Wiffle Ball

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I. Introduction

Wiffle ball (fig. 1) is a variation of the baseball and is designed for people to throw breaking ball easily. We aim to study this interesting phenomenon.

We want to know how the force acting on the ball when we change some variables, the number of the holes, wind speed and rotational speed of the ball. We aim to know how the force acting on the ball and find out which variable has the most conspicuous effect.

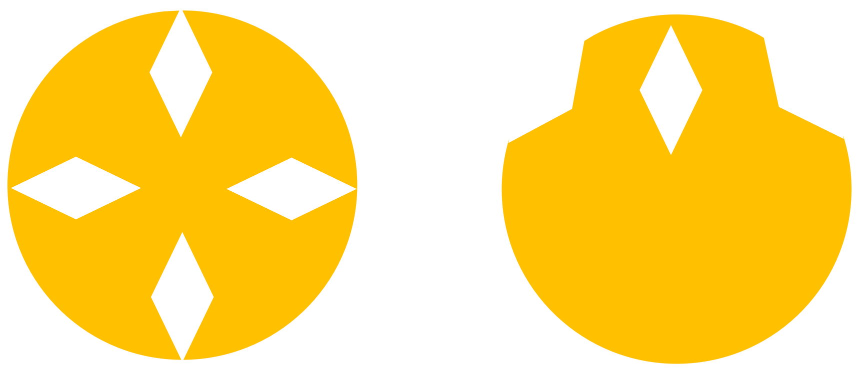
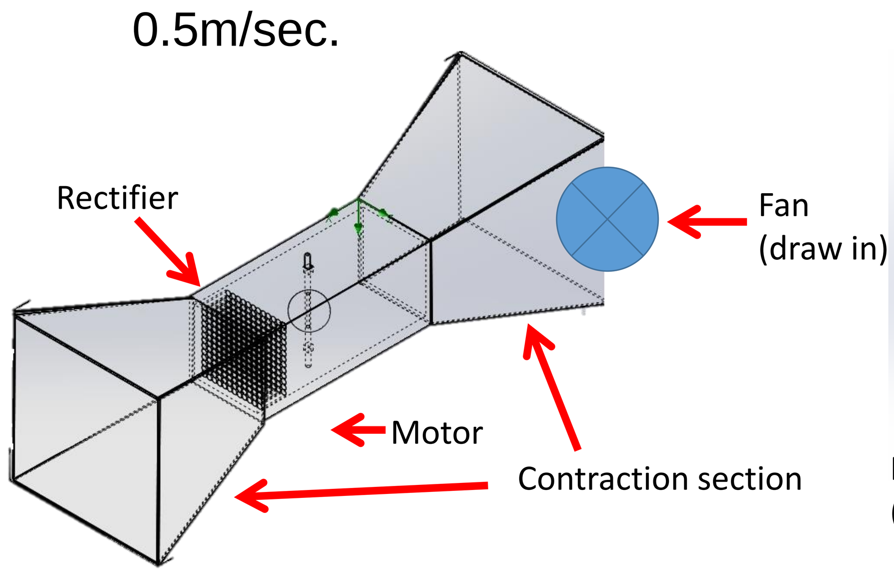


Fig. 1 The waffle ball (four holes)

II. Apparatus for Experiment

Our experiment has three parts, the measurement of the force, analysis of flow field and simulation.

In the first part, we set the weight under the motor, recording the weight-change and calculating the force acting on the ball. In order to observe the flow field, we add rectifiers and place motor at one side, using liquid nitrogen to create visible streamlines. Lastly, We simulate this system by the software "Solidworks", confirming the flow field and the force. We have three samples, balls with four, six and eight holes, each tested in four rotational speed, 2800, 3300, 3800 and 4200rpm, and just one wind speed 0.5m/sec.



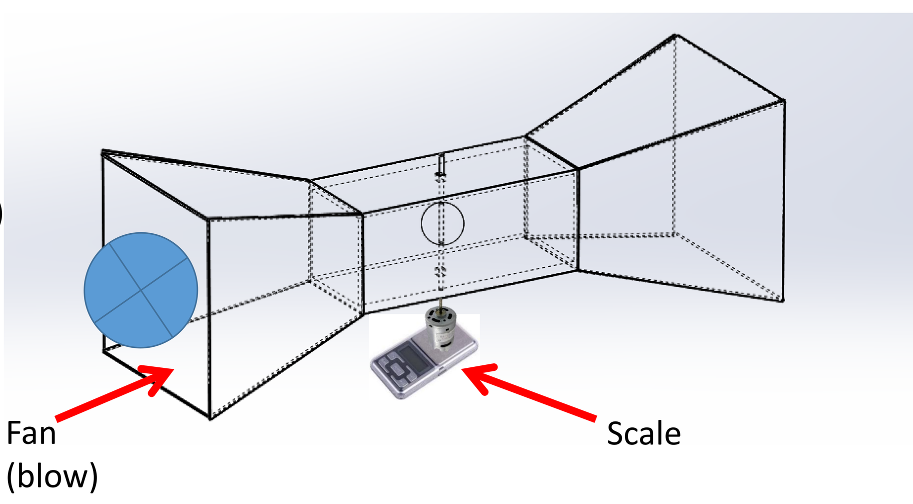
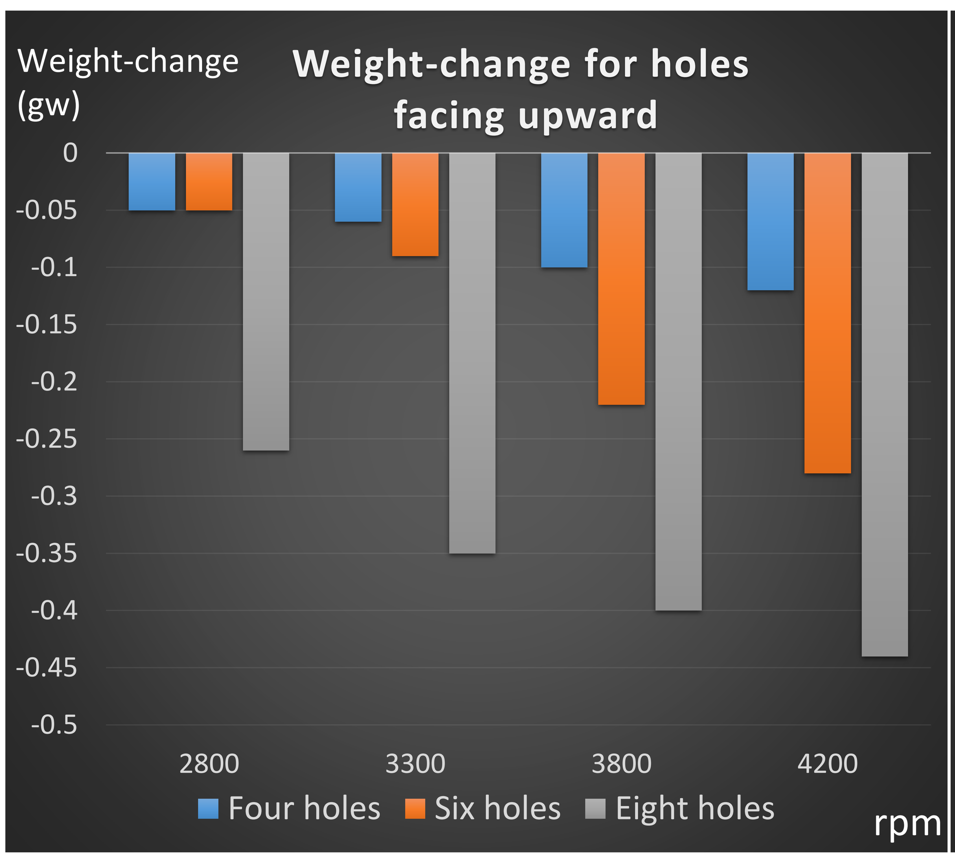


Fig. 2 Wind tunnel (Analysis of flow field) left
Fig. 3 Wind tunnel (measurement of force) right

III. Experimental Results



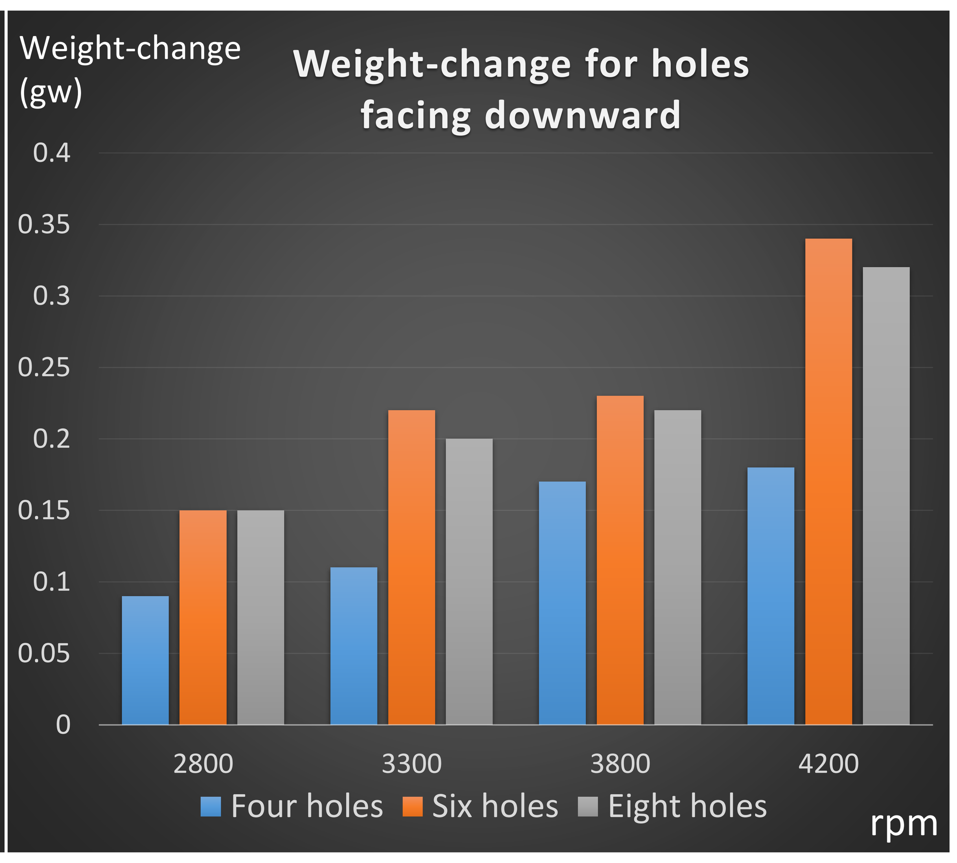


Fig. 4 Measurement of force (holes facing upward)
Fig. 5 Measurement of force (holes facing downward)

We test the ball in wind tunnel and measurement the vertical force it acting on it. With the wind speed~0.5m/sec. As Fig4. Fig5. show, we can see that the weight-change increase proportionally to the rotational speed. In addition, the more the number of holes, the more the change of weight. And the force in the direction of the holes orientation. When the holes facing upward, the ball endures an upward force; otherwise, it endures a downward force. Then, we explain this phenomenon by flow field and simulation.

In the simulation of the ball without rotation, we found that the ball with holes would endures much upward force than intact sphere. The main difference between them is that the wind can blow into the ball with holes, producing an internal pressure-difference.

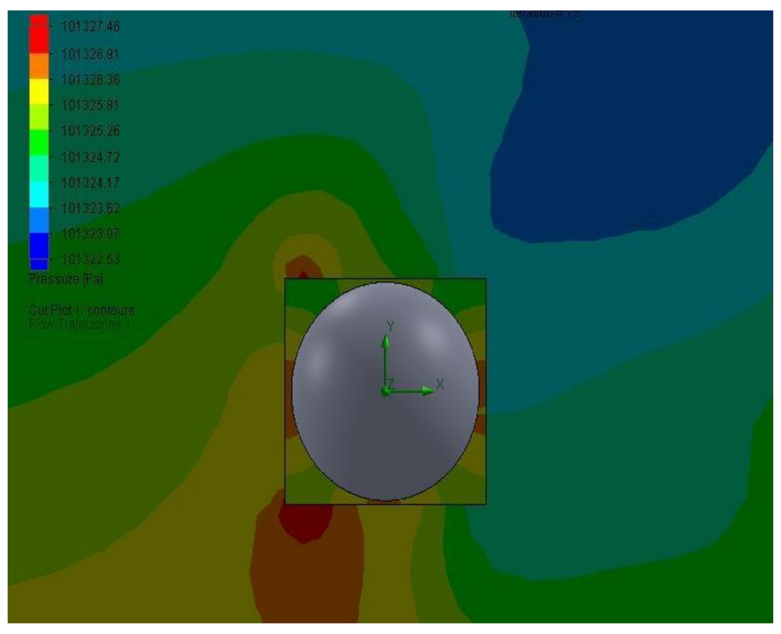


Fig 6. Intact sphere

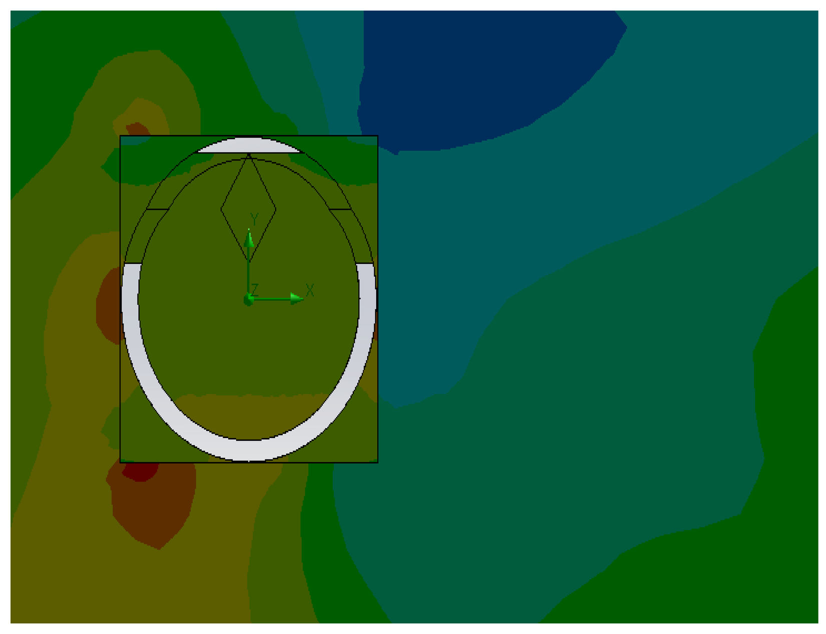


Fig 7.Four holes

(With wind speed 2m/sec, rotational speed 200rpm)

From Fig6 and Fig7,we can know that the four holes ball would endure much force than intact sphere. Compare to the flow field of a ball at rest, the flow will be inhaled into the ball because of the centripetal force produced by the rotation. The flow will accumulate at the half of ball without holes (relatively high-pressure), outflowing at the half of ball with holes (relatively low-pressure). With the support of the external wind (the region the flow passes through, the pressure will decrease), the weight-difference will be bigger than the ball at rest. In Fig7, the ball endures 0.15gw of rising force, and in Fig6, it endures 0.107gw of rising force. The result is corresponding to our experiment result, though the variable has a great difference. We also simulate the vertical force exerts on a ball with four holes and with the rotational speed of 700rpm. The result is that the ball endures 1.368gw of rising force. Compare to the situation in Fig7, we can see that the rotational speed is positive related to the force.

Fig 8. Flow field of ball (eight holes)

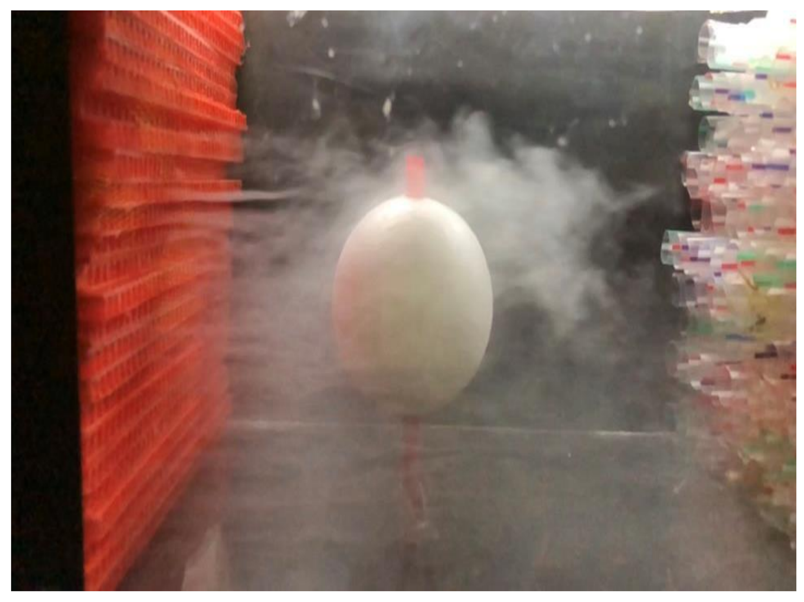


Fig 9. Flow field of ball (sphere)

There aren't conspicuous streamlines around the ball. We see that there's turbulent after the gas pass through the surface of the ball, but we can't differentiate the sphere and the ball with holes. Originally, we expect to observe something special between the top and down of the ball, for the reason that the force is acting in this direction. Even in simulation, we can't get the expectation.

As the paper said, the critical reason that a wiffle ball endures lateral force is because of the turbulent in the interior of the ball, which is hard to measure.

IV. Discussion

Originally, we adapted higher wind and found that the weight is always getting lighter, and we contribute this phenomenon to Bernoulli's principle that because of different wind speed between outside and testing part, there's pressure pointing upward. Therefore, we adapt lower wind speed to minimize this effect.

V. Conclusion

By simulation and measurement of force, we proved that the force acting on the ball is in the direction of the holes orientation. The more the number of holes is, the more force it endures.

Reference:

[1] A review of the Magnus effect in aeronautics by Jost Seifert https://www.sciencedirect.com/science/article/pii/S0376042112000656#!