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Influence of Surface Texture on the Flight and Drag Characteristics of Soccer Balls

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INTRODUCTION & AIM

This study investigates how the surface features of soccer balls—specifically the structure of dimples and seams—affect their aerodynamic properties and flight trajectories. Using 3D printing, eight different soccer ball prototypes were fabricated with various dimple shapes (conical, hemispherical, cylindrical) and seam structures (depth and width variations). Wind tunnel experiments measured drag, lift, and lateral forces under controlled conditions.

METHOD

The wind tunnel test experiment used a circulatory, low-speed, low-turbulence wind tunnel (San Technologies Co., LTD) (Figure 1) at Tsukuba University. The maximum wind speed of this wind tunnel is about 55m/s, with jet size of 1.5m x 1.5m, wind speed distribution within ±0.5% and turbulence of less than 0.1%. The experiment was performed by mounting each of the 8 types of soccer balls created using a 3D printer within the wind tunnel. This experiment set wind speed (U) from 7 to 30m/s, taking two measurements at 1m/s intervals.

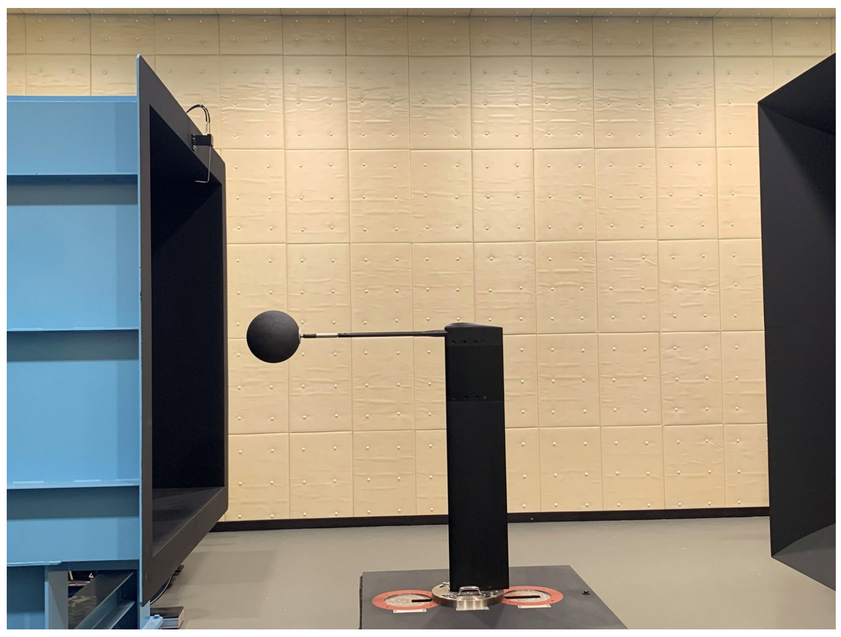

Figure 1. Experimental setups for wind tunnel experiment

RESULTS & DISCUSSION

Key findings revealed that both the number and shape of dimples significantly influenced the critical Reynolds number (Re_{crit}), which marks the transition in airflow behavior. Balls with conical dimples and deep seams exhibited higher drag but faster transition to supercritical flow. A strong correlation ($R^2 = 0.98$) was found between dimple/seam surface ratios and Recrit, indicating these surface features greatly impact aerodynamic performance. Balls with reduced dimple counts (25–50%) showed lower drag and slower airflow transitions.

CONCLUSION

From the results, it was possible to confirm that dimple structure and seam characteristics on the surface of the soccer ball were strongly related to the aerodynamic forces applied to the soccer ball. As such, from the fact that motive aerodynamics changed depending on a soccer ball's surface shape, it was possible to determine that not only are shape and number of panels important, but the shape of the ball's surface is also an important factor in determining the aerodynamic characteristics of a soccer ball.

FUTURE WORK / REFERENCES

Hong & Asai. Aerodynamic effects of dimples on soccer ball surfaces, Helliyon. 3(10) e00432 (2017)