High Speed Blade Screening

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Introduction

Whether you are designing blades for propellers or airfoils for high speed executive jets, as an engineer you must have an efficient tool that is capable of screening and designing custom airfoil shapes over all speeds of operations. An aerodynamic problem that arises (and this is a potential show stopper) is the tendency of the pressure drag to increase by an order of magnitude through the transonic regime of operation. This sudden drag rise depends on such factors as airfoil thickness, camber and angle of attack. For a propeller design, the efficiency can decrease dramatically after reaching a certain helical tip mach number (this limits forward airplane speed and/or available power). For a wing design, the performance of the airplane can be severely limited due to airfoil shapes that were poorly designed and tested across the transonic regime of flight. Engineers can avoid these problems by using VisualFoil Plus, our new software for airfoil analysis.

VisualFoil Plus is an update to version 4.1 that incorporates the capability to analyze airfoils at transonic and supersonic flows. Figure 1 shows the pressure drag rise for a NACA 2412 airfoil as predicted using VisualFoil Plus. The NACA 2412 is a popular airfoil for the wings of general aviation aircraft. It is also used in some propeller designs. Currently, propeller companies design and test propeller blades based on modern (often proprietary) airfoil shapes. Using an airfoil that pushes the drag rise towards the right side of the graph could result in a significant performance boost.

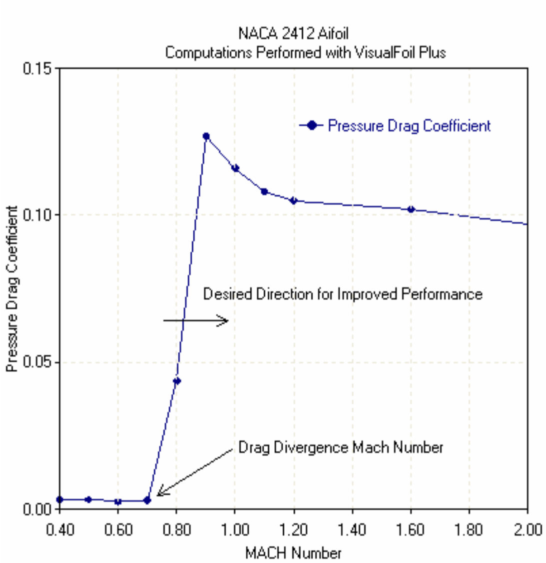


Figure 1: Pressure Drag as a function Mach Number.

VisualFoil Plus to the Rescue

VisualFoil Plus is the perfect screening tool for high speed airfoils. The program is easy-to-use, fast, accurate and has the capability to solve custom airfoils in addition to any of the over 1000 thousand airfoils in its built-in library. Airfoils can also be modified to a more efficient shape using the built-in airfoil modification tools.

The figures below show the detailed solution generated for producing figure 1. A typical run for the Euler solver is about one minute on a Pentium based notebook computer.

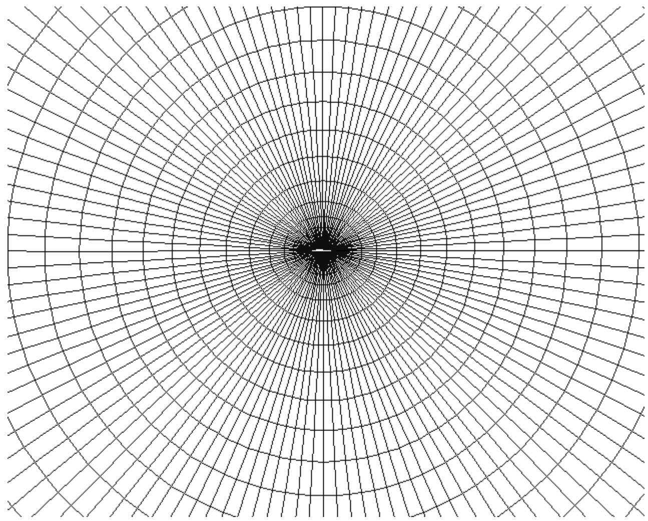


Figure 2: The Computational Grid is Automatically Generated So there is No Need for an External Grid Generation Package.

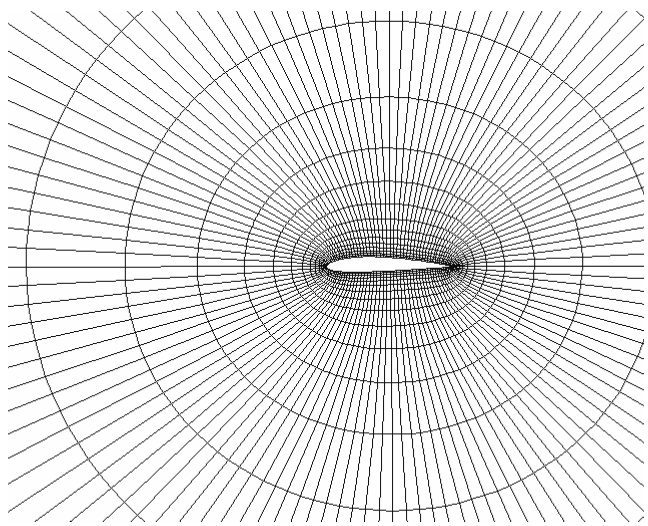


Figure 3: Close-Up of the Grid: The Computational Grid is Generated in less than a second for any of the thousands of airfoil found in VisualFoil Plus.

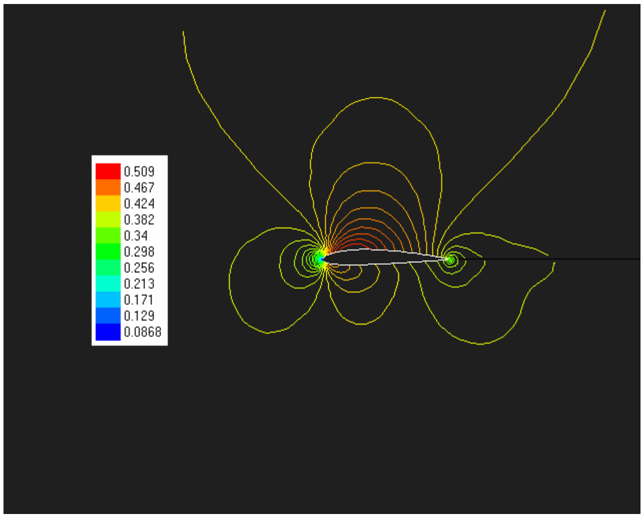


Figure 4: Mach Number Contours for $M_\infty = 0.4$

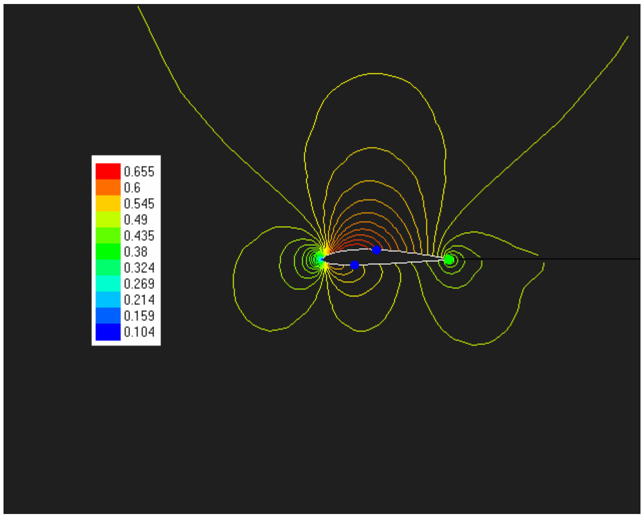


Figure 6: Mach Number Contours for $M_\infty = 0.5$

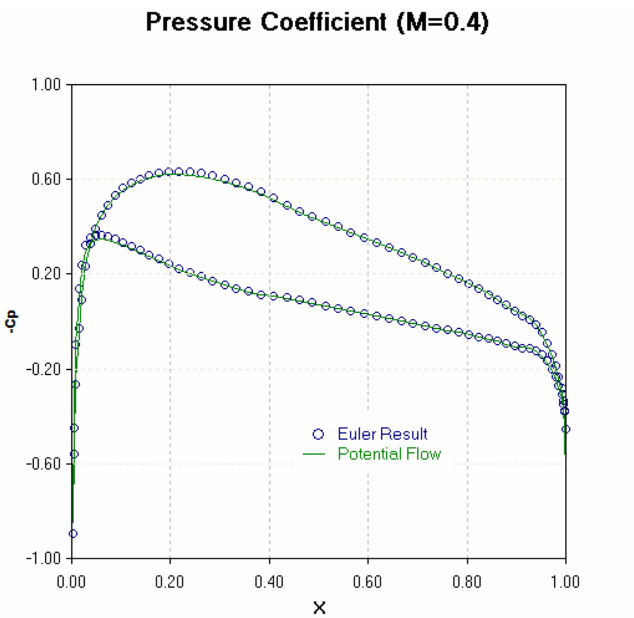


Figure 5: Comparison of Potential & Compressible Solutions at M= 0.40. Note the similarity to the potential flow solution (modified with the Prandtl-Glauert correction factor).

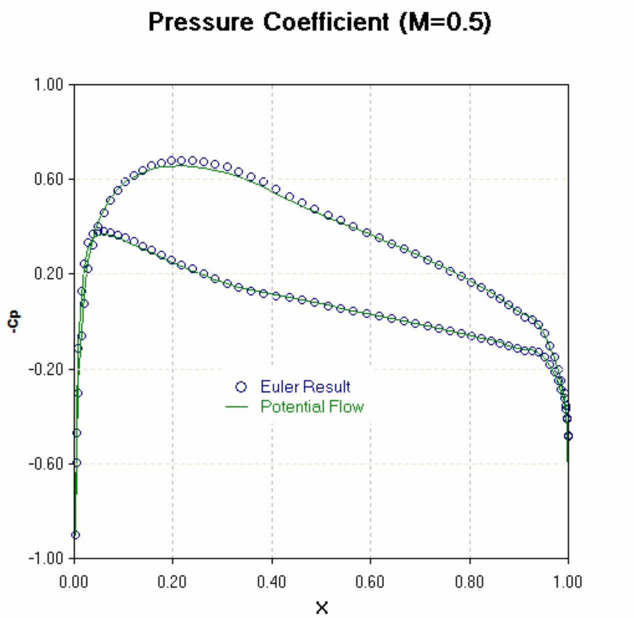


Figure 7: Comparison of Potential & Compressible Solutions at M= 0.50

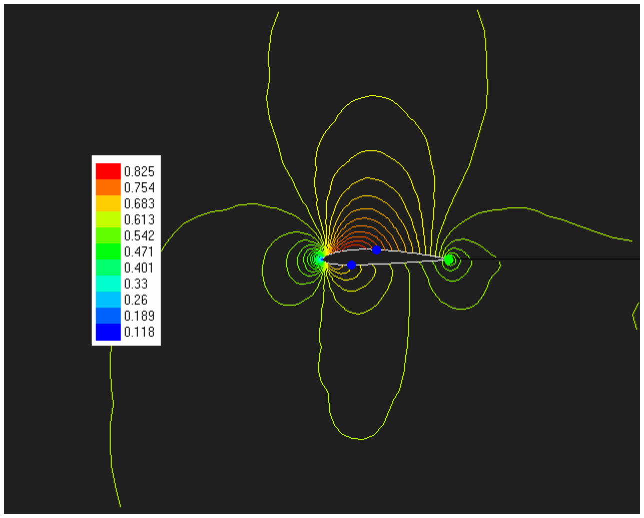


Figure 8: Mach Number Contours for $M_{\infty} = 0.6$

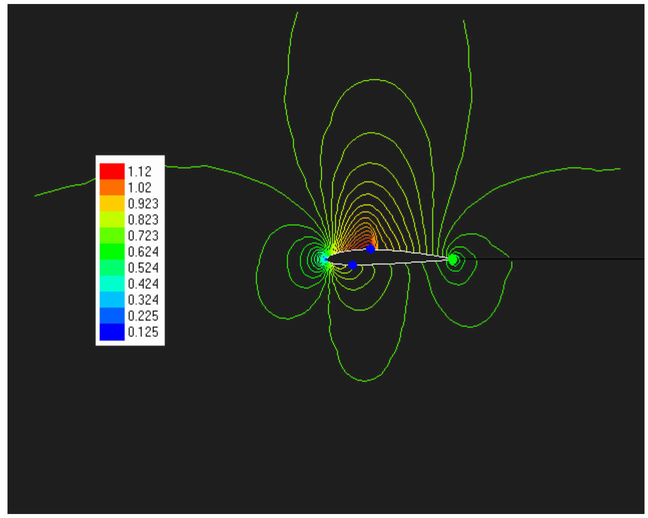


Figure 10: Mach Number Contours for $M_{\infty} = 0.7$

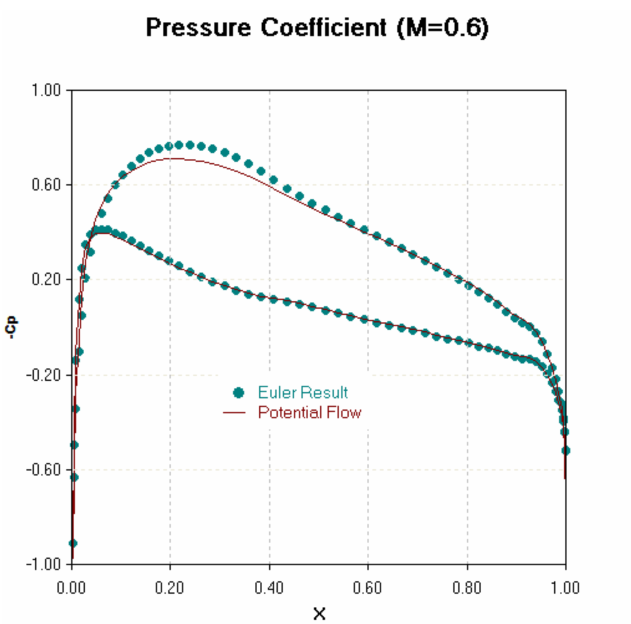


Figure 9: Comparison of Potential & Compressible Solutions at M= 0.60 . The compressible Flow solution begins to diverge from the Potential solution.

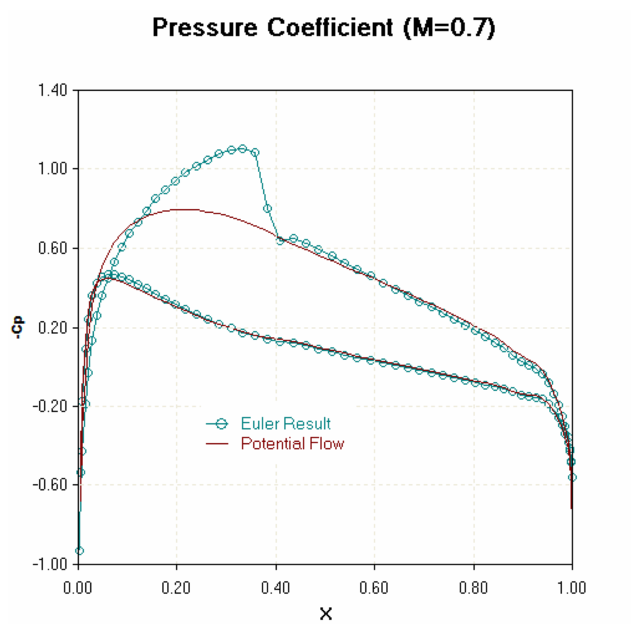


Figure 11: Comparison of Potential & Compressible Solutions at M= 0.70. The figure shows a divergence in the pressure coefficient from the potential solution at the upper surface of the airfoil.

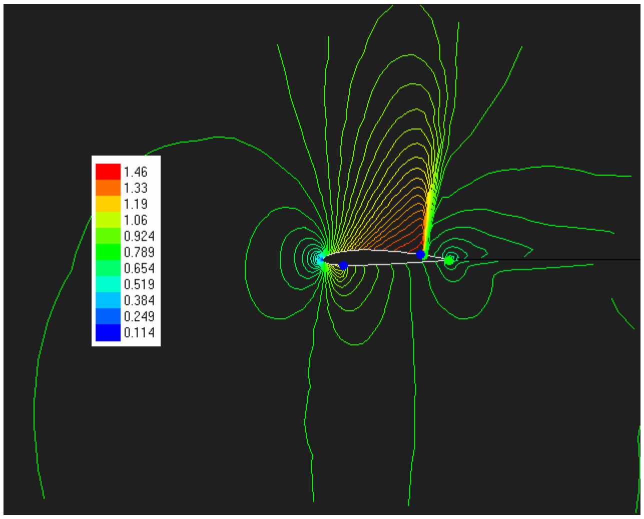


Figure 12: Mach Number Contours for $M_\infty = 0.8$

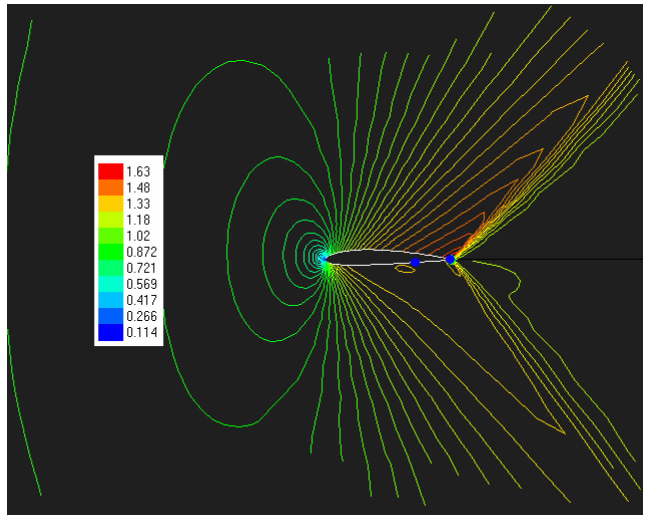


Figure 14: Mach Number Contours for $M_\infty = 1.0$

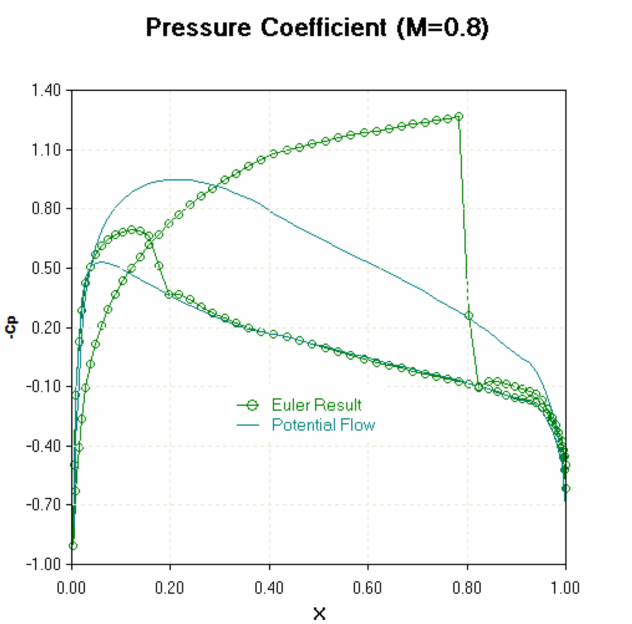


Figure 13: At M=0.8, the compressible pressure coefficient is radically different than the potential theory results on both the upper and lower surfaces of the airfoil.

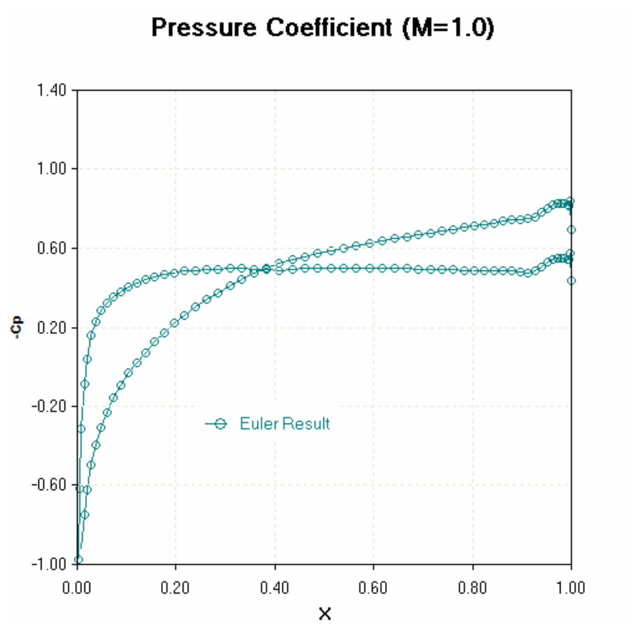


Figure 15: Subsonic Potential theory software can no longer predict the pressure coefficient at M=1.0.

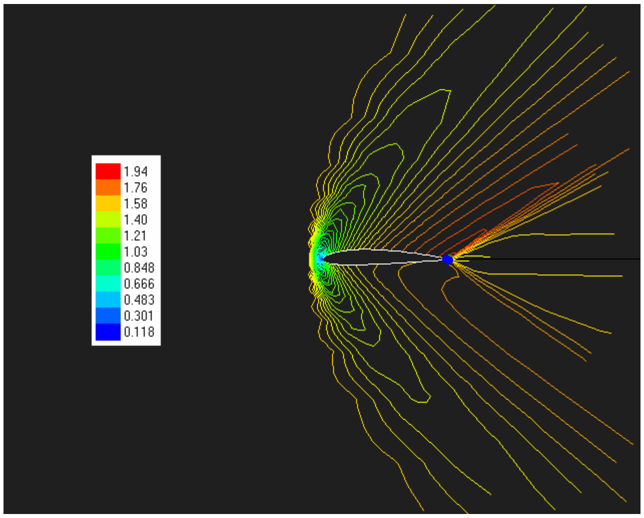


Figure 16: Mach Number Contours for $M_{\infty} = 1.6$

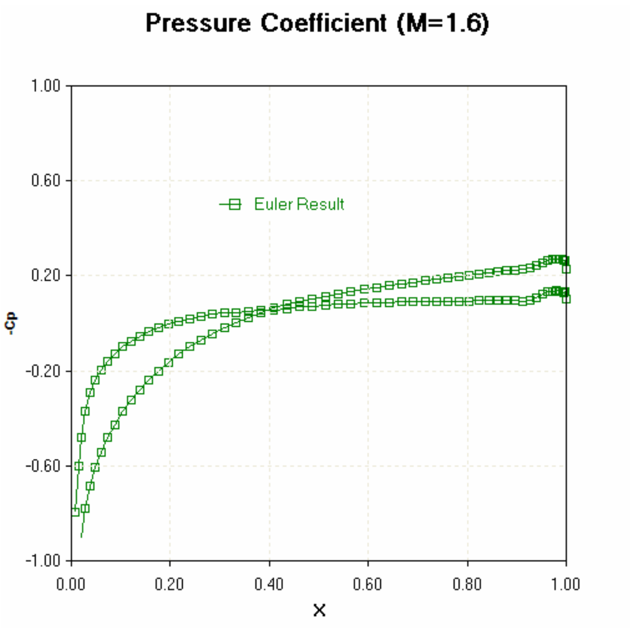
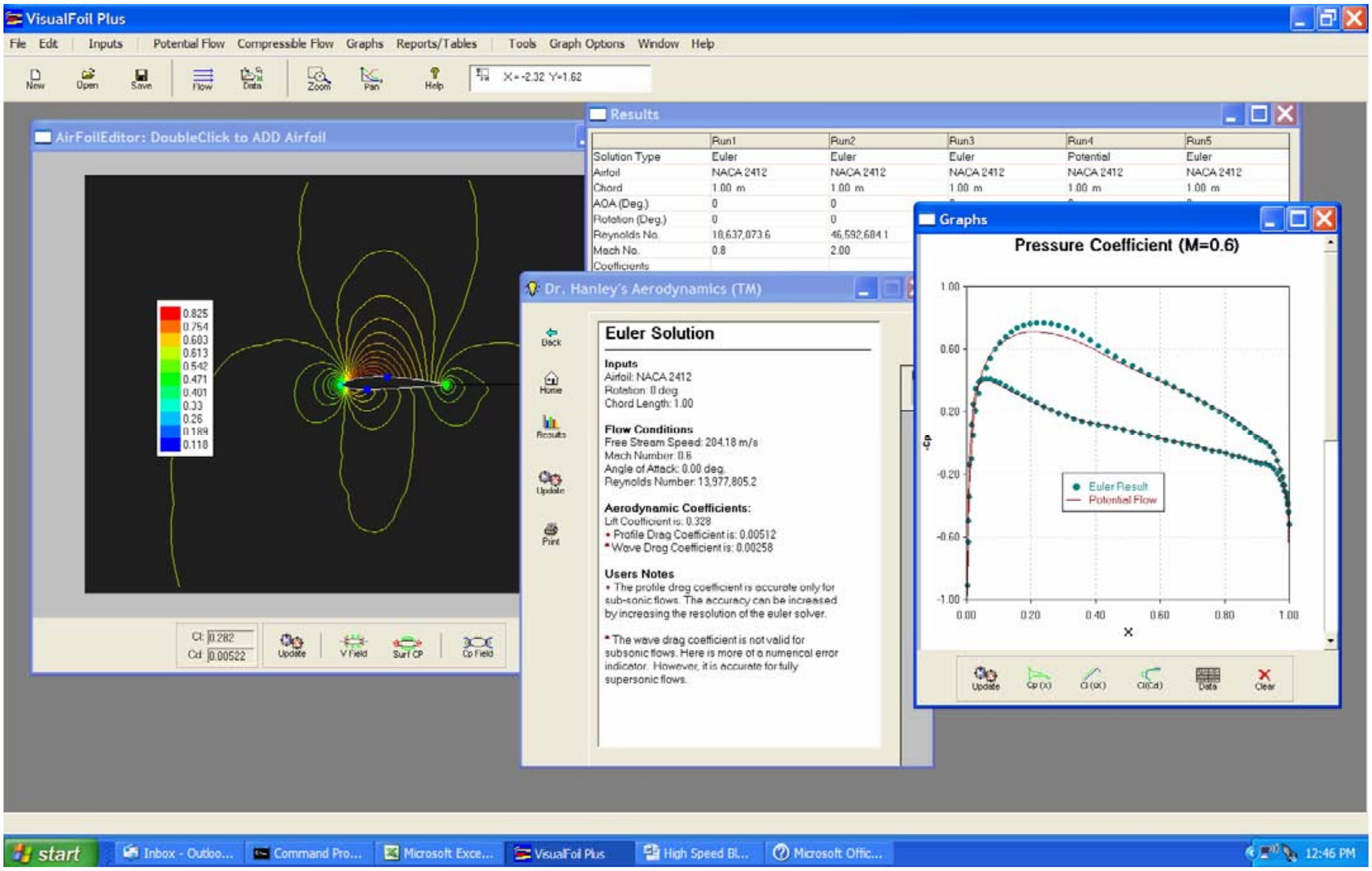
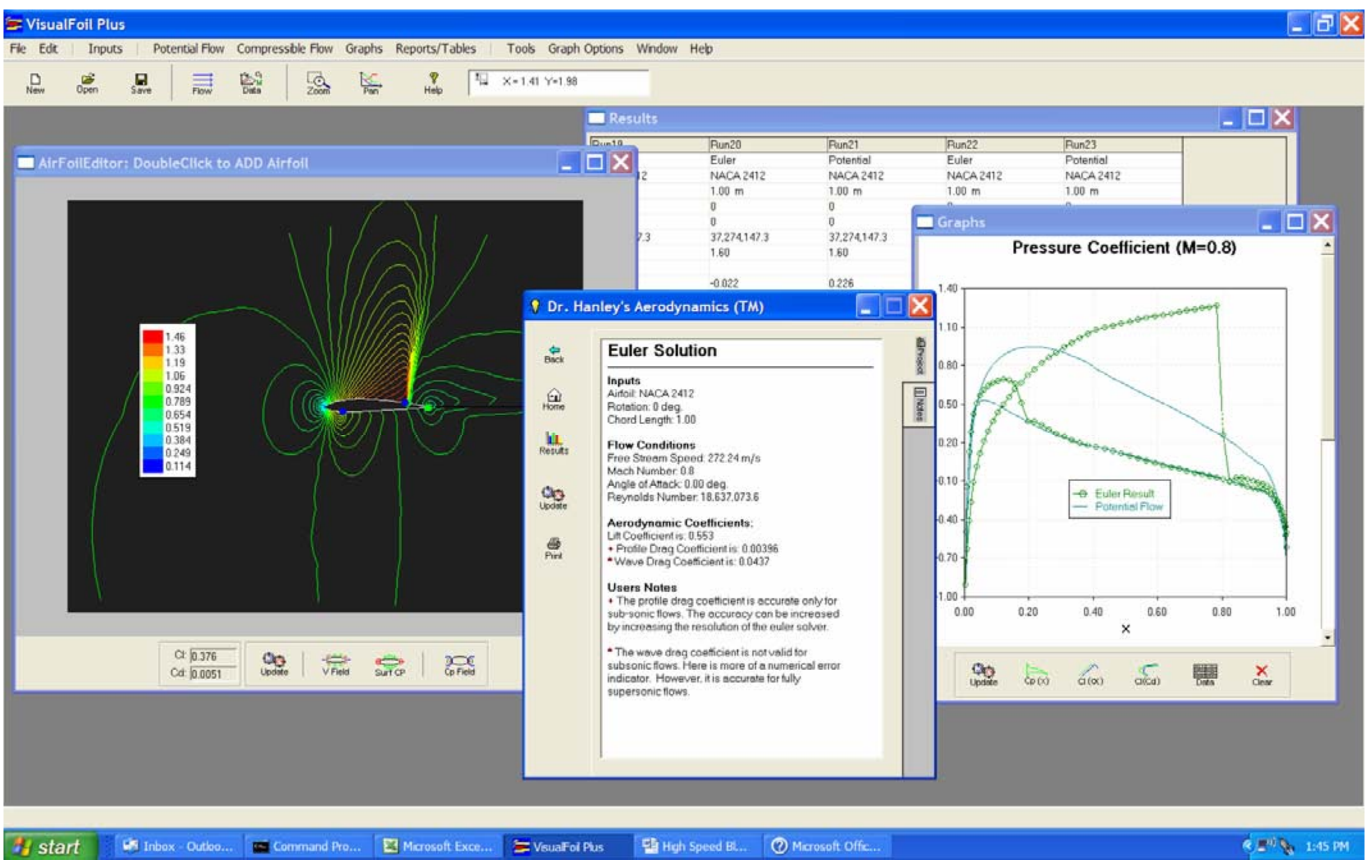


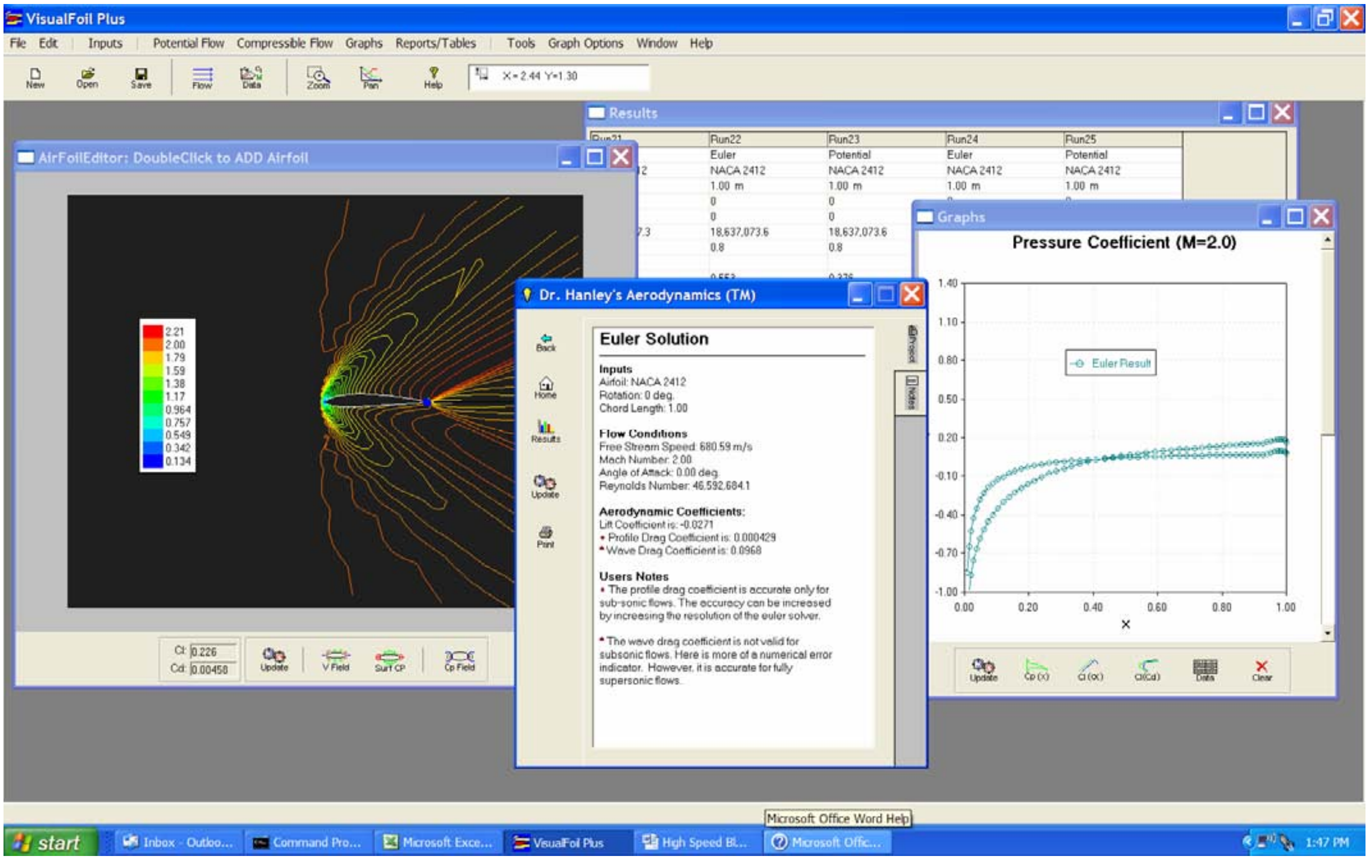
Figure 17: Pressure Coefficient at M=1.6

More Information
More information about VisualFoil Plus can be found at http://www.hanleyinnovations.com. The software is available for $2,995 US for the perpetual license and $695.00 for a monthly lease.
Please see below for screen shots……

Screen Shots






VisualFoil Plus
File Edit Inputs Potential Flow Compressible Flow Graphs Reports/Tables Tools Graph Options Window Help
New Open Save Flow Data Zoom Pan Help
X=2.44 Y=1.30
Results
Run22 Run23 Run24 Run25
Euler Potential Euler Potential
NACA 2412 NACA 2412 NACA 2412 NACA 2412
1.00 m 1.00 m 1.00 m 1.00 m
18,637,073.6 18,637,073.6
0.8 0.8
AirFoilEditor: DoubleClick to ADD Airfoil
2.21
2.00
1.79
1.59
1.38
1.17
0.964
0.757
0.549
0.342
0.134
Cl: 0.226
Cd: 0.00458
Update V Field Surf CP Cp Field
Graphs
Pressure Coefficient (M=2.0)
Euler Result
1.40
1.10
0.80
0.50
0.20
-0.10
-0.40
-0.70
-1.00
0.00 0.20 0.40 0.60 0.80 1.00
X
Update Cp (x) Cl (α) Cl(Cd) Data Clear
Dr. Hanley's Aerodynamics (TM)
Back Home Results Update Print
Euler Solution
Inputs
Airfoil: NACA 2412
Rotation: 0 deg.
Chord Length: 1.00
Flow Conditions
Free Stream Speed: 680.59 m/s
Mach Number: 2.00
Angle of Attack: 0.00 deg.
Reynolds Number: 46,592,684.1
Aerodynamic Coefficients:
Lift Coefficient is: -0.0271
• Profile Drag Coefficient is: 0.000429
• Wave Drag Coefficient is: 0.0968
Users Notes
• The profile drag coefficient is accurate only for sub-sonic flows. The accuracy can be increased by increasing the resolution of the euler solver.
• The wave drag coefficient is not valid for subsonic flows. Here is more of a numerical error indicator. However, it is accurate for fully supersonic flows.
Microsoft Office Word Help
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