NOZZLE Program

Version 4.0

User Guide

April 2016

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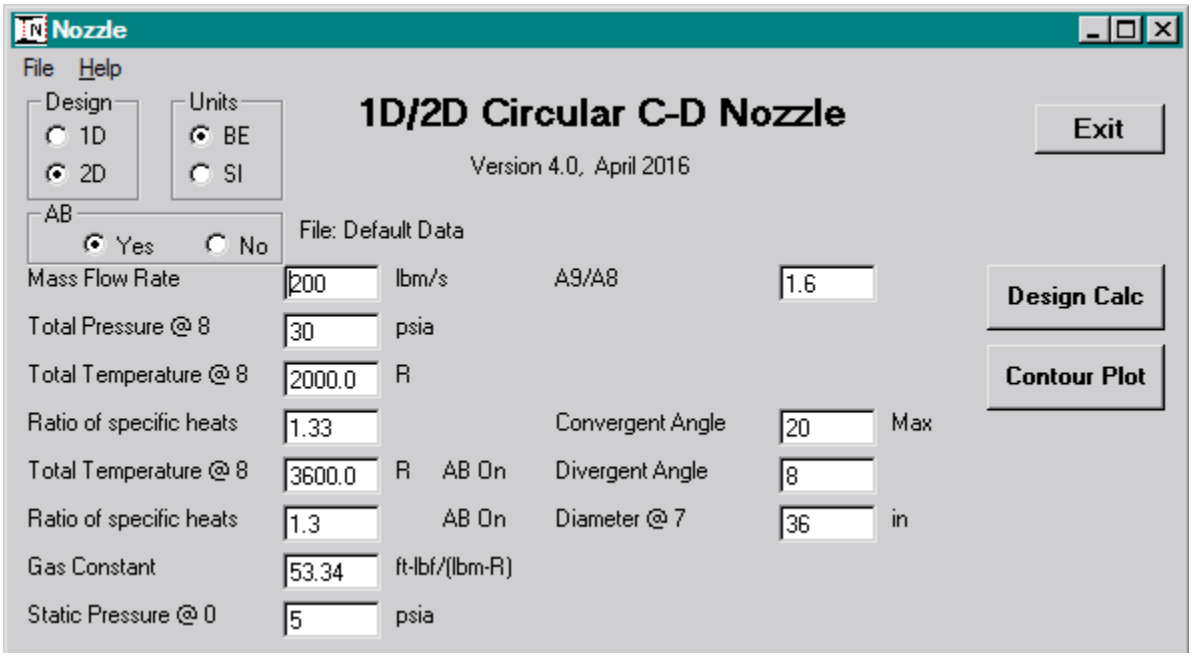
1. MAIN Window

The NOZZLE conceptual design program analyzes both 1-D and 2-D circular convergent-divergent nozzles. It is based on the equations developed in Chapter 10 of *Aircraft Engine Design*, *Second Edition.*

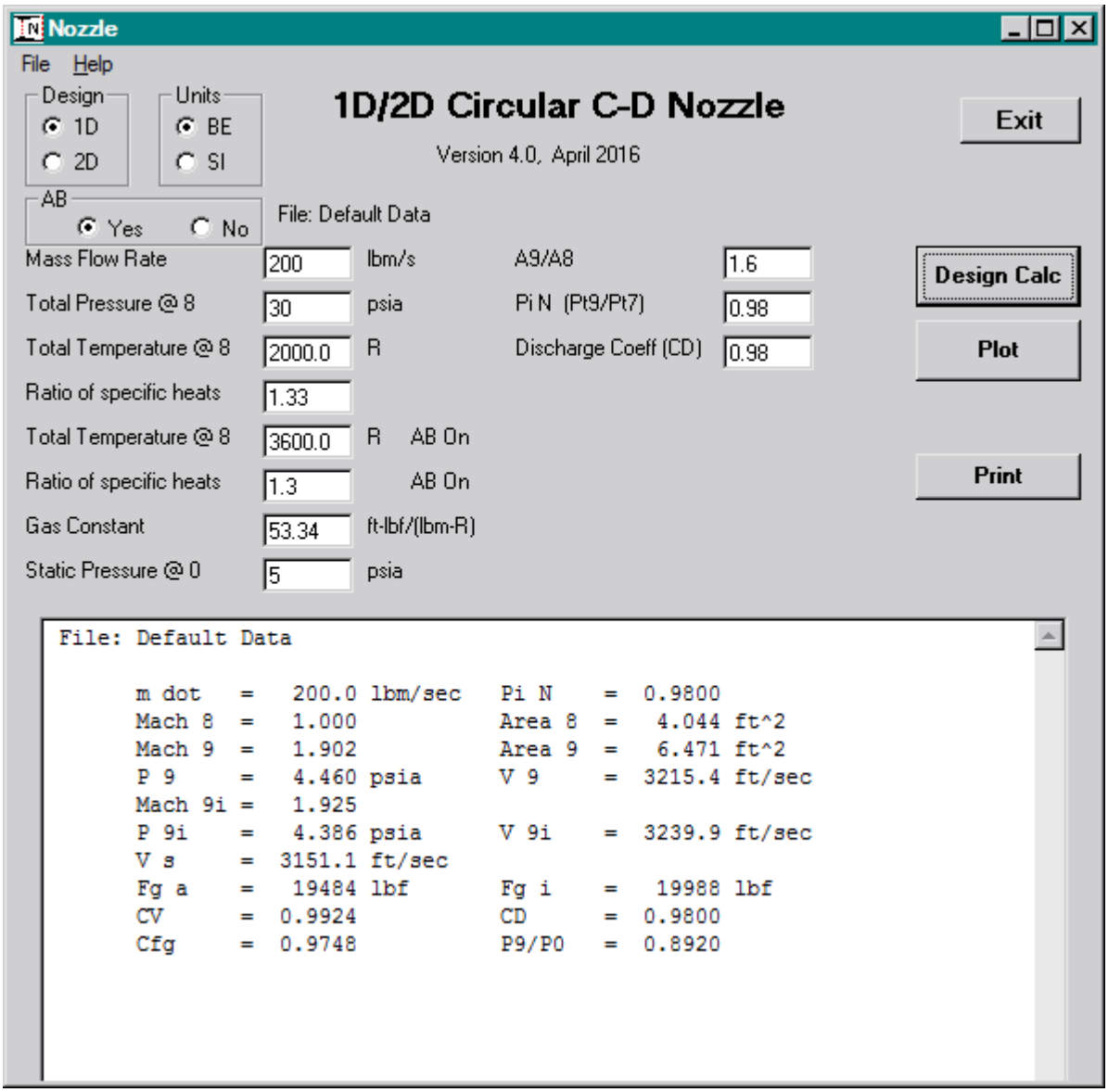
This program is designed to be user-friendly and multiple windows are used for program control and data input. NOZZLE input data files may be saved on disk for later use (the file extension "NOZ" is used for these files). Also, saved input data files may be read from disk for current use. The current data file name is displayed in the upper left of the Main window and in output windows. Program output is directed to output windows and may be sent to a printer.

When the NOZZLE program is run, the Main window is displayed. The top of the Main window is shown below.

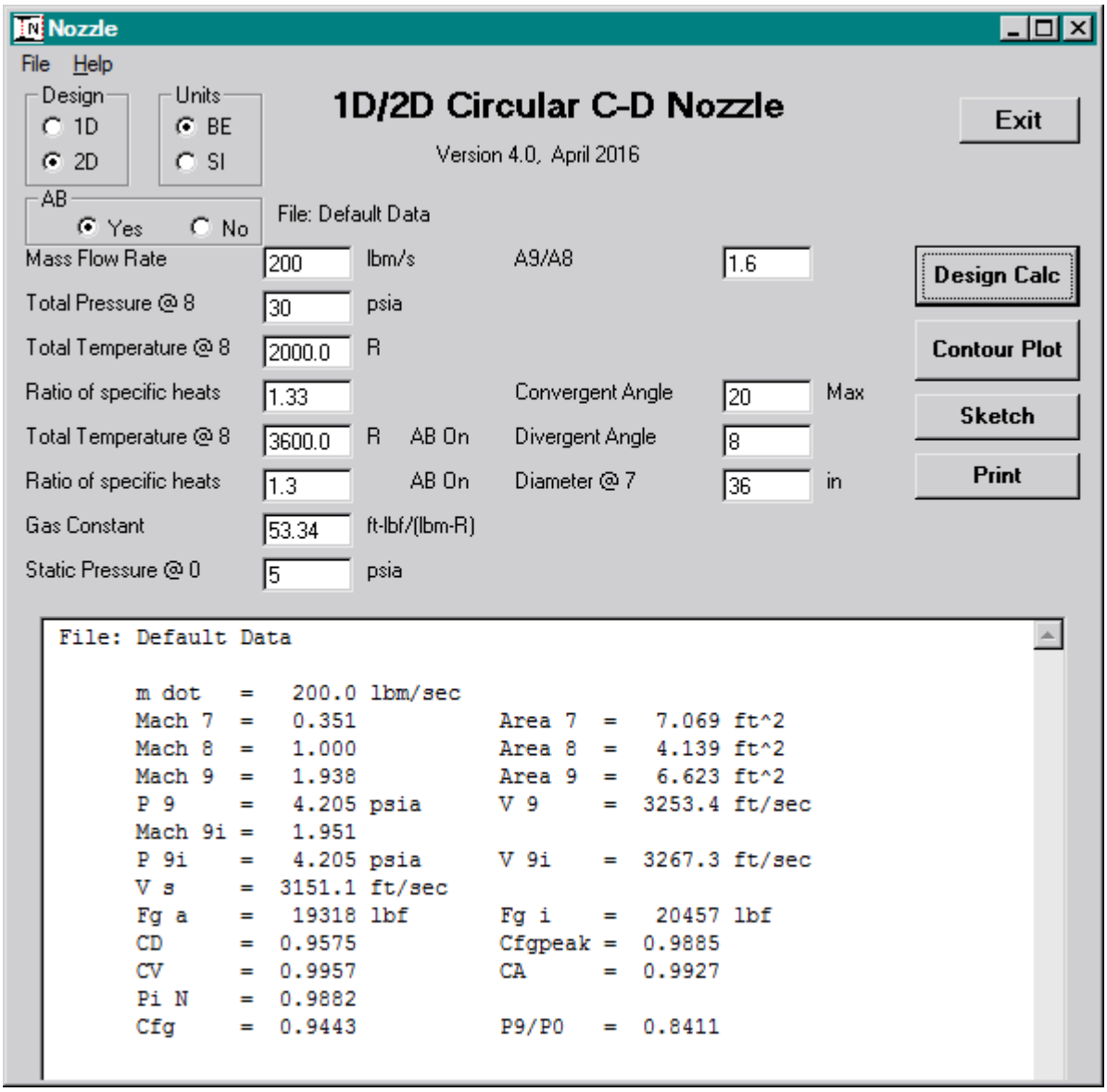


2. Design Calculation

Pressing the **Design Calc** button causes the program to calculate the nozzle performance using the input design data and displaying the results in the output window. The one-dimensional (1-D) analysis has only dimensions normal to the flow direction (flow areas) and does not have length dimensions. The results for a 1-D circular nozzle are shown below.

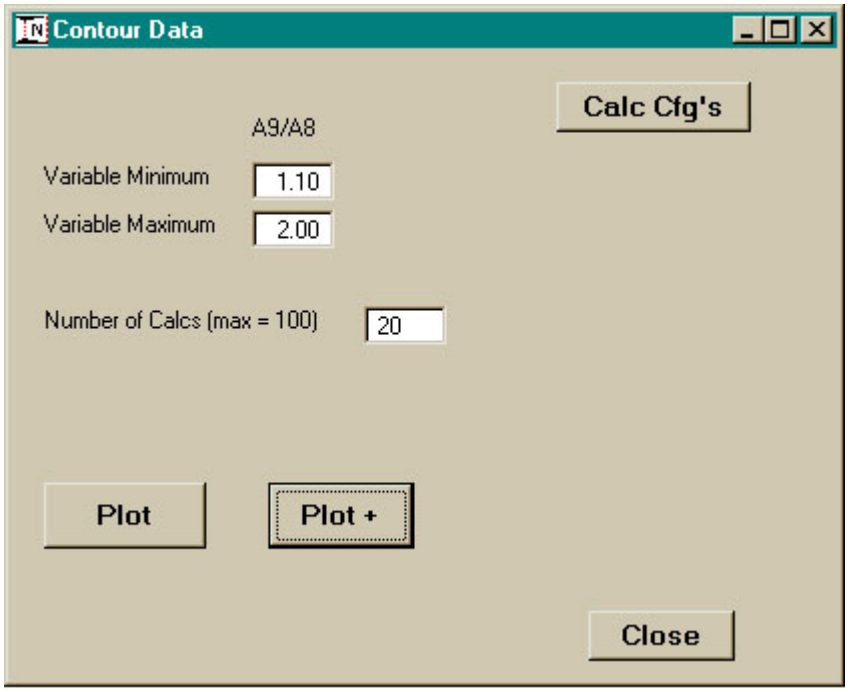


The two-dimensional (2-D) analysis has both dimensions normal to the flow direction (flow areas) and length dimensions. The results for an example 2-D circular convergent-divergent nozzle are shown below. Note that the nozzle can be sketched for the 2-D analysis.

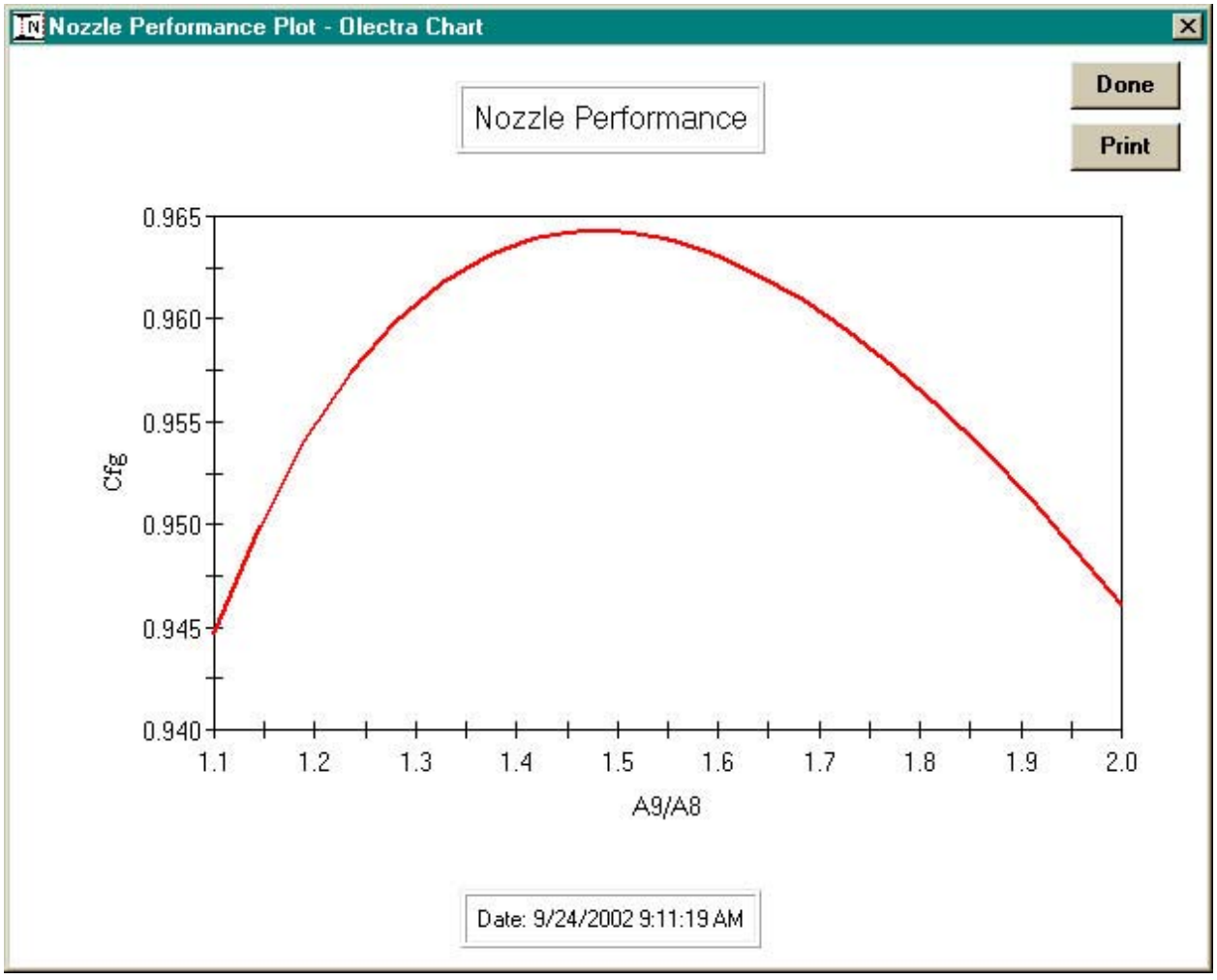


3. Gross Thrust Coefficient Contours

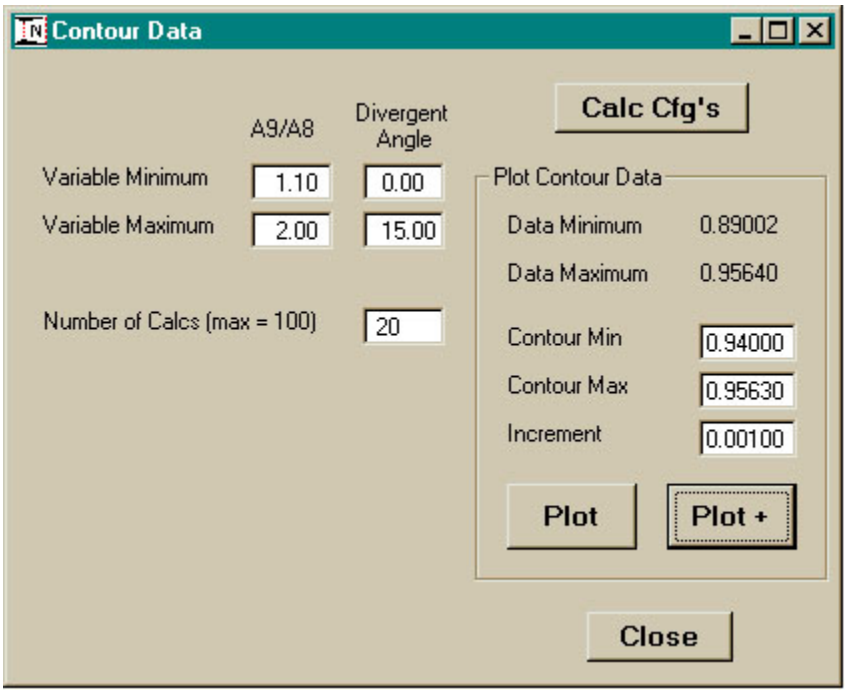
The variation of the gross thrust coefficient (C_{fg}) with design variable(s) can be calculated and presented using the **Contours/Plot** button. The following data window is displayed for the 1-D circular nozzle. The **Plot** and **Plot+** buttons become active after the **Calc Cfg's** button has been pressed and the performance calculated. Similar to the INLET program, the **Plot** button displays a plot where the mouse arrow becomes a cross-hair when the user moves the mouse across the plot. This feature allows the user to capture and display at the bottom of the screen the coordinates and total pressure value by pressing the left mouse button. Pressing the **Plot+** button produces an Olectra Chart plot of the gross thrust coefficient versus nozzle area ratio.



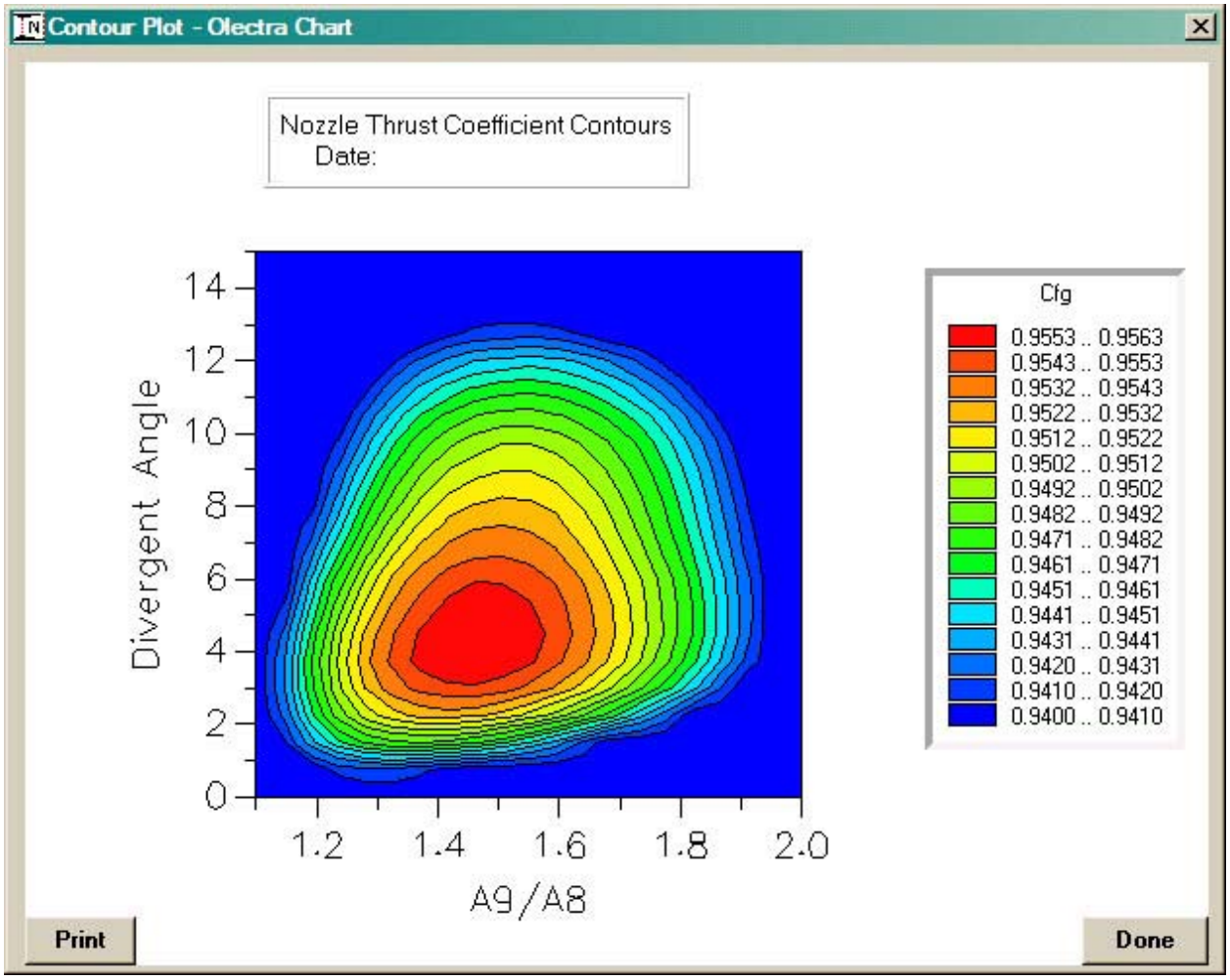
The plot generated by the **Plot+** button for the 1-D circular convergent-divergent nozzle is shown below.



The following data window is displayed for the 2-D circular nozzle when the **Contours/Plot** button is pressed.



After the **Calc Cfg's** button is pressed, values of the gross thrust coefficient are calculated over the input ranges of the area ratio and divergent angle. The **Plot** and **Plot+** buttons also become active. Similar to the INLET program, the **Plot** button displays a contour plot where the mouse arrow becomes a cross-hair when the user moves the mouse across the contour plot. This feature allows the user to capture and display at the bottom of the screen the coordinates and gross thrust coefficient value by pressing the left mouse button. Pressing the **Plot+** button produces an Olectra Chart contour plot of the gross thrust coefficient versus nozzle area ratio and divergent flap angle as shown on the next page.


Contour Plot - Olectra Chart
Nozzle Thrust Coefficient Contours
Date:
Divergent Angle
14
12
10
8
6
4
2
0
1.2
1.4
1.6
1.8
2.0
A9/A8
Cfg
0.9553 .. 0.9563
0.9543 .. 0.9553
0.9532 .. 0.9543
0.9522 .. 0.9532
0.9512 .. 0.9522
0.9502 .. 0.9512
0.9492 .. 0.9502
0.9482 .. 0.9492
0.9471 .. 0.9482
0.9461 .. 0.9471
0.9451 .. 0.9461
0.9441 .. 0.9451
0.9431 .. 0.9441
0.9420 .. 0.9431
0.9410 .. 0.9420
0.9400 .. 0.9410
Print
Done

4. SKETCH Window

After design calculations have been performed for a 2-D circular convergent-divergent nozzle, pressing the **Sketch** button on the Main window opens the Sketch window and displays the outline of the nozzle at the design point as shown below for a nozzle with afterburning. The nozzle without afterburner operation is shown in black and the nozzle with afterburner operation is shown in red. The lengths and radii of the nozzle are given on the left of the sketch. The bit map image on the Sketch Pad can be copied to the Windows clip board by pressing the "Alt" and "PrtSc" keys simultaneously. From the Window's clip board, the image can be pasted into the Paint program and saved to a file for later use.