It was a last-minute adjustment, but would it be possible to squeeze more mileage out of a “super-mileage” car with a new aerodynamic rear spoiler? That’s what Chang Ho Kim was wondering before a regional motorsport rally. Kim, an avid autocross racer and owner of FunHondas Racing, remembered that I work in the area of aerodynamics design. In fact, we had met on the auto race circuit. Kim recalled: “I knew my friend David White was involved in aerodynamics; I have seen how fast his autocross car is, so I figured he would be a good person to contact.” He called me at Alden Labs, and the rest, as they say, is history.
Kim first got involved in car design after he saw a forum post about the Fuel Economy Run, a competition sponsored by the Adirondack Motor Enthusiasts Club (AMEC). AMEC reinvented this competition in 2008 (The first Economy Run was held in 1954.), with awards focused on best miles-per-gallon and miles-per-dollar performance achieved on a course through the southern Adirondack Mountains in New York. When Kim learned of the competition, he had just purchased a 1989 Honda CRX HF, and he thought it would be fun to give the competition a try.

To improve mileage, he set out to reduce weight and improve the aerodynamics of the vehicle. First, he removed unnecessary components. Then, he taped and sealed any panel gaps and seams on the car’s exterior that hindered its aerodynamic performance. Finally, toward the end of the design process, he began considering a rear baffle, an acrylic addition, that would extend the length of the car and reduce drag. But what shape and design would work best?

During his first contact with Alden Labs on the project, Kim explained that he was adding front and rear extensions and a sideskirt over the car’s rear wheels to improve its aerodynamic performance. What he hoped Alden Labs could help him with was the shape of the acrylic rear baffle. Kim provided some pictures of the car, and the work began.

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The modified Honda CRX ready to race

A tight deadline meant that there was only a day to complete the analysis. The first step was to create a 3-D model of the existing car. Next, the project involved determining if a rear extension would be helpful and, if yes, which shape was best. ANSYS Fluent software provided the necessary tools to analyze alternative rear extension designs. On a standard 1989 Honda CRX HF, the hatchback is sloped and then stops abruptly. Computational fluid dynamics (CFD) analysis using Fluent revealed that the car’s standard design led to significant turbulence and drag. Analysis suggested that the optimal shape was to extend the rear of the car and add some side vents, but a question remained: “Should it be enclosed for a full tail or open like a hood?”

At first thought, it was expected that closing in the rear baffle would work better. However, Fluent quickly proved this assumption wrong, delivering results with just a few changes to the solver settings. For instance, to investigate the effect of an open rear baffle, the designer simply replaced the closed baffle with the open baffle and selected project update. The geometry change of the baffle automatically propagated throughout the entire Fluent simulation system: The CAD model was automatically updated, geometry remeshed, boundary conditions re-applied, physics and solver settings re-applied, solution recomputed, and results updated. During the analysis, Alden Labs used the ANSYS Mesher in combination with Fluent to look carefully at drag over the car, the velocity profile of the air, how turbulent the air was behind the car, and what its trail looked like. When the baffle was closed, the air waffled freely around the rear of the car, which made airflow unsteady behind the vehicle. In contrast, the open baffle contained the highly turbulent air in its pocket, which reduced aerodynamic drag. A typical vehicle has a drag coefficient (Cd) of 0.3 to 0.4, and most vehicles use more than half of their power to overcome this drag during highway travel. By including an open rear baffle, it was possible to realize a 5 percent reduction in Cd compared to an unmodified Honda shape.

Once Alden Labs computed the optimal design, Kim quickly completed the baffle according to instructions and entered the competition. The rally consisted of a 104 mile journey along mountainous roads. In addition to making weight and aerodynamic adjustments to the car, Kim modified his driving style to maximize fuel efficiency. In the end, he was the winner, finishing with the best fuel economy. He used an impressive 0.88 gallons of fuel (which translates to 118 miles per gallon) to complete the 104 mile drive. The optimized aerodynamic performance of the car was due, in large part, to the rear extension design.

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