Title: Studies on Dynamics of a Unmanned Aerial Vehicle With Variable-Span and Variable-Sweep Wing

This material gives a main framework including basic concepts, figures, and some preliminary conclusions.

I. INTRODUCTION

The traditional unmanned aerial vehicle (UAV) generally only has a single flight mode, and its optimal functionality and performance of flight is often embodied in certain tasks, such as low-speed cruising or high-speed penetration. In recent years, many higher requirements, in terms of maneuverability, reliability, especially the multi-task capability, are put forward to the new generation of UAVs. The variable-configuration UAV, as a new concept of multi-purpose unmanned aircraft, has gained more and more attentions. Reasonable design of the variable aerodynamic configuration will enables UAVs to meet the requirements of the large airspace and speed domain, and maintain optimal flight performance in a variety of flight conditions so that the UAVs are able to perform multiple tasks beyond the capability of the conventional. However, the research of the large-scale deformation UAVs is still in the initial exploratory stage in both theory and application.

In order to make the UAVs maintain optimal flight performance in a variety of flight conditions, a new concept of the variable-configuration unmanned aerial vehicle is proposed this paper presents that combines two different deformation modes, and its configurations are shown in Fig.1. This variable-configuration UAV has the characteristics of both the variable-span wing and variable-sweep wing, thereby providing more deformation degree of freedom to achieve the larger-scale deformation.

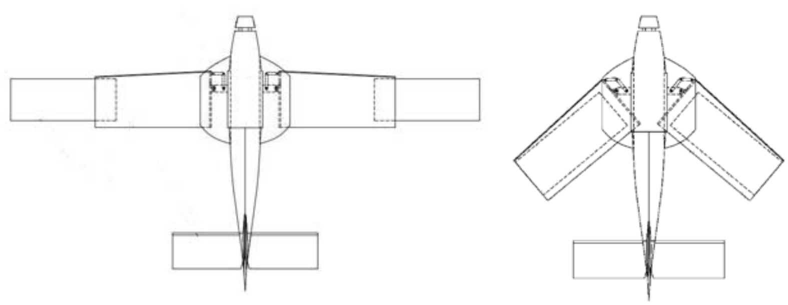


Figure 1. Trail interception.

The main characteristics of this UAV are as follows:

1) The larger-scale deformation characteristics provide the UAV a better adaptability for different flight velocity and airspace. Through a reasonable mission planning and control system design, the UAV is able to maintain optimal flight performance under the entire process of single flight task, and also variety of different tasks.

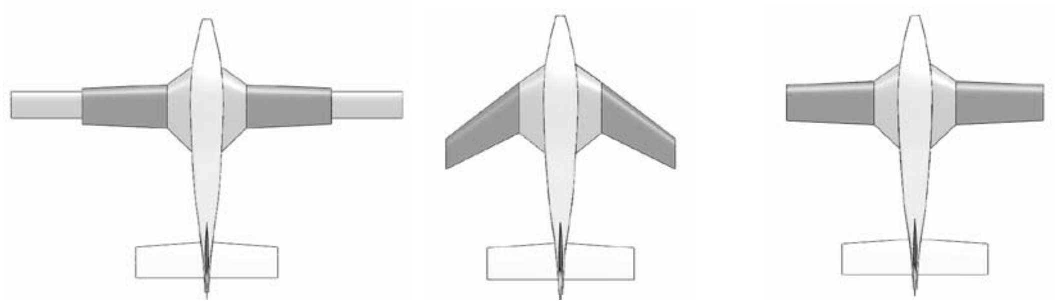
2) Considering the asymmetric deformation of the aerodynamic configuration, the UAV can obtain asymmetric aerodynamics distribution, and thus achieves attitude motion. The aerodynamic effects caused by the asymmetric variable-span wing can be used to replace that of the traditional aileron, being expected to provide considerable rolling moment. Accordingly, by the active asymmetric deformation, the UAV can obtain the desired attitude control.

The studies in this paper mainly focus on the following aspects:

ⅰ. Design the aerodynamic configuration of the UAV with variable-span wing and variable-sweep wing, analyze the structural properties and determine the reasonable range of deformation parameters. Calculate the aerodynamics through the Computational Fluid Dynamics method and engineering prediction method and analyze the aerodynamic characteristics of the typical static configurations which are shown in Fig.2.

ⅱ. Establish the multi-rigid-body model of the UAV based on the Kane method. Designate the fuselage as the primary rigid body, then the variable-span wing and variable-sweep wing as the subsidiary rigid bodies. Define the appropriate generalized coordinates and generalized velocity according to the constraint relations between the primary rigid body and subsidiary rigid body, and then obtain the kinetic model of first-order differential equations.

ⅲ. Analyze the dynamics and control characteristics of the variable-configuration UAV. Verify whether this UAV can meet the maneuverability requirements of different tasks through a comprehensive analysis of the static stability, freed disturbance motion characteristics and maneuvering characteristics under asymmetric control conditions.



(1) (2) (3)

Figure 2. Three typical static configuration states.

II. PART OF THE PRELIMINARY WORK

This section directly lists the preliminary studies.

A. Aerodynamics and structure analysis

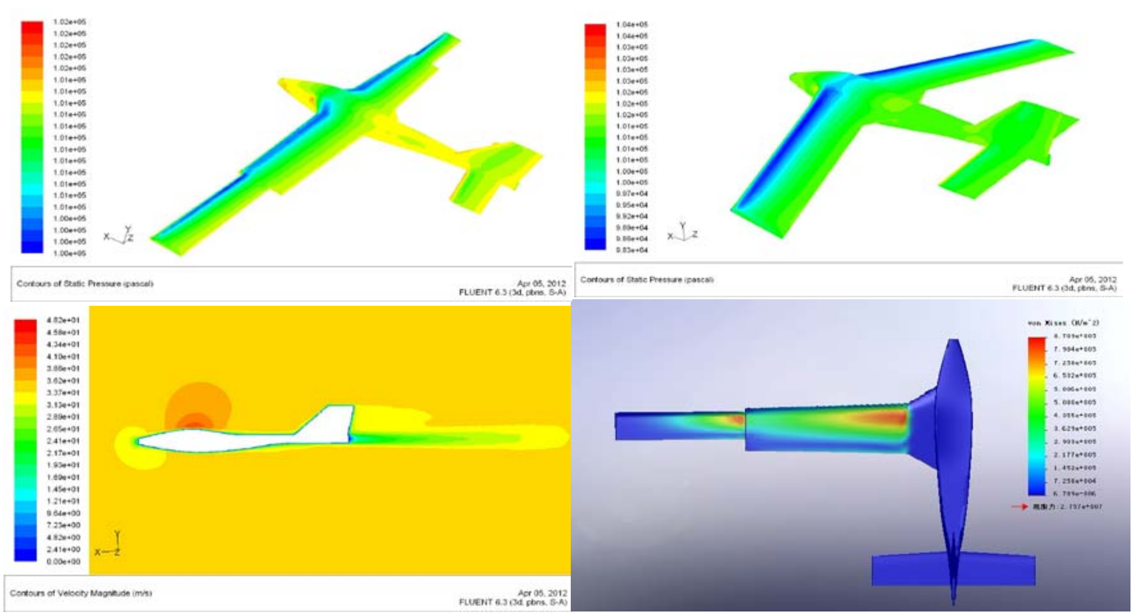


Figure 3. Aerodynamics and structure analysis.

B. Sample of Preliminary aerodynamic calculation results

Comparison of the aerodynamic characteristics of configurations shown in Fig.2, the left is for configuration (1) and the right is for configuration (2).

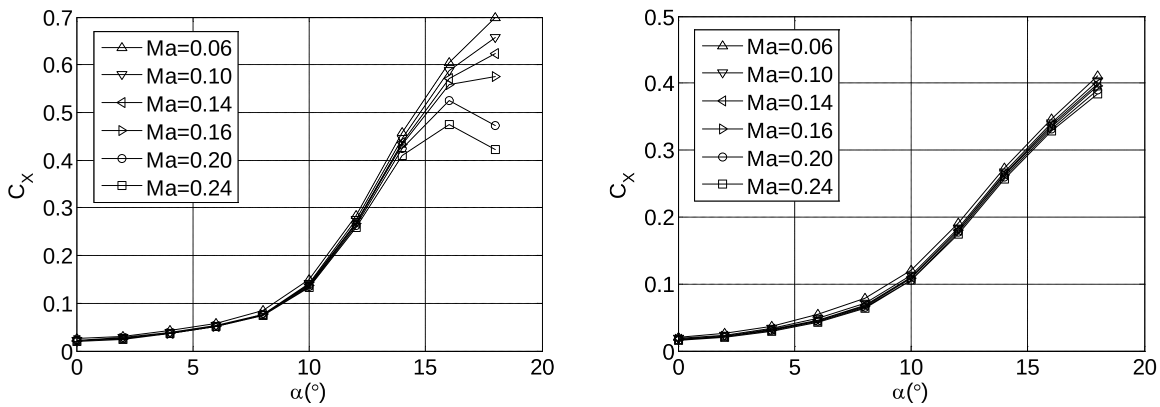


Figure 4. Drag coefficient.

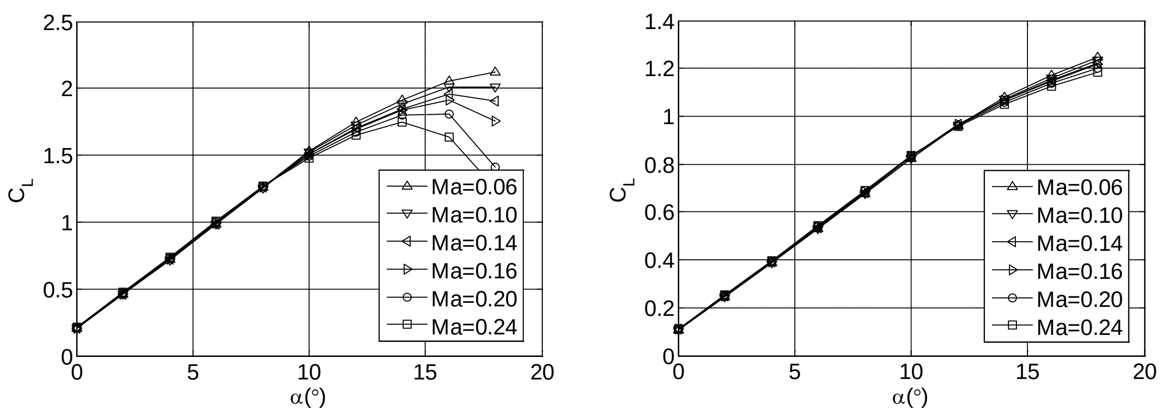


Figure 5. Lift coefficient.

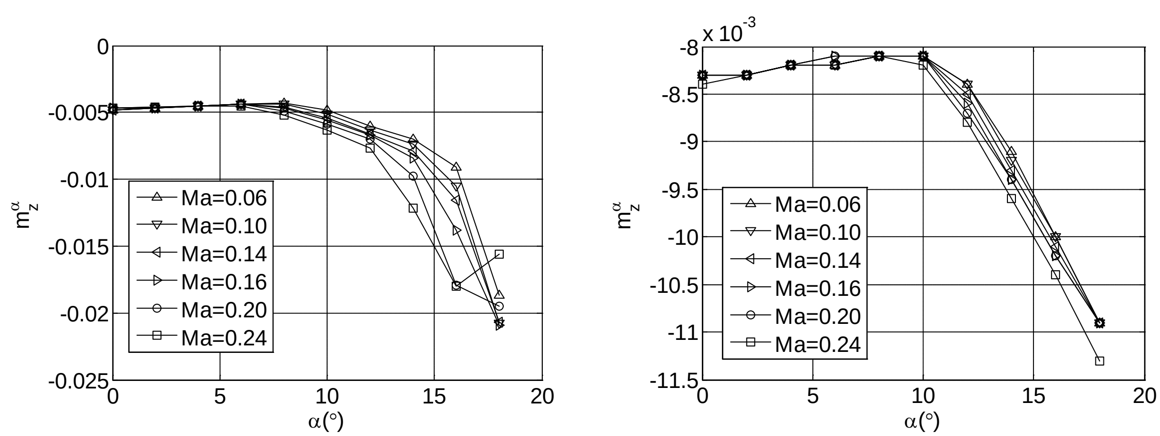


Figure 6. Longitudinal static stability moment coefficient.

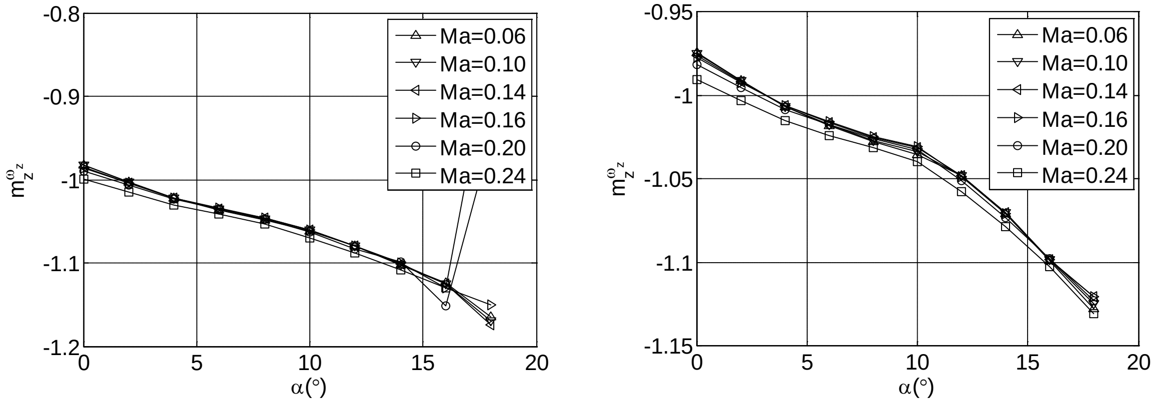


Figure 7. Derivative of longitudinal damping moment coefficient.