Aerodynamic Characteristics Test for Two Kinds of Propeller with Different Blade Angle

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Abstract. This paper introduces the wind tunnel tests and test results of two kinds of propeller with different blade angle. The 3D test section of NF-3 wind-tunnel of Northwestern Polytechnical University is used to perform the wind-tunnel test. In the test, wind speed are 0m/s, 20m/s, 30m/s and 40m/s, propeller speed are 900, 1200, 1500, 1800, 2100, 2400, 2700, 3000, 3300, 3600, 3900(r/min). The wind tunnel test results show that when the two propellers with the same airfoil and the chord length distribution along radial direction, different blade angle distribution along radial direction, the thrust, torque, power and efficiency have a significant difference. The propeller with more blade angle has more thrust and power, the propeller with more blade angle is suitable for high advanced ratio, the propeller with less blade angle is suitable for low advanced ratio.

Introduction

Generally, new energy aircraft utilized the propeller to generate the thrust. In the design phrase of new energy aircraft, it’s very necessary to predict the efficiency, thrust, power, torque of propeller.


In this paper, the wind-tunnel test of two kinds of propeller with different blade angle is presented. The thrust, torque, power and efficiency of propeller are obtained and analyzed.

Wind-tunnel Test

The 3D test section of NF-3 wind-tunnel of Northwestern Polytechnical University is used to perform the wind-tunnel test. Width of test section is 3.5 meter, height is 2.5 meter, and length is 12 meter. The wind-tunnel is shown in Figure 1. The VXI data acquisition system is shown in Figure 2. The test propeller in the wind-tunnel is shown in Figure 3.
Figure 1. Wind-tunnel.

Figure 2. VXI data acquisition system.
Test propeller is two wooden two-blade propellers with diameter 0.96 meter (Figure 4). The blade angle distribution of 1# propeller and 2# propeller are shown in Figure 5.

**Test Content and Method**

Wind velocity $V=0\text{m/s}, 20\text{m/s}, 30\text{m/s}$ and $40\text{m/s}$. Rotation speed $n=900$, $1200$, $1500$, $1800$, $2100$, $2400$, $2700$, $3000$, $3300$, $3600$, $3900$ ($\text{r/min}$).
\[ \rho = 0.0034831 \times P / (273.15 + t) \]  
\[ \lambda = \frac{V}{n_s D} \]  
\[ C_T = \frac{T}{\rho n_s^2 D^4} \]  
\[ C_Q = \frac{Q}{\rho n_s^2 D^5} \]  
\[ C_W = \frac{W}{\rho n_s^3 D^5} \]  
\[ \eta = \frac{C_T \lambda}{C_W} \]

Where \( \eta \): Efficiency; \( \lambda \): Advanced ratio; \( \rho \): Air density, \( \text{kg/m}^3 \); \( C_T \): Thrust coefficient; \( C_W \): Power coefficient; \( C_Q \): Torque coefficient; \( D \): Propeller diameter, \( m \); \( n_s \): Rotation speed, \( \text{r/s} \); \( P \): Atmosphere pressure, \( \text{Pa} \); \( Q \): Torque, \( \text{N} \cdot \text{m} \); \( t \): Temperature, \( ^\circ \text{C} \); \( T \): Thrust, \( \text{N} \); \( V \): Flight velocity, \( \text{m/s} \); \( W \): Power (\( W = 2\pi n_s Q \)), \( W \).

**Test Results**

The comparison of thrust coefficient of 1# and 2# propeller is shown in Figure 6. The comparison of power coefficient of 1# and 2# propeller is shown in Figure 7. The comparison of efficiency of 1# and 2# propeller is shown in Figure 8. It can be found from the Figures. 6-8 that the thrust coefficient and power coefficient of 1# propeller is greater than those of 2# propeller. The efficiency of 1# propeller is less than that of 2# propeller at the low advanced ratio. The efficiency of 1# propeller is higher than that of 2# propeller at the high advanced ratio.

![Figure 6. The comparison of thrust coefficient of 1# and 2# propeller.](image)
Conclusion

This paper introduces the wind tunnel tests and test results of two kinds of propeller with different blade angle. The 3D test section of NF-3 wind-tunnel of Northwestern Polytechnical University is used to perform the wind-tunnel test. Test results show that the propeller with more blade angle has more thrust and power, the propeller with more blade angle is suitable for high advanced ratio, the propeller with less blade angle is suitable for low advanced ratio.

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References


