Environmental Effect on Golf Ball to Increase Driving Distance

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Golfers often buy new equipment in attempts to improve their drive, but their efforts are usually focused solely on their choice of golf clubs. In this study, drop and hit tests were performed on golf balls to determine the optimal temperature and humidity conditions that produce the longest driving distance. Proper conditioning of a golf ball can reduce the cost of buying new golf clubs and increase driving distances for both professional and amateur golfers.

1. Introduction

The golf market is maturing quickly. The Korea's domestic golf market, which has recently increased due to the popularization of the game, is now the third largest in the world. Based on this trend, golf equipment directed at improving a golfer's score have rapidly increased in popularity. The market for golf clubs in 2007 grew by 40% worldwide compared to 2004, as shown in Figure 1. Brand new golf clubs made using new technology are developed every year to meet the demand by golfers for increased driving distance and accuracy. Some people buy new golf clubs almost every year. The consumption and development of golf balls have also increased by 15% in 2007 compared to 2006. Two-piece golf balls were mainly used in the past, but now three- or four-piece golf balls are also in use. Golfers are attempting to improve their driving distance and accuracy through their choice of ball, and select one that meets their taste.

Despite these efforts, a golfer's driving distance is affected by the climate. Most golfers have longer driving distances in hot weather than in cold weather. The change in driving distance according to temperature and humidity is embodied by the conditioning of the golf ball. Therefore, we performed a drop test to check the coefficient of restitution (COR) of a golf ball, which is directly related to a golfer's golf score. We then performed a hit test with a driver to examine the influence of temperature.

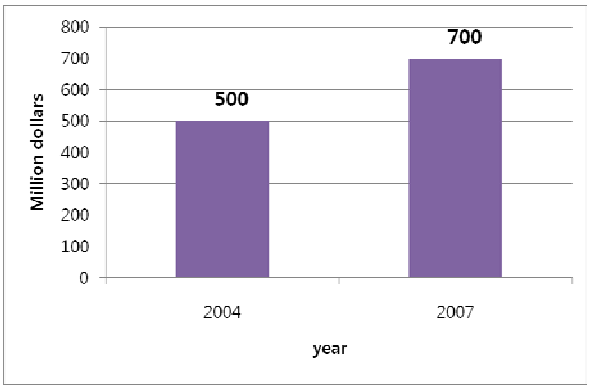

Figure 1.Global golf club market[1]

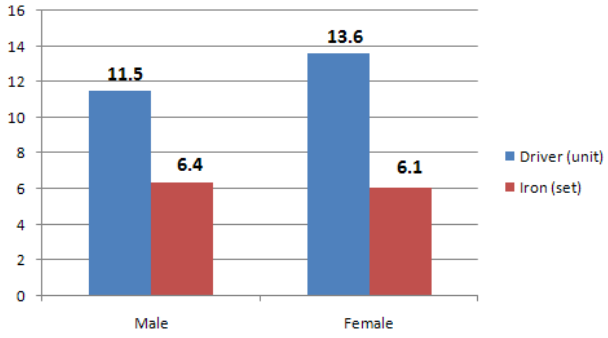

Figure 2. Consumption of golf club in Korea, 2007[2]

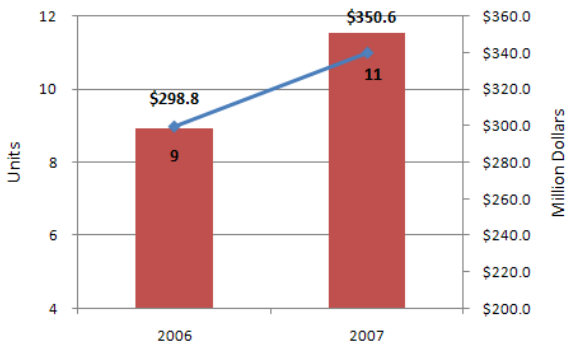

Figure 3. Golf Ball Sales On-Off Course Shops in U.S.A. (Units/Thousand Dozen Balls)

Figure 4. Conditioning chamber

Figure 5. High speed video camera

2. Experiment

Two experiments were performed: a drop test to determine the COR of the ball and a hit test to determine the initial speed of the ball and the driving distance.

2.1 Drop test

A fixed height suitable for measuring the COR was determined. The golf balls were dropped from that height onto a steel board, which was installed to ensure that the balls would bounce well. The COR was calculated from the velocity just before the ball collided with the ground and the velocity just after the ball hit the ground.

The procedure for this test was as follows.

1) Measure the diameter and mass of the golf ball at normal temperature.
2) Maintain the golf ball at the desired temperature and humidity for a given length of time in a conditioning chamber.
3) Remove the ball from the conditioning chamber and measure the diameter and mass of the golf ball again.
4) Fix the ball with a jig and drop it from the fixed height.
5) Use a high-speed video camera to capture the ball colliding with the steel plate.
6) Identify the two video frames just before and after the ball collides with the steel plate.
7) Measure the height of the golf ball in each frame.

We used a two-piece golf ball made by Yamazaki consisting of urethane and surlyn. The urethane formed the outside layer of the ball while the surlyn formed the inner core. The COR was calculated from

$$COR = \frac{v_2' - v_1'}{v_1 - v_2} = \frac{v_2'}{-v_2} = \frac{\frac{d_4 - d_3}{\Delta t}}{\frac{d_1 - d_2}{\Delta t}} = \frac{d_4 - d_3}{d_1 - d_2} \quad (1)$$

where d_i is the measured height of the golf ball in frame i (see Figure 4).

Figure 6. YAMAZAKI 2piece Golf ball

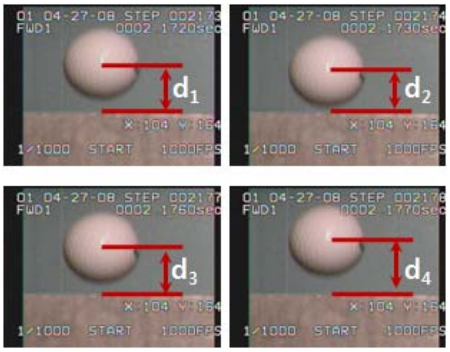

Figure 7. Captured pictures and height of golf ball

2.2 Hit test

This experiment considered the driving shot, which is the first shot in a golf game. The data were gathered using a golf machine with a screen made by family golf, shown in Figure 8. The humidity was fixed, based on the drop test results. The club head velocity, ball initial velocity, ball initial spin, and angle of the club face were measured.

Figure 8. Configuration of screen golf machine

The experiment was performed on two-piece Top Flite XL golf balls made by Callaway and four-piece Pro V1x golf balls made by Titleist using the following procedure.

1) Place the balls into an ice box until the desired temperature is reached.
2) Remove the balls from the ice box, verify their temperature,

and record their ball numbers.

3) Place a ball on a tee so that the golfer does not know its temperature or number.

4) After the golfer hits the ball, record the club head speed and ball initial velocity printed out on the screen of the golf machine.

5) Interview the golfer to find out how the ball "felt" in terms of weight, hardness, and other properties.

This procedure was repeated until all the balls had been tested.

Figure 9. TOP FLITE XL & Pro V1x

3. Experimental Results

The results from the two experiments were analyzed to determine the effect of temperature and humidity on the driving distance of a golf ball.

The driving distance can be calculated as follows. The initial velocity of the golf ball is

$$v_1 = \frac{(1+e)\cdot V_1}{1+\frac{m}{M}} \tag{2}$$

The driving distance can then be deduced from

$$\frac{d^2x_n}{dt^2} = -\frac{\rho A}{2m}\left(\frac{dx_n}{dt}^2 + \frac{dy_n}{dt}^2\right)(C_D\cos\theta + C_L\sin\theta)$$

$$x_{n+1} = x_n + \frac{dx_n}{dt}\cdot dt + \frac{1}{2}\frac{d^2x_n}{dt^2}\cdot dt^2$$

$$\frac{dx_{n+1}}{dt} = \frac{dx_n}{dt} + \frac{d^2x_n}{dt^2}\cdot dt$$

$$\frac{d^2y_n}{dt^2} = \frac{\rho A}{2m}\left(\frac{dx_n}{dt}^2 + \frac{dy_n}{dt}^2\right)(C_L\cos\theta + C_D\sin\theta) - g$$

$$y_{n+1} = y_n + \frac{dy_n}{dt}\cdot dt + \frac{1}{2}\frac{d^2y_n}{dt^2}\cdot dt^2$$

$$\frac{dy_{n+1}}{dt} = \frac{dy_n}{dt} + \frac{d^2y_n}{dt^2}\cdot dt$$

3.2 Hit test

4. Conclusions

The above tests were performed by a woman golfer, and the optimal temperature range could be different for a male golfer. Thus, in the future, we will conduct tests using a male golfer. We will also test a three-piece golf ball since many such balls are currently in use.

ACKNOWLEDGEMENT

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REFERENCES

1. http://www.golfdatatech.com

2. Digital Times

3. P. W. Bearman and J. K. Harvey, "Golf ball aerodynamics, Aeronautical Quarterly," pp. 112-122, May 1976