



NEWS ARTICLE ANALYSIS

Read: *Improving Aerodynamics to Boost Fuel Economy* By Sue Elliott-Sink (Posted 05-02-2006)

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QUESTIONS

1. What is Aerodynamics & Drag? (2 Marks)
2. Use the internet to find out the significance of the Chrysler Airflow? (2 Marks)
3. Why is there now such a focus on car aerodynamics? (2 Marks)
4. What is the 'Coefficient of Drag (Cd)'? (1 Mark)
5. What is the formula for calculating the force acting against a car by the air? (1 Mark)
6. Calculate the force acting on a car with the following features:

Car	Cd	Frontal Area (Square Feet)	Density of Air	Speed Squared (miles per gallon)	Force Acting
Hummer	0.57	35.6	1.3	70	
MBW 7 Series	0.31	19.6	1.3	50	
Toyota Prius	0.26	23.5	1.3	60	

7. Explain why you think pickups (trucks, utes etc) and SUV's (4WD) typically have more drag? (3 Marks)
8. What are 3 ways that car designers try to reduce drag? (3 Marks)
9. Try to explain how you think a tonneau cover helps with the fuel economy of a truck? (2 Marks)
10. What are 3 ways that you can reduce the drag of your vehicle yourself? (3 Marks)
11. What does an increase in noise mean? (1 Mark)

Improving Aerodynamics to Boost Fuel Economy By Sue Elliott-Sink (05-02-2006)

Automakers have been interested in aerodynamics at least since the introduction of the Chrysler Airflow in 1934. But the need to improve fuel economy in recent years has pushed aerodynamics toward the top of automakers' priority lists.

It turns out we — the car-buying public — have helped cause this emphasis on aerodynamics. You see, the easiest way to improve a vehicle's fuel economy is to make it smaller and lighter and give it a smaller engine. But we want 400-hp sports cars and seven-passenger SUVs and 5,000-pound-capacity tow vehicles — and we want good gas mileage, too.

Lucky for us automakers have found a way to do that: by making their vehicles slip more smoothly through the air.

"The main driver for lower aerodynamic drag is fuel economy," says Max Schenkel, General Motors technical fellow, aerodynamics. "As long as federal standards for fuel economy increase and fuel costs go up, aerodynamic drag will have to be improved."

Automakers focus on aerodynamics for financial reasons, too. "Aero benefits can almost be cost-free to some extent — just how you bend the metal and how you execute gaps and joints, and...a lot of that is design," says Rick Aneiros, Chrysler Group's vice president of Jeep and truck design. "If you're trying to reduce weight by adding expensive exotic materials, that's not easy to do. And improving engine efficiency, that's not easy to do. So the leading strategy is to improve aerodynamics whenever possible. That's why we built our own full-size wind tunnel here."

In fact, today's wisdom says you can't start measuring a vehicle's aerodynamics too early in the design process. From the earliest conceptual stages on through the working-prototype stage, automakers rely on computer software and wind tunnels to ensure vehicles meet their aerodynamic targets.

How Drag Affects Mileage

When you consider aerodynamics from a fuel economy standpoint, you're primarily looking at coefficient of drag (known in the business as "Cd"). Essentially, this is how easily a vehicle moves through the air, though drag isn't the only factor that is considered. "There's more to aerodynamics than just drag," says Doug Frasher, strategic design chief at the Volvo Monitoring & Concept Center. "There's downforce and lift. And there is yawing moment, which is basically when you're in a crosswind, how much does the vehicle get steered by the wind that is pushing on it? And then there's noise. So we try to look for all of those factors.

"For a full-size truck, a change in drag coefficient of 0.01 is approximately equal to an improvement in fuel economy of 0.1 mpg on the combined city/highway driving cycle," says GM's Schenkel. "The same drag coefficient reduction can improve a car's fuel economy by approximately 0.2 mpg."

Volvo's Frasher says the force acting against a car by the air it moves is a function of:

$$\text{Cd} \times \text{Frontal Area} \times \text{Density of Air} \times \text{Speed Squared}$$

Speed clearly is an important part of the equation. At stop-and-go speeds, drag isn't a big deal, but the faster you go, the more it matters. At 70 mph, you've got four times the force working against your vehicle that you have at 35 mph.

To put Cd changes in perspective, Frasher put some numbers to a hypothetical sedan. Our imaginary car has a curb weight of 3,527 pounds, a Cd of 0.30, a frontal area of 23.7 square feet and 9 pounds of rolling resistance for every 1,000 pounds of weight.

According to Frasher, "If we put a gas-burning engine in this car, expect reasonable performance and drive it on a combined driving cycle, we can expect to get 23.8 mpg.... Add 10 percent to the drag coefficient, we'll now get 23.3 mpg.... Take 10 percent from the drag coefficient, we'll now get 24.3 mpg."

Comparing Vehicles' Drag Numbers

It's easy to get a feel for drag numbers by comparing Volvo sedans. According to Frasher, during Volvo's boxy-but-safe era, a Cd of 0.36 for the 960 model was typical for a sedan. Today's Volvos have come a long way, with the much sleeker S80 coming in at just 0.28.

"Not too long ago, anything below 0.3 was considered a sports carlike silhouette," says Bill Kwong, Toyota's product communications administrator. Now, Toyota has several vehicles in the sub-0.3 range, including the Avalon and Camry at 0.28 and the Solara at 0.29.

Vehicles for which fuel economy is a primary goal receive even more focus on aerodynamics. For instance, Toyota's Prius is rated at 55 mpg (combined), and it has an outstanding drag coefficient of just 0.26.

Cars typically have a much lower Cd than pickups and SUVs, which sit higher, are bigger and have greater cooling needs. Cooling is a big deal, aerodynamically speaking, since it requires airflow into the vehicle through the radiator, which increases drag.

Steve Wegryn, manager of Ford Motor Co.'s aerodynamics department, says, "For trucks, we're anywhere in the range of 0.40 to 0.43, 0.44.... For cars, on the order of 0.30 to 0.34. And SUVs are somewhere in between 0.36...to...0.41."

How Automakers Improve Aerodynamics

While some shapes are inherently more aerodynamic than others, aerodynamicists and designers subtly shape every vehicle to reduce drag. "We look at all areas of the car that come in contact with the air. Upper surface shape, under floor, wheels and even cooling and engine bay," says Ian Anderton, aerodynamicist at the Jaguar Design Studio in Gaydon, England. Automakers fine-tune the way the air attaches to the vehicle's surface, and the way it leaves the rear end.

To improve Cd, designers may make the following changes:

- Round the edges of the front end
- Tune the grille and fascia openings
- Tune the wheel openings
- Place spats (small spoilers) in front of the tires to reduce turbulence
- Tune the size and shape of the outside mirrors and their attachment arms
- Reshape the water channel on the A-pillars
- Adjust the front fascia and air dam to reduce drag under the vehicle
- Add side skirts
- Tune the deck height, length and edge radius
- Install a rear spoiler
- Adjust the angle of the rear window
- Tuck up the exhaust system
- Use a diffuser to tune air coming off the underside
- Install "belly pans," underbody panels that cover components and smooth airflow

Ford's Wegryn also predicts increased use of active aerodynamic devices in the future, such as:

- Active air dams that drop lower at higher speeds (when driveways and speed bumps are not an issue)
- Active rear spoilers that pop up to reduce lift at higher speeds, as on the Porsche 911 Carrera
- Active ride height that lowers the vehicle at speed, which Ford employed on the Lincoln Mark VIII and which appears on Mercedes-Benz vehicles with Airmatic suspensions. According to Mercedes, "Lowering the ride height at speed results in a 3-percent improvement in drag."

How to Improve the Aerodynamics of Your Car

Automakers spend a lot of time optimizing vehicles' aerodynamics. But is there anything we can do to improve — or at least not degrade — the aerodynamics of our own vehicles?

It turns out the biggest gains are to be found on pickups — not by dropping the tailgate (a common misconception), but by installing a tonneau cover. "A tonneau cover improves the aerodynamics dramatically — on all pickup trucks," according to Ford's Wegryn. "In general, a tonneau cover can provide a drag reduction of 2 to 7 percent, depending on cab style, box length and overall vehicle Cd. Average fuel economy improvement ranges from 0.1 to 0.3 mpg." From an aero standpoint, it doesn't make a difference if you choose a soft or hard cover.

You'll also improve aerodynamics by:

- Reducing the use of roof racks
- Rolling up your windows and turning on the air conditioner at higher speeds, typically above 35 mph
- Replacing a broken or missing front air dam
- Lowering your vehicle
- Running narrower tires
- Choosing smoother wheels (ideally, flush discs like those on vehicles trying to set land speed records)

You can reduce your vehicle's aerodynamics by:

- Lifting it — "an inch of increased ride height degrades the coefficient of drag by about 10 drag counts [.01]," says Wegryn.
- Adding wider tires
- Choosing more "open" wheel designs (although, for many owners, this advantage will be offset by the fact that "open" wheels promote better brake cooling)
- Installing a bug shield
- Adding a rear spoiler, in some cases

As a rule, an increase in noise is a sign of increased drag that is reducing your aerodynamics.

Slippery Styling

Several automakers recently unveiled concept cars that are dramatically more aerodynamic than today's production vehicles — concepts like Volvo's 3CC (with a Cd 30-percent better than the S40) and Mercedes' bionic car (at 0.19 Cd). Could these companies be trying to gauge buyers' reactions to strikingly different designs — or even prepare us for more radical-looking vehicles to come?

Aerodynamics — and aerodynamicists — certainly are influencing designers more than ever before. Hitoshi Takagi, an engineer in the Nissan Aerodynamics Performance Engineering Department, says, "We seek to proactively propose many aerodynamic models to our designers. It is our goal to stimulate new ideas for design, rather than to wait for their proposed design and then seek an aerodynamic solution."

Still, most automakers predict a slow and steady evolution, rather than a huge leap forward. A Mercedes spokesperson says the company's "engineers and designers are always striving for improvement, but the constraints placed on the designers by consumer tastes, practicality, legislation and production technologies will prevent giant strides."

Or, as Chrysler Group's Aneiros says simply, "We're not about to make the world's most aero vehicle that no one would buy."