Experiment of Hypersonic Waverider Vehicle

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Abstract

The purpose of the current study is to examine the aerodynamic characteristics of hypersonic waveri der vehicle by simulation and experiment.

The simulation was accomplished using NS aerodynamic codes developed in Northwestern Polytechn cal University. The objective of experiment are twofo ld. The first is to examine the accuracy of si mulation. The second is to examine the effects of shockwave an d boundary layer interactions on aero dynamic perfor mance hypersonic configurations.

1 Introduction

Waveriders are promising shapes for the Hypersonic vehicles. These configurations can form the basis of airframes with very high lift-to-drag ratio(L/D). Furthermore, because they are designed with an inverse methodology, the flowfield is first selected, then the approprrate generating shape is determined; they lend themselves especially well to inlet optimization, as vide relatively uniform inlet conditions, corresponding to the flow conditions of the original generating flow[1][2].

The purpose of this paper is to test a hypersonic w averider configuration performance.

2 Experiment

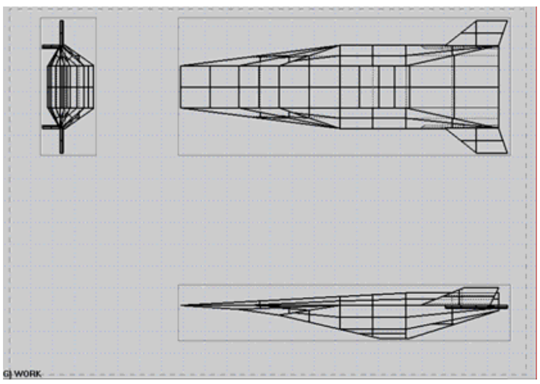

Fig.1 Experiment model of hypersonic waverider

The top view waverider vehicle[3] and pressure tap locations are plotted in Fig.2.

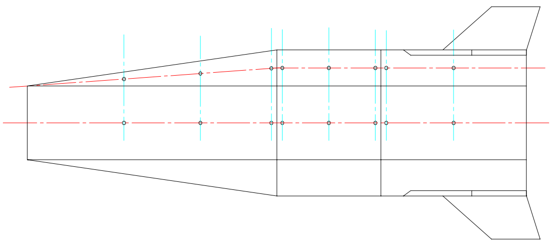

Fig.2 The top view and pressure tap locations of waverider experiment model

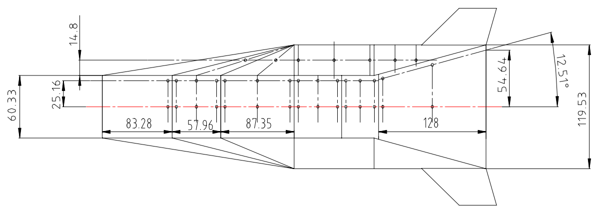

Fig.3 The bottom view and pressure tap locations of waverider experiment model

The bottom view waverider vehicle and pressure tap locations are plotted in Fig.3.

The facility used in this study was $\phi 500mm$ hypersonic wind tunnel in China Academy of Aerospace Aerodynamics(CAAA).

Table.1 Mach Test conditions of Waverider vehicle

Nominal Values(Ma)	Values among runs(Ma)
5	4.937
6	5.933
7	6.971

The Mach number range test in this paper is 5 to 7. The attack angle range α is -10 to 20. The sideslip angle range β is 0 to 15.

The Ma test conditions are plotted in Table.1 Some of vapor-screen photographs of experimental waverider vehicle are plotted in the flowing:

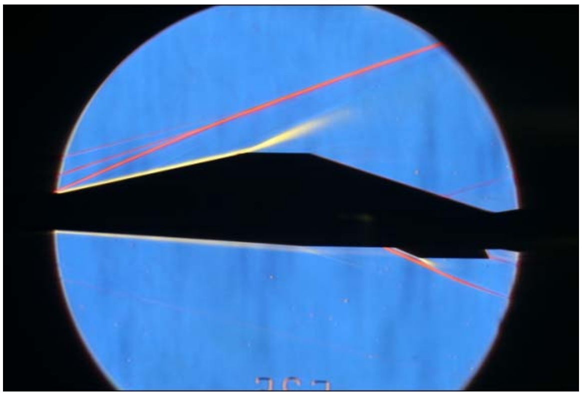

Fig.4 vapor-screen photograph
Ma=5.0 $\alpha = 0$ $\beta = 0$

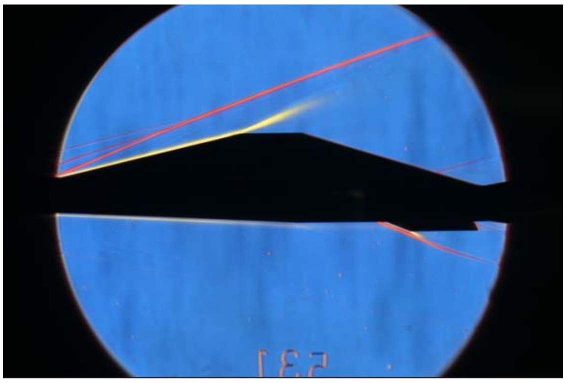

Fig.5 vapor-screen photograph
Ma=6.0 $\alpha = 0$ $\beta = 0$

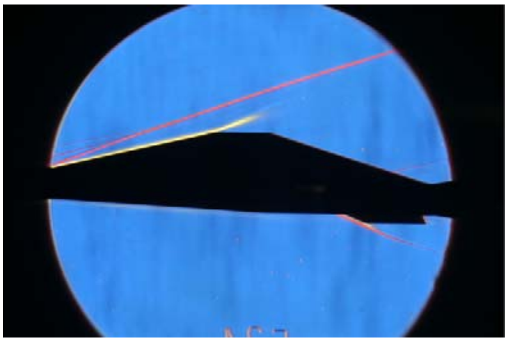

Fig.6 vapor-screen photograph
Ma=7.0 $\alpha = 0$ $\beta = 0$

3 Simulation of waverider vehicle

Simualation was conducted by CFD-Fastran software. In order to have a more coherent set of calculations, fastran computed the waverider vehicle using 1200000 node grids. Tubulence is modeled by the algebraic Baldwin-Lomax model.

Simulation results are plotted in the flowing.

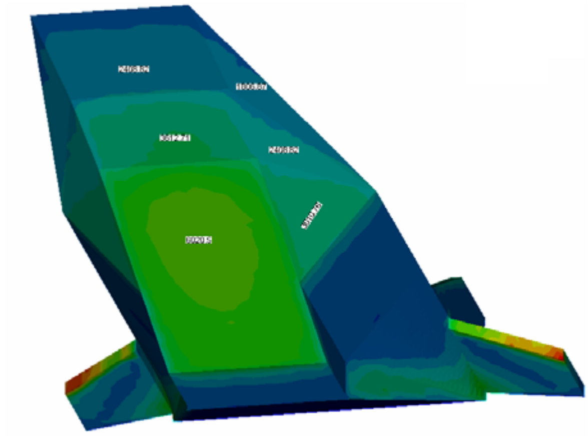

Fig.7 Pressure of waverider vehicle in design condition

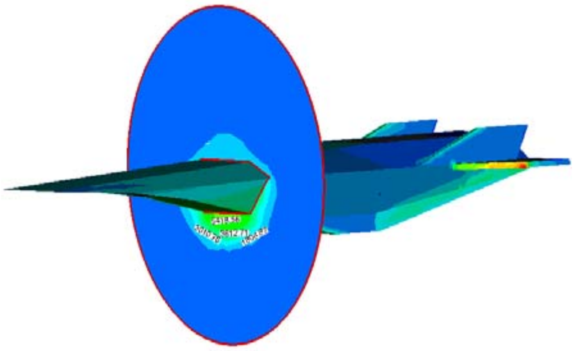

Fig.8 Pressure of waverider vehicle forebody in design condition

4 Comparison of simulation and experiment

Some figures of simulation and experiment res ults are plotted in the flowing.

In the comparison figure, the 1 and 2 are the center line and borderline of waverider pre-compress surface respectively ; the 3 is side face.

From fig.10 to fig.13, we can conclude that simulation dates are very closed with experiment dates except the afterbody.

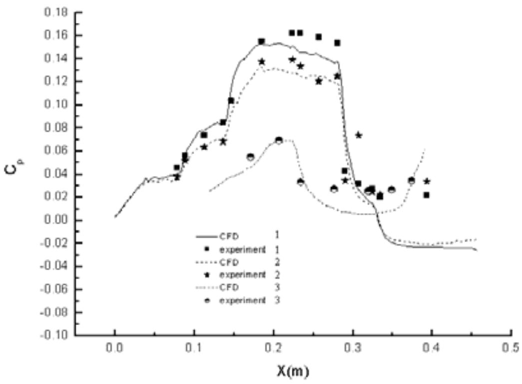

Fig.9 Comparison of Simulation and experiment in Ma=7 $\alpha = 0$ $\beta = 0$

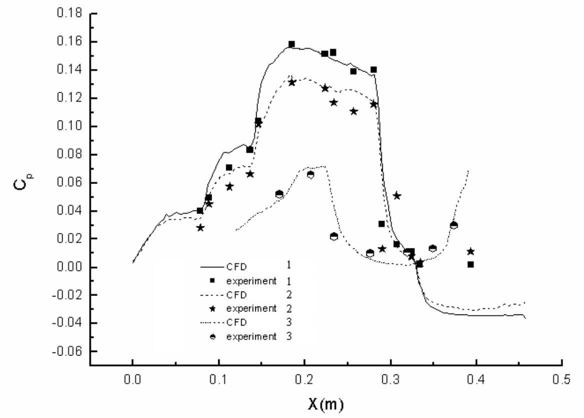

Fig.10 Comparison of Simulation and experiment in Ma=6 $\alpha = 0 \ \ \beta = 0$

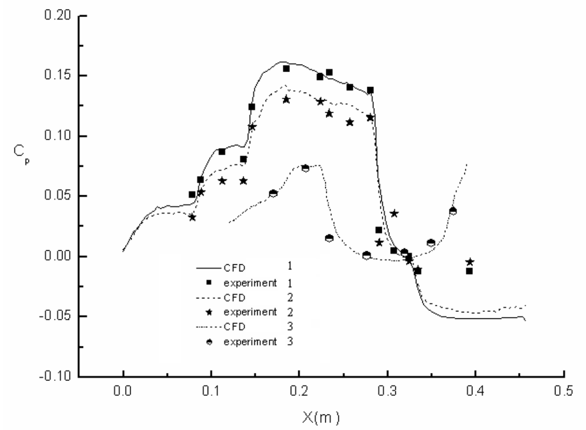

Fig.11 Comparison of Simulation and experiment in Ma=5 $\alpha = 0 \ \ \beta = 0$

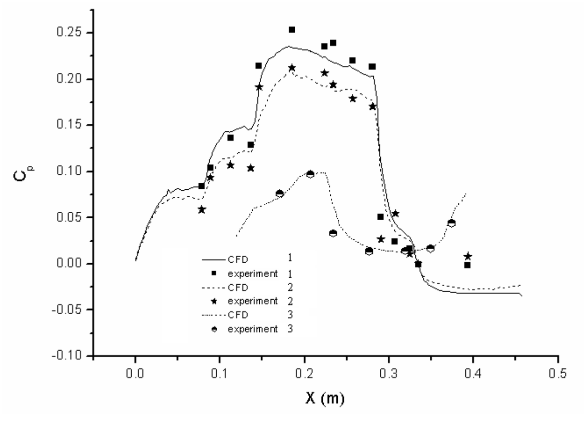

Fig.12 Comparison of Simulation and experiment in Ma=6 $\alpha = 4 \ \ \beta = 0$

In the forebody, the pressure coefficients of centerline and sideline are very closed. It indicated that the flow of waverider pre-compress is uniform.

Some figures of L/D and pitch simulation results are plotted in the flowing.

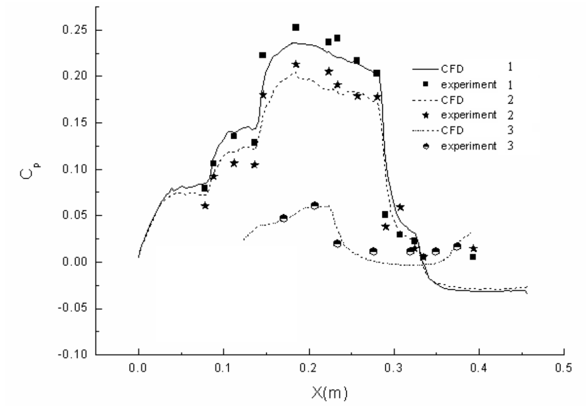

Fig.13 Comparison of Simulation and experiment in Ma=6 $\alpha = 4 \ \ \beta = 4$

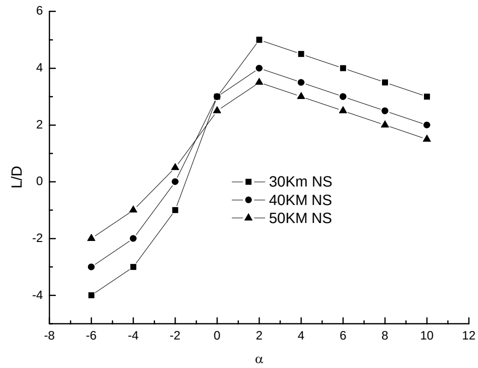

Fig.14 L/D of waverider in different altitude Ma=6 $\alpha = 0 \ \ \beta = 0$

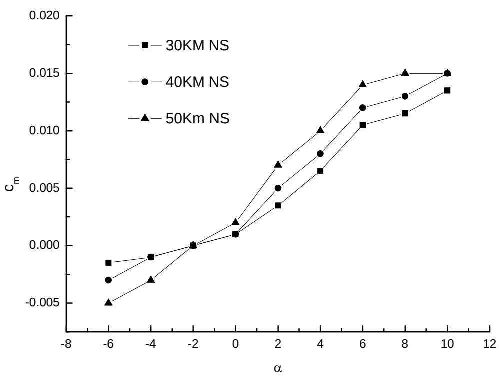

Fig.15 pitch of waverider in different altitude Ma=6 $\alpha = 0 \ \ \beta = 0$

5 Conclusion

we can conclude that simulation dates are very closed with experiment dates except the afterbody.

In the forebody, the pressure coefficients of centerline and sideline are very closed. It indicated that the flow of waverider pre-compress is uniform

Bouh computational predictions and experiment tal data show that waverider vehicle has higher lift and lower lower drag values.

The Maximum lift-drag ratio occurs near 40 attack angle of waverider vehicle. Waverider vehicle shows higher maximum lift-drag ratios in lower Mach number than the design point.

Acknowledgments

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