Development of the Planar Inlet Design and Analysis Process (PINDAP)

Christopher R. Gruber
University of Notre Dame
Aerospace Engineering
Undergraduate, Junior
Mentor: Dr. John W. Slater

PROJECT SUMMARY

The aerodynamic development of an engine inlet requires a comprehensive program of both wind tunnel testing and Computational Fluid Dynamics (CFD) simulations. To save time and resources, much "testing" is done using CFD before any design ever enters a wind tunnel.

The focus of my project this summer is on CFD analysis tool development. In particular, I am working to further develop the capabilities of the Planar Inlet Design and Analysis Process (PINDAP). "PINDAP is a collection of computational tools that allow for efficient and accurate design and analysis of the aerodynamics about and through inlets that can make use of a planar (two-dimensional or axisymmetric) geometric and flow assumption."[1] PINDAP utilizes the WIND CFD flow solver, which is capable of simulating the turbulent, compressible flow field.

My project this summer is a continuation of work that I performed for two previous summers. Two years ago, I used basic features of the PINDAP to design a Mach 5 hypersonic scramjet engine inlet and to demonstrate the feasibility of the PINDAP. The following summer, I worked to develop its geometry and grid generation capabilities to include subsonic and supersonic inlets, complete bodies and cowls, conic leading and trailing edges, as well as airfoils. These additions allowed for much more design flexibility when using the program. This summer, I am working with Dr. Slater to add

1"Planar Inlet Design and Analysis Process (PINDAP)" John W. Slater additional automation capabilities to PINDAP in order to make it more user-friendly so that a non-CFD expert could use PINDAP to design and analyze an inlet, duct, airfoil, etc.

The development focus for this summer is to add several "design modules" to PINDAP which would allow a designer to model an aerodynamic object without the numerous and tedious design inputs previously required. For example, a NACA 4-Digit Series airfoil design module is currently under development. This would allow a designer to inut minimal geometry information such as chord length and 4-digit airfoil number in addition to other grid spacing parameters and then using that information, PINDAP would generate the airfoil geometry and grid for use with CFD simulations. Previously, a designer would have had to individually input all of the curve entities making up the airfoil shape in addition to many other grid and zone parameters. Concurrently with the airfoil design module, a supersonic inlet design module is also being developed. This module will significantly simplify the rather complex task of designing the appropriate inlet geometry as well as simplify the grid generation process for supersonic inlets. This design module could potentially be applied to current design concepts of the Supersonic Business Jet.

Following the addition of several design modules to PINDAP, I will be using the software to run through the design and analysis of an inlet (or airfoil, etc) utilizing all PINDAP components. This will be used as an example case (tutorial) for a PINDAP user's manual that is being written as the software is developed.

Dr. Slater has set the goal of an alpha release of the software to several branch members during the summer, and if all goes according to plan, the months of work on this project will culminate with a beta release to the Inlet Branch sometime in August

2004. These pre-releases will allow branch members to evaluate the software and provide additional input and suggestions prior to the release of version 1.0. A timetable has not been set for that release. Dr. Slater has also begun work on an AIAA (American Institute of Aeronautics and Astronautics) paper on PINDAP which he is planning to submit to one of the upcoming AIAA conferences.