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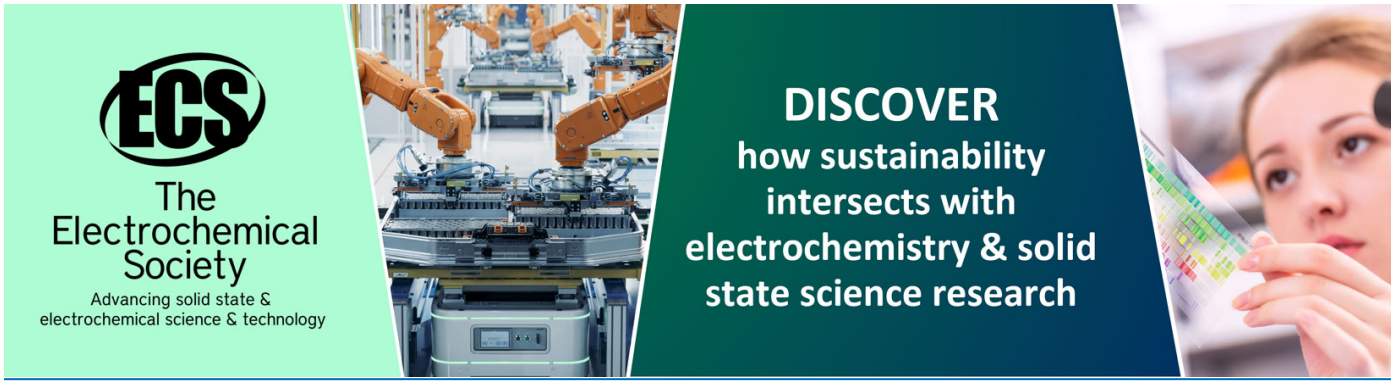

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Simulation analysis the aerodynamic characteristics of variable sweep wing missile

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Abstract. When the sweep of the variable sweep folding wing missile changes, the lift-drag ratio is improved so that the missile is able to adapt to subsonic flight, transonic flight and supersonic flight. This paper designs different 3D models of variable sweep wing missile aerodynamic shape and completes the aerodynamic characteristics analysis of the missile by CFD according to the Basic Aerodynamics, Missile General Design Principle, Flight Dynamics of Missile. The simulation analysis of the missile in different flight conditions with different sweeps is carried out, and the wing sweeps applicable to different flight conditions are summarized.

1. Introduction

Along with research on morphing wing of many countries, it is believed that missile airfoil development will be toward to the direction of morphing wing, breaking the limit of missile aerodynamic performance under different flight Mach numbers, realizing the intelligent control of aerodynamic performance as the change of the flight Mach numbers and having a broader speed adaptive [1].

Nowadays, many countries have extended morphing wings to the missile configuration design. The missile's aerodynamic configuration is developing toward an intelligent, deformable and self-adaptive directions. So many countries successively carry out researches into physical design of morphing wing and its aerodynamic performance [2-4]. At the present stage, our country has previously made some achievements in the applications of morphing wings on aircraft. However, the application of it is only theoretical. Its theories and related technologies are still needed to be further studied and explored [5].

This paper is based on wing aerodynamic characteristics of different aerodynamic configurations, combined with the related research of morphing wing missiles at home and abroad, with reference to the structure design formula of the missile aerodynamic configuration, designing and calculating aerodynamic configuration of variable sweep wing missile and doing primary research on aerodynamic performance of variable sweep wing missiles. Through 3D modeling, theoretical analysis and CFD calculation of the aerodynamic characteristics of the variable sweep wing missile, the aerodynamic characteristics of the missile at different sweeps are obtained. The suitable flight conditions and Mach number of the missile at different sweeps are summarized and the aerodynamic characteristics of the variable sweep wing missile are summarized, which provides theoretical reference for the aerodynamic design of the missile [6-7].

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2. Missile aerodynamic configuration design Introduction

2.1 The missile body design

Missile bodies are mainly divided into two types: bodies of revolution and non-rotated bodies. The advantage of bodies of revolution is that it is easy to manufacture, store and transport. It also takes advantage of low resistance. The theoretical research and manufacture of circular cross section body design have been fully developed. It has been broadly used in the design of various missiles domestic and overseas. Therefore, the circular cross section body is used in the missile design in this paper.

According to the characteristics and mission requirements of the missile design, basic parameters of the missile body are determined by using engineering experience and some related design schemes at home and abroad. The diameter of missile body: D=0.4m, the length of missile body: LB =5.8 m, wing span: L=1.55 m, as shown in Fig 1.

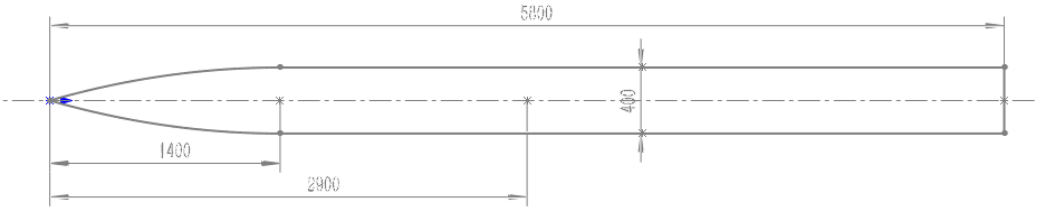


Figure 1. Basic parameters.

2.2 The missile wing design

In consideration of subsonic, transonic and supersonic flight of the missile designed, in order to make the missile have a good supersonic flight performance, modified double wedge airfoil profile is selected as the analytical model of the airfoil, as shown in Fig 2[8].

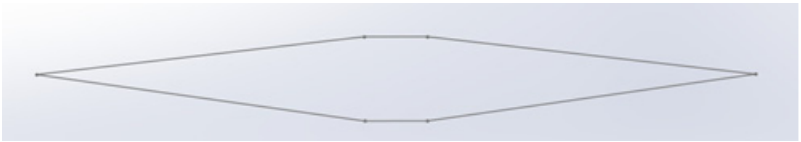


Figure 2. Airfoil profile.

2.3 The establishment of 3D missile model

Refer to the existing aerodynamic configuration, the 3D model of variable sweep wing missile is built as shown in Fig 3.

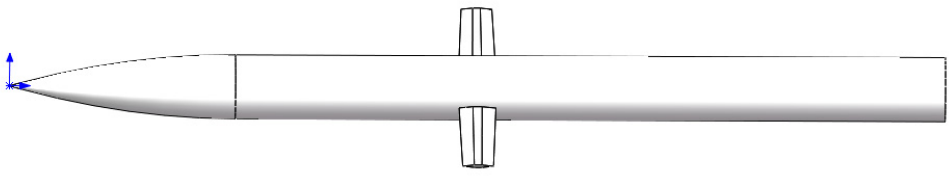


Figure 3. Model establishment.

According to the design, the wing is transformed from the folded state to fully expanded state and its sweepback can change from 15° to 75°. The 3D missile models with sweepbacks of 15°、30°、45°、60°、75° are established, as shown in Fig 4.

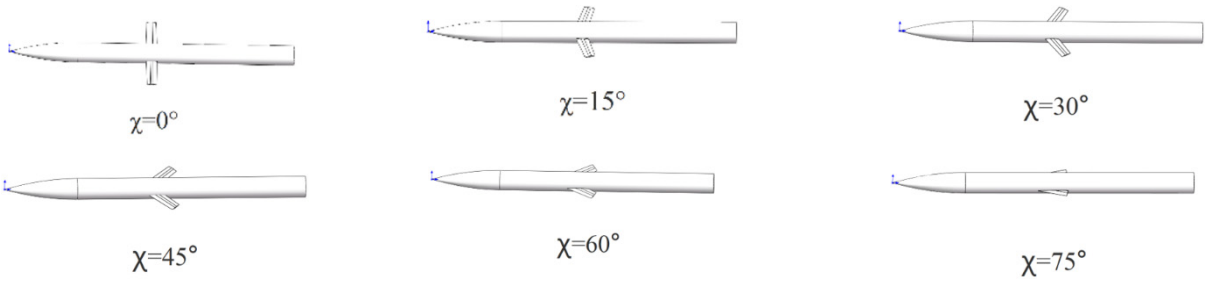


Figure 4. Models under different sweep angles.

3. Simulation analysis the aerodynamic characteristics of variable sweep wing missile

3.1 Meshes

The missile model consists of body and wing, making the simulation analysis more complex, so the unstructured mesh is used to the divide the model. Firstly, node division is carried out for each edge of the model, then surface mesh division is completed for each surface, and all the surfaces of the missile body are selected. Lastly, set Elements Options to Tri and set Type Options to Pave.

3.2 Loading of boundary conditions and output of meshes

After the mesh division, the boundary conditions of the analysis model should be loaded. Symmetry plane of air flow field is set as SYMMETRY boundary conditions. The two semi-circular surfaces and the cylinder plane of the cylinder flow field are set as PRESSURE-FAR-FIELD boundary conditions. The surfaces of missile bodies and wings are set as WALL boundary conditions. So far, the boundary conditions loading of the research model is completed.

3.3 Simulation analysis of aerodynamic characteristics of missiles with different sweeps

The mesh files of flow field are imported into CFD software to analyze the aerodynamic characteristics of missile. The aerodynamic analysis of the missile model is carried out by five mesh files with 15 °, 30 °, 45 °, 60 ° and 75 ° sweeps. In order to analyze the adaptability of the variable sweep wing missile with different speeds, the flight Mach number Ma is set to be 0.3, 0.5, 0.8, respectively, and the angle of attack is set to be 4 ° according to the speed of the missile, so as to do the constant analyze of the variable sweep wing missile.

3.4 Simulation calculation

Missile models with 5 different sweeps are simulated and analyzed under 3 groups of different flight speeds. A total of 15 groups of simulation calculation results are as follows:

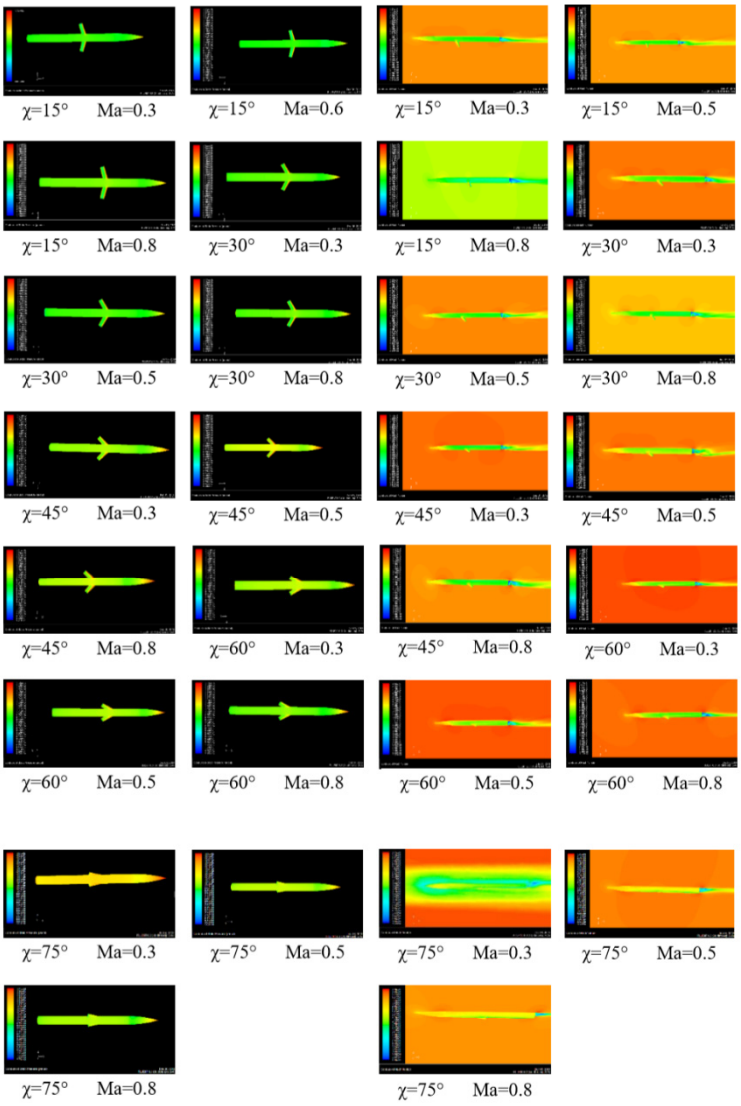
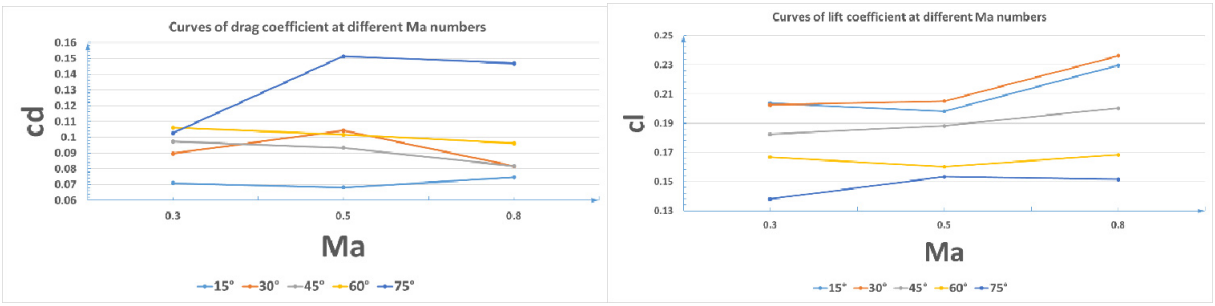


Figure 5. A total of 15 groups of simulation calculation results



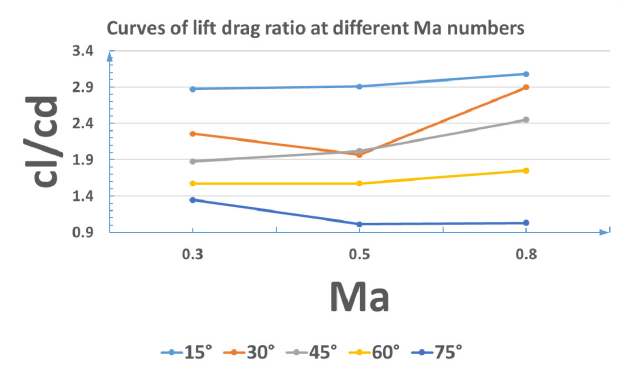


Figure 6. Graph

4. Summary and Prospect

4.1. Summary

With the development of modern missiles in the direction of high Mach number, high maneuverability and large attacking range, missiles are required to be able to adapt to subsonic flight, transonic flight and supersonic flight. But the aerodynamic shape of the fixed wing missile is difficult to meet all the above requirements, and the variable sweep wing missile can change the aerodynamic shape of the wing through the folding of the wing to adapt to different flight conditions and obtain good aerodynamic performance.

In this paper, the development of missiles and the research status of variable sweep wing missile at home and abroad are briefly described. The aerodynamic shape design of variable sweep wing missiles is mainly completed according to Basic Aerodynamics, Missile General Design Principle, Flight Dynamics of Missile. Considering that the missile is mainly in the subsonic stage, the aerodynamic performance of the missile in subsonic flight is mainly analyzed. Through the research methods of 3D modeling and numerical simulation, the model of different sweep angles of variable sweep wing missile is established, and the aerodynamic characteristics of different sweep angle missile model are analyzed by FLUENT. The lift coefficient, drag coefficient and lift drag ratio of different flight Mach numbers are calculated. Through data processing and comparative analysis, the following conclusions are drawn:

(1) At low Mach number, the aerodynamic characteristics of the missile become better with the increase of aspect ratio.

(2) In subsonic flight, smaller sweep angle can make the missile have larger lift drag ratio and better aerodynamic characteristics.

4.2 Prospect

The mission of the aircraft is developing and improving, which requires higher flight speed, attack range and maneuverability. The shape of the deformed wing is changed by folding, stretching and flexible deformation to obtain better aerodynamic performance, which has become the research and development direction of domestic and foreign. The deformed wing can provide better lift drag ratio characteristics for the aircraft at different flight speeds, reduce flight resistance by changing the airfoil shape, improve fuel utilization, and increase flighting range.

This paper focuses on the aerodynamic characteristics of subsonic flight. The sweep angle selected is not enough, and this paper based on the case of no sideslip angle, so the analysis results still exist limitations. It is necessary to analyze the aerodynamic characteristics of the missile in the transonic, supersonic and hypersonic stages for the subsequent research on the variable sweep wing, so as to further enrich and improve the theoretical basis for the aerodynamic shape design of the variable sweep wing missile.

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