ground effects, innovations and safety in Automobile Racing

Question for Analysis

What are the technologies and innovations behind ground effects and safety features in automobile racing?

Introduction

Of the many special innovations and concepts developed over automobile-racing history, most involve science and physics principles that have been expanded and further developed in engineering race cars. Many of these innovations and concepts are used today in our passenger cars.

Concepts

Aerodynamics

The way the shape of an object affects the flow of air over, around or under it.

Airfoil

A winglike device on a race car that creates downforce as the air flows over it.

Air resistance

The force created by the air when it pushes back against an object's motion.

Bernoulli's principle

Air moving faster over the longer path on a wing will cause a decrease in pressure, resulting in a force in the direction of the decrease in pressure.

Downforce

The aerodynamic force on a car that pushes it downward, resulting in better traction.

Force

Any push or pull.

Ground effects

The effects from aerodynamic designs on the underside of a race car, which create a vacuum.

Pressure

Force divided by area.

Relative motion

The comparison of the movement of one object with the movement of another object.

Roll bar

A heavy metal tube or bar wrapped over the driver in a race car; the roll bar prevents the roof from crushing the driver during a rollover.

Safety features

In an automobile, things that make the car safer or that make racing safer.

Oral History Interviews

Watch the following oral history interviews to understand how race car builders work toward innovating new ways to go faster. Al Unser, Sr. also talks about the need for teamwork in order to accomplish any goal.

Racing Oral History Interviews

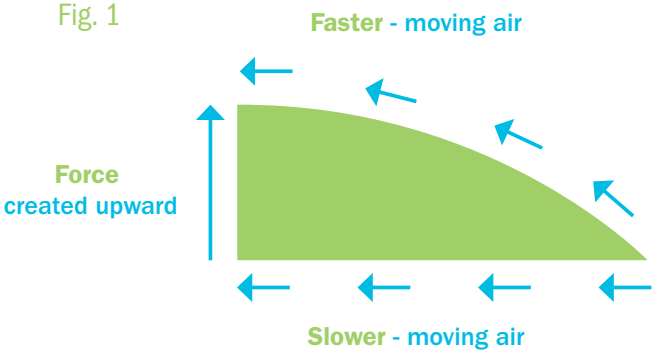
– Jim Dilamarter: Getting Downforce and Pushing Air

Airflow

Race car designs can manipulate the motion of air around the cars through aerodynamics. A ground effect results from an aerodynamic design on the underside of a race car, which creates a vacuum.

One of the most interesting aspects of automobile racing involves Bernoulli's principle. Fast-moving air causes a drop in air pressure and a force in the direction of the pressure drop. If you look at a wing of an airplane, you will see the top of the wing has a longer surface than does the bottom of the wing (see Fig. 1). The air has to travel faster over the longer, upper surface. The faster moving air produces a drop in pressure, giving the bottom of the wing comparatively higher pressure, and there will be a force created from the pressure difference. The resulting force will push or lift the wing upward.

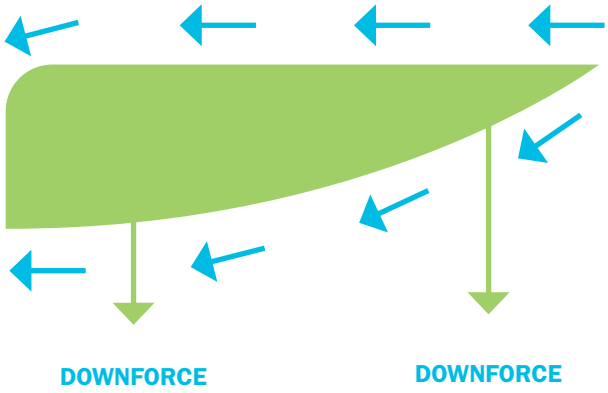
Fig. 1



Airfoils

Race car engineers have used Bernoulli's principle to make winglike objects called airfoils. The "wing" of the airfoil is turned upside down, so that the longer surface is on the bottom. The airfoil is attached to either the front or the back of the car to push down on it and gain better traction. Look at the airfoil on the Texaco Star race car [March 84C Race Car, 1984 (aerial view ID# THF69371)]. The winglike airfoils are attached to the nose of the car and the rear of the car. As the air passes over the airfoil, the pressure difference caused by the air moving faster below the airfoil than above it produces a downforce (see Fig. 2).

Fig. 2



Downforces

The fronts of race cars (and of passenger cars) are slanted downward, not to take advantage of Bernoulli's principle, but simply to allow air to pass over the car without pushing on the front of the car. Notice the front of the red #9 Ford Thunderbird [Ford Thunderbird NASCAR Winston Cup Race Car Driven by Bill Elliott, 1987 (aerial view ID# THF69260)]. The front of the Thunderbird is slanted forward. The forward slant allows two advantages. First, the air rides over the top of the car without pushing straight back against the car so that there is less force opposing the car's motion. Second, there is a downward force on the front of the race car allowing the tires to grip better and the car to corner faster. When the air hits the front of a race car that has a low front and then continues over the top of the car, the air actually pushes down on the front of the car to give better traction (see Fig. 3). Notice the low front on this Thunderbird; it causes the oncoming air to push down on the front of the car.

Fig. 3

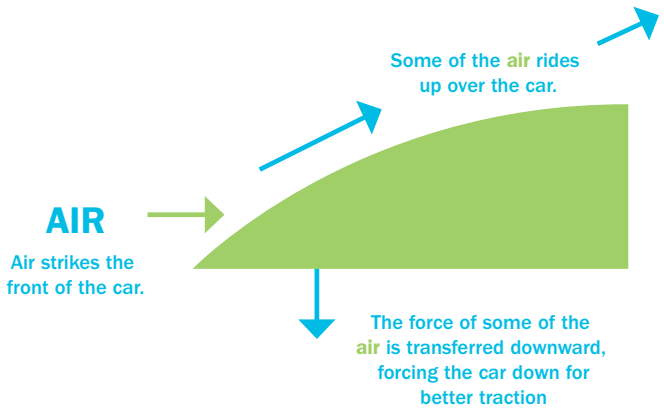
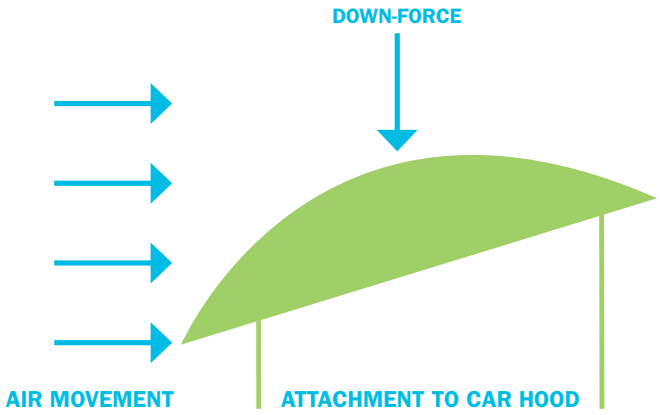


Fig. 4



Sometimes the airfoil itself is tilted so that the airfoil transfers force directly downward to the car. When the air strikes the tilted airfoil, there are two forces produced. Not only is Bernoulli's principle in effect, but the tilt of the airfoil causes a transfer of the force downward. The angle of the airfoil can be adjusted for different racing conditions. If the track has more straight sections, the foil is kept level with the track. If there is a lot of cornering, the foil is tilted to produce more downforce. Notice the airfoils on the 1984 March 84C-Cosworth Indianapolis race car [March 84C Race Car, 1984 (aerial view ID# THF69371)].

Notice how the air moves. The air strikes the front of the airfoil, which is slanted down. The angle of the air against the foil causes a push, or force, downward. The airfoil is attached to the hood and therefore forces the car downward onto the track, allowing greater traction for cornering (see Fig. 4).

There is a drawback to using the airfoil angled downward – it increases the force against the front of the car and slows it down. This presents a trade-off: The car gains cornering ability but loses overall straightaway speed. An airfoil angled downward would only be useful on tracks with short straightaways and a higher percentage of curves.

Safety

Race car designs are always being improved to allow the race cars to travel faster and more safely. The cars have roll bars to strengthen the roof during a rollover. The driver wears a 5-point seat belt that totally and securely straps him or her in. The driver wears fireproof clothing and fireproof gloves. Many safety features that are designed for race cars are later adapted for passenger cars