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DEVELOPMENT OF SPECIALIZED GRID GENERATION PROGRAM FOR EFFICIENT AERODYNAMIC ANALYSIS OF 3-D WINGS USING OPENFOAM FLOW ANALYSIS CODES

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ABSTRACT

This work describes a grid generation program which is under development in authors' laboratory and would enable its users to generate grid system around 3D wings easily and efficiently for flow analysis by using OpenFOAM flow solvers. Key features of current system include its problem-oriented feature which could exclude many chores required for users in generating 3D wing grid system according to general procedure, and deformation of wing geometry and grid system as its consequence are also included. This paper describes and demonstrates how the grid system is initially generated and exported as grid file with proper boundary conditions attached for OpenFOAM solvers, and briefly shows how the grid system is efficiently deformed with grid quality maintained properly.

Keywords: wing design, geometry optimization, wing aerodynamics, grid generation.

INTRODUCTION

Lifting force of a fixed wing aircraft is mostly produced by the wings attached to fuselage, and optimal design of their geometrical shape is very important to achieve better aerodynamic performance of the aircraft. In developing a new aircraft, engineers need to model and analyze different combination of wing shape parameters in several senses, and it would require iterative and repeated analysis of 3D wing aerodynamics. Computational Fluid Dynamics (CFD) approach offers a good alternative analysis method replacing experimental approach for such an iterative procedure. The geometry of aircraft wings can vary according to the selection of those shape parameters in their planform geometry as well as cross-sectional airfoil shape. For the usage of CFD codes, the user firstly generates proper grid system around the wing geometry as a pre-requisite process, and it is definitely beneficial to have efficient way to prepare proper grids for each variation of shape parameters with reasonable quality.

OpenFOAM is a collection of sub-procedures or modules for the solution of partial differential equations governing flow phenomena (OpenCFD Ltd., 2004), and it is an outcome of open-source movement in the field of Computational Fluid Dynamics (CFD). The user community of OpenFOAM is growing rapidly and getting widely-spread all over the world mainly due to one of its strong advantages, so-called free-of-charge for acquiring and using it. Many users are utilizing OpenFOAM solvers to solve their own engineering problems or to produce data for their research works. This study is focused on developing grid generation program which would enable its users to generate grid system around 3D wings of structured type easily and efficiently for flow analysis by using OpenFOAM flow solvers. Once the input parameters for wing shape and domain boundary are given, the structured grids are generated by using hyperbolic-type marching method which can maintain grid orthogonality at the wing surface meanwhile keeping overall smoothness (Byoungsoo, 1994). The program also automatically produce boundary conditions which are required to be assigned to each patches of domain boundary usually in the earlier part of solution procedure.

RESULTS AND CONCLUSIONS

A screen shot of the grid generation program is shown in Fig. 1. It is programmed by using JAVA language and JOGL library. The program can be run either as a local execution file or as a web-based remote applet. Structured grids for aerodynamic analysis of wing can have different topology, and Fig. 2 shows two typical grid types, that is, O-O type and C-O type grids which are generate by using the current program with minimized user interaction for input.

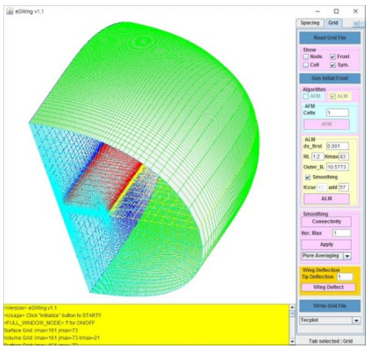

Fig. 1 - Grid generation program

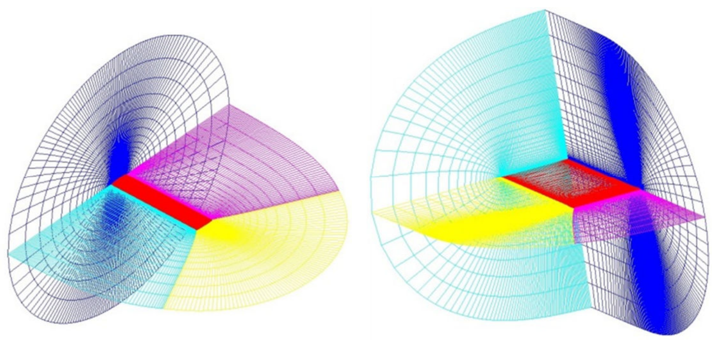

Fig. 2 - Examples of resultant grids (O-O type and C-O type)

This study shows that the developed program can be used to study wing aerodynamics and its selling point is that it can be integrated with OpenFOAM flow solvers which would enable iterative analysis with different shape parameters in a quite automatic sense, and the current approach would be applied to the optimal design of wings.

ACKNOWLEDGMENTS

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