Improving Vehicle Efficiency with Aerodynamic Modifications

by Phil Knox

Improving aerodynamics is just one of many fuel-saving techniques discussed on the ecomodder.com forum
Factors contributing to the force of aerodynamic drag:
- Size of the object
- Shape and orientation of object
- How hard the wind is blowing
Drag Force = (Wind Pressure)(Shape and orientation factor)(size factor)

\[ \frac{1}{2} \rho V^2 C_D \text{Area} \]
<table>
<thead>
<tr>
<th>Shape</th>
<th>Drag Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>sphere</td>
<td>0.47</td>
</tr>
<tr>
<td>half-sphere</td>
<td>0.42</td>
</tr>
<tr>
<td>cone</td>
<td>0.50</td>
</tr>
<tr>
<td>cube</td>
<td>1.05</td>
</tr>
<tr>
<td>angled cube</td>
<td>0.80</td>
</tr>
<tr>
<td>long cylinder</td>
<td>0.82</td>
</tr>
<tr>
<td>short cylinder</td>
<td>1.15</td>
</tr>
<tr>
<td>streamlined body</td>
<td>0.04</td>
</tr>
<tr>
<td>streamlined half-body</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Measured Drag Coefficients
Resistance, 100%

Resistance, 50%

Resistance, 15%

Resistance, 5%
Sharp changes in contour are highly upsetting to fluid flow
Flow Separation
The flow field around an automobile is characterized by flow separations.
Since the '80's car drag coefficients are closer to 0.3

<table>
<thead>
<tr>
<th>( c_D )</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.04</td>
<td>Body of revolution, optimized for low drag</td>
</tr>
<tr>
<td>0.05</td>
<td>Body of revolution</td>
</tr>
<tr>
<td>0.15</td>
<td>Basic body near ground</td>
</tr>
<tr>
<td>0.43</td>
<td>Average 1970-80’s passenger car</td>
</tr>
</tbody>
</table>

Figure 4.117 Drag coefficients for bodies of revolution, a body close to the ground and an average car, after ref. 4.85
PROJECT CAR: “CRISIS-FIGHTER” PINTO

BY DON SHERMAN

All we did was apply some race technology to a street car. The result: a 25% increase in gas mileage from $10 worth of sheet aluminum, $1 worth of plexiglass and a set of radial-ply tires.

Gentlemen, man your tin snips

• Right now, right here, is where racing technology meets the road. To ease this season's current oil crisis, the fast-shooting, we've transplanted a few GT-racing techniques onto a standard car. Not to increase its capability for speed, but to improve efficiency. The changes are simple yet effective. At seventy mph they add up to a solid 20% improvement in gas mileage...not an oven wildly expensive, specially designed car, but a standard Pinto. What's more they are all the type of changes you can make—without going broke—and the type of change the car makers will have to make for coming model years. Briefly, this is the way it will be.

These gains in fuel economy come solely from modifications to make the engine's job easier. As you motor down the highway at constant speed, your car's engine must supply power to overcome both rolling and wind resistance. Power is also consumed by friction within the engine and drivetrain and by engine-driven accessories. Simultaneously, any one of those power requirements will reduce the engine's load and allow it to do the same job for less fuel.

At highway speeds, wind resistance is the biggest user of energy, accounting for about 50% per cent of the engine's load. So substantial gains in highway fuel economy would naturally follow any improvements in your car's aerodynamics. Two aerodynamic approaches are in vogue: (1) streamlining the car's front end and (or) (2) reducing its bore drop. First is hopeless from a personal checkbook standpoint, so we have ignored that path. But whiffle-streamlining that can be done to allow a given front end area to slip through the air with less hassle will pay off handsomely. So reduction in front drag was the spearhead of our attack against energy consumption.

Our testing of the real world on the high-speed oval at Pocono International Raceway. A 1974 Pinto Runabout with the base 2-liter engine and automatic transmission was the guinea pig in this test, but the results will apply to any car. All testing took place at a constant speed of 70 mph with distance measurements supplied by a fifth wheel and electronic counter. To measure the fuel used during each 2.4-mile test lap, we had an onboard fuel flow meter.

Since front drag was our prime aerodynamic concern, we concentrated on the nose of the Pinto for improvements. To begin with, experience told us that air flowing under the car is "bad." Turbulence between the static road surface and the irregular bottom of the car consumes a lot of energy. As a first step, we built an air dam (or spoiler) to block as much air as
Automakers know how to make highly aerodynamic cars but they generally do not choose to market them.
Figure 1  Typical Drag Reductions For Various Bed Configurations

Note: Bar lengths indicate estimated ranges of drag reduction for the variety of vehicles currently on the road.
This two-dimensional diagram shows typical airflow around an unmodified pickup truck. Air moves over the cab, swirls in the bed and pushes against the back of the tailgate.

The addition of a half tonneau over the rear of the bed alters the air turbulence in the bed and alleviates pressure against the tailgate.
Late ‘80’s simulation set-up by CMR. Executed as a batch job on a mainframe computer – got the results the next day.
1978 Daimler-Benz, Mercedes-Benz C-III III drag as a function of aerodynamic boat-tailing. Adapted from Fig. 4.42, Hucho, 2nd Ed., 1987
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Drag Coefficient

0.237

0.195

0.178
Figure 8.64 Extensible trailing airfoil
Questions?