

DEVELOPING A WING-SHAPED CAPTIVE BALLOON

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Abstract

Many meteorological observations in urban area were made in recent years in order to investigate the mechanism of heat island. Captive balloons are easy to make observations especially in urban area. Conventional balloons are, however, influenced by the wind and difficult to keep the specified position. To overcome these difficulties, we are developing a new type of captive balloon. It has a wing form to gain lift and keep its position. The wing form NACA4424 is adopted to minimize the drag force. To check the aerodynamic properties of the balloon, we made wind tunnel test with 1/10 model of it. It has shown the aerodynamic properties to keep it position and an angle of it.

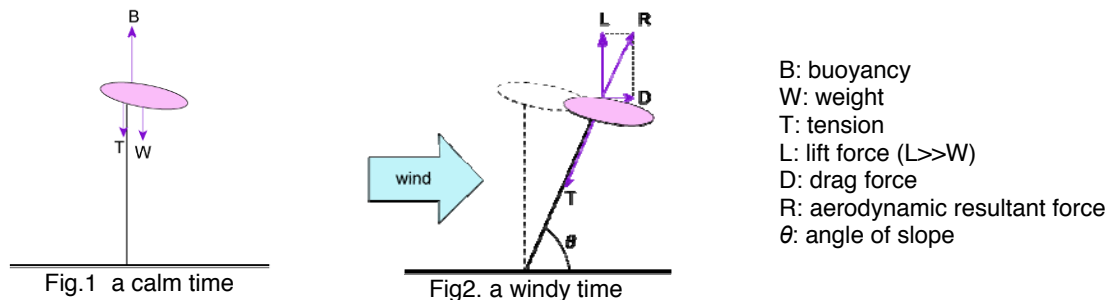
Key words: vertical meteorology, observation method

1. INTRODUCTION

Many meteorological observations in urban area are made in recent years in order to investigate the mechanism of heat island. For this purpose, high density observations in both space and time are required. Generally vertical meteorological observations can be made by towers, radars, balloons. Among these methods, captive balloons are the easiest way to make observations especially in urban area. Conventional balloons are, however, influenced by the wind and difficult to keep the specified position. Once they are stalled, they keep stall condition and great drag force act on them. Moreover, it can be dangerous to conduct such observations in the highly build-up area. To overcome these difficulties, we are developing a new type of captive balloon.

2. A NEW TYPE OF CAPTIVE BALLOON

A new type of balloon has wing form and it's filled with helium gas. Principles of wings and gliders are applied to this balloon. A wing gains lift force and keep a slope of its mooring rope. Fig.1 and Fig.2 are a view showing a frame format of the force each of case.



The wing form NACA4424 is adopted to minimize the drag force. Fig.3 is a view showing the dimension of it. This wing form is, however, rather thin and does not have enough volume to hold helium gas for floatation. To boost up the floatation, two gasbags with an airship form are installed at the ends of the wing. We can take these gasbags apart and keep them in a carport with holding helium gas.

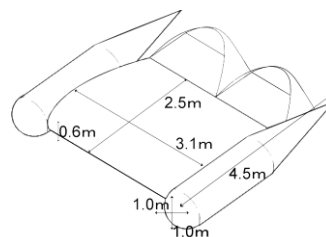


Fig.3 dimension of the captive balloon

3. PROPERTIES OF THE BALLOON

3.1. Stability

Two mooring points in alignment aren't influenced by an angle of attack and the angle is decided by the fuselage. The fuselage in itself has autonomous property and aerodynamic stability.

3.2. Aerodynamic properties

If a balloon slopes heavily, it can be dangerous to conduct such observations in the highly build-up area and then we concern for safety. Moreover, the angle of slope is 70 degrees and observational height error is a mere 6%. An angle of slope is defined as the angle between horizontal plane and mooring point. It's a parameter that lift/drag ratio is over 2.7 to keep over an angle of slope 70 degrees.

To check the aerodynamic properties of the balloon, we made wind tunnel test with 1/10 model of it. It shows lift/drag ratio as well as an angle of stall, the aerodynamic center and the moment around aerodynamic center. Fig.4 is a view showing a result of it. It shows that maximum lift/drag ratio is 5, which is enough large to keep balloon height, even when the large gasbags are installed and an angle of stall is 12 degrees. In addition, we can calculate the moment of aerodynamic center about the balloon. Using this result, we got out an angle of attack 10.1 degrees to keep postural stability.

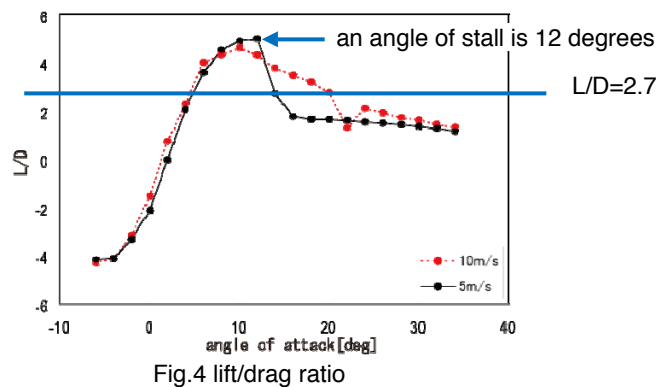


Fig.4 lift/drag ratio

The balloon was made based on these results. In order to check the properties were reproduced even by the exact size we performed flight test on May, 2009. It held stable state (Fig.5).



Fig.5 flight test

4. CONCLUSION

A wing-shaped captive balloon is designed for meteorological observations. We made wind tunnel test to check the aerodynamic properties of it. It has shown the aerodynamic properties to keep it position. These results are enough to gain the lift and certify to achieve our aims. A future task is more a flight test on windy day. If this equipment is finished, we can observe gravity wave and current etc.. Therefore cooling process in urban area becomes evident.

Acknowledgments

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