TURBN Program

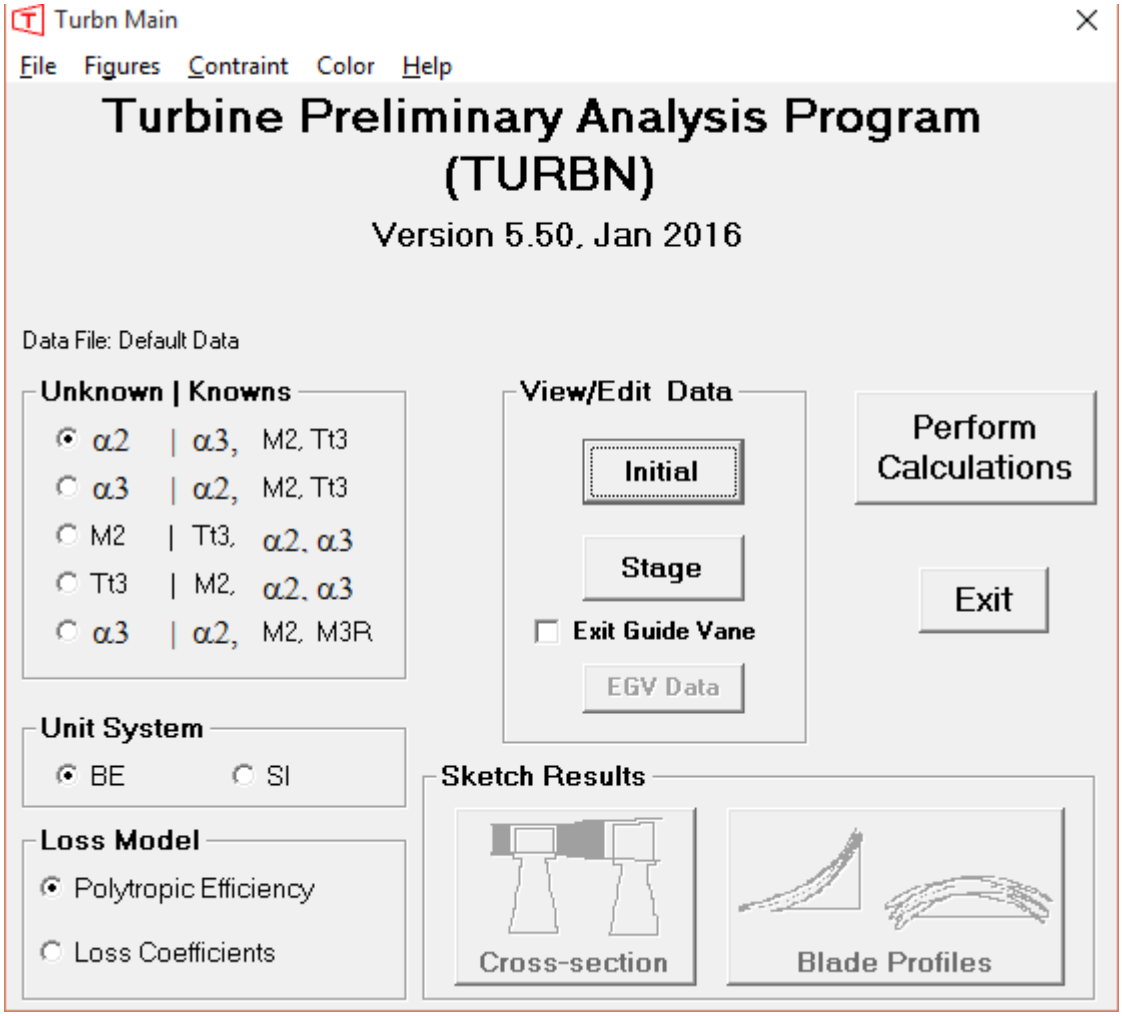
User Guide

January 2016

Table of Contents

1. MAIN Window

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



The turbine mean-line design program TURBN is based on the equations developed in *Elements of Gas Turbine Propulsion* and *Aircraft Engine Design, Second Edition.* It analyzes a constant mean-line design with free vortex swirl distribution for the following five different cases of unknown and known data:

1. α_2 unknown; α_3, M_2, T_{t3} known.
2. α_3 unknown; α_2, M_2, T_{t3} known.
3. M_2 unknown; $T_{t3}, \alpha_2, \alpha_3$ known..
4. T_{t3} unknown; M_2, α_2, α_3 known.
5. α_3 unknown; α_2, M_2, M_{3R} known.

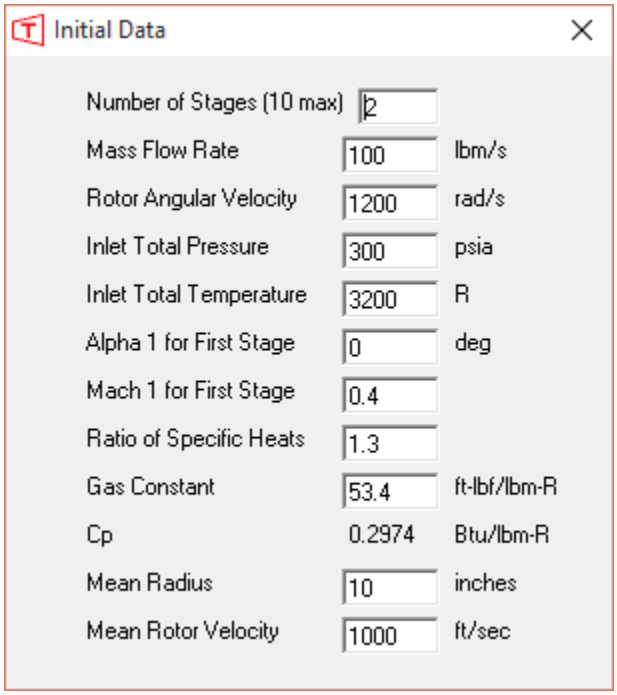
Each of these designs can be analyzed using the user-selected unit system (English or SI) and loss model (polytropic efficiency or loss coefficients).

This program is designed to be user-friendly and multiple windows are used for program control and data input. TURBN input data files may be saved on disk for later use (the file extension “tbn” is used for these files). Also, saved input data files may be read from disk for current use. Program output is directed to an output window and may be sent to a printer.

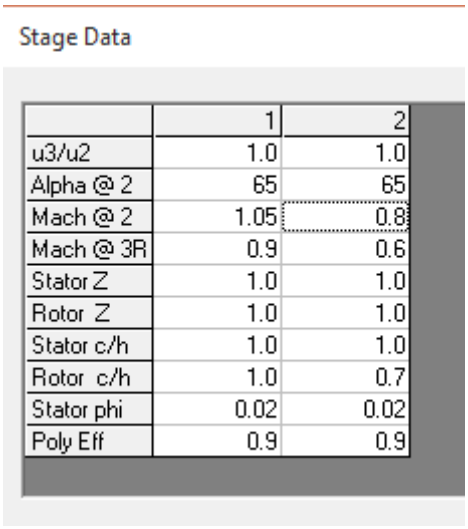
It is recommended that a multi-stage turbine design begin with the α_3 unknown; α_2, M_2, M_{3R} known. Starting from the results of this design, each stage can be custom designed using the other unknown and known combinations.

2. VIEW/EDIT DATA Windows

When the **Initial** data button is pressed, the following Initial Data window is displayed:



When the **Stage** data button is pressed, the Stage Data window similar to that shown below is displayed. Data is edited in this window by moving to the desired data cell, double-click on the cell to open an edit window. Make the changes and then press either the Enter key or Tab key and the updated window is displayed. Shown below is a two-stage turbine with α_3 unknown; α_2, M_2, M_{3R} known. The values of α_2 were changed to 65 and M_2 for the second stage changed to 0.8.

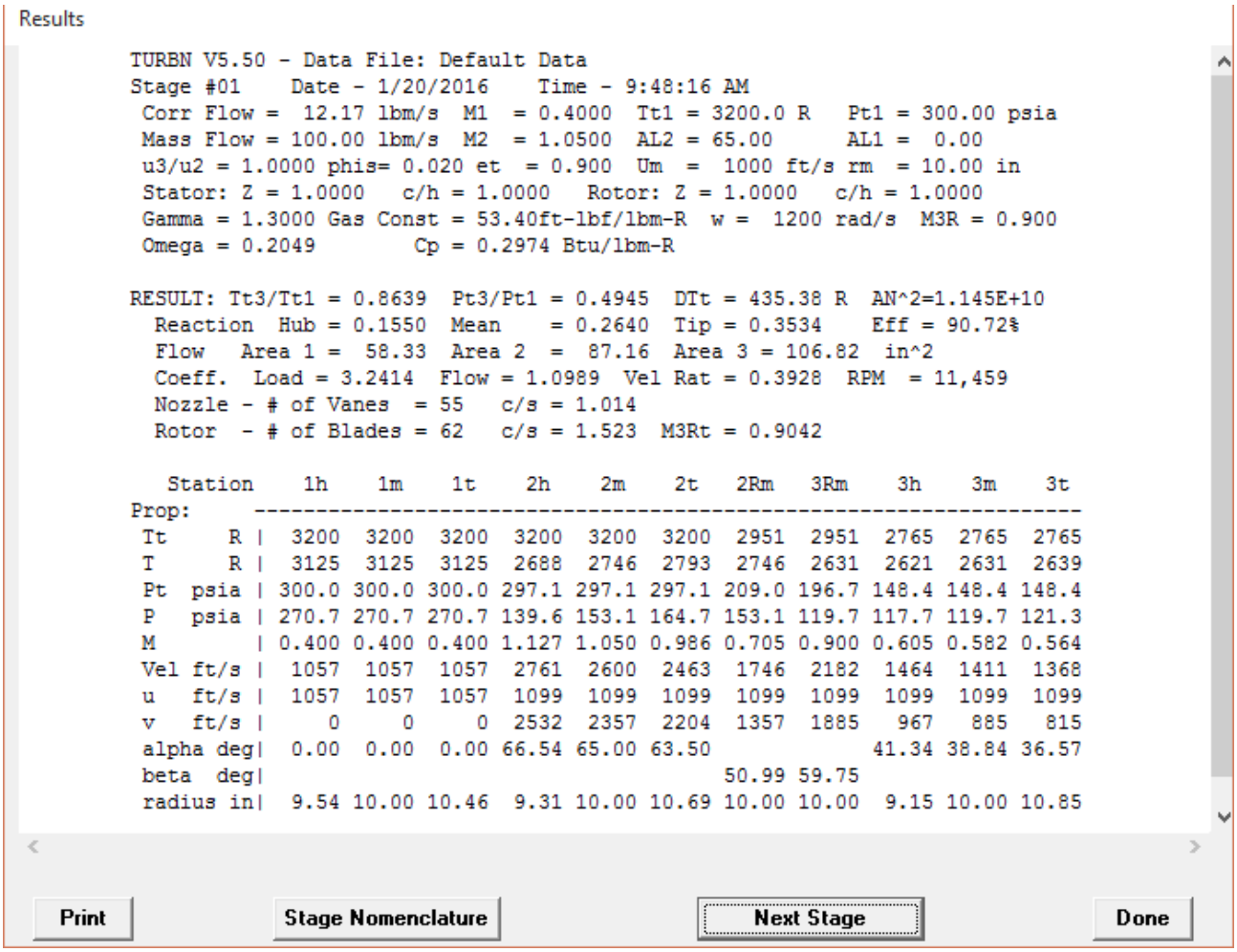


	1	2
u3/u2	1.0	1.0
Alpha @ 2	65	65
Mach @ 2	1.05	0.8
Mach @ 3R	0.9	0.6
Stator Z	1.0	1.0
Rotor Z	1.0	1.0
Stator c/h	1.0	1.0
Rotor c/h	1.0	0.7
Stator phi	0.02	0.02
Poly Eff	0.9	0.9

If the **EGV** check box is marked on the Main window, the **EGV** button becomes active. Pressing the **EGV** button opens the EGV Data window.

3. RESULTS Window – Perform Calculations

Pressing the **Perform Calculations** button on the Main window causes the Results window to be opened and the input data and results displayed for the first stage as shown below for the first of a two-stage turbine with α_3 unknown; α_2, M_2, M_{3R} known.

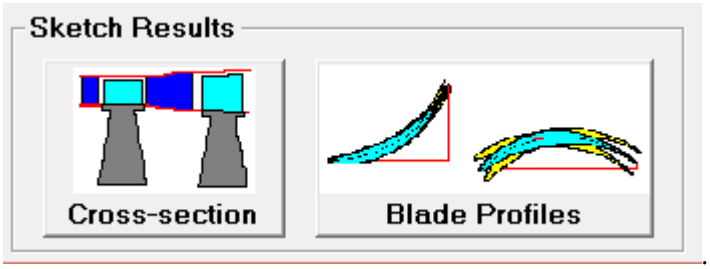


If the computer has a default printer, the **Print** button is visible and the user can use it to have the results printed. The **Next Stage** button is active for advancement to the next stage calculations.

The results for the Exit Guide Vane of this two-stage design are shown below.

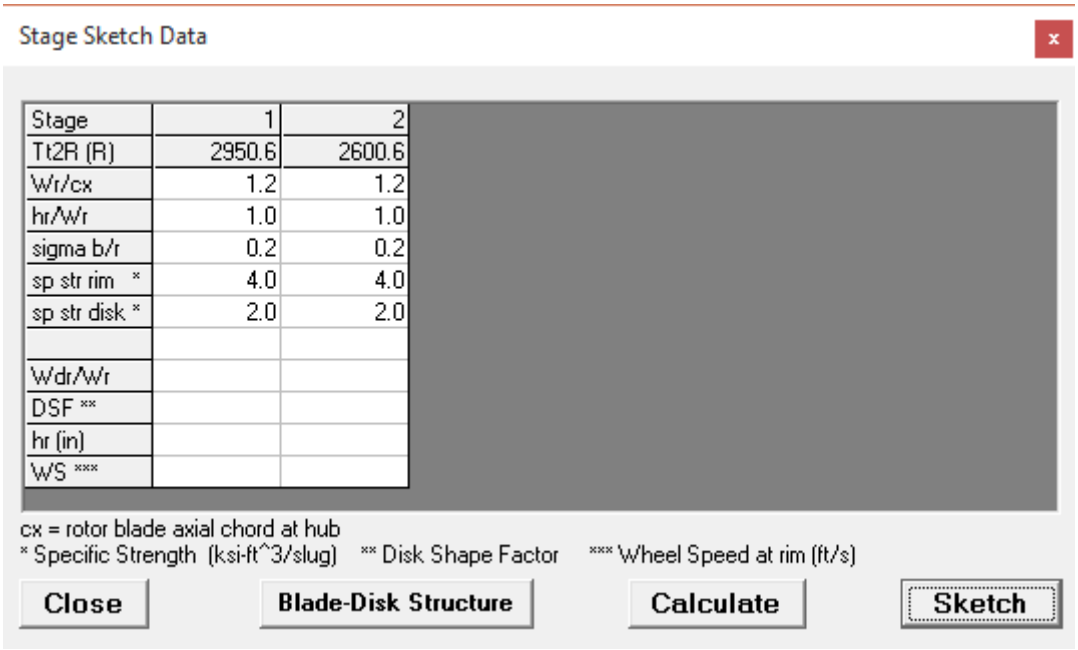
```
Turbine Exit Guide Vane
 Corr Flow =  34.56 lbm/s  M1  = 0.3484  Tt1 = 2512.3 R  Pt1 =  93.58 psia
 Mass Flow = 100.00 lbm/s  AL1 =  11.11  Tt2 = 2512.3 R  Pt2 =  93.31 psia
 Z  = 0.900  c/h = 1.000   phis = 0.020  AL2 =  0.00     M2 = 0.500

 Flow Area 1 = 189.71 ft^2  rh1 =  8.49  rm1 = 10.00  rt1 = 11.51 in
 Flow Area 2 = 139.79 ft^2  rh2 =  8.89  rm2 = 10.00  rt2 = 11.11 in

 Number of EGV Blades =      6
 Solidity (c/s)       =  0.250
```

Pressing the Done button displays the Main window with both Sketch Results buttons active as shown below.

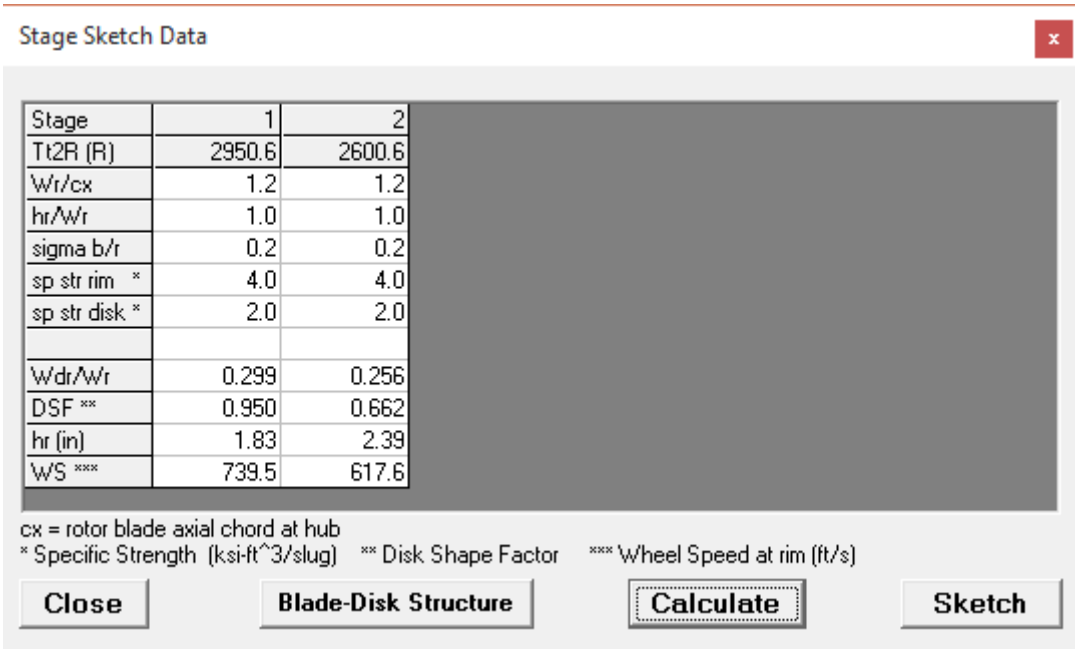


4. SKETCH RESULTS Window

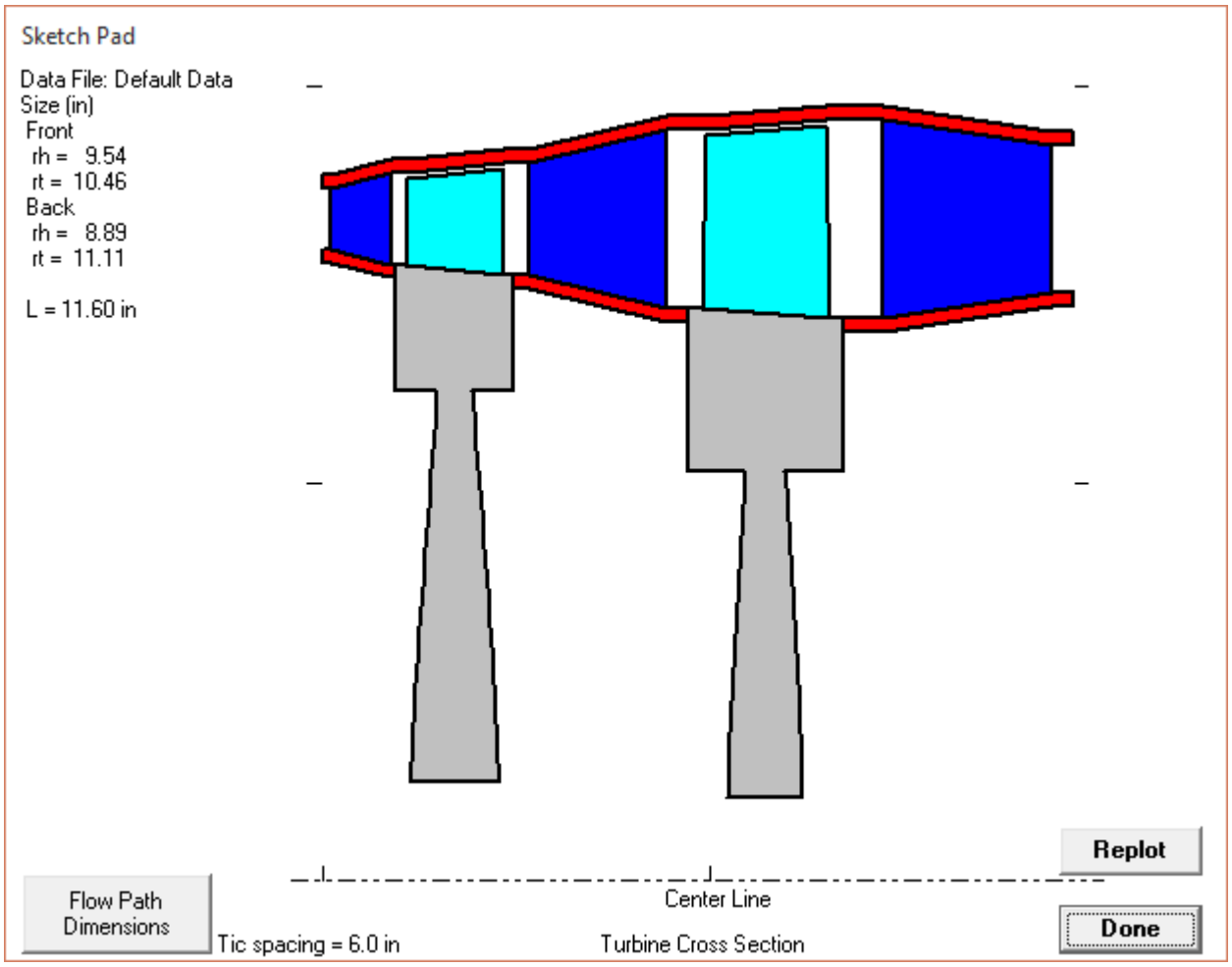
Pressing the **Cross-section** button on the Main window causes the Stage Sketch Data window to be opened and the input data displayed as shown below.



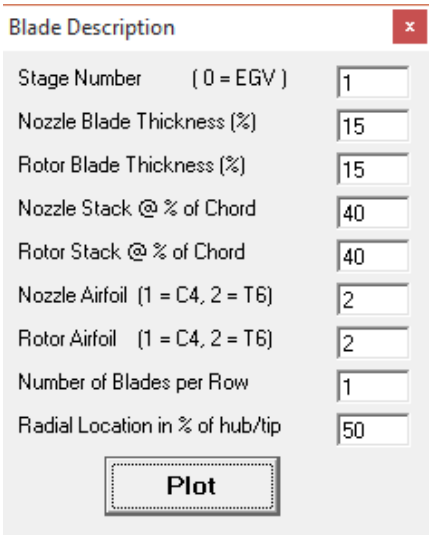
Pressing the **Calculate** button on the Stage Sketch Data window displays the results on an updated window as shown below. If the **Sketch** button is selected before the **Calculate** button, the results are calculated but not displayed



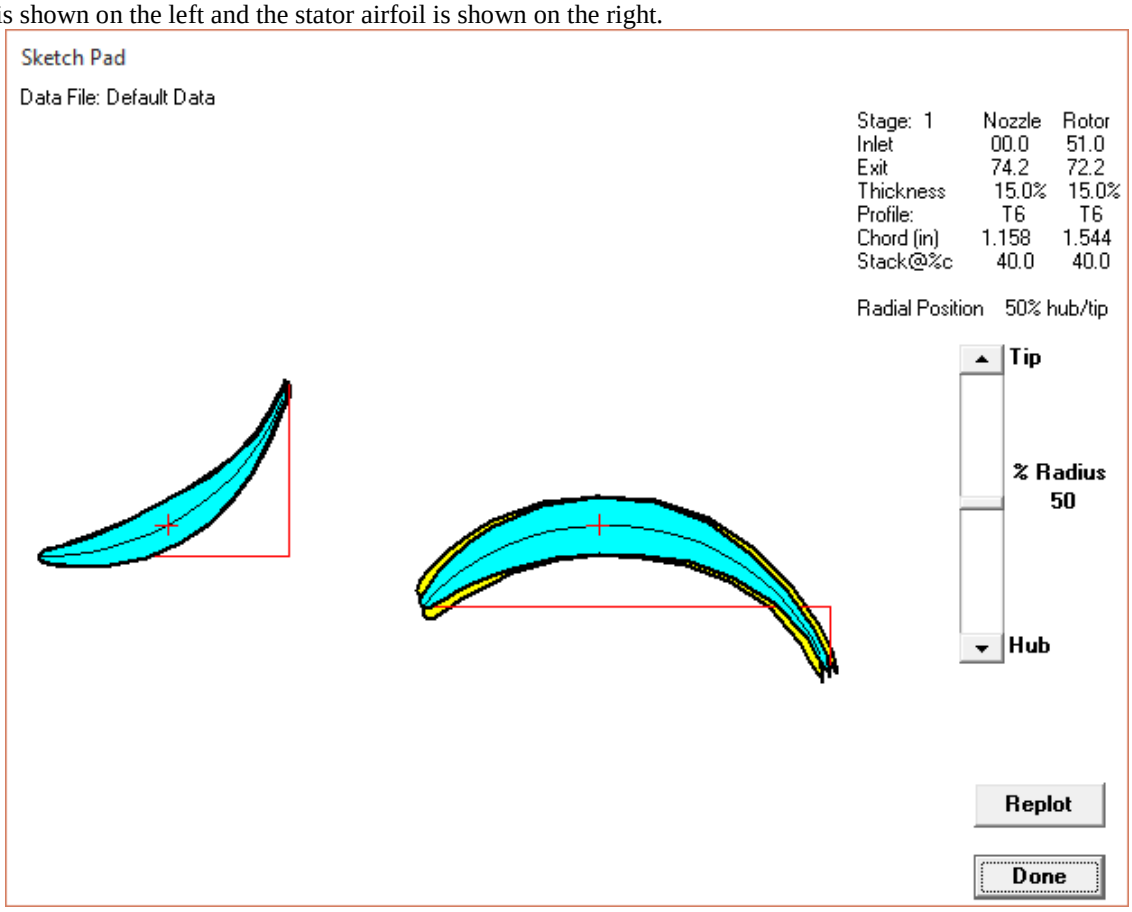
Pressing the **Sketch** button displays the Sketch Pad window with a cross-sectional sketch of the multi-stage axial flow turbine.



Pressing the **Blade Profiles** button on the Main window causes the Blade Description window to be opened and the input data displayed as shown below.

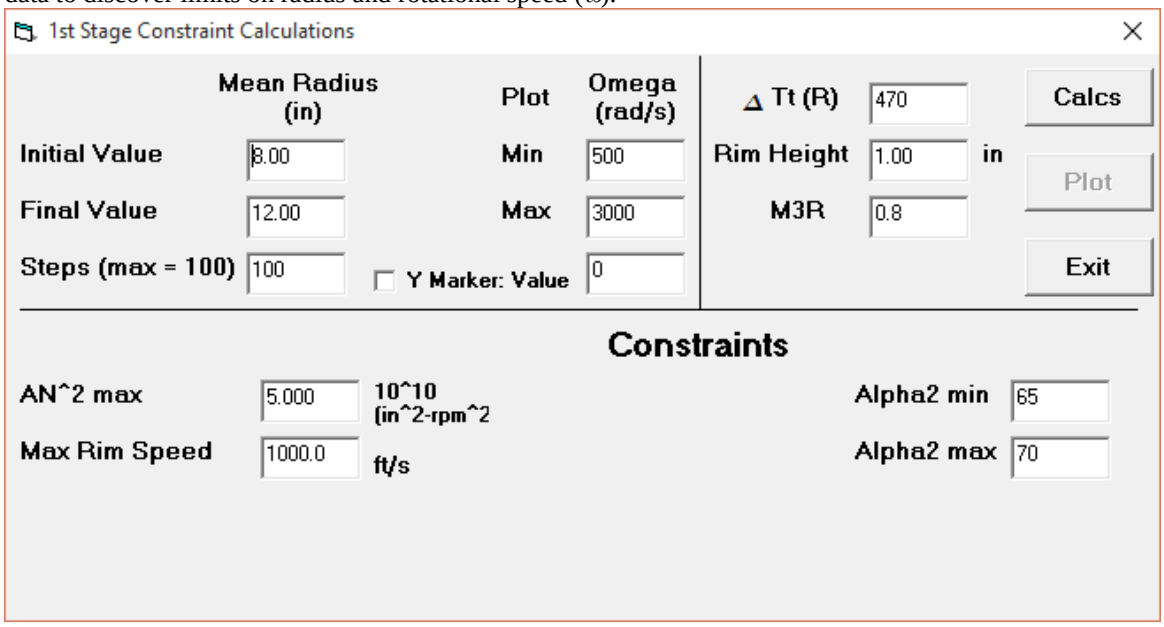


Pressing the **Plot** button for the data above displays the Sketch Pad window with a sketch of the blade shape. The hub and tip blade profiles are shown in yellow and the profile at the radius of interest is shown in light blue. The rotor airfoil is shown on the left and the stator airfoil is shown on the right.

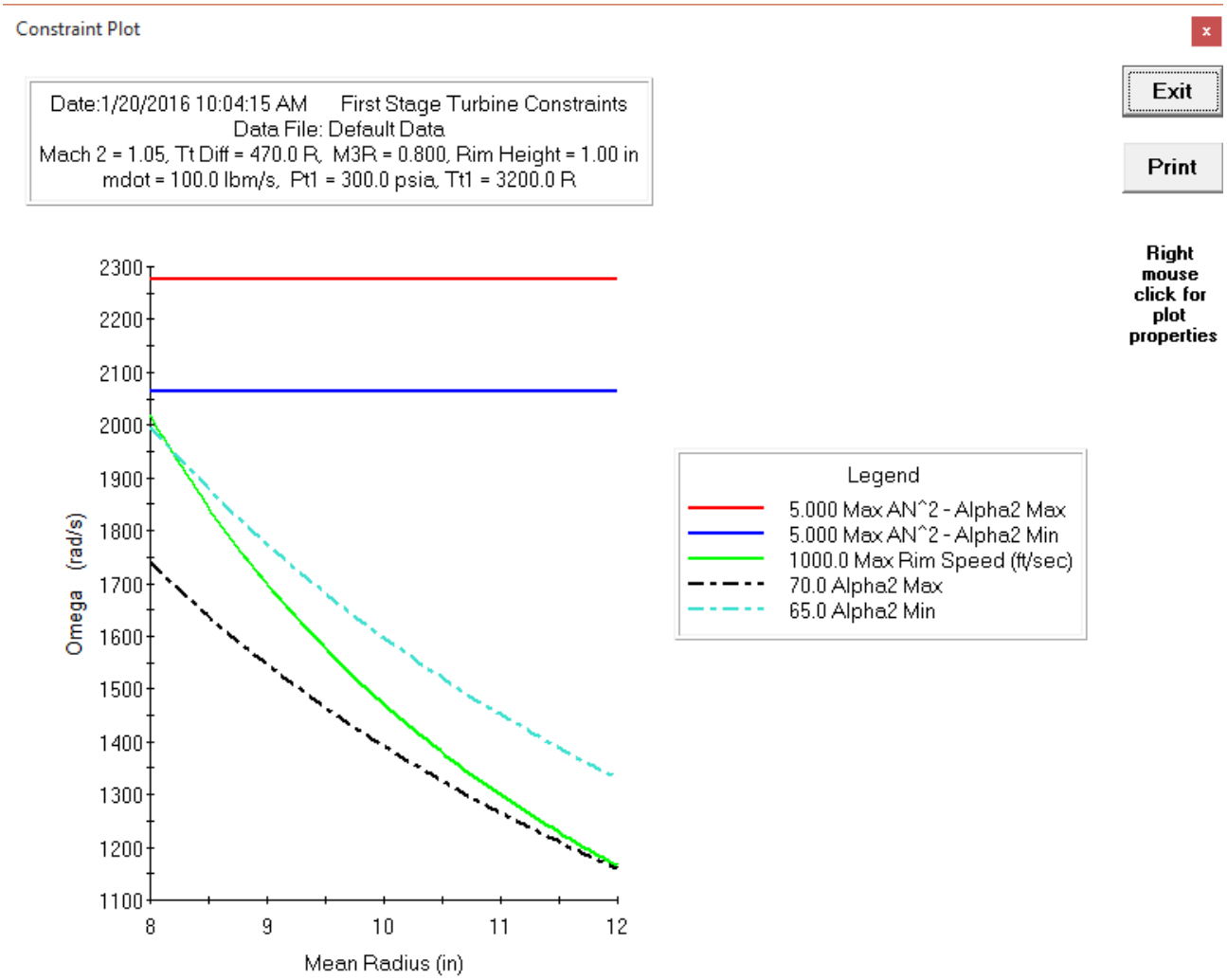


5. Constraint Analysis

Selecting Constraint from the pulldown menu will display the following window where the yuser can input data to discover limits on radius and rotational speed (ω).



After calculations are performed, pressing the Plot button displays the results like below.



The plot above shows that the AN^2 do not limit the rotational spped (ω) but the Rim Speed does. The user would thus choose a combination of ω and *r* that in below the limit (green line).