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on Supersonic Transport Design

Aerodynamic Design of SJAC Phase-Ⅱ SST Configuration

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Abstract

SJAC Phase-Ⅱ SST configuration was designed by JADC SST working group[1]. CFD analysis was conducted on the wing-body configuration to obtain preliminary aerodynamic data including non-linear effects such as transonic effect and so on, which are not counted in the primary design procedure. The results and the information obtained though this study are going to be discussed on this paper.

1 Introduction

1.1 Baseline Configuration

SJAC Phase-Ⅱ SST configuration is presented in Fig.1.

1.2 Preliminary Design

Vortex Lattice Method was employed to design the wing planform and warped shape. After some candidates were designed, the baseline was selected by comparing the maximum takeoff weight estimated by JADC CAD PROGRAM(Ref.1), which included required structure weight, fuel amount for a certain flight profile, and so on. Supersonic area rule theory was adopted to define the cross section area distribution of the body.

2 Objective of CFD Analysis

CFD analysis was conducted on the wing-body configuration in the symmetric flow to obtain preliminary aerodynamic data including non-linear effects such as transonic effect, which are not counted in the primary design procedure.

3 Analysis

3.1 Methods

Following methods were used;

- Code : "UG3" (3-D CFD code for Un-structured grid;Ref.2) using Euler analysis mode
- Space Discretization : Simple High-resolution Up-wind Scheme
- Time Integration : Implicit Scheme using LU-SGS Method

3.2 Grid

Un-structured grid was employed(Fig.2,3), which has 300,000 points including 74,000 surface points.

3.3 Condition

Mach Number : 0.3 ～ 2.2 (8 Points)
Angle of Attack : More Than 3 points for Each Mach Number

4 Results

4.1 Drag due to lift

Fig.4 shows the characteristics of Phase-Ⅱ configuration obtained by Euler analysis, and by VLM analysis. Fig.5 shows the characteristics of Phase-Ⅰ configuration (Ref.3) obtained by VLM analysis and by wind tunnel testing. With comparison of these two figures, it can be said that we could obtained the preliminary aerodynamic data by Euler analysis, which seems somewhat appropriate, containing non-linear effects in transonic region. However, Euler analysis for Phase-Ⅰ configuration has not been executed. So we can't present the evidence certifying the reliability of the results. But we will examine its validity after the wind tunnel test, now planning and partly executing.

And the aerodynamic data shown here are

[1] Members include KHI, MHI, FHI and IHI

used for re-evaluation of the Phase-Ⅱ baseline by JADC CAD PROGRAM mentioned before. The results will be published as the fruit of JADC activities in near future.

4.2 Wave Drag due to Volume

Fig.6 shows the characteristic of minimum drag. Assuming that it is negligible of the contribution of drag due to lift to the minimum drag, the minimum drag can be regard as same as wave drag due to volume under this invicid condition.

The results of linear theory rises as mach number decrease. But the one of Euler analysis keeps almost constant above mach number 1 in the transonic region.

Although we consider this difference also may come from non-linear effect of transonic region, much more study will be done after wind tunnel test.

4.3 Pressure Distribution

Some examples of pressure distribution around the airplane are presented in Fig.7,8.

The pressure distribution at mach number 2.2, and angle of attack 3.4 degrees is presented in Fig.7.This flight condition is near the supersonic cruising. Higher pressure regions are seen around the wing, which is considered to be caused by shock waves. And the lower pressure region on the upper surface spreads from root leading part to outer trailing part.

The pressure distribution at mach number 0.95, and angle of attack 3.6 degrees is presented in Fig.8.This flight condition is near the transonic cruising. The lower pressure region on the upper surface is limited near the leading edge, and no lower pressure region is spreading near the trailing edge in contrast with the case mentioned avove.

These pressure distributions are being utilized by structural part of JADC SST working group.

5 Conclusion

Euler analysis was executed for SJAC phase-Ⅱ SST configuration. By this analysis, the preliminary aerodynamic data was obtained, which is considered to include non-linear effects in transonic region.

Now, wind tunnel test is planning and partly executing. The validation of this analysis will be done with this wind tunnel test data.

6 Acknowledgment

This study was conducted under the sponsorship of MITI and SJAC.

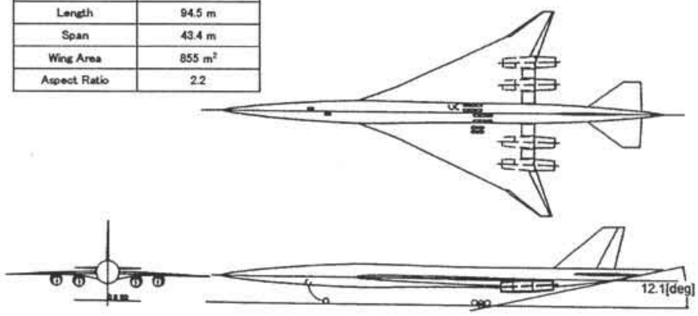
7 References

Ref.1) Takasu,T., Maekawa,S., Ugai,T., Mizuno,H. (JADC),"Preliminary Sizing of a Supersonic Commercial Transport Between Mach 2.0 and 2.4", SAE-965589.

Ref.2) Shima,E."An Unstructured Navier-Stokes Solver UG3",Proceedings of the 11th NAL Symposium on Aircraft Computational Aerodynamics, pp.25-30,1994 in Japanese

Ref.3) Futatsudera,N., Inoue,T., Tsuji,H., "A Conceptual Design of the SST without Horizontal Tail", Proceedings of the 30th Aircraft Symposium,2A8,1992 (in Japanese)

M_{CRUISE}	2.2
PAX	300
MTOW	399 ton
Length	94.5 m
Span	43.4 m
Wing Area	855 m^2
Aspect Ratio	2.2



SJAC PhaseⅡ SST Baseline Configuration

Fig.1 SJAC Phase-Ⅱ SST Configuration

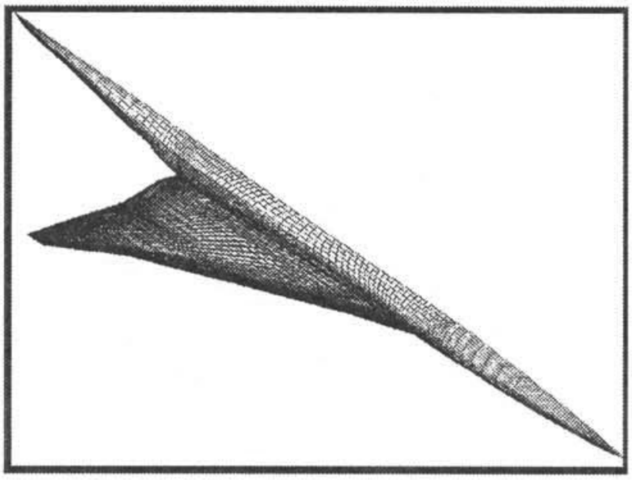


Fig.2 Surface Grid

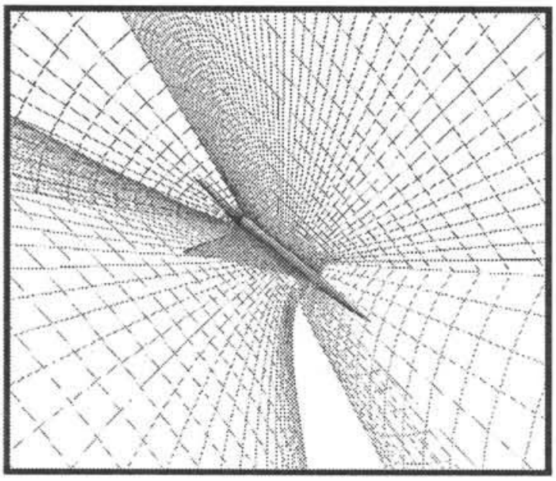


Fig.3 Space Grid

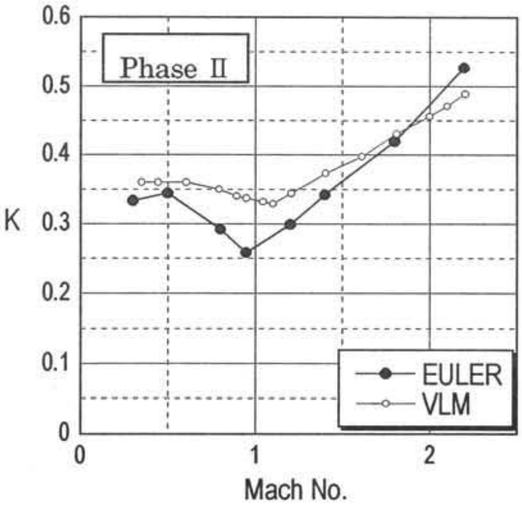


Fig.4 The characteristics of drag due to lift for Phase-II configuration

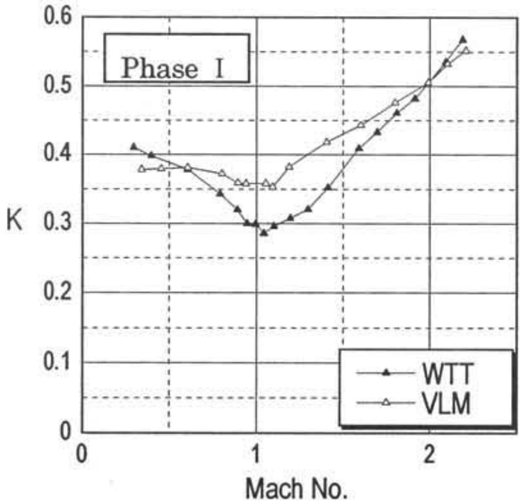


Fig.5 The characteristics of drag due to lift for Phase-I configuration

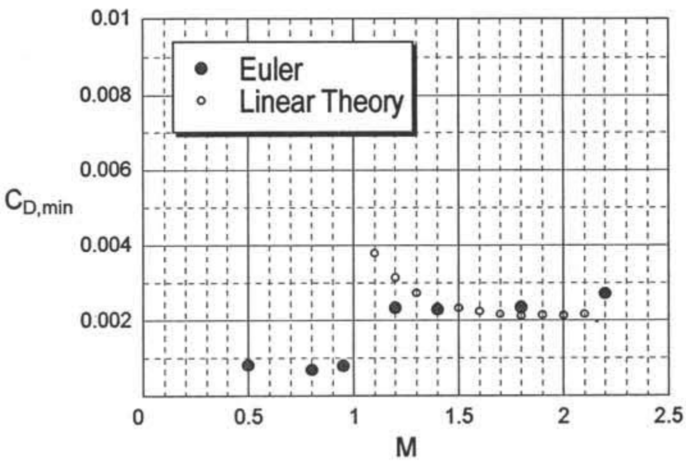
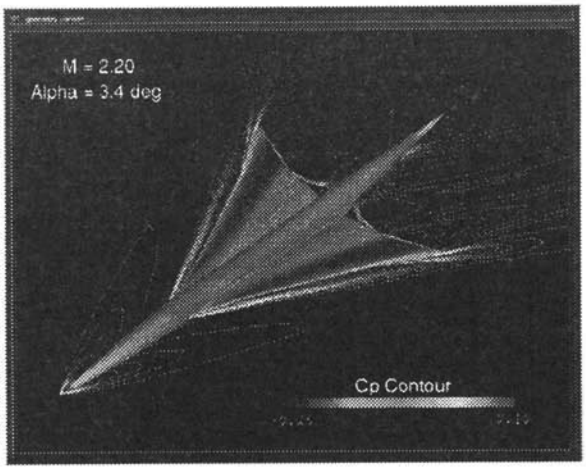
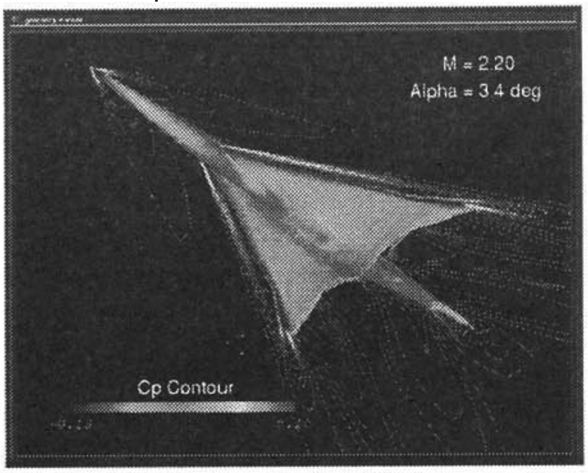


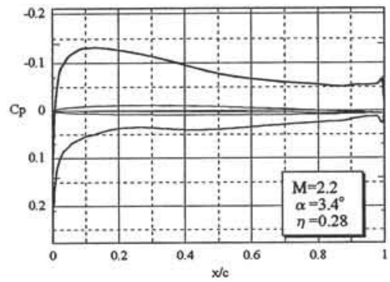
Fig.6 The characteristics of minimum drag for Phase-II configuration



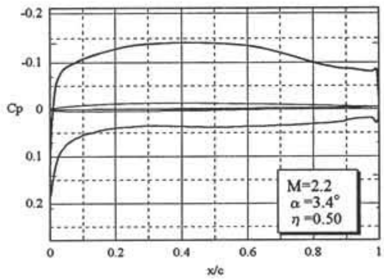
(a) Upper surface



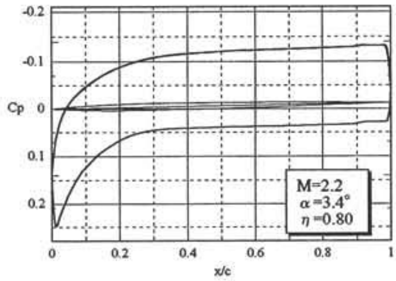
(b) Lower surface



(c) 28%semispan

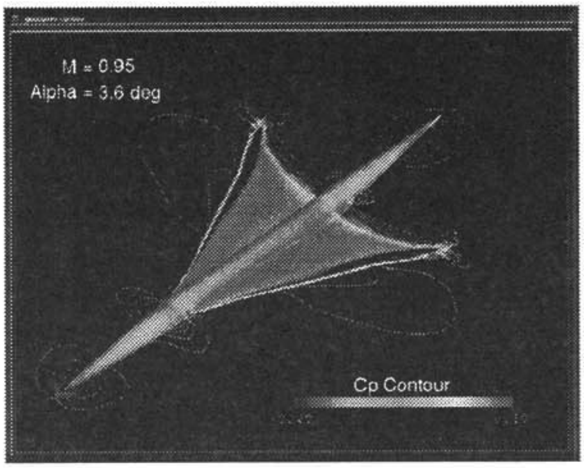


(d) 50%semispan

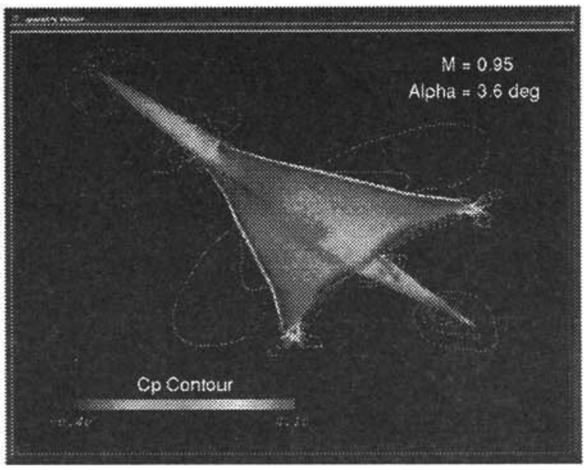


(e) 80%semispan

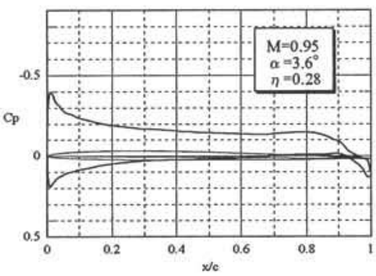
Fig.7 Pressure distribution at M=2.2,alpha=3.4deg.



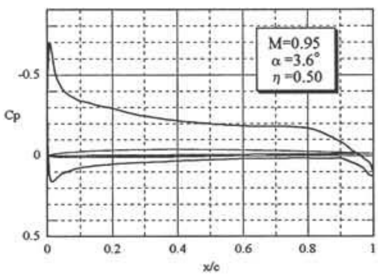
(a) Upper surface



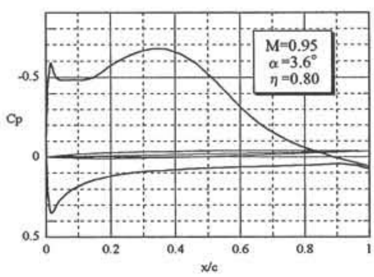
(b) Lower surface



(c) 28%semispan



(d) 50%semispan



(e) 80%semispan

Fig.8 Pressure distribution at M=0.95,alpha=3.6deg.