The effect of wing camber on the pressure on the wing surface

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Abstract

With the rapid development of technology in recent decades, various types of aircraft have gradually come into people's eyes. Among them, different wing types are the foundation of various aircraft models. Based on aerodynamics, this paper explores the influence of wing camber on the upper and lower surface pressure when the wing passes through the airstream from several aspects such as instrument equipment, experimental data and result analysis. Although there are errors in the results obtained from the analysis, the general conclusion can still be drawn that for the wings with higher camber and wings with lower camber , when at different attack angles, the pressure difference between the upper and lower surface is opposite. Further conclusions need to be verified by subsequent experiments. In this paper, a 3D model of the wing is designed through SolidWorks. In the case of length of 25, width of 10 and relative thickness of 0.3, two wings with relative camber of 0.17 and 0.13 are calculated. After a series of experiments and analysis, the conclusion is drawn.

Keywords

Wings,Wind tunnel,Aerodynamics.

1. Introduction

In recent years, with the continuous development of low-speed wind turbines and micro-aircrafts, people have gradually increased their attention to low-speed airfoil. Its development is particularly evident in the use of military airfoil, such as the improvement of the airfoil on the Su-33 "sea guard" shipborne fighter plane. When air flows through the upper and lower surfaces of the wings, the thickness and camber of the wings greatly affect the pressure on the upper and lower surfaces of the wings. Under different thickness conditions, the low-speed aerodynamic characteristics of the wing would change from trailing edge separation to leading edge separation and then to thin wing separation. Different airfoil designs have emerged in recent years, including supercritical airfoil and low-Reynolds number rotor airfoil, which are closely related to the data of airfoil.

2. Principle of instrument equipment

2.1 3D printer

The type of 3D printer used in this experiment is CUBEPRO, and the material used for printing is ABS, all known as Acrylonitrile butadiene Styrene copolymers, which has good thermal stability and can be used for processing in various ways. The printer works by heating the PLA to between 175 and 200 degrees Celsius, allowing the material to melt and enter the printer's nozzle. The 3D model to be printed by the printer is then parsed and printed from the bottom layer. The ABS printed on each layer are only 0.2mm thick, so it takes about 10 hours to print the wing model.

2.2 Wind tunnel

Wind tunnel refers to wind tunnel laboratory, which is a kind of pipeline experimental equipment that generates and controls air flow in an artificial way to simulate the flow of air around the aircraft or entity, so as to observe physical phenomena. It is one of the most commonly used and effective tools for conducting aerodynamic experiments.

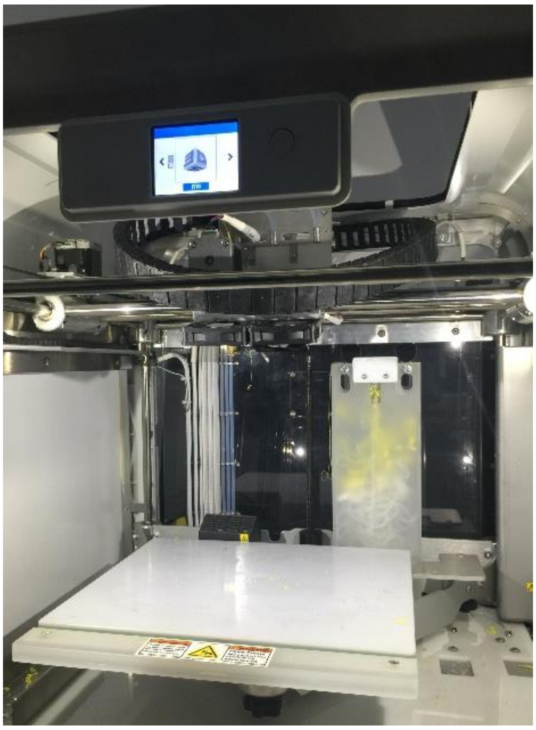

Figure 1. 3D printer used in the experiment

Figure 2. Wind tunnel used in the experiment

The wind tunnel used in this experiment is a low-speed wind tunnel with open loop and suction type. The wind speed is about 9 to 15 meters per second. It is mainly used in PIV flow measurement, airfoil lift resistance measurement, aircraft model dynamic stability test and other experiments. In this experiment, the purpose of using wind tunnel is to run the wind tunnel and use the differential pressure gauge to test the pressure of the wings on the upper and lower surface when the airflow is passing through.

2.3 Differential pressure gauge

There are many kinds of differential pressure gauges and their principles are also different. This experiment uses the red oil differential pressure gauge , and its principle is simple. A section of the differential pressure gauge connects the air, so the pressure is one standard atmosphere. A needle tube is extended at the other end of the differential pressure gauge. Before the experiment, the red oil differential gauge should be adjusted to zero to ensure the accuracy of the experiment. In the measurement process, the needle tube should be on the same plane as the wing surface to be measured. After the measurement, because the pressure at the position of the needle tube is different from that at the other end of the differential pressure gauge, the red oil in the differential pressure gauge is pushed up to the corresponding indicator, that is, the difference between the atmospheric pressure and the pressure at the position of the needle tube. The pressure at the position of the needle tube can be obtained by subtracting this number from one standard atmosphere.

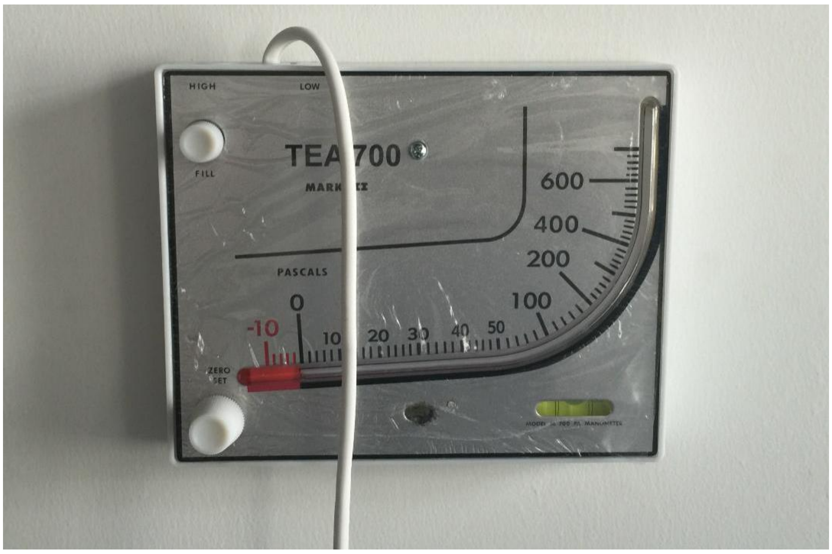

Figure 3. Differential pressure gauge used in the experiment

3. Results and analysis

In this paper, the experiment on the pressure of the upper and lower surfaces of the wings is divided into five different attach angles, which are 30 degrees, 15 degrees, 0 degrees, -15 degrees and -30 degrees. At each attach angle, the maximum camber position of the wings and the pressure on the upper and lower surfaces at position 2 with its vertical interval of 2 cm are measured. Two students of the same team and I respectively explore the airfoil with larger camber and smaller camber, and complete the experiment under the control of other variables as far as possible.

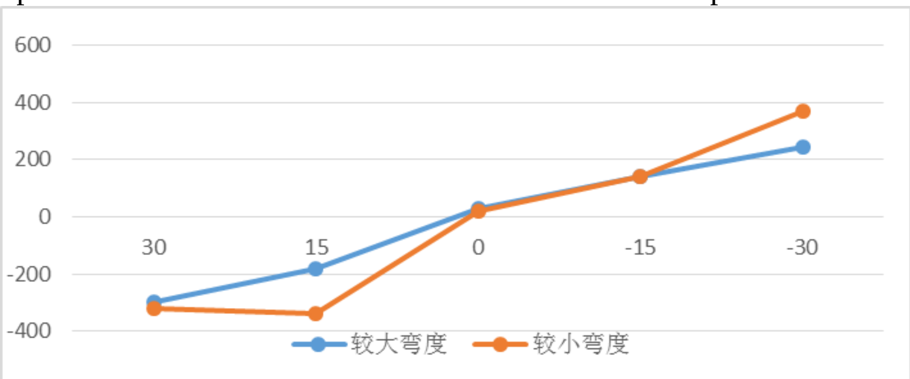

Figure 4. Pressure difference between the upper and lower surfaces of the wings at the maximum camber position

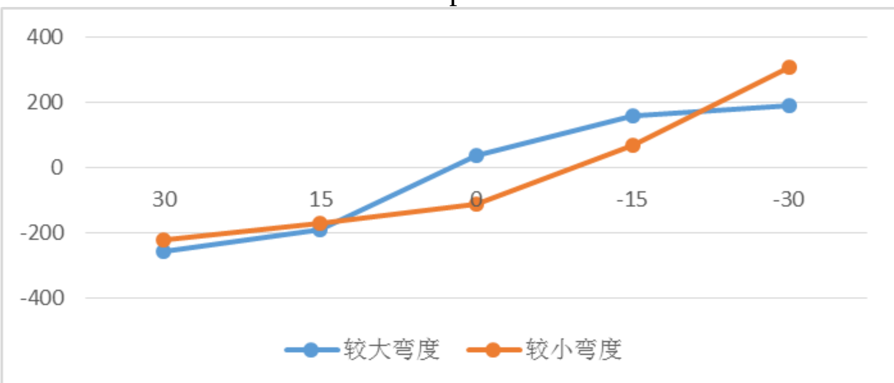

Figure 5. Pressure difference between the upper and lower surfaces of the wings at position 2

As shown in figure 4 and 5, the pressure difference between the upper and lower surfaces of the wings with larger camber and that of the wings with smaller camber has a significant difference at different attach angles. It can be seen that when the absolute value of attach angle is less than and equal to 15 degrees, the pressure difference between the upper and lower surface with the larger camber is generally larger than that with the smaller camber. On the contrary, when the absolute value of attach angle is equal to 30 degrees, the pressure difference between the upper and lower surface with the larger camber is generally smaller than that with the smaller camber. This difference is not easy to be seen at the maximum camber position, but it becomes more apparent at position 2.

Therefore, we can further analyze the reasons. First of all, when the attach angle is small, the airflow through the wings is unseparated and attached, and the areas on the surface and the trailing edge of the airfoil are very thin. As the attach angle increases, the stagnation point gradually moves back, so the pressure difference between the upper and lower airfoil increases, and thus the lift increases. At the maximum camber of the wing, the pressure difference between the upper and lower surface at this position is not large because the airflow is at a smaller attach angle and the larger camber is close to the smaller stagnation point. But at position 2, the airflow has passed through the maximum camber position. At position 2 of the wing with greater camber, the upper surface velocity is larger, so the pressure difference is larger. On the contrary, the upper surface velocity is smaller when passing through position 2 of the wing with less camber, so the pressure difference is smaller.

4. Conclusion

Through a series of wind tunnel experiments and data analysis, we can get some conclusions about the influence of wing camber on the pressure of the upper and lower surfaces when the wing passes through the airflow. For the wings with relatively large camber, when the attach angle is relatively small, the pressure difference between the upper and lower surfaces of the wings is relatively large, so the lift generated is relatively large. When the attach angle is large, the pressure difference between the upper and lower surfaces of the wings is relatively small, which leads to less lift.

For wings with relatively small camber, the pressure difference between the upper and lower surfaces is larger when the attach angle is larger, while the pressure difference is smaller when the attach angle is less than or equal to 15 degrees. This result is completely opposite to that of the wings with relatively high camber. The pressure difference of the two between the upper and lower surfaces is relatively close when the attack angle is 15 degrees, but the that with the larger camber are still slightly higher than that with the smaller camber .

Although there are some experimental errors in this conclusion, we can still draw a general conclusion. The more experiments on attack angle and at what specific angle the two can get balanced are the questions to be considered in the subsequent experiments. So more experiments can be carried out and further analyzed.

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