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Generation of dynamic grids and computation of unsteady transonic flows around assemblies

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KEYWORDS

Transonic flow;
Unsteady flow;
Full-potential equation;
Assembly;
flight delays
(About 5–8 words separated with ";". Use small letters except technical terms. Abbreviations should contain full name with abbreviation included in parentheses. Selection of 1–2 from EI controlled term list is preferred.)

Abstract

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Low service ability of an airfield area causes frequent air traffic congestion and flight delays at busy airports. The airport system calls for capacity and efficiency improvements urgently to relieve the current congested situation. In this work, an optimization approach for the collaborative operating modes of multi-runway systems is proposed to balance the demand and capacity. Based on the theory of runway capacity envelope, a corresponding optimization model is established by introducing the capacity loss coefficient which objectively reflects the mode switching characteristics. Then an elitist non-dominating sorting genetic algorithm is designed combined with the mul-ti-objective optimization theory, Compared with the single runway mode, the combined runway modes bring about a striking optimization effect which results in a 38.1% reduction in the cost of flight delays and a 46.4% decrease in the quantity of adjusted flights. The approach provided can significantly enhance collaborative operating efficiency of a multi-runway system, and effectively improve air traffic punctuality.

1. Introduction

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The computation method of unsteady transonic flow based on N-S equations should be best accurate, but to three-dimensional complex problems, it can be achieved only on large computers, and moreover, the results are not ideal sometimes [1]. A viscous/inviscid interaction method is an applicable one and the computation time can be reduced by two orders.

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2. Computation scheme

2.1. Governing equation

2.1.1. Principle

The unsteady full-potential equation written in a body fitted coordinate system is given by

$$(\rho \boldsymbol{J})_\tau + (\rho U \boldsymbol{J})_\xi + (\rho V \boldsymbol{J})_\eta + (\rho W \boldsymbol{J})_\zeta = 0 \tag{1}$$

where ρ is density, U, V, and W are the contravariant velocity components in the ξ, η, and ζ directions, τ means time, and $\boldsymbol{J}$ is Jacobian. Eq. (1) is solved by the time-accurate approximate factorization algorithm and internal Newton iterations[2]; body conditions and wake conditions are implicit embedded.

2.2. Generation of grids

Taking the incompressible potential flow round a cylinder for example, the stream function is

$$\psi = V_\infty \left(r - \frac{a^2}{r} \right) \sin\theta \tag{2}$$

where a is radius, and v_∞ the velocity of free stream. Magnifying its radius to $a + \epsilon$.

3. Presentation of results

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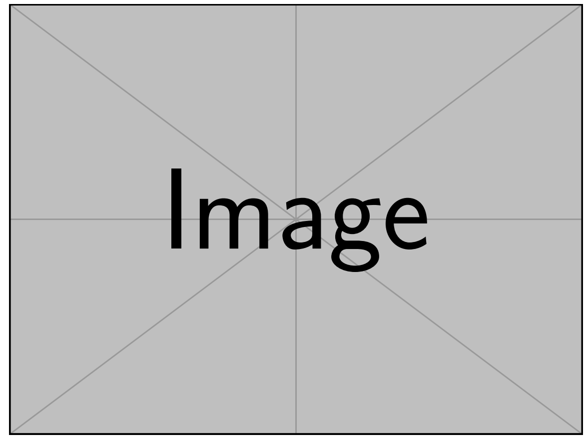

Fig. 1 Actual control input curves

Table 1 CPU time ratio of each term.

Computational term	CPU time (%)
Flow field	32.6
Solid temperature field	2.2
Species concentration field	4.3
Radiation transfer/energy field	60.9

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4. Conclusions

(Conclusion should be summarized in points without tedious description of background, method, etc.)

(1) A rapid method of the generation of boundary-fitted dynamic grids is developed in this paper, and the method of Viscous/Inviscid Interaction is used to compute the unsteady aerodynamic forces on wing/missiles and wing/body with control surfaces.

(2) The computation results are in agreement with experimental data.

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Appendix A. Supplementary material

(Appendix is put behind biography unless otherwise specified. If there are more than one, order them with capitalized letters. If there are equations, order them with letters and numbers, such as "(A1)" and "(A2)".)

$$a + b = c \tag{A1}$$