Parameter Estimation and Analysis of Standard-2 Missile

Jian Shen[1, *], Heng Li[2], Junwei Lei[2], and Jing Li[3]

[1]Ordnance Equipment Room of Equipment Project Management Center of Naval Equipment Department, PLA, Beijing, 100000, China

[2]College of Coastal Defense, Naval Aviation University, Yantai, 264001, China

[3]College of Weaponry Engineering, Naval Engineering University, Wuhan, 430000, China

Email: leijunwei@126.com

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Abstract: Firstly, the history and development of Standard 2 missile are introduced, and the characteristics of various types of missiles in service are sorted out. On this basis, the parameters of propulsion system, flight system and aerodynamic configuration of Standard 2 missile are estimated, which provides a basis for the establishment of the following mathematical model.

1. Introduction

For modern surface warships, the main air threat comes from a variety of high-performance anti-ship cruise missiles, including subsonic and supersonic low-altitude anti-ship missiles. Among many ship-to-air missile weapon systems, the American standard series of ship-to-air missile systems have become the representative of air defense missiles because of their superior and comprehensive performance [1-4].

Standard-2 BLOCK IVA missile, as the backbone of American missile defense system, is launched by Aegis system, and its important position is self-evident. In a sense, the operational effectiveness of anti-ship missiles at sea is closely related to the interception capability of standard-2 missiles. Therefore, it is necessary to study the interception model and effect of standard-2 ship-to-air missile to anti-ship missile, so as to provide useful support and help for the design of anti-ship missile in China [5-8].

The significance of studying the model of air defense missile intercepting anti-ship missile is that through the simulation of attack-defense confrontation, the tactical and technical indexes of the weapons used by both sides can be analyzed in non-actual combat situations, and the virtual combat environment can be generated by computer on the basis of establishing the physical and mathematical models of the participating weapons. As a low-cost research means, the simulation of attack-defense confrontation can not only greatly simplify the design process, save test funds and development cycle, but also make the analysis more scientific and accurate.

2. Propulsion System Estimation of Standard-2 Missile

The power plant of standard-2 missile is a MK 72 solid rocket propeller and a MK 104 solid rocket main motor. The maximum speed Mach number of the missile is 3.5.

The general parameters of MK 72 solid rocket propeller are as follows:
Booster quality: 787.7 kg;
Propellant quality: 474.6 kg;
Booster working time: 6s;
Thrust: 174 kN;
Specific impulse: 2200 m/s;
The general parameters of MK 104 solid rocket motor are as follows:
Engine quality: 567.3 kg;
Propellant mass: 358.5 kg;

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Engine working time: 40s;
Thrust: 22 kN;
Specific impulse: 2500m/s.

3. Aerodynamic Profile Estimation of Standard-2 Missile

Aerodynamic shape design of missile involves the determination of aerodynamic layout form and geometric parameters. It is the primary system design problem in the process of missile development, and also an important part of missile scheme design. Aerodynamic shape estimation is basically consistent with aerodynamic shape design in ideas and methods. Its main contents are the determination of aerodynamic layout form and geometric parameters.

3.1 Aerodynamic layout analysis

According to different classification methods, missiles can be divided into two categories: wingless missile and wingless missile according to different aerodynamic shapes; normal missile, duck missile, tailless missile and rotary missile according to the layout of wings and rudder surface; axisymmetric missile and face-to-face missile according to shape symmetry; The dynamic axisymmetric missile can be divided into'X-X','+-+','X-+'and'+-X' types according to the placement of the front wing (wing or rudder) and the rear wing (rudder or wing) relative to the missile body (from the front view). The standard-2 missile belongs to the normal wing configuration of the'X-X'type.

3.2 Estimation of shape parameters

The determination of missile shape parameters mainly includes the shape selection of missile body and wing control surface and the determination of geometric parameters. The shape of supersonic missile should be considered and selected according to the requirements of aerodynamics, guidance, warhead and structure. Following is the selection and determination of the shape and parameters of the body and tail rudder of the standard-2 missile. The projectile body is 6.55m in length and is divided into four parts: the projectile body and its head, wing, tail rudder and booster.

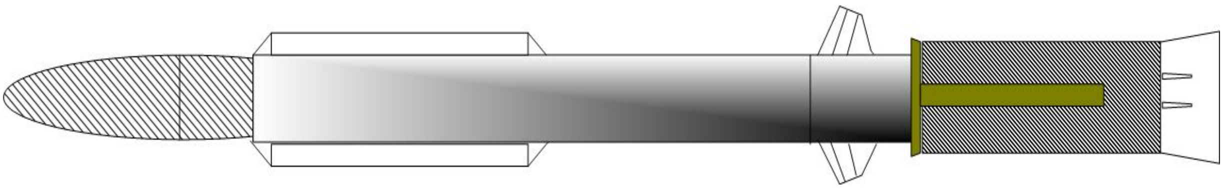

Figure 1. Schematic Chart of Standard-2 Missile Structure Composition

(1) Estimation of head shape and parameters

For homing anti-aircraft missiles, radome is only allowed in the head, so the radome shape is the warhead shape. The standard-2 missile uses a pointed arch head, because the radar seeker used in the missile allows the radome to be quadratic shape, and the pointed arch head has larger internal space and smaller wave resistance, so it is easy to manufacture. Therefore, it is reasonable to use a pointed arch head. The head length is 0.53M and the diameter is 0.34m.

(2) Shape and parameter estimation of projectile body

Cylindrical shape is mostly used in the middle part of missile body. Because cylindrical shape is easy to manufacture, it can improve the bearing capacity of missile body and reduce resistance, so it is widely used. The standard-2 missile adopts a cylindrical body, the distance from the top of the missile head to the bottom of the booster is 6.55m, the distance from the top of the missile head to the bottom of the booster is 4.64m, and the diameter is 0.34m.

(3) Shape and parameter estimation of wing body

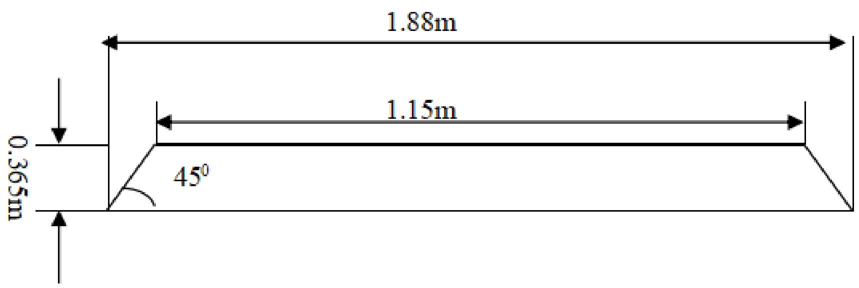

Figure 2. Profile Size of Side Strip Wing of Standard-2 Missile

The basic wing shape and size of the standard-2 missile are shown in the figure above. It is a strip wing with a wingspan of 1.07 m, a thickness of 0.03 m and a wingspan of 0.43 m2.

(4) Estimation of tail shape and parameters

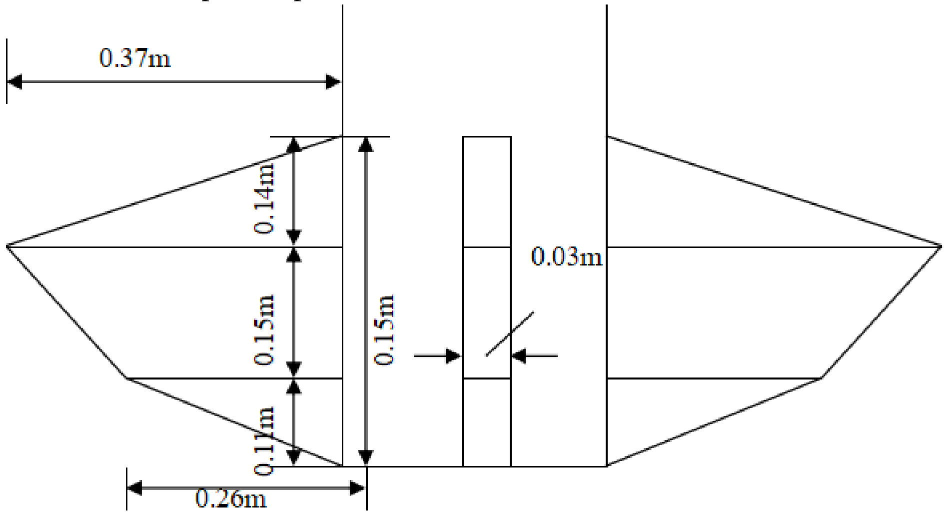

Figure 3. Profile Size of Side Strip Wing of Standard-2 Missile

The tail of the projectile can be made into contraction and cylindrical shape. Shrinkage can reduce the area of negative pressure at the bottom, thereby reducing the resistance at the bottom. However, the shrinkage tail also produces differential pressure resistance. These two will partly offset. Moreover, when missiles fly at subsonic or supersonic speeds at an angle of attack, the increase of the thickness of the boundary layer at the tail of the contraction will lead to the separation of airflow. Therefore, it is very difficult to accurately calculate the aerodynamic forces at the bottom and tail of the missile. In this paper, the cylindrical tail is used for simplified consideration. In fact, the cylindrical tail is also used for the standard-2 missile. The shape and size of rudder surface of standard-2 missile are shown in Fig. 2.4, and the thickness of rudder surface is 0.03m.

4. Conclusion

Firstly, the development of Standard-2 missile is introduced, and the characteristics of various types of missile in service are sorted out. Then, Aegis defense system is evaluated from three aspects: development situation, system composition and operational advantages and disadvantages. Finally, the propulsion system and aerodynamic configuration of Standard-2 missile are estimated according to available data. It is helpful for the establishment of the following mathematical model. The main purpose is to have a preliminary understanding of the standard-2 missile and its equipments, so as to make the simulation analysis more clear.

References

[1] Xixiaoyun, Yao Tenggang, Xie Hongsheng. Research on anti-ship missile defense system [J].

Ship electronic engineering. (11), 2008:10-18.

[2] Zang Xiao. Developing Standard Missile Series [J]. Aerial Missile. (10), 2001:24-30.

[3] Liu Zhanrong. Structural Analysis of Aegis Operational System [J]. (1), 2004:24-30.

[4] Liu Xinjian, Tang Dawei. Application of Vertical Launch Technology in Air Defense Missiles [J]. (3), 2004:24-30.

[5] Zhao Songyan. Modeling and Simulation of standard-2 missile weapon system. Harbin University of Technology. 2008.

[6] Wang Guanghui, Yan Jiangang. An Effectiveness Evaluation Model for Ship-to-Air Missile Interception Mode. Journal of Systems Simulation. (3), 2008:4829-4834.

[7] Shilei, Zhang Zhanyue. Ballistic Modeling and Simulation of Sea-based Interception Missile [J]. Journal of Systems Simulation, (11), 2009:89-96.

[8] Li Yingjie, Jia Yanjun. Modeling and Simulation of short range air defense missile intercepting anti-ship missile [J]. Military automation. (12), 2010:38-41.