TO: Dr. William Mason, and AOE 4124

FROM: Tim Miller

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SUBJECT: How to make a viscous drag and lift polar of a file-saved profile using XFOIL.

These are instructions on how to create a file that saves the viscous drag and lift polars using the XFOIL program written by Mark Drela of MIT. These instructions are useful because the ones supplied in the instruction manual can be difficult to figure out. I did this for my Technical Writing class, which required that I write to a very basic level. Also attached is the coordinate file for a Clark Y airfoil, which shows the proper format to input coordinates into XFOIL.

ASSUMPTIONS

These instructions assume that a Windows operating system is being used. Before getting started it is critical to make sure that if you are using a saved coordinate file for the airfoil profile that you make sure this file is saved in the same folder as the one you have installed the XFOIL program executable in. This file is named xfoilP3.exe, or xfoilP4.exe, depending on which version of the program you've downloaded. If you don't remember where this folder is, you can find it using the "Find -> Files or Folders" option in the Start Menu. This is important because this is the default folder for the program, and as such is where all the outputted data will be saved.

PROCEDURE

1. Start the XFOIL program by either:
   a. double clicking on the xfoil3.exe icon in the Windows Explorer program
   b. double clicking on the xfoil3.exe icon in the Find: Files or Folders program (after have searched for the file)

2. Load the desired airfoil into the XFOIL program by typing at the prompt: load file.suffix (enter) . Where "file" is the name of your coordinate file, and "suffix" is the proper file designation, i.e. "txt", "dat", etc. An example of this would be: load testfoil.txt <enter>

NOTE: As mentioned above, this load will only work if the file testfoil.txt is saved in the same folder as the XFOIL executable.

3. There is a possible error that will occur if you don't have enough points around the Leading Edge (LE). This will indicate that you need to go to the GDES menu, and then enter CADD. I have found that simply hitting (enter) through all the options solves this problem. Then head back to the main XFOIL menu, type PANE. In order to alleviate having to do this each time you load the airfoil, enter SAVE and type in a new name, such as testfoil_smooth.txt

4. Calculate the Reynolds Number that this polar is required for using the equation: Re = *(□Vl)/□*. This is important because most airfoils are entered into XFOIL with a non-dimensional length. Steps 7 and 8 tell XFOIL what flight speed, chord length, and altitude the airfoil is operating at.

5. Calculate the Mach Number using the formula M = V / a . If you don't know the local speed of sound (a) for your altitude you can use the Standard Atmosphere Calculator at: http://www.digitaldutch.com/atmoscalc/index.htm.

6. Enter the operational menu of XFOIL by typing at the prompt: oper (then enter)

7. Enter the viscous mode of XFOIL by typing the visc command followed by the calculated Reynolds number.

E.g.

visc 8.8e5 (enter)

or

visc 880000 (enter)

both set the Reynolds number to 880000. If you type: visc (enter), XFOIL will prompt you to enter the Reynolds Number followed by enter. YOU MUST HAVE CALCULATED A REYNOLDS NUMBER TO USE THE VISCOUS REGIME.

8. Enter the flight Mach number at the prompt with: mach 0.4 (enter). Where 0.4 stands for the Mach number you calculated.

9. Allow XFOIL to output polar data to a file by typing: PACC

10. Enter the (new) filename that the data will be saved to at the following prompt. E.g. clarkY_polar.txt

11. Skip the dump file naming by hitting the enter key. This accumulation is usually superfluous, and clutters up your folder.

12. Direct XFOIL to do an angle of attack (or "alpha") sweep. This can be done in either one step or three. The data required is first angle of attack, final angle of attack, and angle of attack increment.

    An example of the one step is: as -4 18 1 (enter)

    This will start the airfoil at negative four degrees, and proceed to 18 degrees in 1 degree increments. It is important to be conservative in your maximum negative alpha because XFOIL often times has trouble doing the computation. If you simply enter "as" XFOIL will prompt you for the next three numbers.

    b. Another method of accumulating data is a C_L sweep. This method might be more convenient if you are doing complete aircraft polar estimation. To do this is similar; the data required is the first C_L, the final C_L, and the C_L increment.

    An example of the one step is: cs -0.4 1.4 0.1 (enter)

    This will start the airfoil at negative 0.4 C_L, and proceed to 1.4 C_L in 0.1 C_L increments. It is important to be conservative in your maximum negative alpha because XFOIL often times has trouble doing the computation. If you simply enter "as" XFOIL will prompt you for the next three numbers.

NOTE: It is best to shutdown, and then restart the XFOIL program before each polar accumulation. The program remembers the solution to the last alpha or Cl computed, and uses it to aid in the current solution. Thus, too large a jump in alpha, or Cl can cause the solution to not converge. However, XFOIL can do either ascending or descending sweeps, and produce the same results. As yet, XFOIL does not have any corrections to predict the hysteresis of an airfoil.

13. Shut off the polar accumulation by entering: PACC (enter).

14. View the polar by typing PPLO. If you have done several airfoils, and want to compare their polars, type PGET, and then enter the saved polar name and file extension. I.e., if you would enter

testfoil_polar.txt if you wanted to add that previously accumulated polar file to the just calculated clarkY_polar.txt. You have to enter PPLO each time a polar is loaded into XFOIL. PDEL the function that deletes saved polars.

15. Shut down the XFOIL program by hitting the "X" box in the upper right corner of the window.

16. Access the data by double clicking on the filename in the Windows Explorer program. It is often more helpful to view the data in a different program such as EXCEL, Matlab, Mathmatica, etc.

I hope that these instructions prove useful. If you have a problem please email me at timille2@vt.edu. Good luck analyzing your airfoils.