ONX Program

Version 5.603

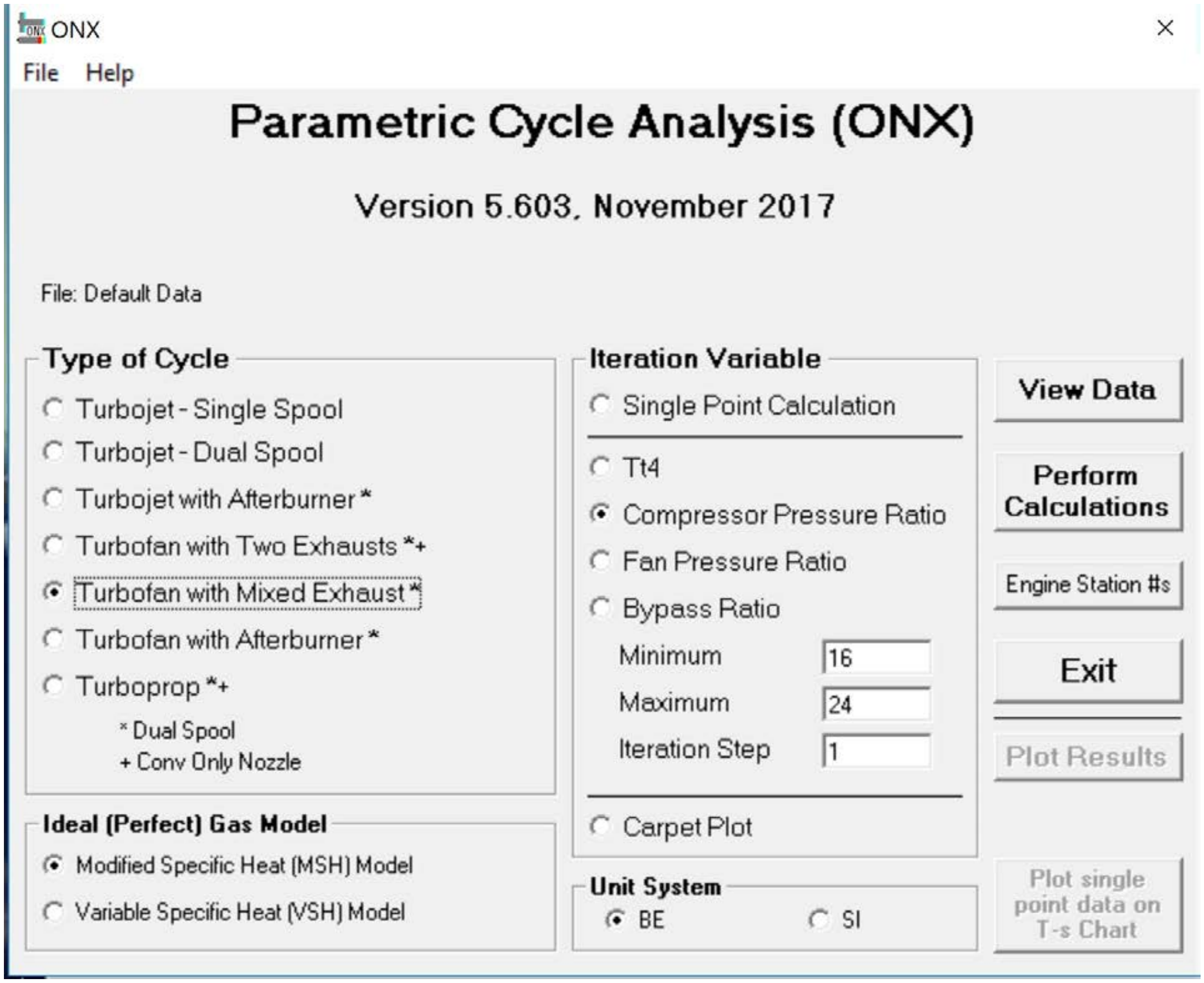
User Guide

November 2017

Table of Contents

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:

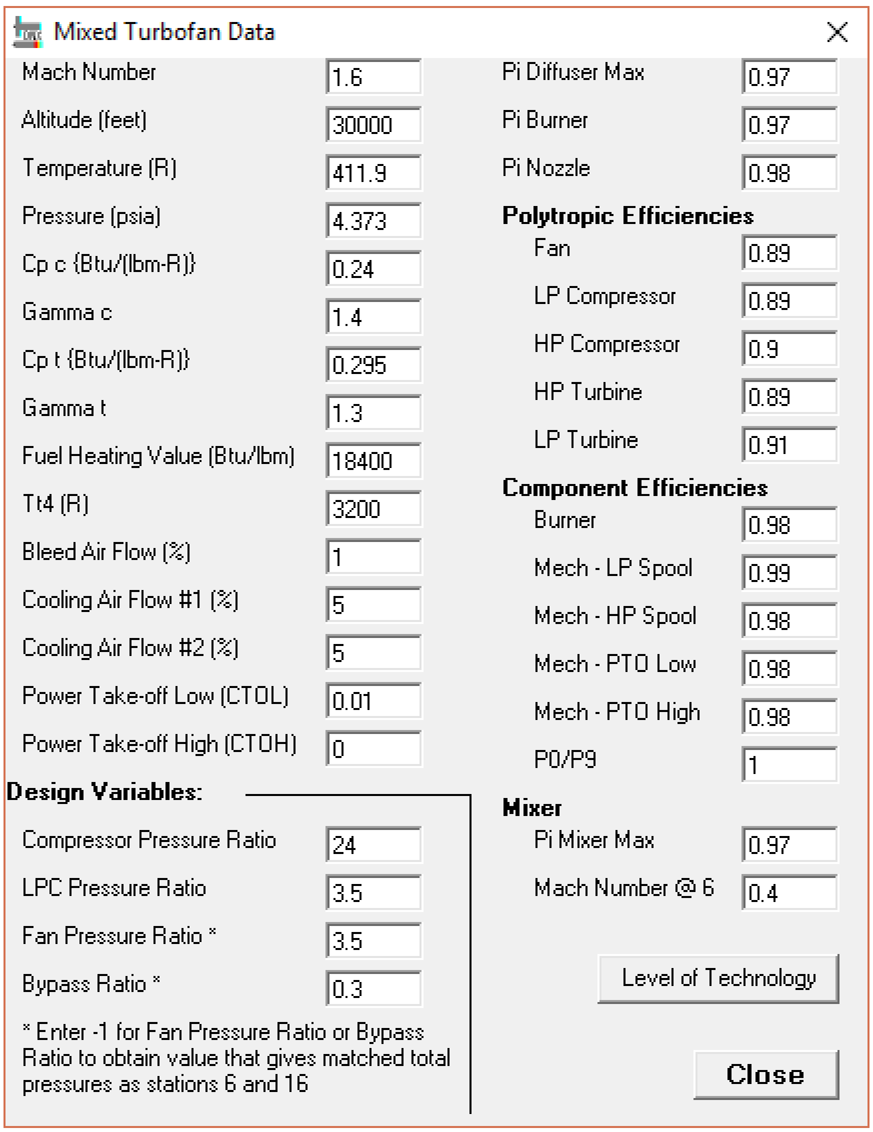
1. Turbojet without afterburner – single spool.
2. Turbojet without afterburner – dual spool.
3. Turbojet with afterburner – dual spool.
4. Turbofan with separate exhausts (convergent-only exhaust nozzles) – dual spool.
5. Turbofan with mixed exhaust and no afterburning – dual spool.
6. Turbofan with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



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.

Level of Technology

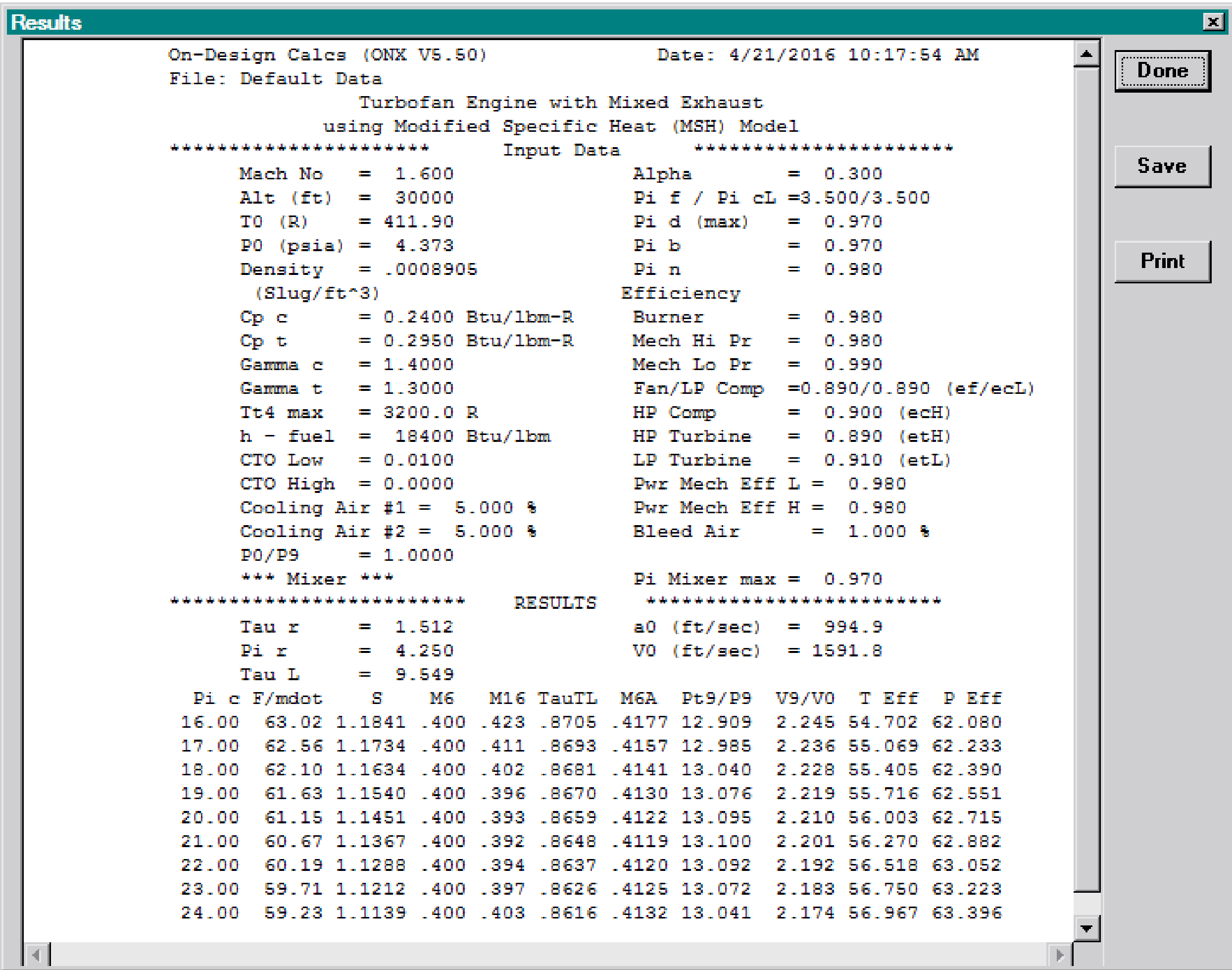
Component	Figure of Merit	Type	1945-65 1	1965-85 2	1985-05 3	2005-25 4	2025-45 5	Current Value
Diffuser	$\pi_{d\,max}$ P_{t2}/P_{t1}	A - M<1 nacelle	0.90	0.95	0.98	0.995	0.998	0.97
		B - M<1 airframe	0.88	0.93	0.96	0.98	0.985	
		C - M>1 airframe	0.85	0.90	0.94	0.96	0.97	
Compressor	e_{cL}		0.80	0.84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

Double click radio button to select

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

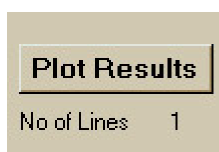
3. RESULTS Window – Multiple Calculations

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.



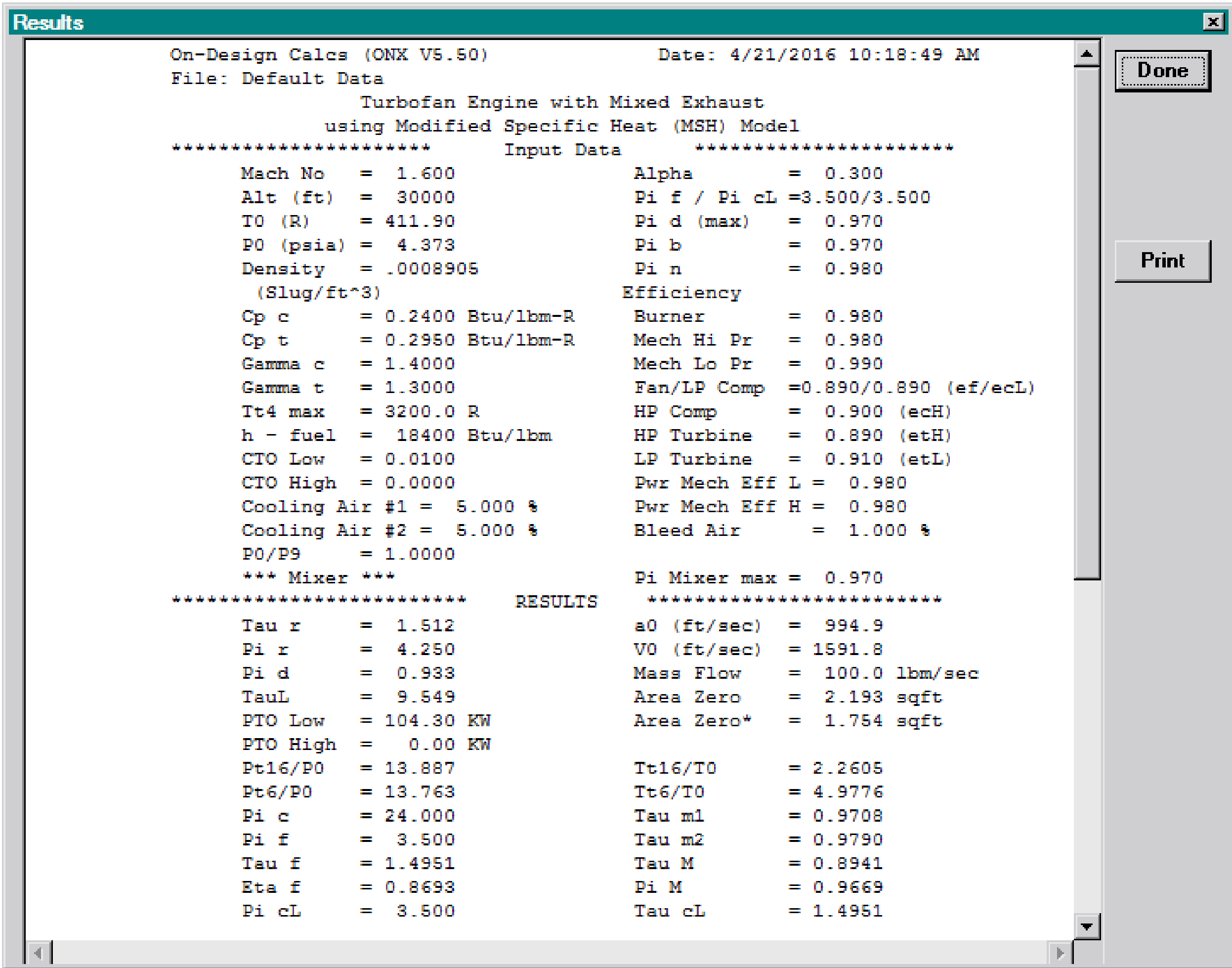
```
Results
            On-Design Calcs (ONX V5.50)           Date: 4/21/2016 10:17:54 AM
            File: Default Data
                            Turbofan Engine with Mixed Exhaust
                         using Modified Specific Heat (MSH) Model
            **********************         Input Data        **********************
                  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)                             Efficiency
                  Cp c       = 0.2400 Btu/lbm-R             Burner        =  0.980
                  Cp t       = 0.2950 Btu/lbm-R             Mech Hi Pr    =  0.980
                  Gamma c    = 1.4000                       Mech Lo Pr    =  0.990
                  Gamma t    = 1.3000                       Fan/LP Comp   =0.890/0.890 (ef/ecL)
                  Tt4 max    = 3200.0 R                     HP Comp       =  0.900 (ecH)
                  h - fuel   =  18400 Btu/lbm               HP Turbine    =  0.890 (etH)
                  CTO Low    = 0.0100                       LP Turbine    =  0.910 (etL)
                  CTO High   = 0.0000                       Pwr Mech Eff L =  0.980
                  Cooling Air #1 =  5.000 %                 Pwr Mech Eff H =  0.980
                  Cooling Air #2 =  5.000 %                 Bleed Air      =  1.000 %
                  P0/P9      = 1.0000
                  *** 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
Done
Save
Print
```

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.



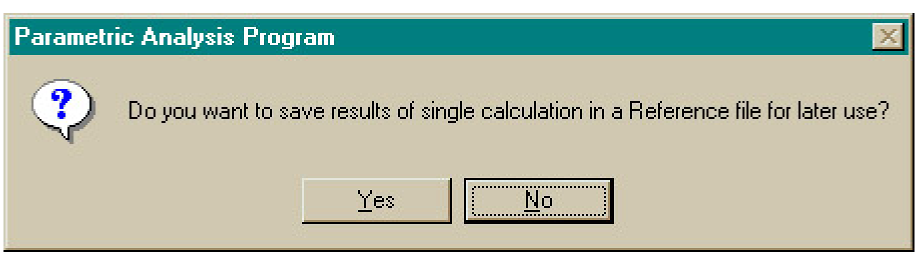
4. RESULTS Window – Single Point Calculation

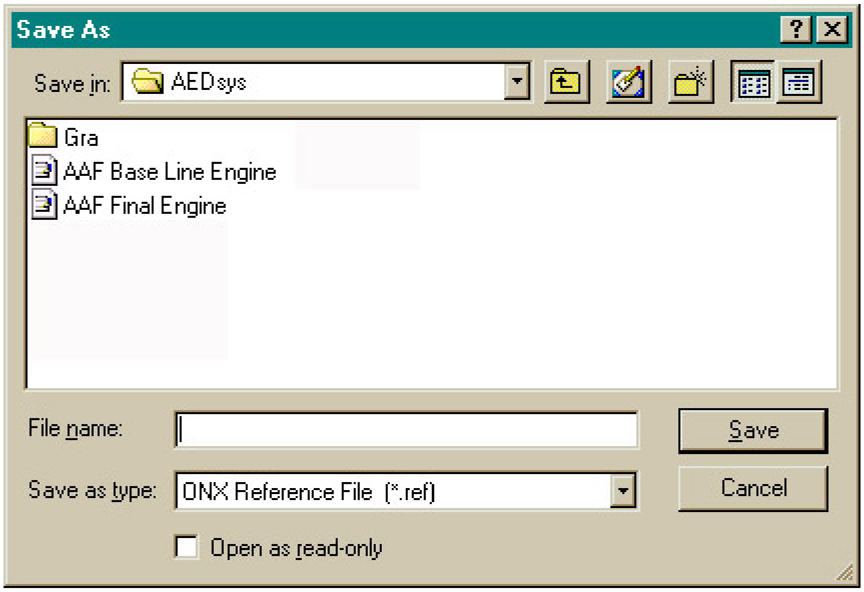
Pressing the **Perform Calculations** button on the Main window causes the Results window to be opened and the input data and results displayed as shown below. The results for this single point calculation are saved for later plotting.




```
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)                   Efficiency
      Cp c       = 0.2400 Btu/lbm-R   Burner         =  0.980
      Cp t       = 0.2950 Btu/lbm-R   Mech Hi Pr     =  0.980
      Gamma c    = 1.4000             Mech Lo Pr     =  0.990
      Gamma t    = 1.3000             Fan/LP Comp    =0.890/0.890 (ef/ecL)
      Tt4 max    = 3200.0 R           HP Comp        =  0.900 (ecH)
      h - fuel   =  18400 Btu/lbm     HP Turbine     =  0.890 (etH)
      CTO Low    = 0.0100             LP Turbine     =  0.910 (etL)
      CTO High   = 0.0000             Pwr Mech Eff L =  0.980
      Cooling Air #1 =  5.000 %       Pwr Mech Eff H =  0.980
      Cooling Air #2 =  5.000 %       Bleed Air      =  1.000 %
      P0/P9      = 1.0000
      *** 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
```

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.



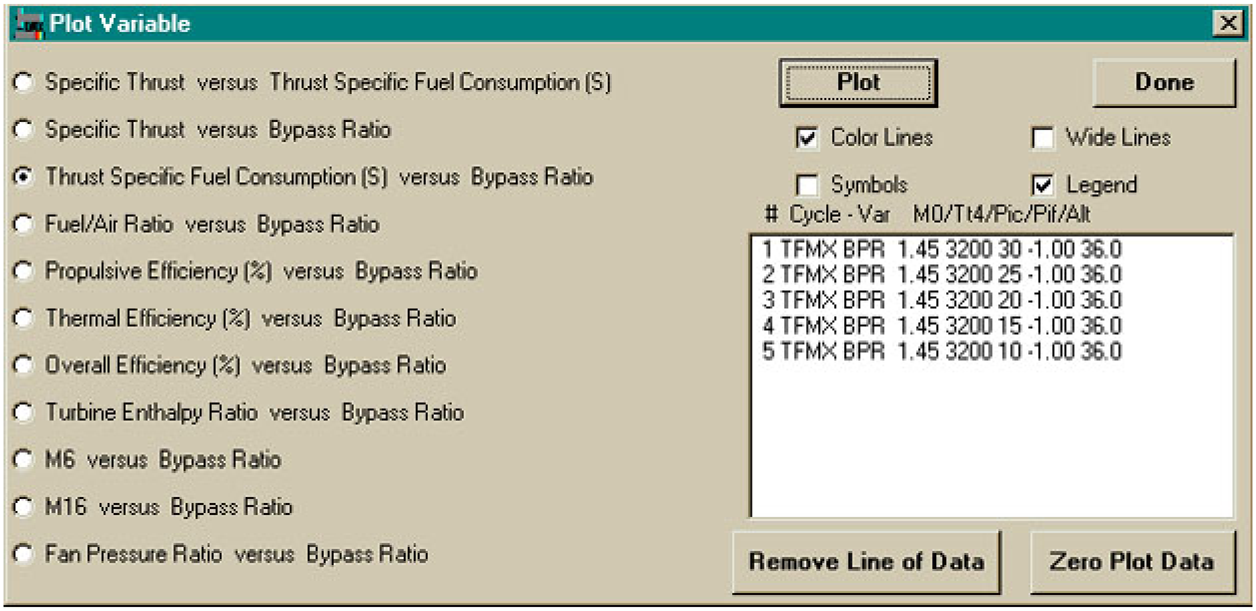


Note: The reference data file required for input to the performance (off-design) cycle analysis program portion (Engine Test) of the AEDsys program can only be generated by performing a single design point calculation and then saving the required output data to a user-named reference data file (the file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

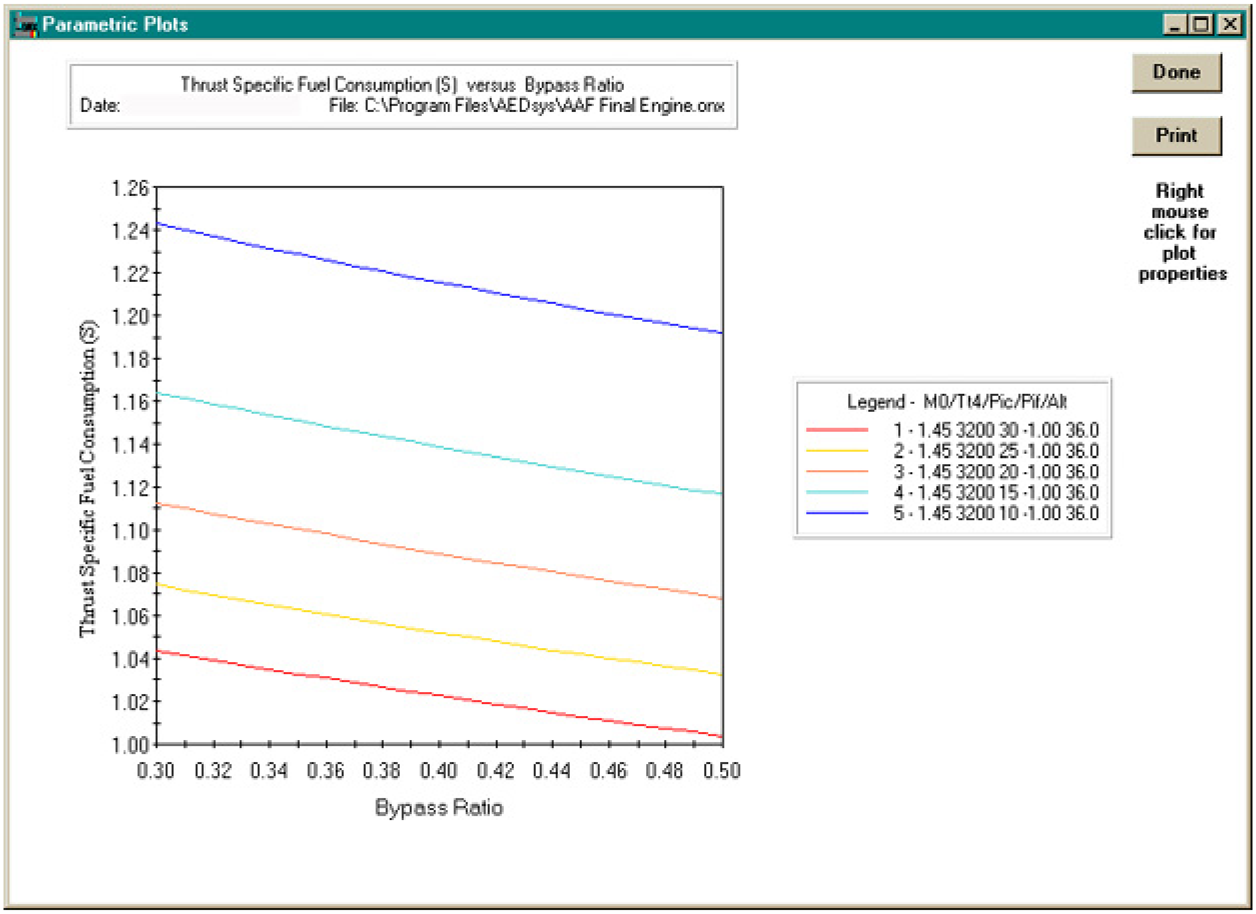
After the single point calculation has been performed, the **Plot Single Point on Mollier Chart** button on the Main window becomes active as shown below.

5. PLOT Window – Multiple Calculations

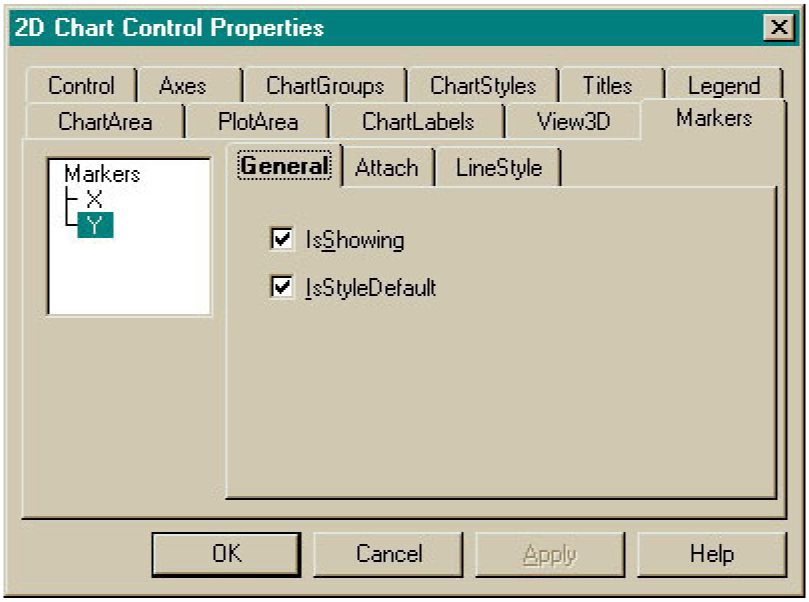
Pressing the **Plot Results** button on the Main window opens the Plot window as shown below for user selection.



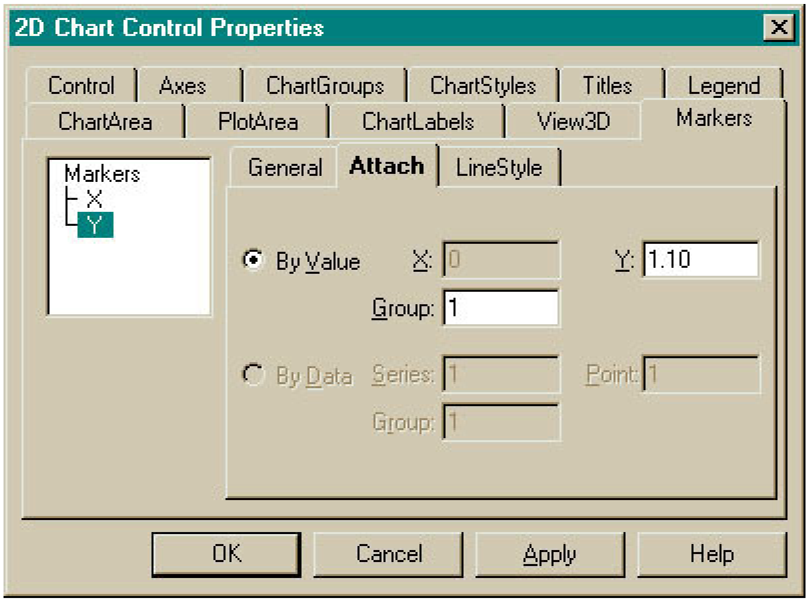
Pressing the Plot button gives.



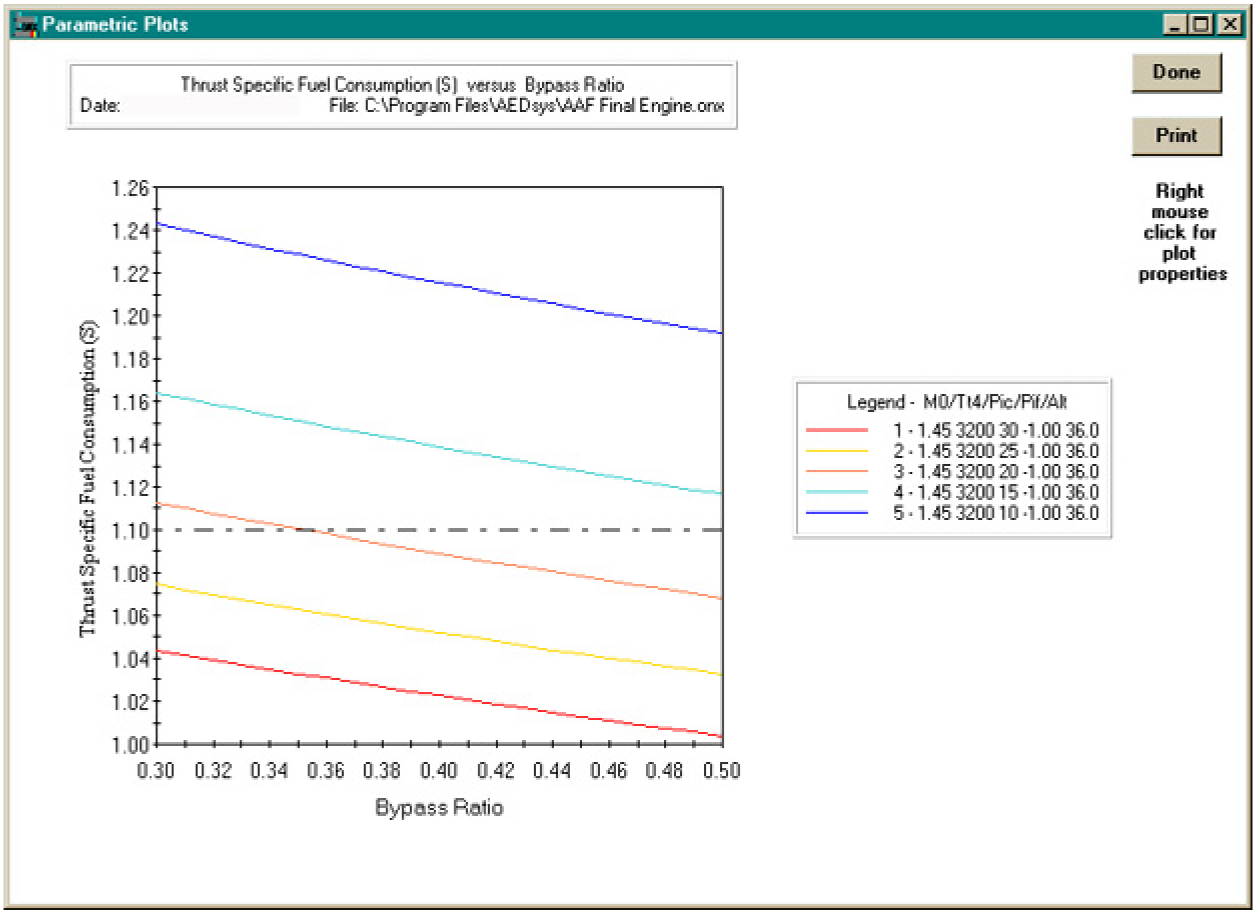
Let's mark the maximum allowable thrust specific fuel consumption (*S*) on this plot. First, right mouse click on the plot. Select **Markers**, click on **Y**, check **IsShowing**, then select **Attach**.



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

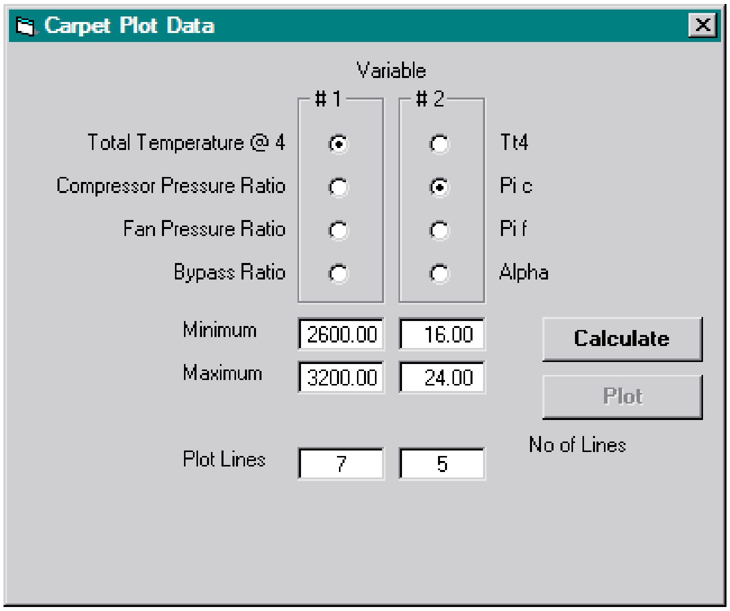


The plot now has a line indicating the maximum value of S as shown below.

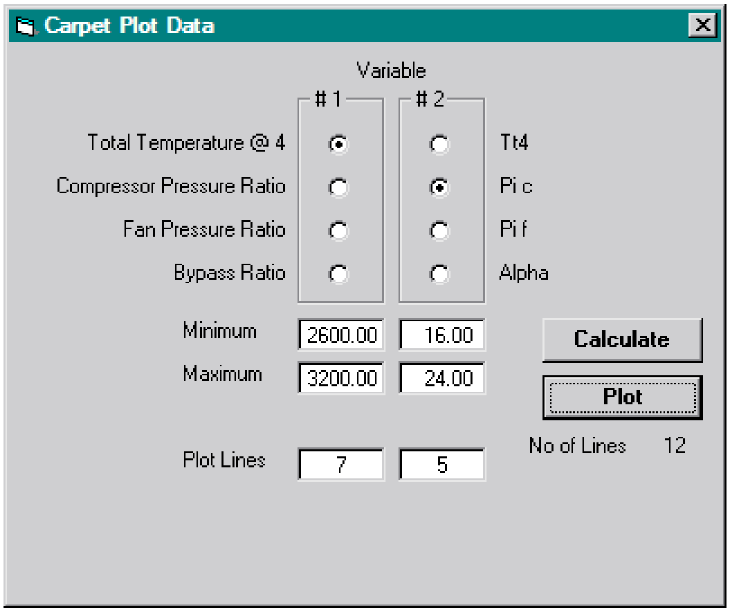


6. CARPET PLOT

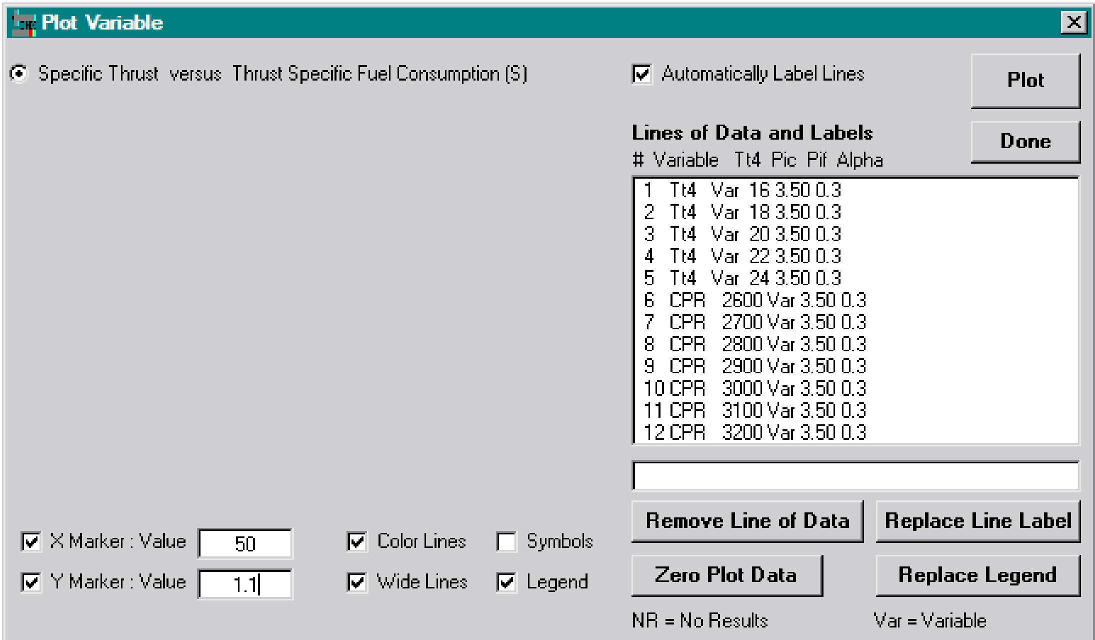
Carpet plots similar to Figs. 4.E2 and 4.E3 can be generated by performing the calculations with two different independent variables. Select the Carpet Plot button on the Main Window and the following window is displayed. The user can select the two variables and their range (min and max) and number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



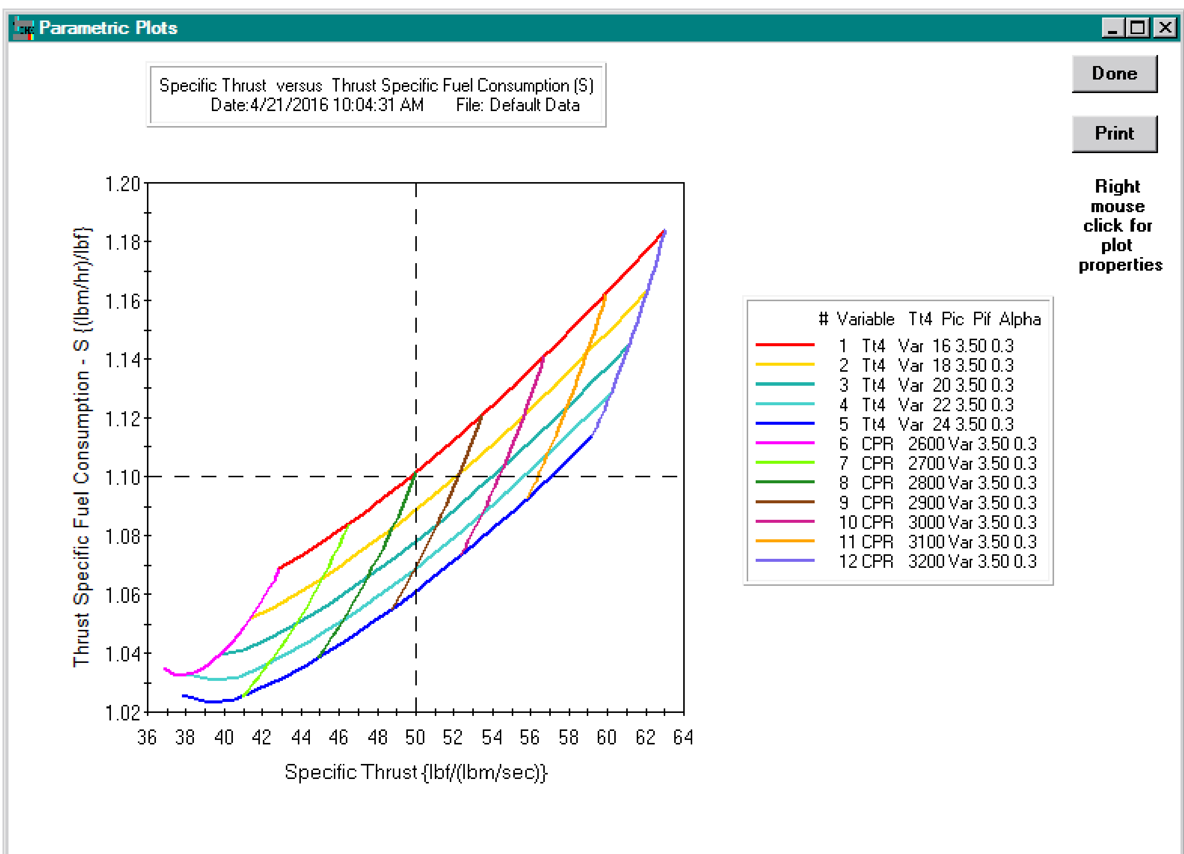
The Plot button is activated when calculations are complete as shown below.



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

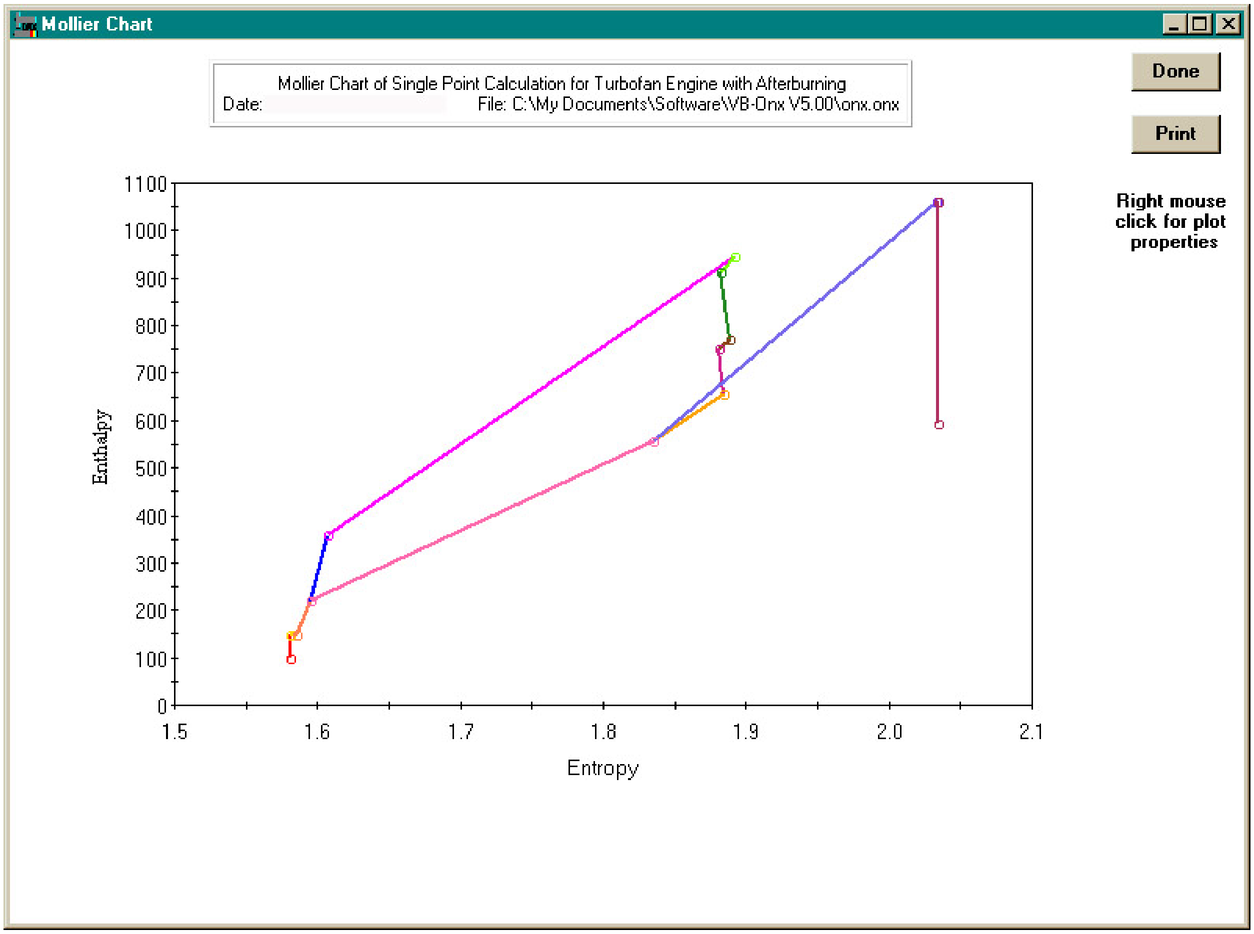


Press the Plot button and the carpet plot is shown – see below.



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