NEW TRACKMAN RESEARCH – BALL FLIGHT CURVATURE

D-PLANE, OFF CENTER IMPACT, CLUB FACE ROTATION

Since the introduction of club delivery measurements by TrackMan, significant research has been completed to understand the connection between club delivery and the resulting ball flight.

Because of TrackMan's measurement of the entire ball flight and club delivery, TrackMan has been used intensively to understand what is causing a given ball flight. TrackMan has, from its own research, pioneered this deeper-level understanding in many ways.

In particular, understanding what causes the ball to curve in the air has been a key point of interest for golf instructors and players.

Ball flight curvature is directly related to the orientation of the spin axis. A positive spin axis will curve the ball to the right, while a negative spin axis will curve the ball left. As a rule of thumb, a spin axis of 10° will curve the ball 7% to the side relative to the initial starting direction and based on the Carry distance. For example, a 200 yard carry with a 0.0* launch direction and a +10* spin axis will curve 14 yards to the right of the target line.

When used outdoors, TrackMan makes no assumption on how the spin axis is generated from the club delivery. The ball data, including spin axis, is measured completely independent of the club delivery data.

TrackMan has analyzed hundreds of thousands of shots with full ball flight measurements and club delivery data to determine the relationship and explanations between spin axis and club delivery. We have found, to a very high degree, this relationship can be explained by two things: D-Plane and off-center impact.

D-PLANE

The primary source of generating the spin axis is explained by the D-Plane. Because of the oblique impact between the club face and the ball, the ball will start rolling up the club face, hereby creating a spin axis 90 degrees to the D-Plane. If there is any difference between the club path and the face angle, the D-Plane is tilted and consequently, spin axis is tilted.

Note it requires friction between the club and the ball before the ball will spin and thereby establish a spin axis.

OFF CENTER IMPACT (HORIZONTAL GEAR EFFECT)

If the ball is impacted anywhere but in front of the center of gravity of the club head, the club head will rotate during impact. The counter action of the ball is to rotate the other way – like a gear. This added component of spin will add to (or subtract from) the D-Plane spin axis, tilting the spin axis away from 90 degrees relative to the D-Plane.

Again, it requires friction between the club and the ball for the gear effect to happen. If no friction, there is no 'gear'.

CLUB FACE ROTATION (GEAR EFFECT)

However, in the search for explaining every degree of spin axis, we have more recently found that D-Plane and horizontal impact location is not always enough to fully explain the resulting spin axis tilt (and as a result the ball flight curvature).

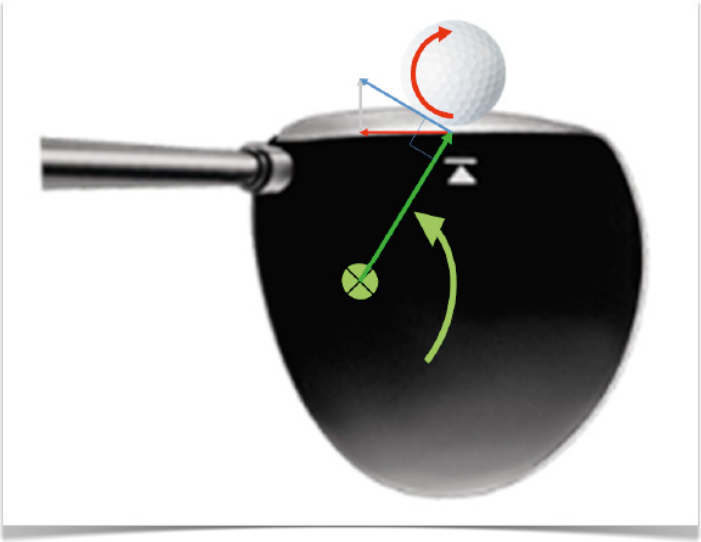

Figure 1. A club face rotation around an axis located behind the club face will create a rotation in the opposite direction (gear effect) of the ball due to friction between club and ball.

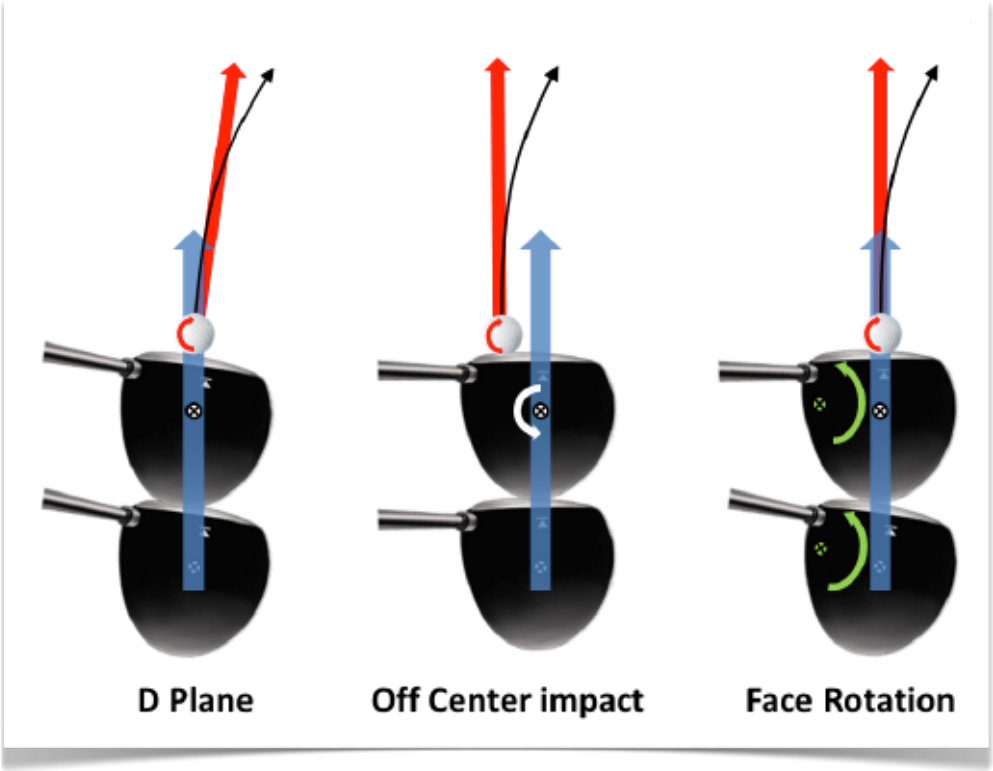

Figure 2. Three different fade components: an open (positive) face to path, a heel impact creating gear effect, and a face rotation (closure rate) creating a slight positive tilt of the Spin Axis.

The first step in this analysis was to double check the accuracy of TrackMan measurements. The common reaction for any human is to question things that do not make sense. When the TrackMan numbers do not match the user's expectations (or explanation for ball flight curvature), the data is assumed to be incorrect. However, the TrackMan data has been rechecked and verified to be accurate.

While we are not talking about big differences in spin axis that fail explanation, sometimes as much as 6 degrees of spin axis tilt cannot be explained from the D-Plane and off center impact alone. Deeper research has shown the shortcoming in accounting for the spin axis generally resulted in a fade ball flight. Interestingly, the missing element seems to be correlated with swing style, or more precisely, how fast the club face is rotating through impact - correlated with the player, not the club!

What we are finding is a rotating club face through impact can create the counter action of the ball to rotate the other way – like a gear – exactly as explained above for off center impact. So it seems highly plausible that club face rotation can have an effect on spin axis. Important for quantifying the effect of the rotating club face through impact is to determine the location of the axis of rotation for the club face. Initial analysis shows that the rotation typically happens around an axis located behind the club face, with the net effect that the ball will have a fade component added to its spin axis.

This means that there are three components that have to be considered when trying to explain ball curvature: 1) The face to path relationship (D-Plane), 2) Off center impact, and 3) club face rotation rate through impact.

TrackMan's future research hopes to quantify the significance of club face rotation on the spin axis, to see if club face rotation (closure rate) together with D-Plane and off center impact can fully explain the spin axis.