Probing Question: How do dimples make golf balls travel farther?

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A golfer's worst enemy may be divots, but his or her best friend may be dimples -- the dimples on a golf ball that send it sailing farther down the fairway.

"In the early days of golf in Scotland, golfers discovered that their old golf balls went farther than the new, smooth ones," said Mark Maughmer, professor of aerospace engineering at Penn State. The beat-up balls reacted differently to the forces they encountered while flying through the air, Maughmer explained.

It wasn't long before golfers were intentionally pitting their brand-new balls to improve their games. By 1905, golf balls were being manufactured with dimples, as they have been ever since.

What's the magic in those dimples?

All flying objects are subject to the forces of lift and drag, Maughmer explained. An airplane produces lift when the air flowing over its wings is forced downward, causing the plane to rise. At the same time, the plane's forward motion creates drag or resistance.

A golf ball can produce lift in a similar fashion. For example, if a struck ball has backspin, which changes the flow of the air around the ball, it produces lift, a force that is perpendicular to its flight path. As Maughmer explained it, this is a result of high pressure being created at the bottom of the airborne ball relative to its top, and the lift, he said, is a consequence of these differences in pressure.

At the same time, the struck ball also experiences drag, a retarding force that acts in the direction opposite to the direction of its flight path. Part of the drag force is due to the flow not being able to stay attached to the surface and "come together" on the back side of the ball. This "separated flow" forms a low-pressure wake behind the ball, and the difference between these pressures and the higher ones found on the front of the ball produce what is termed "pressure drag."

The other part of the drag force experienced by the ball is due to "skin friction," a tendency to pull the air nearest its surface along with it. "It's just air rubbing on an object, which retards its motion," Maughmer says.

Skin friction depends largely on the pattern of airflow in the boundary layer very close to the surface of the ball. If the flow is smooth, or laminar, it has lower skin friction, but is less able to stay attached to the rear surface of the ball. A turbulent boundary layer, however, although having more skin friction, is better able to stay attached to the back of the ball. That, Maughmer said, is where the dimples come in.

"By putting the dimples on a golf ball, I force the boundary layer to transition from a laminar one to a turbulent one," he explained. The greater "mixing" of air in the turbulent boundary layer allows passing air to cling to the flying ball a little bit longer before it separates, which in turn narrows the ball's wake, the region of low-pressure air created behind it. A smaller wake means less air pressure pulling on the back of a golf ball as it sails toward the green.

In effect it's a positive trade-off: "The ball pays a skin friction penalty, but gains a pressure drag advantage," Maughmer said. The difference is huge in terms of the distance a golf ball can be driven, he adds. Dimpled balls can travel nearly twice as far as smooth ones.

As an aerodynamicist, Maughmer admitted, he's somewhat limited in how much he can engineer a small, round object. "I can't mess with the shape of a golf ball," he said. "For something this size, shape and speed, dimples are the optimal solution."

Source: By Mike Shelton, Research Penn State