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Numerical Simulation Study on Propeller Slipstream Interference of High Altitude Long Endurance Unmanned Air Vehicle

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Abstract

In this paper ,the control equation of Multiple Reference Frame(MRF) as the propeller calculation model was present and analyzed, the propeller slipstream interference on HALE UAV was studied with three-dimensional numerical simulation. It is shown that the flow field of the MRF model is good consistent with true propeller flow, and MRF can accurately simulate aerodynamic interference on the aircraft. The stream traces on the V-tail surface were deflected and shrank, pressure distribution ,C_{mx} and C_{mz} on V-tail surface was changed apparently too.But slipstream had little effect on wing. The influence of propeller slipstream on the aerodynamic performance of the UAV at the status of taking off is biggest, become weaker at status of climbing and smallest at the status of cruising. The influence of propeller slipstream is enhanced with increment of propeller thrust and basically familiar in the same thrust between the two blade attack angle. The pressure drag on aft of UAV fuselage increased rapidly by the interference of propeller slipstream, leading aerodynamic performance of UAV become badly.

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Keywords: unmanned air vehicle(UAV); propeller slipstream; multiple reference frame(MRF); computational fluid dynamics(CFD); numerical simulation

1. Introduction

Turboprop engine has low fuel consumption, high efficiency and low-speed flight characteristics, thus, many medium tactical transport aircraft and small unmanned aerial vehicles still widely used turboprop propulsion systems. Such as the European Airbus A400 transport aircraft and the U.S. C-130 "Hercules" transport aircraft and Predator

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series of UAV (shown as fig.1)[1-2],as well as domestic MA60, YUN7, YUN8, YUN12 transport aircraft and so on[3], are all using turboprop propulsion systems. In the development process of propeller aircraft aerodynamic design must take into consideration on the aerodynamic performance of the propeller slipstream interference on the configuration .This interference is more prominent than the slipstream affect of turbojet, even can determine the success of the entire aircraft design .So it is very important to carry out research of the aircraft propeller slipstream aerodynamic interference .Propeller slipstream aircraft interference assessment has been one of the difficulties of propeller aircraft aerodynamic design[4-9]. This paper uses MRF model to simulate propeller rotation, both the axial and rotational effect, to study the effects of slip effect push type propeller of high altitude long endurance UAV using numerical simulation method ,as shown in Fig2.

Fig.1 Propeller thrusting layout of Predator UAV

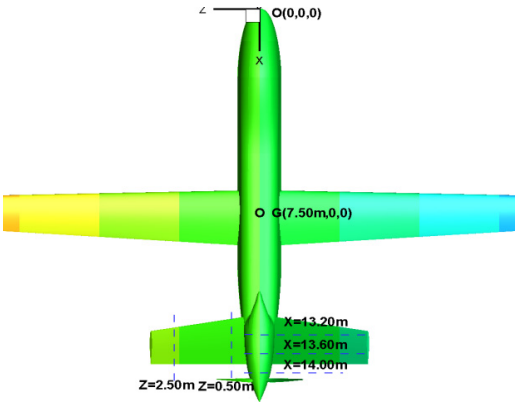

Fig.2 Propeller thrusting layout of HALE UAV, calculation coordinate and V-tail section defined

2. MRF model

MRF model is a common and simple effective steady method for rotational fluid motion calculation, widely used in fields of rotary fluid machinery and propeller design. The basic idea of MRF model is the computational grid area, which was divided into fixed region and rotation region. The flow field in rotating propeller is located within the region, which was simplified as instantaneous flow blades in a position and made the unsteady problem with constant method. Rotation region of grid remained stationary in the calculation, the effect of Coriolis and centripetal force were steady computed in rotating coordinates; and the fixed region of aircraft in the inertial coordinates was in accordance with the steady calculation .Exchange fluid parameters of inertial coordinates at the junction of the two sub regions, to ensure the continuity of interface, achieved using steady calculations to study the unsteady problem.

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