Evolutionary Computation of Supersonic Wing Shape Optimization

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1 INTRODUCTION

To respond future increase of air traffic demand, development of next generation supersonic transport is considered worldwide. Aerodynamic design of such aircraft must account for drag reduction as well as sonic boom reduction. However, drag reduction is in conflict with sonic boom reduction. Since acceptability of supersonic transport is very sensitive to the sonic boom over populated areas, one of the design choices is to limit supersonic flight over sea and to enforce transonic flight over land. Although such decision excludes the sonic boom from the design consideration, the designer now has to face transonic performance of the supersonic aircraft.

Thereore, this paper considers multipoint aerodynamic optimization of a wing shape for supersonic aircraft both at the supersonic cruise condition and at the transonic cruise condition. Aerodynamic drag will be minimized at both cruise conditions under lift constraints. Aerodynamic optimization of the wing planform, however, drives the wing to have an impractically large aspect ratio. Therefore, minimization of the wing root bending moment is also considered as a third design objective.

2 RESUTLS

Flow conditions are $M_\infty = 2.0$ and $C_L = 0.1$ for supersonic cruise and $M_\infty = 0.9$ and $C_L = 0.15$ for transonic cruise. The supersonic inviscid drag is evaluated by using an Euler flow solver (Obayashi et al. 1998). The transonic inviscid drag is evaluated by using a full potential flow solver (Jameson and Caughey, 1977). The bending moment is evaluated by directly integrating the pressure load at the supersonic cruise condition. Wing shapes are represented by in total of 66 design variables.

Thre present MOGA uses the Pareto ranking, fitness sharing and best-*N* selection (Obayashi, Takahashi and Takeguchi, 1998). Flow calculations were parallelized on 32 PE's of NEC SX-4 computer at Computer Center of Tohoku University, using the simple *Master-Slave* concept. The populations size was set to 64 and 50 generations were run. To constrain the lift coefficient, three flow calculations were used per drag evaluation. The total computational time was roughly 70 hours.

Figure 1 presents a sample planform shape of the optimized wings that perform better in all three design objectives than the existing wing designed at National Aerospace Laboratory optimized only by using the linearized theory (Iwamiya, 1998).

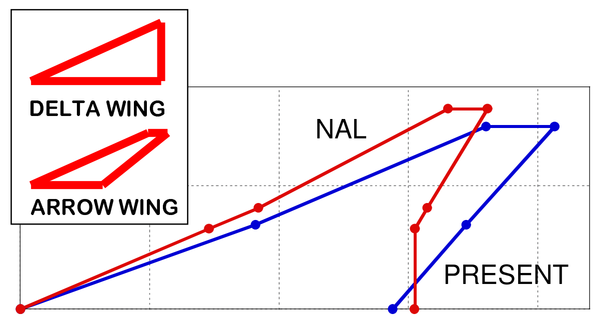

Figure 1: Comparison of one of palnform shapes of the present Pareto solutions with the NAL design

Detailed tradeoff study using the present Pareto front revealed that the wing planform shape should be changed to the arrow shape instead of the delta shape to improve the aerodynamic performance of the NAL design.

References

T. Iwamiya (1998). NAL SST Project and Aerodynamic Design of Experimental Aircraft, In *Proceedings of the Fourth ECCOMAS Computational Fluid Dynamics Conference*, 580-585. Chichester, UK: John Wiley & Sons.

A. Jameson and D. A. Caughey (1977). A Finite Volume Method For Transonic Potential Flow Calculations. AIAA paper 77-677, Washington, DC: American Institute of Aeronautics and Astronautics.

S. Obayashi, K. Nakahashi, A. Oyama and N. Yoshino (1998). Design Optimization of Supersonic Wings Using Evolutionary Algorithms. In *Proceedings of the Fourth ECCOMAS Computational Fluid Dynamics Conference*, 575-579. Chichester, UK: John Wiley & Sons.

S. Obayashi, S. Takahashi and Y. Takeguchi (1998). Niching and Elitist Models for MOGAs. In *Parallel Problem Solving from Nature - PPSN V*, 260-269, Lecture Notes in Computer Science. Berlin, Germany: Springer.