidelines for Handling Automotive External Aerodynamics* as well as Angel Huminic and Gabriela Huminic's Aerodynamics of curved underbody diffusers using CFD

- The flow domain of the Ahmed simulation body were based on the length (L) and the Width (W) of a 2013 Toyota Corolla.

- After performing a mesh study, the best results were found around an element amount of 500,000

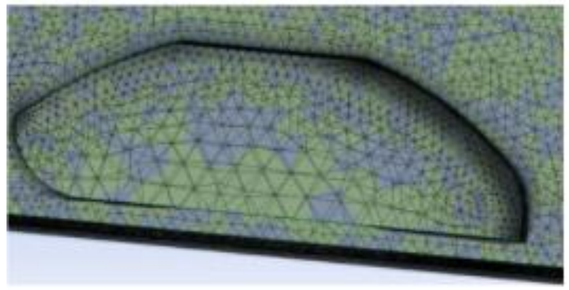


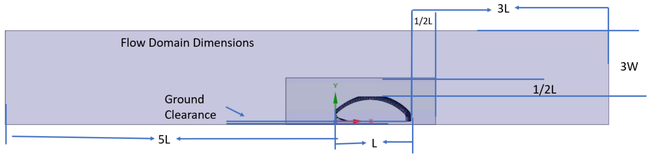
Table 1 (CFD)

CFD analysis	
Case A	0.345
Case B	0.341
Case C	0.299
Case D	0.286

Table 2 (Road Test)

Road Test stock values		Road Test Diffuser values	
0.319	Uncertainty	0.339	Uncertainty
0.349	0.012942179	0.308	0.013485932
0.317		0.341	
0.35		0.307	
0.317		0.341	
0.349		0.307	

Road Test	
Stock	0.333
Diffuser	0.323



Results

Table 1 shows the CFD analysis results of the Ahmed body with no diffuser and then with the diffuser design in terms of the coefficient of drag. These tests were performed with equal environments and speeds, the car was traveling at 25 m/s and the density of air was set to 1.225 kg/m^3. As shown with each modification to the diffuser the coefficient of drag had decreased. The physical test of the Corolla with the diffuser will not be the same due to the difference in the geometry as well as the difference in speeds and with the way the physical test is carried out. The things that are the same with this way of testing is the trend of the diffuser decreasing the amount on drag on the vehicle. From the physical testing the Corolla got a drag coefficient of 0.333± 0.013 before the diffuser test and then the Corolla got a drag coefficient of 0.323± 0.013 after installing the diffuser to the vehicle.

Modifications to the Diffuser

One of the major sources of drag on an automobile is from the low-pressure region behind the vehicle. This is created from the flow separation from the sharp angle of the cars rear, and with a diffuser this allows the air to continue under and out the back of the car with minimal separation. The designs for study were, a smooth plate under the vehicle, the smooth plate with air diverters, an extension attached to the previous, and finally changing the air diverters to fins. The stock body without modification definitely shows the air separating behind the vehicle and the designs with the air diverters and the fins providing the best results in reducing the drag coefficient. This is reflected by the amount of drag that comes from the stock body of the Ahmed design starting at about 0.346 to 0.290 With the design that has the air diverters and fins. The physical testing also supports this with the trend following a similar curve as the stock Corolla bumper showing around 0.333± 0.013 For the coefficient and then the corolla with the diffuser showing a value of 0.323± 0.013 This design for a diffuser shows great opportunities for reducing drag on these vehicles if this can be created with proper tools for design and creation of the abs plastic being used for this design. The biggest difference between these tests causing the most error is with the geometries being different.

Acknowledgements

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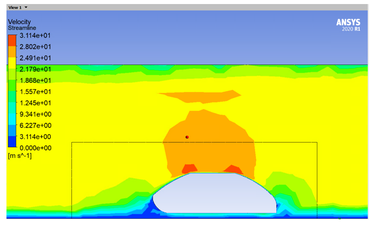
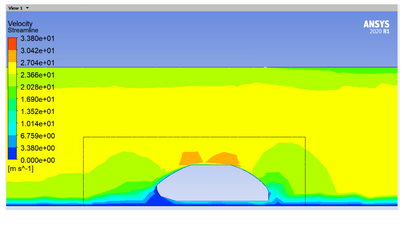
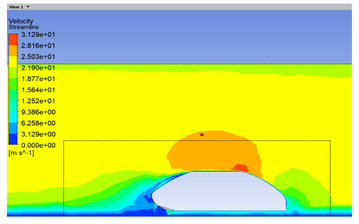
No diffuser, Stock (Case A)



Smooth (Case B)



Diverters (Case C)



Diverters with Extension (Case D)