PARA Program

User Guide

Version 5.0

April 2016

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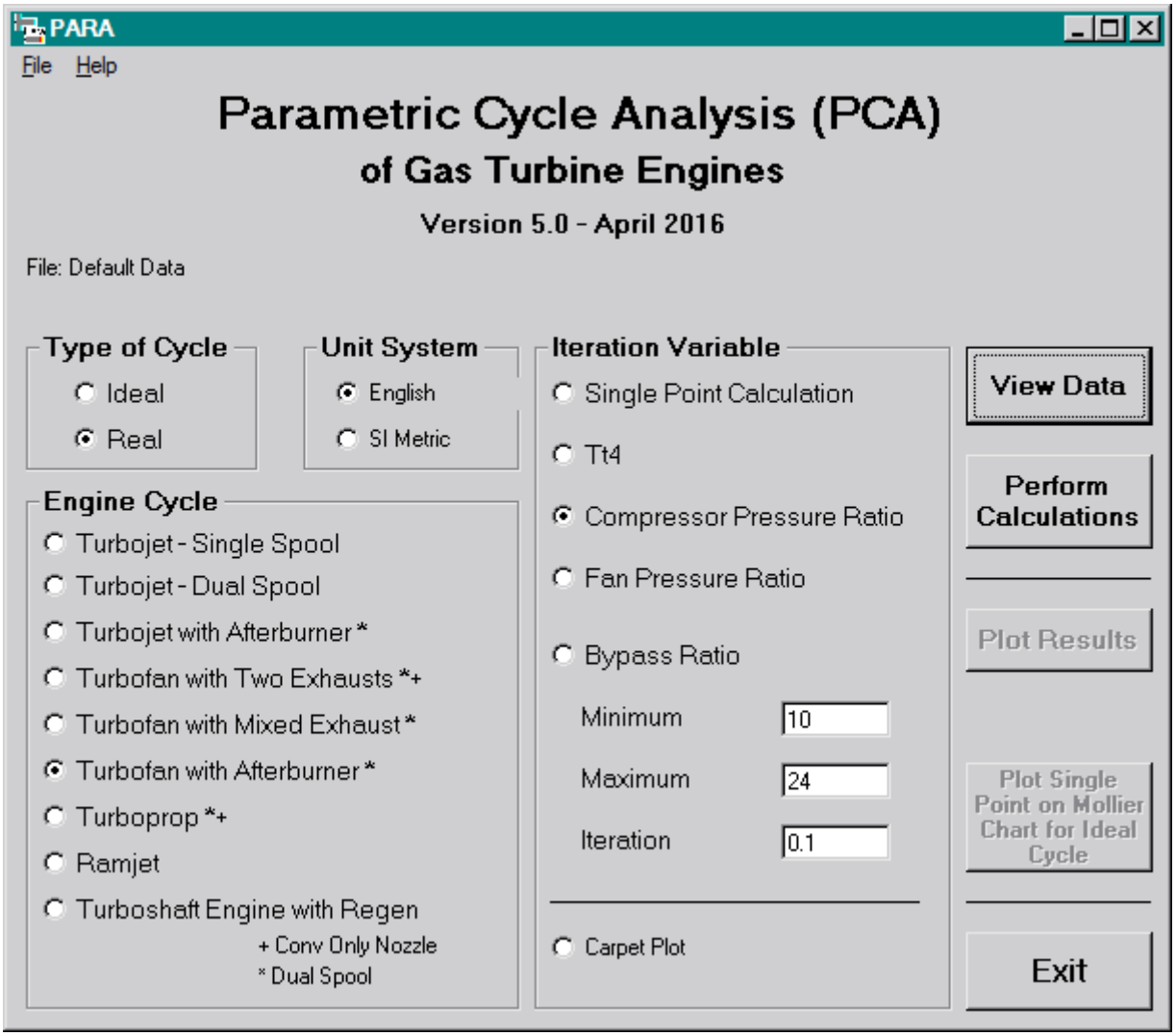
Hint for Data Editing: This program uses edit fields for user editing of each piece of data. The program waits until you enter the “tab” or “enter” key to accept your data entry in that field. Use the “tab” key to move between data edit fields.

1. MAIN Window

When the **PARA** program is run, the default data is loaded and the Main window is displayed as shown below.



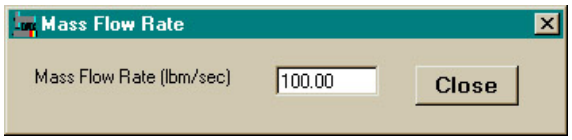
The parametric (on-design) cycle analysis program PARA is based on the equations developed in *Elements of Propulsion, Gas Turbines and Rockets, Second Edition* and can analyze the following seven different engine cycles:

1. Turbojet without afterburner – single spool.
2. Turbojet without afterburner – dual spool.
3. Turbojet with afterburner – dual spool.
4. Turbofan with separate exhausts (convergent-only exhaust nozzles) – dual spool.
5. Turbofan with mixed exhaust and no afterburning – dual spool.
6. Turbofan with mixed exhaust and afterburning – dual spool.
7. Turboprop (convergent-only exhaust nozzle) – dual spool.
8. Ramjet

Each of these cycles can be analyzed using ideal or real cycle model, the user-selected unit system (English or SI), and ideal (perfect) gas model {two choices: constant specific heat (CSH) or modified specific heat (MSH)}.

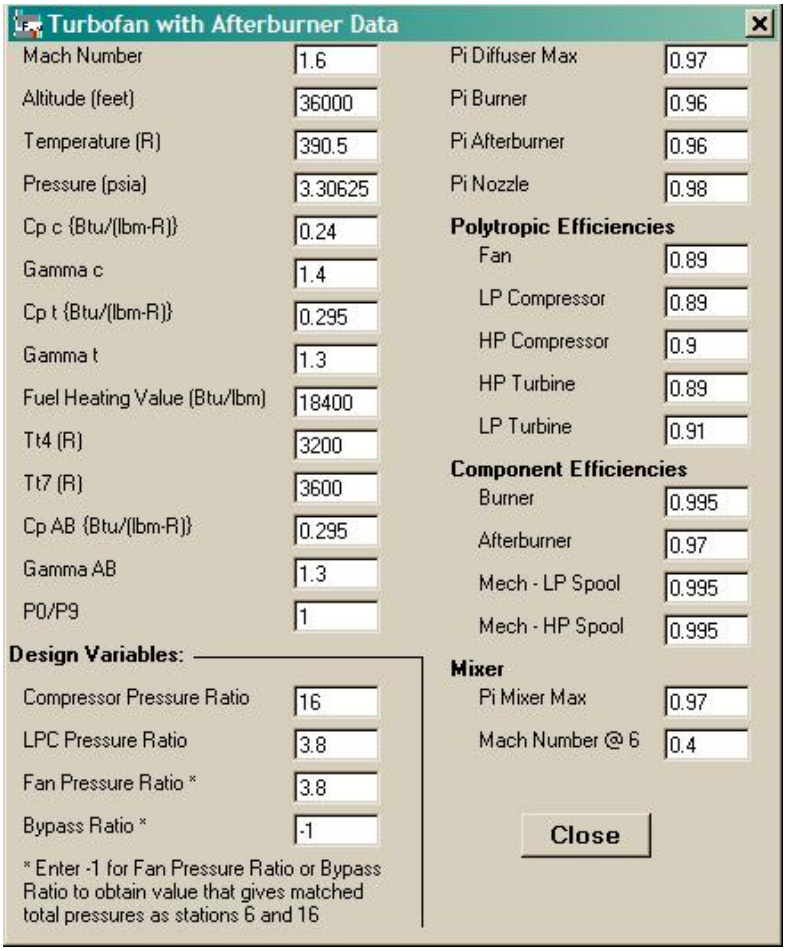
This program is designed to be user-friendly and multiple windows are used for program control and data input. Parametric (on-design) input data files may be saved on disk for later use (the file extension “pca” is used for these files). Also, saved parametric (on-design) input data files may be read from disk for current use. Multiple

calculations for different values of one design variable are possible by selecting the iteration variable from the Iteration Variable menu and then specifying its minimum, maximum, and incremental values. When single point calculation is selected, the Mass Flow Rate window (shown on the next page) opens for user input of this design value. Program output is directed to an output window and may be sent to a printer.

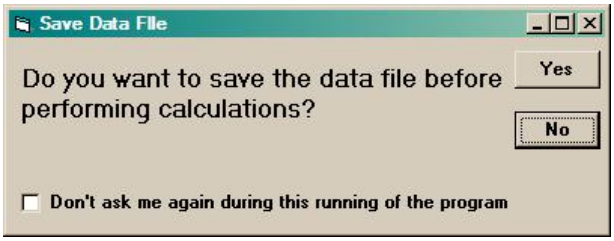


2. VIEW DATA Windows

Pressing the **View Data** button on the Main window opens an input data window for the selected engine cycle and gas model similar to that shown below.

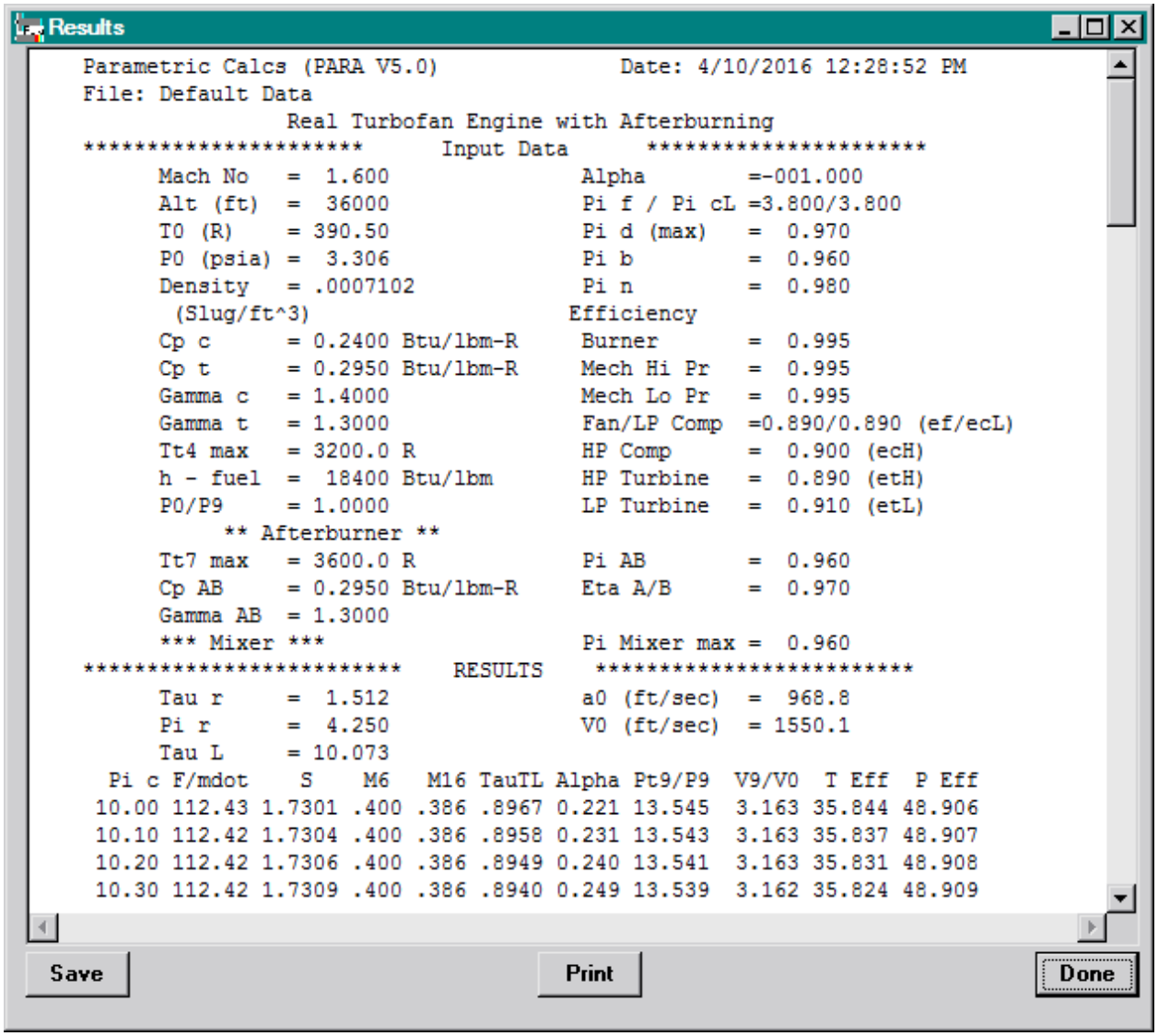


NOTE When the user presses the **Perform Calculations** button, they will be asked if they want to save the input data before the calculations are performed using the **Save Data File** window. The user can check the box and turn off this reminder.



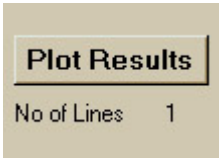
3. RESULTS Window – Multiple Calculations

Pressing the **Perform Calculations** button on the Main window causes the Results window to be opened and the input data and results displayed as shown below. The results for each value of the iteration variable are saved for later plotting.



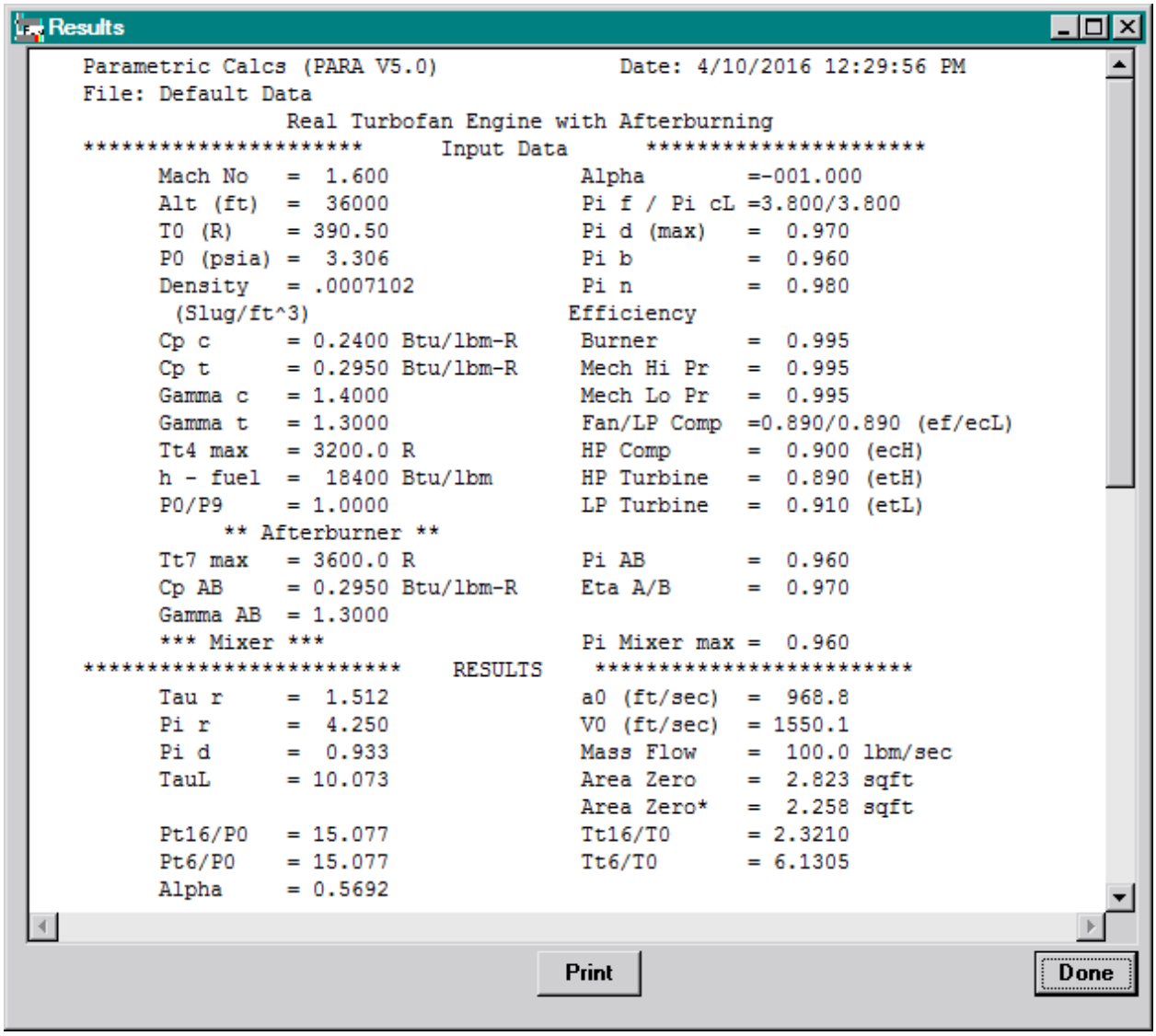
After one set of multiple calculations has been performed, the **Plot Results** button on the Main window becomes active and the number of plot lines listed as shown below. The results of the multiple calculations can be

plotted using the included Olectra Chart software (press **Plot Results** button on Main window) or can be copied to the Windows clipboard for pasting into another program. The results saved to the Windows clipboard can be easily pasted into a program like **Microsoft Excel** (To separate the data, use the **Text to Columns** item in the **Data pull-down menu** and select **Fixed width** for the Original data type).



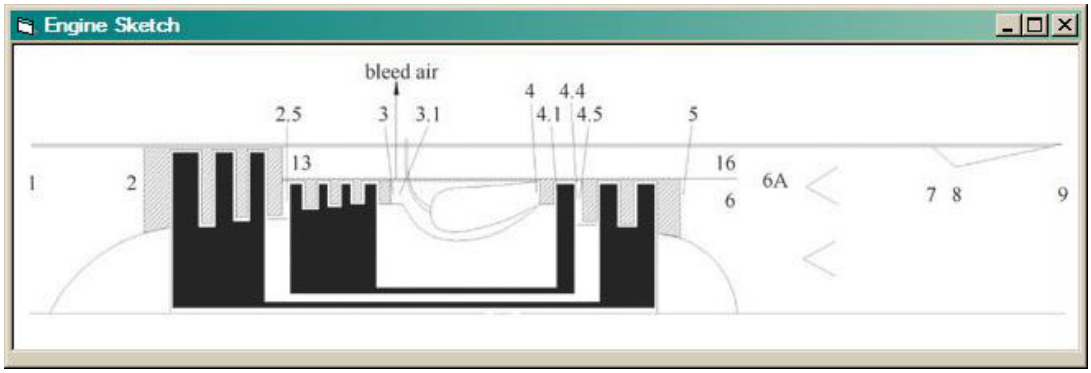
4. RESULTS Window – Single Point Calculation

Pressing the **Perform Calculations** button on the Main window causes the Results window to be opened and the input data and results displayed as shown below. The results for this single point calculation are saved for later plotting.



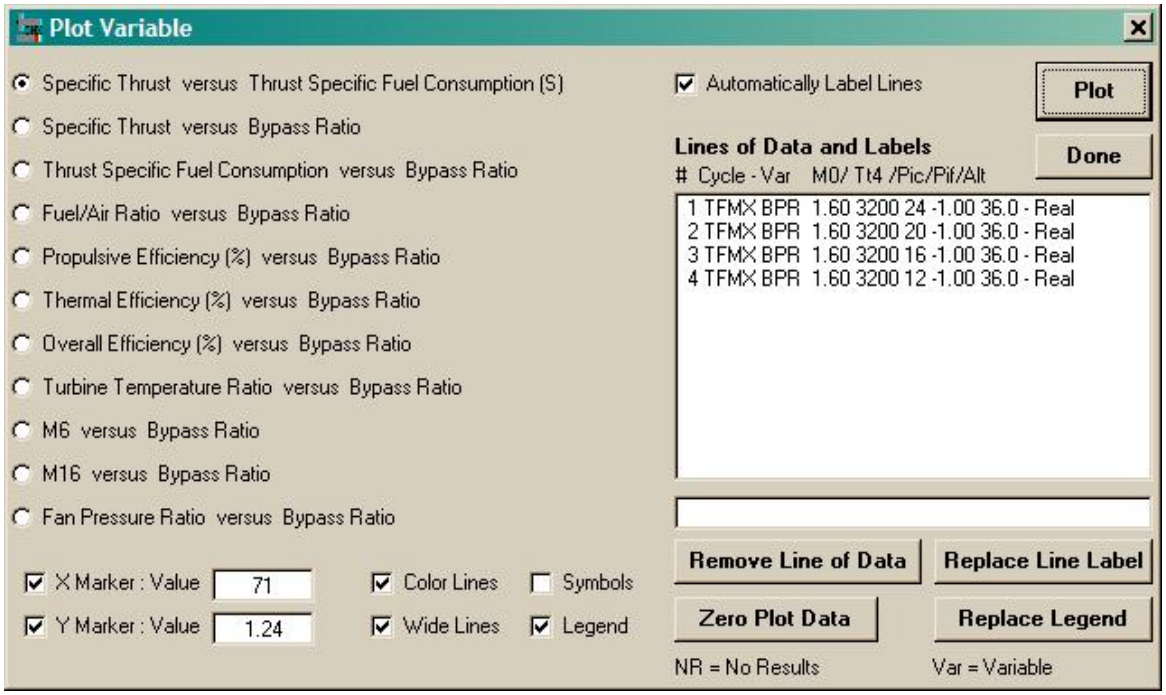
After the single point calculation has been performed for an **Ideal engine cycle**, the **Plot Single Point on Mollier Chart** button on the Main window becomes active as shown below.

Press the **Engine Station #s** button on the Main window to display a sketch of the engine showing engine station numbers as shown below.

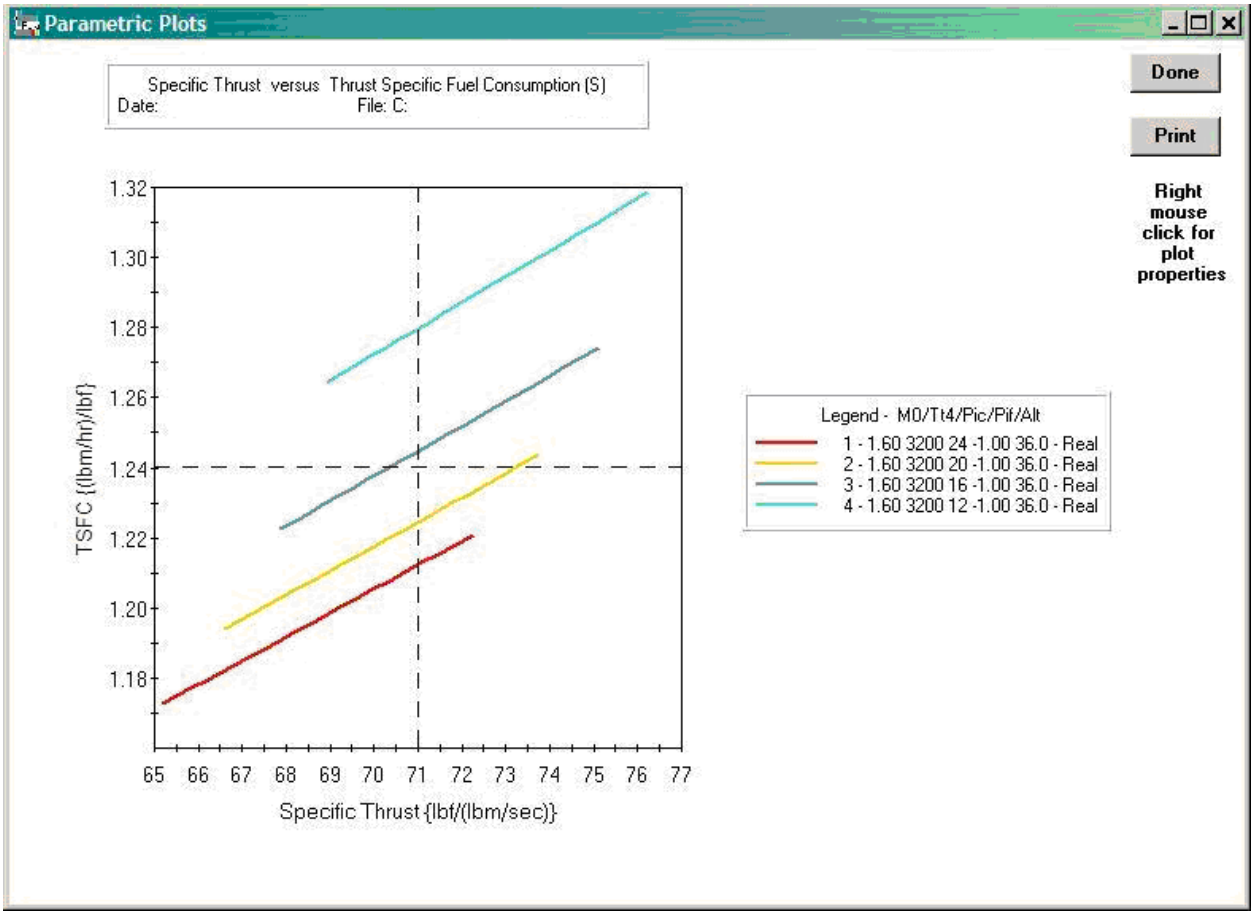


5. PLOT Window – Multiple Calculations

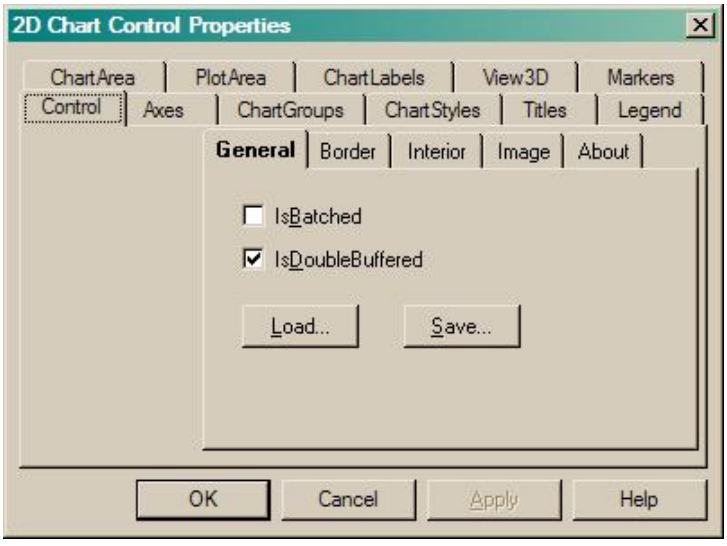
Pressing the **Plot Results** button on the **Main** window opens the **Plot Variable** window as shown below for user selection. This particular result was from calculations of the turbofan engine with mixed exhaust, constant specific heat (CSH) model, and fan pressure ratio (Pif = -1) selected by program to match total pressures entering the mixer. Calculations were performed over the range of bypass ratios from 0.3 to 0.5 for four different compressor pressure ratios (Pic = 24, 20, 16, and 12). **X Marker** check box selected and value of 71 input. Likewise, **Y Marker** check box selected and value of 1.24 input. **Wide Lines** check box selected.



Pressing the **Plot** button on the **Plot Variable** window gives the following plot.

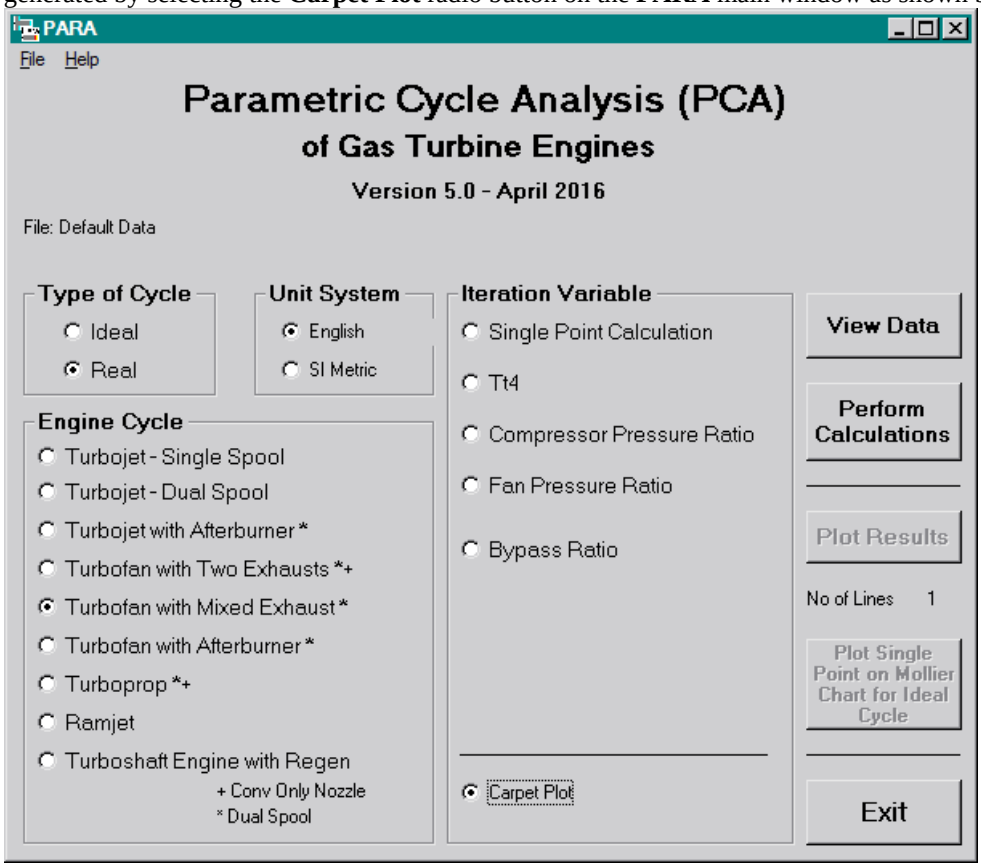


The Olectra Chart plotting package allows the user to customize each plot using the chart control properties window. Clicking the right mouse button over the plot will open the **2D Chart Control Properties** window as shown below. For example the minimum and maximum of the X axis can be changed by selecting **Axes**, then select **Scale**, enter the value for the X axis, and then press **Apply** followed by **OK**.

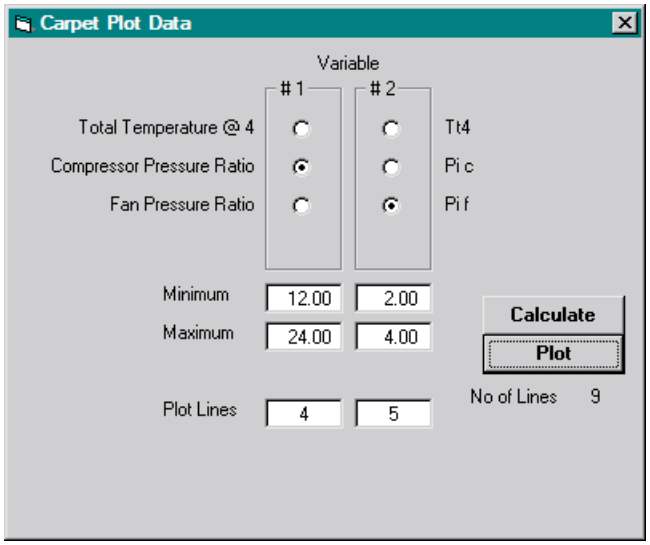


6. Carpet Plot

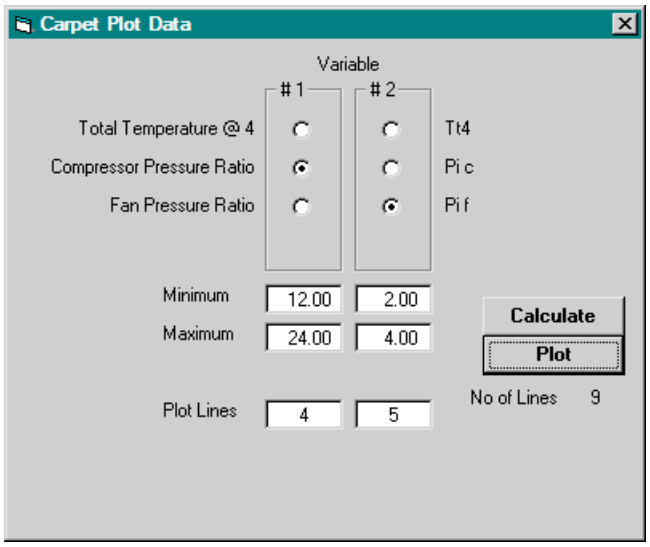
Carpet plots similar to Figs. P5-D1 and P5-D2 in *Elements of Propulsion, Gas Turbines and Rockets, Second Edition* can be generated by selecting the **Carpet Plot** radio button on the **PARA** main window as shown below.



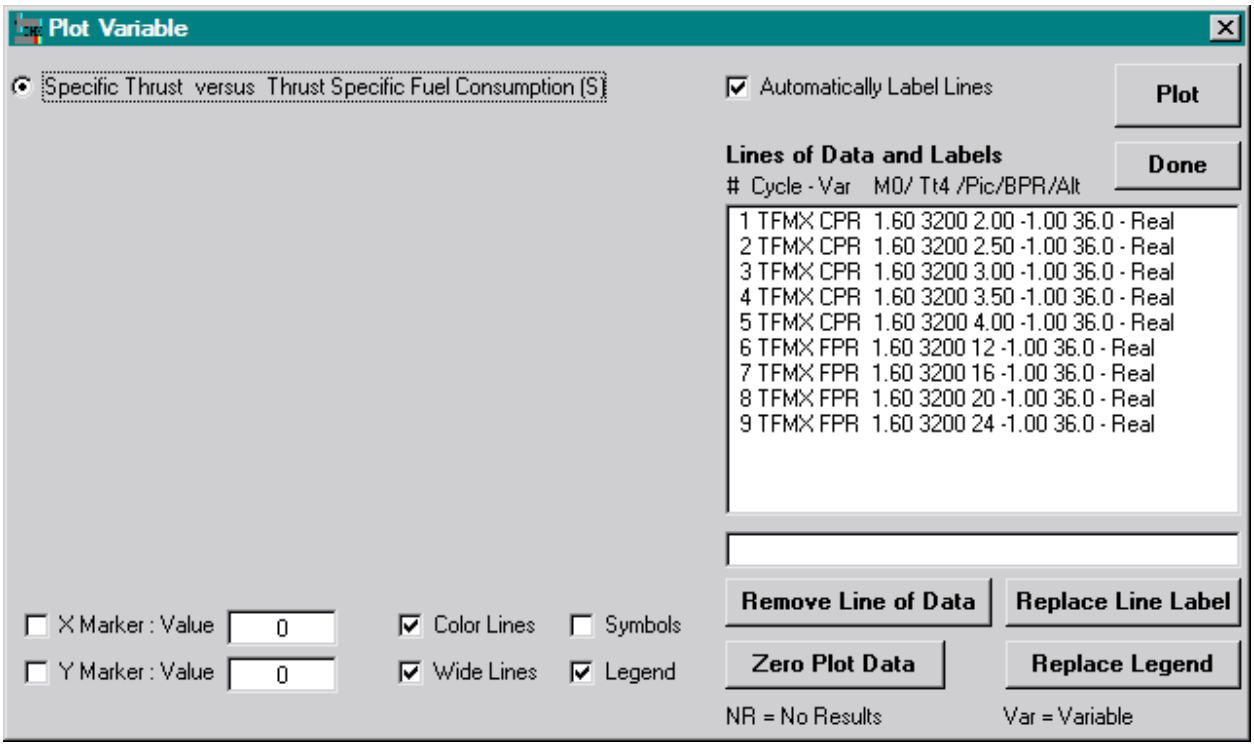
Pressing the **Carpet Plot** radio button opens the **Carpet Plot Data** window, shown below. Compressor pressure ratio and bypass ratio are selected as the two variables with the corresponding data values entered. Press the **Calculate** button to performs all the necessary calculations and when complete the **Plot** button becomes active.

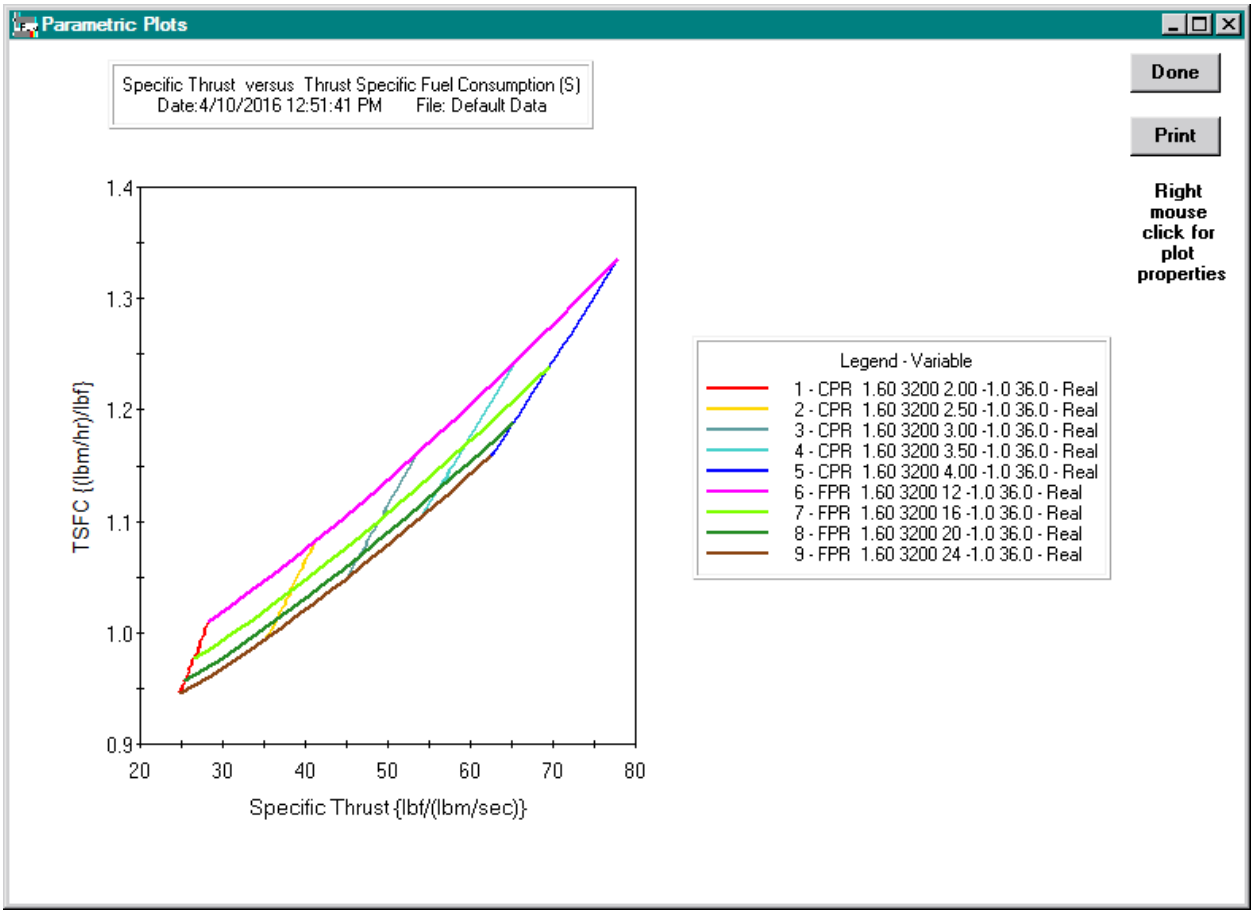


At the completion of the calculations, the **Carpet Plot Data** window will appear as shown below with the **Plot** button active and the number of plot lines shown.



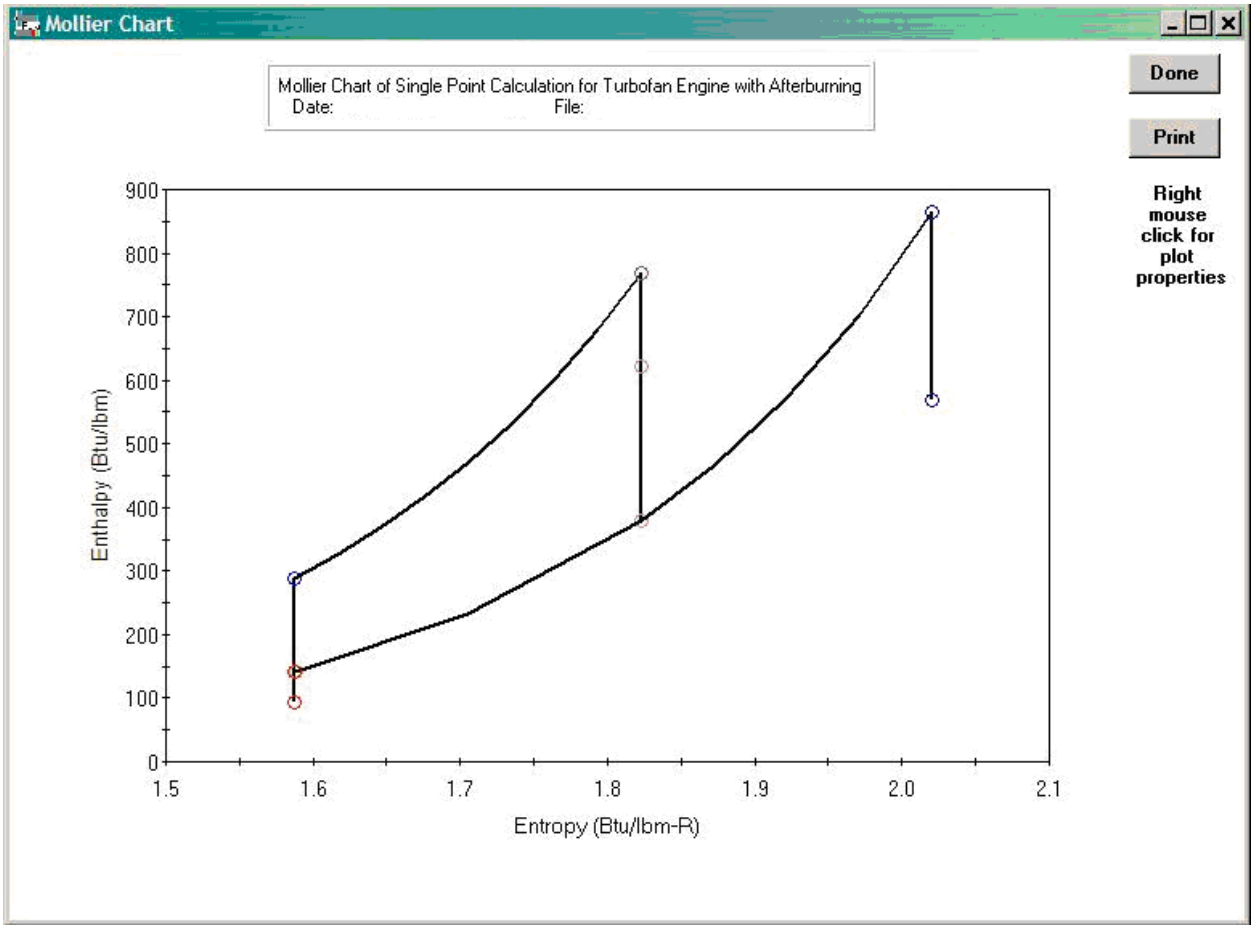
Pressing the **Plot** button opens the **Plot Variable** windows as shown below. With the **Automatic Label Lines** check box checked, the following legend labels are created. Line labels and legend can be input by the user using the text box and **Replace Line Label** & **Replace Legend** buttons. The user can add X and Y Markers to the plot using this window. Pressing the **Plot** button generates the carpet shown on the next page.





7. MOLLIER PLOT Window – Single Point Calculation

After the single point calculation has been performed for an **Ideal** cycle, press the **Plot Single Point on Mollier Chart** button on the Main window to generate a plot similar to that shown below.



8. Optimum

The user can specify that the program determine optimum values of specific design variables by entering a "–1" into that variable's data field. The following engine cycles and corresponding optimum are available:

Engine Cycle	Variable	Description
High Bypass Turbofan	Bypass Ratio	Minimum thrust specific fuel consumption
Mixed Flow Turbofan With/Without AB	Bypass Ratio	Matched total pressures entering mixer
	Fan Pressure Ratio	
Turboprop	Turbine Temperature Ratio	Minimum thrust specific fuel consumption