Effects of Golf Ball Dimple Surface Occupancy, Volume Ratio and Depth on Aerodynamic Characteristics During Rotation

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Problem Statement Golf balls have many concave surfaces called dimples on the surface to improve flight distance. Effects on the occupancy and volume ratio of dimples and presents to the flight distance have not been clified yet.

Purpose Using model balls with different dimples occupancy and volume ratio, we will carry out a lift and drag measurement experiment by using wind tunnel experiment. Next, a flight trajectory simulation was performed using the experimental results, and the influence of these dimpes on the flight distance are clarified. The definition for occupancy is (3) and the volume ratio is (4). O is the occupancy, V_{DR} is the volume ratio, C is the dimple diameter, D is the depth, and N_D is number of dimples.

$$h_1 = d[1 - \sin\{\cos^{-1}(C/d)\}]/2 \quad (1)$$
$$h_2 = D - h_1 \quad (2)$$
$$O = N_D\{{h_1}^2 + (C^2/4)\}/d^2 \quad (3)$$
$$V_{DR} = N_D\left[h_1\{(3C^2/4) + {h_1}^2\} + h_2\{(3C^2/4) + {h_2}^2\}\right]/C^3 \quad (4)$$

Methodology The 15 model balls in diameter of 110 mm are designed by Fusion360, and are made by using a 3D printer. The occupancy of these balls are form 52.6 % to 83.1 %. We changed the dimple diameter or number of dimples to increase the occupancy. The dimple depths were set to 0.50 mm, 0.75 mm and 1.00 mm, respectively. The experimental equipment is used the same equipment as the research by Aoki et al.,[1] And the rotation of the sphere was performed by a motor. The diameter of the piano wire was set to 3 mm in order to ignore the influence of the piano wire[3] supporting the model balls. Drag and lift are measured at wind speeds of 37 m/s and rotational speeds of 400-2000 rpm. From the obtained lift and drag coefficients, the flight trajectory simulation uses the average value of ball speed, number of revolutions, and launch angle in driver shots of a male professional golfer who played on the 2013 PGA Tour.

Results and Discussion Fig.1 shows the relationship between the lift-drag ratio and spin rate. These data are excerpted the characteristic data from the 15 balls. The

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model ball at the dimple depth of 0.50 mm and the highest occupancy is highest lift-drag ratio. However, when the deep dimple depth was 1.00 mm, the occupancy had no effect on the lift-drag ratio. Also, the dimple depth had a greater effect on the lift-drag ratio than the occupancy, and the shallow dimples has a higher lift-drag ratio than deep dimples.

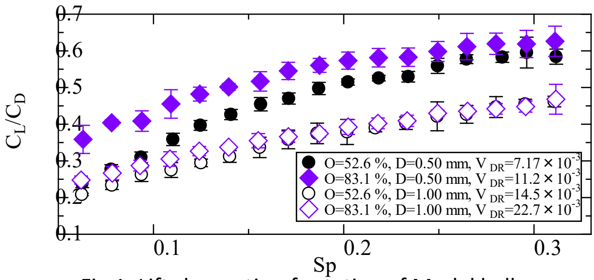

Fig.1: Lift-drag ratio of rotating of Model ball

Fig.2 shows the results of a flight trajectory simulation based on the average values of the drag coefficient and lift coefficient. The orbital model is simulated assuming that the number of revolutions has not changed. The results with the largest flight distance was O=83.1 % with D=0.50 mm, followed by O= 81.2 % with D=0.50 mm. Even though the heights of the highest points of O=81.2 % and O=83.1 % did not change, there are difference in flight distance. The dimple diameter of the model ball of O=83.1 % is the largest compared to others. The highest point of the orbit and the flight distance increase, as the lift-drag ratio is higher.

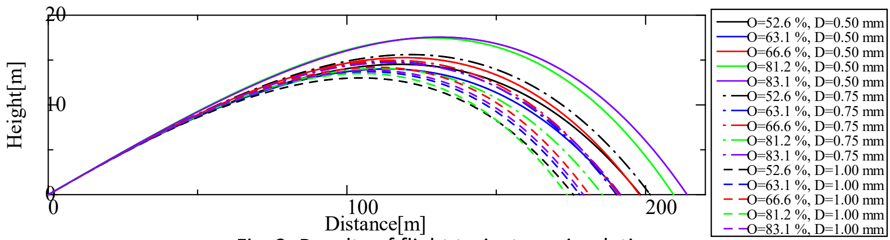

Fig. 2: Results of flight trajectory simulation

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