

ONX Program

Version 5.603

User Guide

November 2017

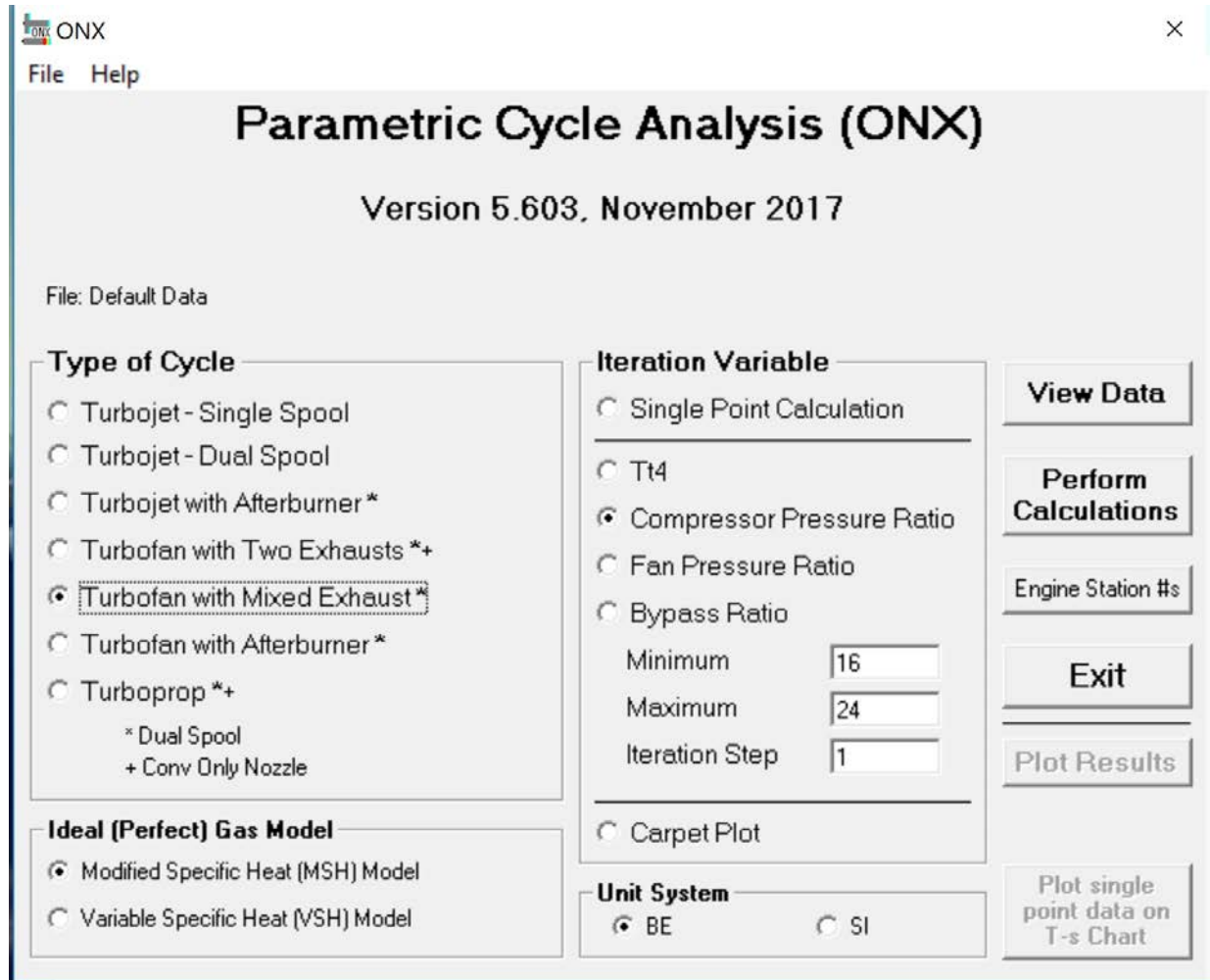
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1. MAIN Window

When the ONX program is run, the default input data is loaded from within the program and the Main window is displayed as shown below.



The parametric (on-design) cycle analysis program ONX is based on the equations developed in *Aircraft Engine Design, 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.

Each of these cycles can be analyzed using the user-selected unit system (English or SI) and ideal (perfect) gas model (three choices: CSH, MSH, or VSH).

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 “onx” 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 (see below) 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.

Mixed Turbofan Data	
Mach Number	1.6
Altitude (feet)	30000
Temperature (R)	411.9
Pressure (psia)	4.373
Cp c {Btu/(lbm-R)}	0.24
Gamma c	1.4
Cp t {Btu/(lbm-R)}	0.295
Gamma t	1.3
Fuel Heating Value (Btu/lbm)	18400
Tt4 (R)	3200
Bleed Air Flow (%)	1
Cooling Air Flow #1 (%)	5
Cooling Air Flow #2 (%)	5
Power Take-off Low (CTOL)	0.01
Power Take-off High (CTOH)	0
Design Variables:	
Compressor Pressure Ratio	24
LPC Pressure Ratio	3.5
Fan Pressure Ratio *	3.5
Bypass Ratio *	0.3
* Enter -1 for Fan Pressure Ratio or Bypass Ratio to obtain value that gives matched total pressures as stations 6 and 16	
Pi Diffuser Max	0.97
Pi Burner	0.97
Pi Nozzle	0.98
Polytropic Efficiencies	
Fan	0.89
LP Compressor	0.89
HP Compressor	0.9
HP Turbine	0.89
LP Turbine	0.91
Component Efficiencies	
Burner	0.98
Mech - LP Spool	0.99
Mech - HP Spool	0.98
Mech - PTO Low	0.98
Mech - PTO High	0.98
P0/P9	1
Mixer	
Pi Mixer Max	0.97
Mach Number @ 6	0.4
Level of Technology	
Close	

The **Level of Technology** button brings forth a window that presents that data from Table 4.4 of *Aircraft Engine Design, Second Edition* to help user select appropriate input data.

Component	Figure of Merit	Type	1945-65 1	1965-85 2	1985-05 3	2005-25 4	2025-45 5	Current Value	
Diffuser	$\pi_{d \max}$ P_2 / P_{t2} / P_{t1}	A - M<1 nacelle	<input type="radio"/> 0.90	<input type="radio"/> 0.95	<input type="radio"/> 0.98	<input type="radio"/> 0.995	<input type="radio"/> 0.998	0.97	Double click radio button to select
		B - M<1 airframe	<input type="radio"/> 0.88	<input type="radio"/> 0.93	<input type="radio"/> 0.96	<input type="radio"/> 0.98	<input type="radio"/> 0.985		
		C - M>1 airframe	<input type="radio"/> 0.85	<input type="radio"/> 0.90	<input type="radio"/> 0.94	<input type="radio"/> 0.96	<input type="radio"/> 0.97		
Compressor	e_{cL} e_{cH}		<input checked="" type="radio"/> 0.80	<input type="radio"/> 0.84	<input type="radio"/> 0.88	<input type="radio"/> 0.90	<input type="radio"/> 0.91	0.89	
			<input type="radio"/> 0.80	<input type="radio"/> 0.84	<input type="radio"/> 0.88	<input type="radio"/> 0.90	<input type="radio"/> 0.91	0.9	
Fan	e_f		<input type="radio"/> 0.78	<input type="radio"/> 0.82	<input type="radio"/> 0.86	<input type="radio"/> 0.89	<input type="radio"/> 0.92	0.89	
Burner	π_b η_b		<input type="radio"/> 0.90	<input type="radio"/> 0.92	<input type="radio"/> 0.94	<input type="radio"/> 0.95	<input type="radio"/> 0.96	0.97	
			<input type="radio"/> 0.88	<input type="radio"/> 0.94	<input type="radio"/> 0.99	<input type="radio"/> 0.999	<input type="radio"/> 0.999	0.98	
Turbine	e_{tH}	Uncooled	<input type="radio"/> 0.80	<input type="radio"/> 0.85	<input type="radio"/> 0.89	<input type="radio"/> 0.90	<input type="radio"/> 0.91	0.89	
		Cooled		<input type="radio"/> 0.83	<input type="radio"/> 0.87	<input type="radio"/> 0.89	<input type="radio"/> 0.90		
	e_{tL}	Uncooled	<input type="radio"/> 0.80	<input type="radio"/> 0.85	<input type="radio"/> 0.89	<input type="radio"/> 0.90	<input type="radio"/> 0.91	0.91	
		Cooled		<input type="radio"/> 0.83	<input type="radio"/> 0.87	<input type="radio"/> 0.89	<input type="radio"/> 0.90		
Mixer	$\pi_{m \max}$			<input type="radio"/> 0.95	<input type="radio"/> 0.97	<input type="radio"/> 0.98	<input type="radio"/> 0.985	0.97	
Nozzle	π_n P_{t9} / P_{t7}	D - Fixed Conv E - Variable Conv F - Variable C-D	<input type="radio"/> 0.95	<input type="radio"/> 0.97	<input type="radio"/> 0.98	<input type="radio"/> 0.995	<input type="radio"/> 0.997	0.98	
			<input type="radio"/> 0.93	<input type="radio"/> 0.96	<input type="radio"/> 0.97	<input type="radio"/> 0.98	<input type="radio"/> 0.99		
Mech Shaft	η_{mL}	Shaft Only	<input type="radio"/> 0.95	<input type="radio"/> 0.97	<input type="radio"/> 0.99	<input type="radio"/> 0.995	<input type="radio"/> 0.996	0.99	
		With Power Takeoff	<input type="radio"/> 0.90	<input type="radio"/> 0.92	<input type="radio"/> 0.95	<input type="radio"/> 0.97	<input type="radio"/> 0.98		
	η_{mH}	Shaft Only	<input type="radio"/> 0.95	<input type="radio"/> 0.97	<input type="radio"/> 0.99	<input type="radio"/> 0.995	<input type="radio"/> 0.996	0.98	
		With Power Takeoff	<input type="radio"/> 0.90	<input type="radio"/> 0.92	<input type="radio"/> 0.95	<input type="radio"/> 0.97	<input type="radio"/> 0.98		

Note: Use of stealth reduces the total pressure ratios of the diffuser and nozzle from the values listed above.

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.

The screenshot shows a 'Results' window with the following content:

```

On-Design Calcs (ONX V5.50)           Date: 4/21/2016 10:17:54 AM
File: Default Data
Turbofan Engine with Mixed Exhaust
using Modified Specific Heat (MSH) Model
***** Input Data *****
Mach No = 1.600           Alpha = 0.300
Alt (ft) = 30000         Pi f / Pi cL =3.500/3.500
T0 (R) = 411.90          Pi d (max) = 0.970
P0 (psia) = 4.373        Pi b = 0.970
Density = .0008905       Pi n = 0.980
(Slug/ft^3)
Cp c = 0.2400 Btu/lbm-R   Efficiency
Cp t = 0.2950 Btu/lbm-R   Burner = 0.980
Gamma c = 1.4000          Mech Hi Pr = 0.980
Gamma t = 1.3000          Mech Lo Pr = 0.990
Tt4 max = 3200.0 R        Fan/LP Comp =0.890/0.890 (ef/ecL)
h - fuel = 18400 Btu/lbm  HP Comp = 0.900 (ecH)
CTO Low = 0.0100          HP Turbine = 0.890 (etH)
CTO High = 0.0000        LP Turbine = 0.910 (etL)
Cooling Air #1 = 5.000 %  Pwr Mech Eff L = 0.980
Cooling Air #2 = 5.000 %  Pwr Mech Eff H = 0.980
P0/P9 = 1.0000           Bleed Air = 1.000 %
*** Mixer ***            Pi Mixer max = 0.970
***** RESULTS *****
Tau r = 1.512            a0 (ft/sec) = 994.9
Pi r = 4.250             V0 (ft/sec) = 1591.8
Tau L = 9.549
Pi c F/mdot   S   M6   M16 TauTL  M6A  Pt9/P9  V9/V0  T Eff  P Eff
16.00  63.02  1.1841 .400 .423 .8705 .4177 12.909  2.245 54.702 62.080
17.00  62.56  1.1734 .400 .411 .8693 .4157 12.985  2.236 55.069 62.233
18.00  62.10  1.1634 .400 .402 .8681 .4141 13.040  2.228 55.405 62.390
19.00  61.63  1.1540 .400 .396 .8670 .4130 13.076  2.219 55.716 62.551
20.00  61.15  1.1451 .400 .393 .8659 .4122 13.095  2.210 56.003 62.715
21.00  60.67  1.1367 .400 .392 .8648 .4119 13.100  2.201 56.270 62.882
22.00  60.19  1.1288 .400 .394 .8637 .4120 13.092  2.192 56.518 63.052
23.00  59.71  1.1212 .400 .397 .8626 .4125 13.072  2.183 56.750 63.223
24.00  59.23  1.1139 .400 .403 .8616 .4132 13.041  2.174 56.967 63.396
  
```

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 image shows a button labeled "Plot Results" with a small downward arrow on its right side. Below the button, the text "No of Lines 1" is displayed.

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.

The Results window displays the following data:

```

On-Design Calcs (ONX V5.50)           Date: 4/21/2016 10:18:49 AM
File: Default Data

Turbofan Engine with Mixed Exhaust
using Modified Specific Heat (MSH) Model
***** Input Data *****
Mach No = 1.600           Alpha = 0.300
Alt (ft) = 30000         Pi f / Pi cL =3.500/3.500
T0 (R) = 411.90         Pi d (max) = 0.970
P0 (psia) = 4.373       Pi b = 0.970
Density = .0008905      Pi n = 0.980
(Slug/ft^3)
Cp c = 0.2400 Btu/lbm-R  Efficiency
Cp t = 0.2950 Btu/lbm-R  Burner = 0.980
Gamma c = 1.4000         Mech Hi Pr = 0.980
Gamma t = 1.3000         Mech Lo Pr = 0.990
Tt4 max = 3200.0 R       Fan/LP Comp =0.890/0.890 (ef/ecL)
h - fuel = 18400 Btu/lbm HP Comp = 0.900 (ecH)
CTO Low = 0.0100        HP Turbine = 0.890 (etH)
CTO High = 0.0000       LP Turbine = 0.910 (etL)
Cooling Air #1 = 5.000 % Pwr Mech Eff L = 0.980
Cooling Air #2 = 5.000 % Pwr Mech Eff H = 0.980
P0/P9 = 1.0000          Bleed Air = 1.000 %
*** Mixer ***          Pi Mixer max = 0.970
***** RESULTS *****
Tau r = 1.512           a0 (ft/sec) = 994.9
Pi r = 4.250            V0 (ft/sec) = 1591.8
Pi d = 0.933           Mass Flow = 100.0 lbm/sec
TauL = 9.549           Area Zero = 2.193 sqft
PTO Low = 104.30 KW    Area Zero* = 1.754 sqft
PTO High = 0.00 KW
Pt16/P0 = 13.887       Tt16/T0 = 2.2605
Pt6/P0 = 13.763        Tt6/T0 = 4.9776
Pi c = 24.000          Tau m1 = 0.9708
Pi f = 3.500           Tau m2 = 0.9790
Tau f = 1.4951         Tau M = 0.8941
Eta f = 0.8693         Pi M = 0.9669
Pi cL = 3.500          Tau cL = 1.4951
  
```

Buttons: Done, Print

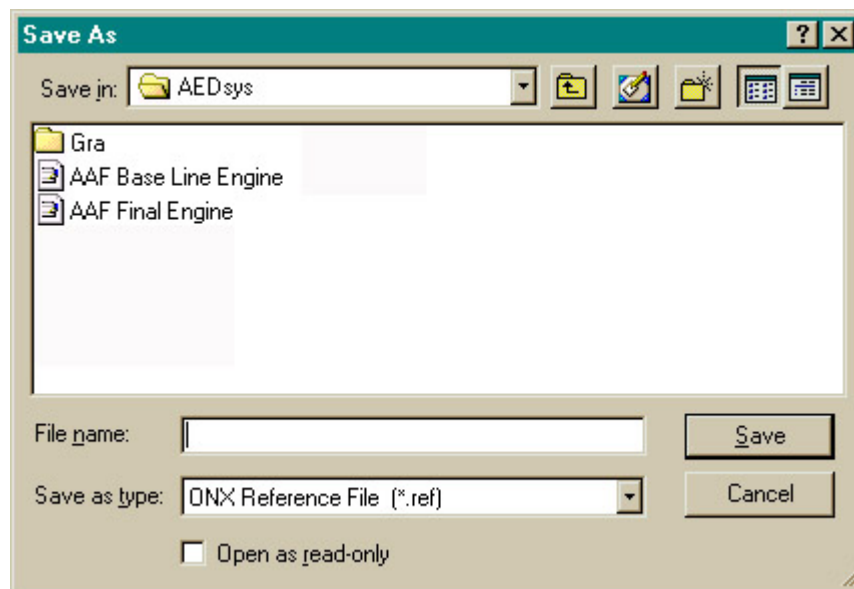
When the **Done** button is pressed, the user is asked if they want to save the reference data that has been calculated for this engine for input into the AEDsys program as shown below. Replying **Yes** opens the Save As file dialog box shown on the next page.

The dialog box contains the following text:

Parametric Analysis Program

Do you want to save results of single calculation in a Reference file for later use?

Buttons: Yes, No



Note: The reference data file required for input to the performance (off-design) cycle analysis program portion (Engine Test) of the AEDsys program can only be generated by performing a single design point calculation and then saving the required output data to a user-named reference data file (the file extension REF is used for these files) as shown above.

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



5. PLOT Window – Multiple Calculations

Pressing the **Plot Results** button on the Main window opens the Plot window as shown below for user selection.

Plot Variable

Specific Thrust versus Thrust Specific Fuel Consumption (S)
 Specific Thrust versus Bypass Ratio
 Thrust Specific Fuel Consumption (S) versus Bypass Ratio
 Fuel/Air Ratio versus Bypass Ratio
 Propulsive Efficiency (%) versus Bypass Ratio
 Thermal Efficiency (%) versus Bypass Ratio
 Overall Efficiency (%) versus Bypass Ratio
 Turbine Enthalpy Ratio versus Bypass Ratio
 M6 versus Bypass Ratio
 M16 versus Bypass Ratio
 Fan Pressure Ratio versus Bypass Ratio

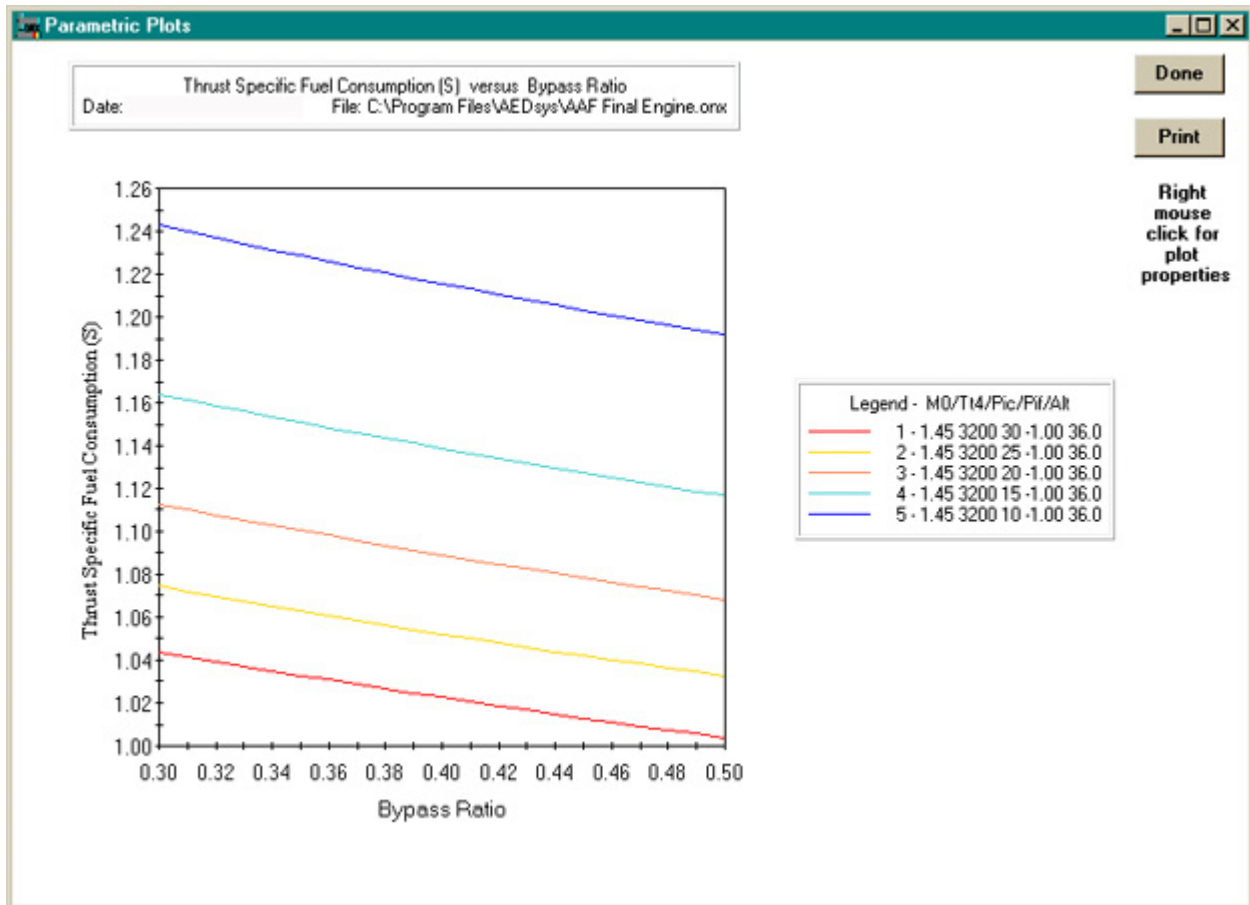
Plot **Done**

Color Lines Wide Lines
 Symbols Legend

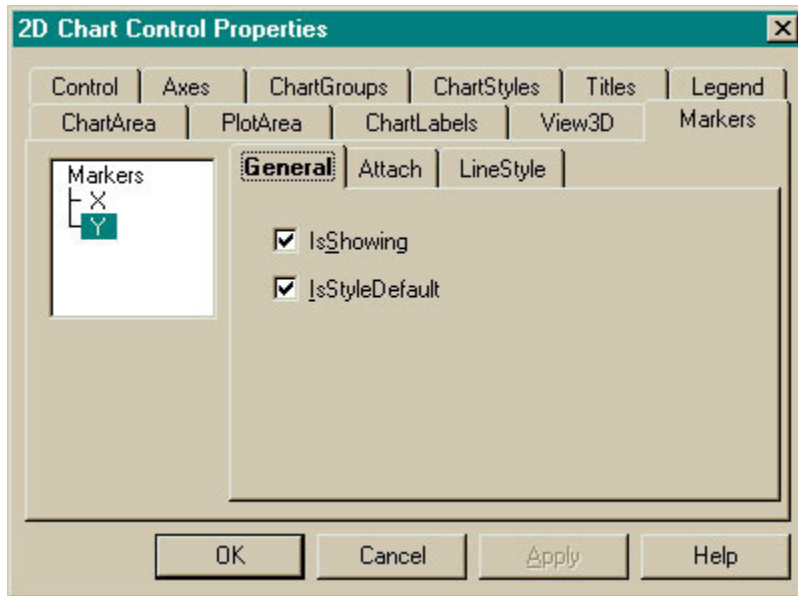
#	Cycle	Var	M0/Tt4/Pic/Pif/Alt
1	TFMX	BPR	1.45 3200 30 -1.00 36.0
2	TFMX	BPR	1.45 3200 25 -1.00 36.0
3	TFMX	BPR	1.45 3200 20 -1.00 36.0
4	TFMX	BPR	1.45 3200 15 -1.00 36.0
5	TFMX	BPR	1.45 3200 10 -1.00 36.0

Remove Line of Data **Zero Plot Data**

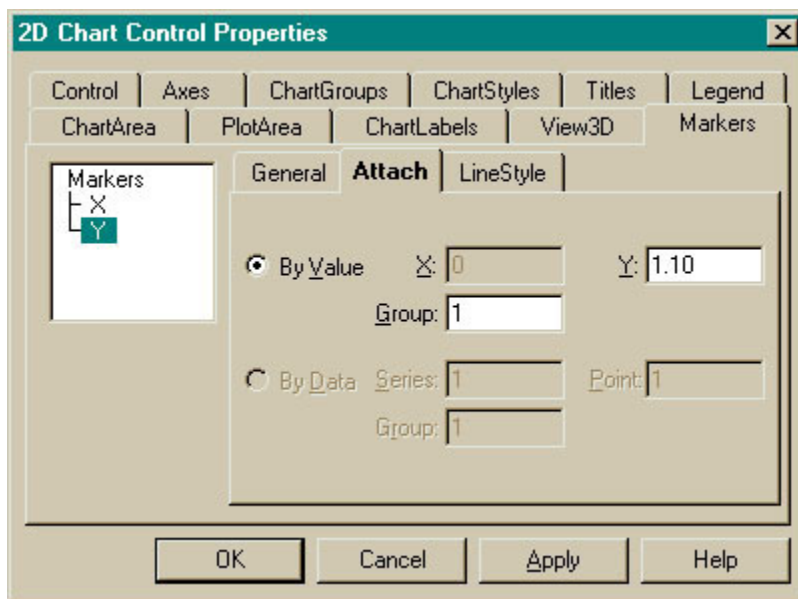
Pressing the Plot button gives.



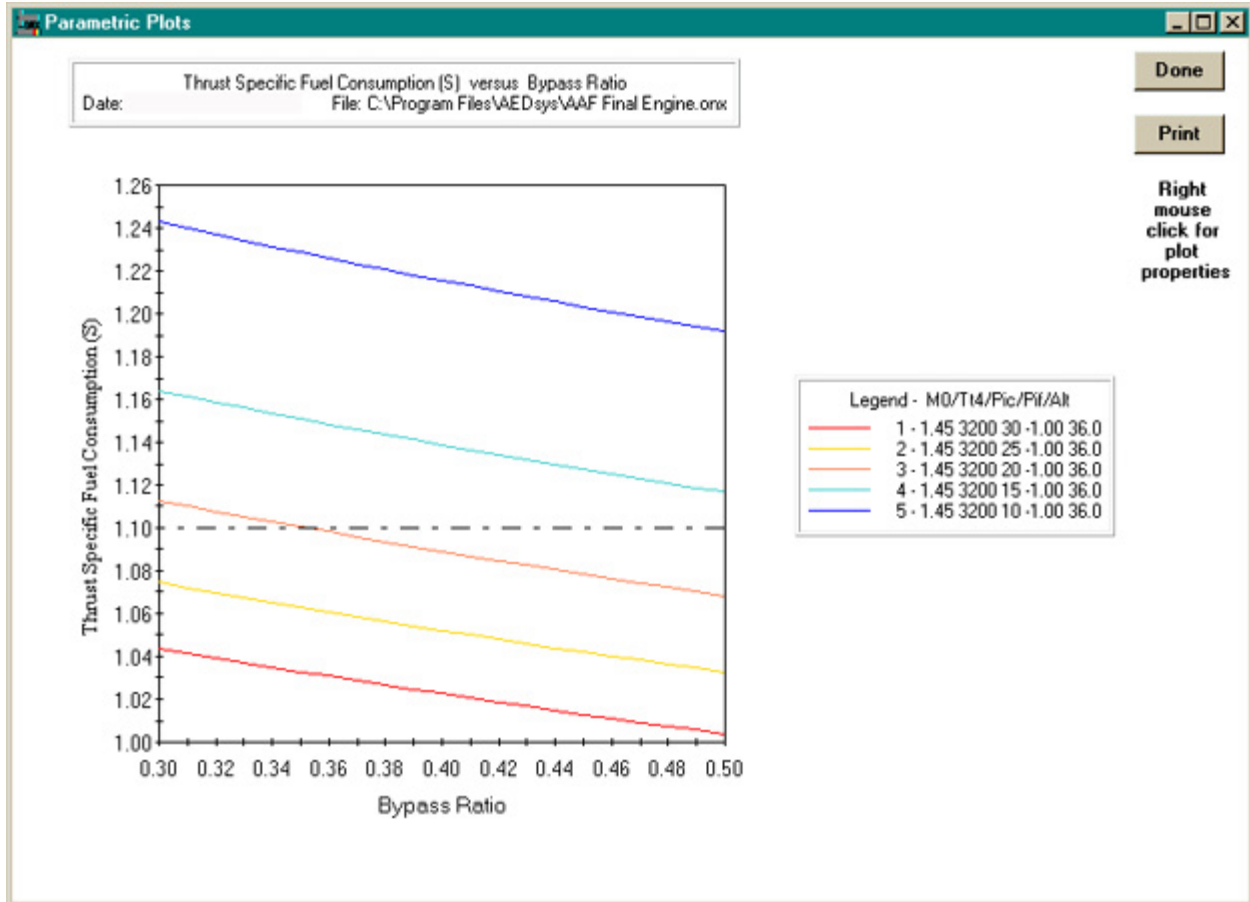
Let's mark the maximum allowable thrust specific fuel consumption (S) on this plot. First, right mouse click on the plot. Select **Markers**, click on **Y**, check **IsShowing**, then select **Attach**.



Select **By Value**; for **Y** type your maximum allowable TSFC, then press **Apply** followed by **OK**.



The plot now has a line indicating the maximum value of S as shown below.



6. CARPET PLOT

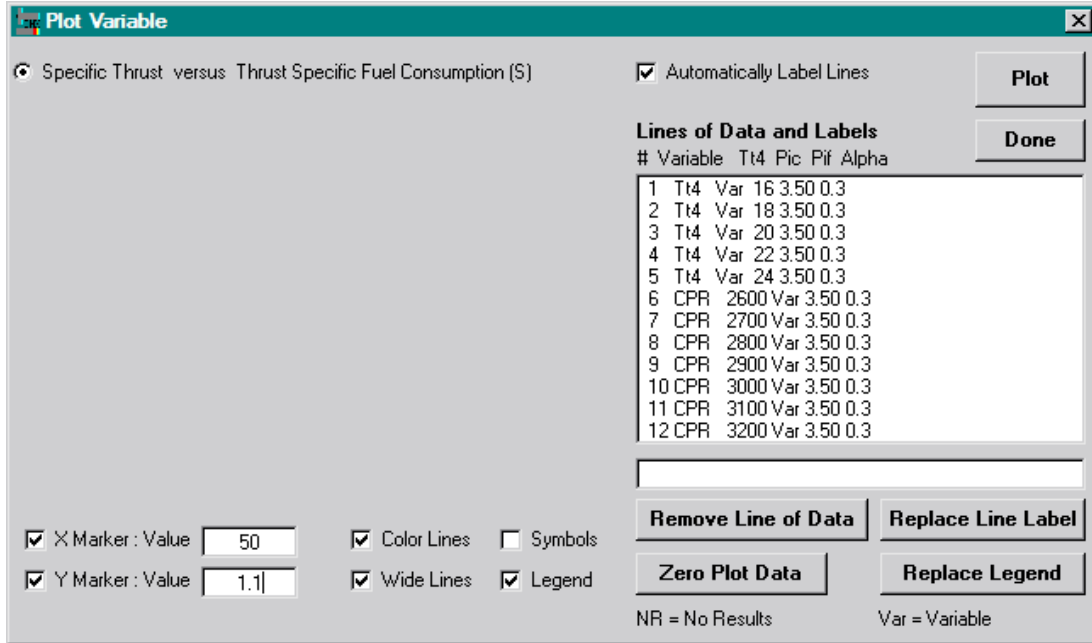
Carpet plots similar to Figs. 4.E2 and 4.E3 can be generated by performing the calculations with two different independent variables. Select the Carpet Plot button on the Main Window and the following window is displayed. The user can select the two variables and their range (min and max) and number of plot lines. Calculations are performed after pressing the Calculate button.

The screenshot shows the 'Carpet Plot Data' dialog box. It has a title bar with a close button. The main area is divided into two columns for variables, labeled '# 1' and '# 2'. The variables listed are: Total Temperature @ 4 (radio button selected in #1, label Tt4), Compressor Pressure Ratio (radio button selected in #2, label Pi c), Fan Pressure Ratio (radio button in #1, label Pi f), and Bypass Ratio (radio button in #1, label Alpha). Below the variable selection are input fields for 'Minimum' and 'Maximum' values for each variable. For variable #1, the minimum is 2600.00 and the maximum is 3200.00. For variable #2, the minimum is 16.00 and the maximum is 24.00. At the bottom, there are input fields for 'Plot Lines' (7 for #1, 5 for #2) and a label 'No of Lines'. On the right side, there are two buttons: 'Calculate' and 'Plot'. The 'Plot' button is currently disabled.

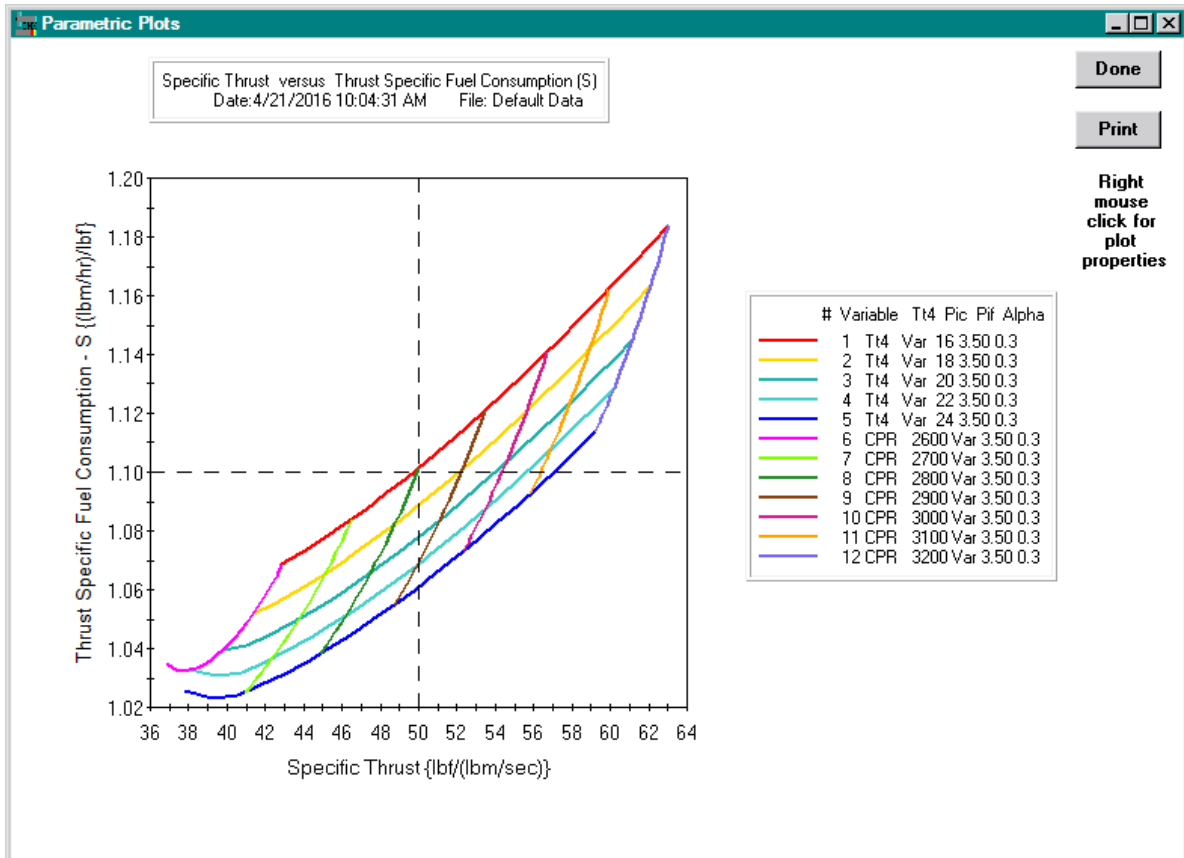
The Plot button is activated when calculations are complete as shown below.

This screenshot shows the same 'Carpet Plot Data' dialog box after calculations. The variable selection and range inputs remain the same. However, the 'Plot' button is now active, indicated by a dashed border. Additionally, the 'No of Lines' label now shows the value '12', which is the sum of the plot lines for both variables (7 + 5). The 'Calculate' button remains active.

Selection of the plot button opens the Plot Variable window where the user can input plot display attributes and X-Y axis markers.

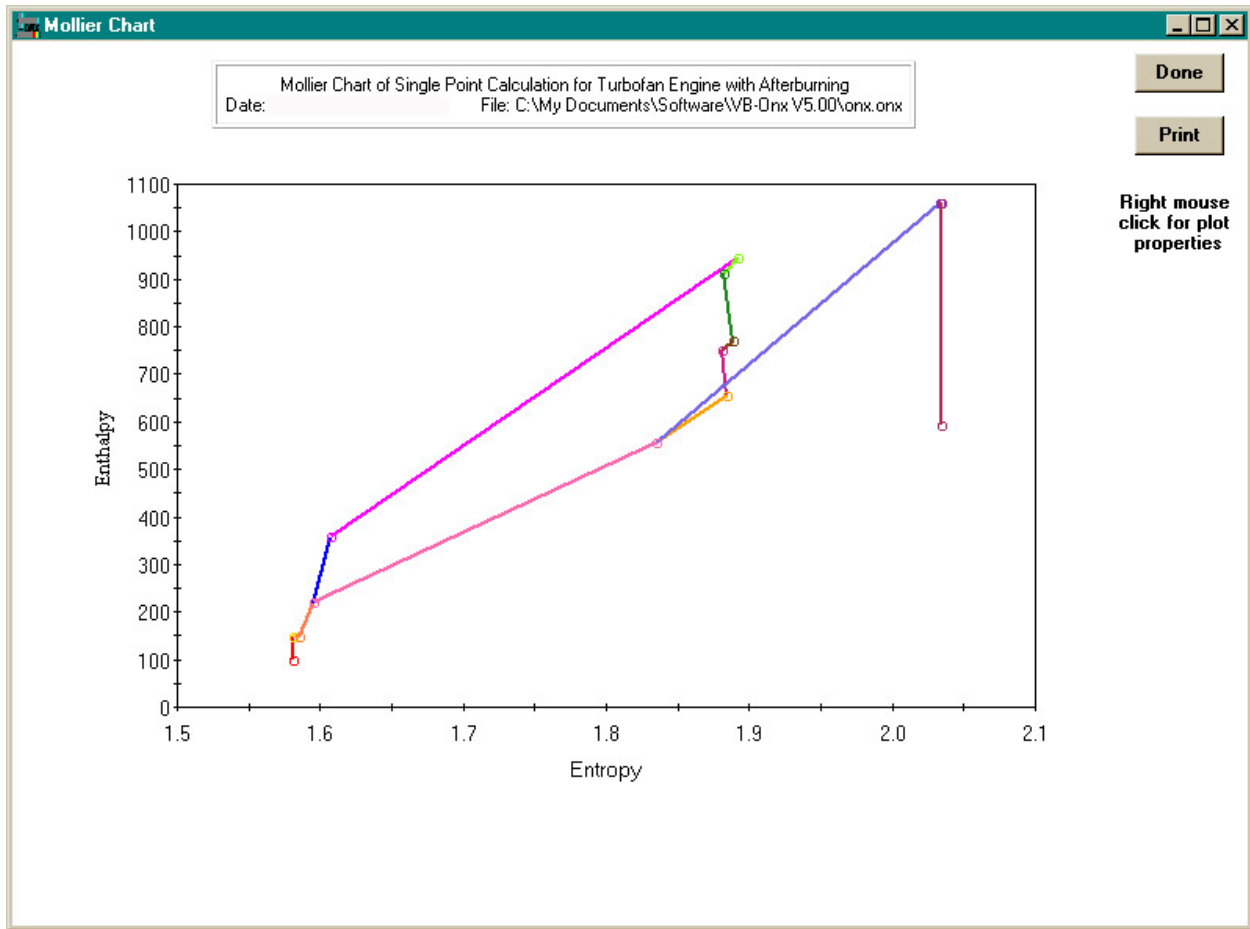


Press the Plot button and the carpet plot is shown – see below.



6. MOLLIER PLOT Window – Single Point Calculation

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



7. 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 Enthalpy Ratio	Minimum thrust specific fuel consumption