



GasTurb 13

COMPONENT MAPS





GasTurb 12 Main Window

Gas Turbine Performance - www.gasturb.de

Exit Program Options... Help

Jet Engines Gas Turbines Propulsion Power Generation About

GasTurb 13

- > Basic Thermodynamics
- ▼ Scope
 - Performance
- ▼ Off Design
 - Standard Maps
 - Selected Maps
 - Engine Model

Turbojet

2 Compr Turbojet

2 Spool Turbojet

2 Spool Turbofan

Geared Turbofan A

Geared Turbofan B

2 Spool Mixed Turbofan

Geared Mixed Turbofan A

Geared Mixed Turbofan B

3 Spool Turbofan

3 Spool Mixed Turbofan

Interc Recup Turbofan

1 Sp Mixed Turbofan

Variable Cycle Engine

Ramjet

For this tutorial we will use a simple Turbojet





We Need Some Data

Jet Engines Gas Turbines Propulsion Power Generation About

GasTurb 13

Basic Thermodynamics

Scope

Performance

Off Design

Standard Maps

Selected Maps

Engine Model

1 Sp Mixed Turbofan Variable Cycle Engine Ramjet

Read Data for the Turbojet

« GasTurb13 » Data

Organisieren Neuer Ordner

Name Änderungsdatum

Name	Änderungsdatum
Demo_jet.CYJ	10.08.2016 18:47
Demo_jet_reheat.CYJ	10.08.2016 18:47
Demo1StageRadComp.CYJ	10.08.2016 18:47
Demo2StageRadComp.CYJ	10.08.2016 18:47
DemoAxRadComp.CYJ	22.08.2016 15:12

Dateiname: Demo_jet.CYJ Cycle Data Files (*.CYJ)

Öffnen Abbrechen

Select the engine model

Open the engine model



Off-Design Input Data Page

Run an Off-Design simulation without changes

Off Design Input for a Turbojet

Cycle Design Main Window Exit Program Help

Off Design Point

Task

- OD Point
- Operat Line
- Parametric
- Mission
- Flight Envel
- Monte Carlo
- Analysis
- Sensitivity
- Init Trans
- Batchjob
- Transient

» Project

» Additional

» Maps and Connections

» Controls

» Extras

Basic Data

- Basic Data
- Modifiers
 - Ambient Conditions
 - alt, Mach, dtamb
 - T1, P1, Pamb
 - Nozzle Calculation
 - Standard
 - Specify CFG and CD
 - Controls
 - Min Limiters
 - Max Limiters
 - EPR Definition
 - Var Geometry
 - Iteration Variables
 - Transient

Basic Data Distortion No

Property	Unit	Value	Comment
Intake Pressure Ratio		0,99	
Fuel Heating Value	MJ/kg	43,124	
Overboard Bleed	kg/s	0	
Rel. Overboard Bleed W_Bld/W2		0,01	
Recirculating Bleed W_reci/W2		0	
Power Offtake	kW	0	
ZXN given (1) or ZT4 given (2)		1	
HPC Spool Speed ZXN		1	
Compressor Delta VG Setting[deg]		0	inactive
d_HPT Efficiency / d_XN		0	

C:\Program Files (x86)\GasTurb13\Data\Demo_jet.CYJ (modified) Off Design Point



Off-Design Point Summary

Have a look at the compressor map

SL static, ISA

Close Help

Overview

- Range Save input Slider
- Unit Conv Title

Diagrams

- T-S H-S P-V
- Station Data

Output

- Print Clipboard Save
- Excel
- Initialize Export Disconnect
- Save

Summary Oper.Point Compr Turb Air System Stations

Station	W kg/s	T K	P kPa	WRstd kg/s
amb		288,15	101,325	
1	31,680	288,15	101,325	
2	31,680	288,15	100,312	32,000
3	31,680	630,42	1203,741	3,944
31	28,195	630,42	1203,741	
4	28,857	1450,00	1167,629	5,617
41	30,441	1411,20	1167,629	5,846
49	30,441	1113,50	367,374	
5	32,025	1091,37	367,374	17,190
6	32,025	1091,37	360,027	
8	32,025	1091,37	360,027	17,541
Bleed	0,317	630,42	1203,738	

FN = 26,37 kN
 TSFC = 25,0985 g/(kN*s)
 FN/w2 = 832,50 m/s
 Prop Eff = 0,0000
 eta core = 0,3884
 P5/P2 = 3,6623 EPR
 WF = 0,66194 kg/s
 s NOx = 0,28659
 XM8 = 1,0000
 A8 = 0,0773 m²
 P8/Pamb = 3,5532
 wBld/w2 = 0,01000
 Ang8 = 20,00 °
 CD8 = 0,9600
 wC1N/w2 = 0,05000
 wC1R/w2 = 0,05000
 Loading = 100,00 %
 e45 th = 0,87139
 far7 = 0,02111
 PWX = 0,00 kw

P2/P1 = 0,9900 P4/P3 = 0,9700 P6/P5 0,9800
 Efficiencies: isentr polytr RNI P/P
 Compressor 0,8500 0,8913 0,990 12,000
 Burner 0,9999 0,970
 Turbine 0,8900 0,8757 1,798 3,178

Spool mech Eff 0,9999 Speed 12499 rpm

hum [%] war0 FHV Fuel
 0,0 0,00000 43,124 Generic

Input Data File:
 C:\Program Files (x86)\GasTurb13\Data\Demo_jet.CYJ

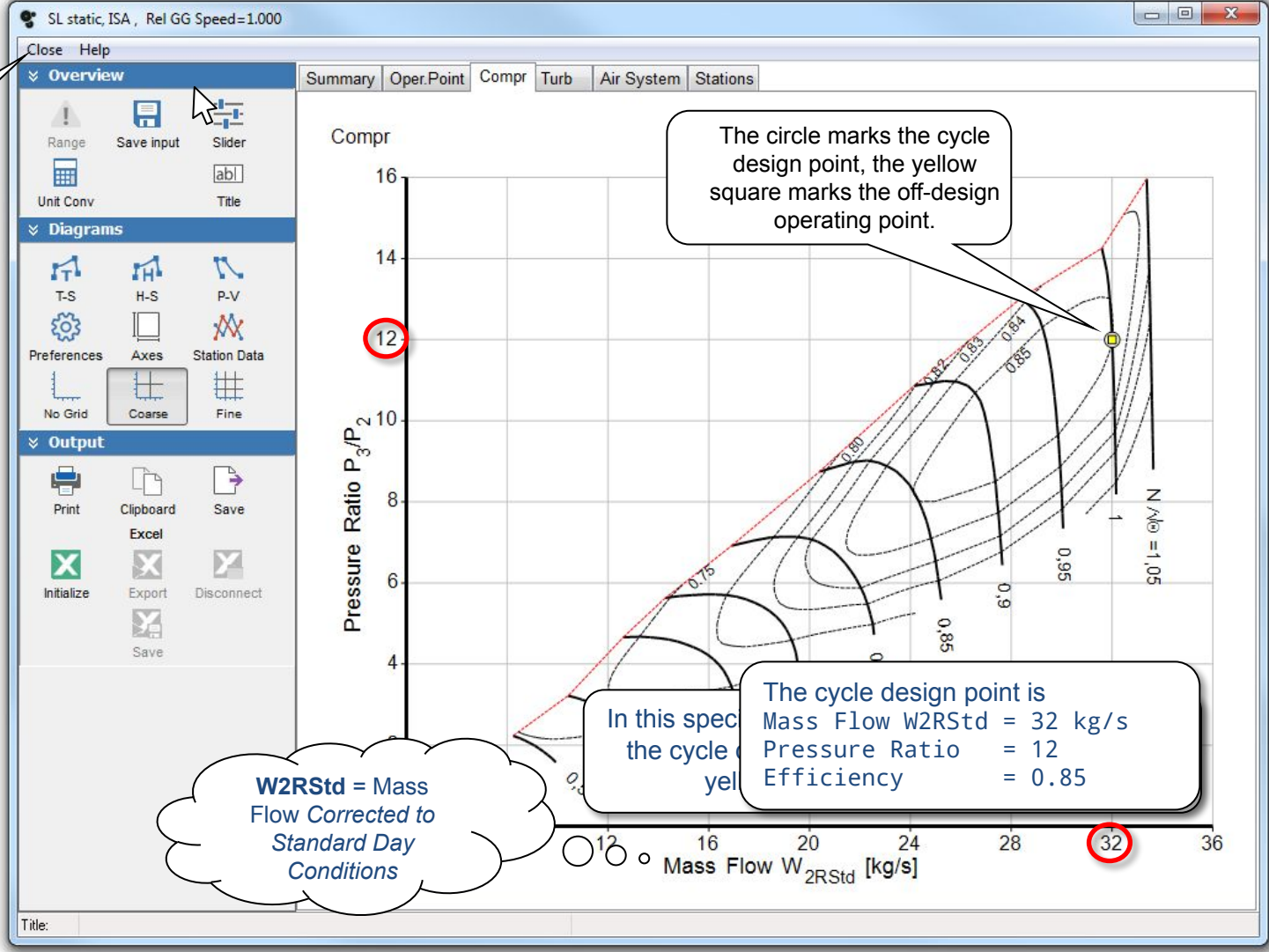
Title:

This is the cycle design point, calculated in off-design mode.



Standard Compressor Map

Close the result window



W_{2RStd} = Mass Flow Corrected to Standard Day Conditions

In this spec the cycle yellow

The cycle design point is
 Mass Flow W_{2RStd} = 32 kg/s
 Pressure Ratio = 12
 Efficiency = 0.85

The circle marks the cycle design point, the yellow square marks the off-design operating point.



Off-Design Input Data Page

Click on Special to configure **Special Maps**

Property	Unit	Value	Comment
Intake Pressure Ratio		0,99	
Fuel Heating Value	MJ/kg	43,124	
Overboard Bleed	kg/s	0	
Rel. Overboard Bleed W_Bld/W2		0,01	
Recirculating Bleed W_reci/W2		0	
Power Offtake	kW	0	
ZXN given (1) or ZT4 given (2)		1	
HPC Spool Speed ZXN		1	
Compressor Delta VG Setting[deg]		0	inactive
d_HPT Efficiency / d_XN		0	

The **Standard Maps** yield in many cases reasonable trends. However, for accurate simulations the Standard Maps must be replaced by **Special Maps**.



HP Compressor Map

Special Component Maps

Close Help

Map Reynolds

Mass flow units in map: Not Known

Read from File:

- Fan (LPC) Maposter (IPC) MAxial HPC Ma
- Compr Map
- HPT Map IPT Map LPT Map
- Scal + Maps
- Axes
- Scaling
- Preferences

Flow Scaler	0
P/P-1 Scaler	1,504
Eff Scaler	0,9884
RN Flow Corr	0,9999
RN Eff Corr	0,9998
Peak Eff	0,8568
Surge Margin	24,13
Beta ds	0,5
N/sqrt(T) ds	1

Do not Scale this Map

C:\Program Files (x86)\GasTurb13\HPC01.MAP

The map is shown un-scaled and without Reynolds corrections

You can either edit the coordinates of the design point or move the design point with the mouse: click it, keep the button pressed, move it.

We will set the cycle design point now to
 $\text{Beta, ds} = 0.4$
 $\text{N/sqrt(T), ds} = 1.05$

At the yellow square the efficiency in the map is 0.86015.
 To scale the map in such a way that it fits to the cycle design point ($\eta=0.85$) the factors $f_{\eta} = 0.9884$ and $f_{\beta} = 0.9998$ are applied:

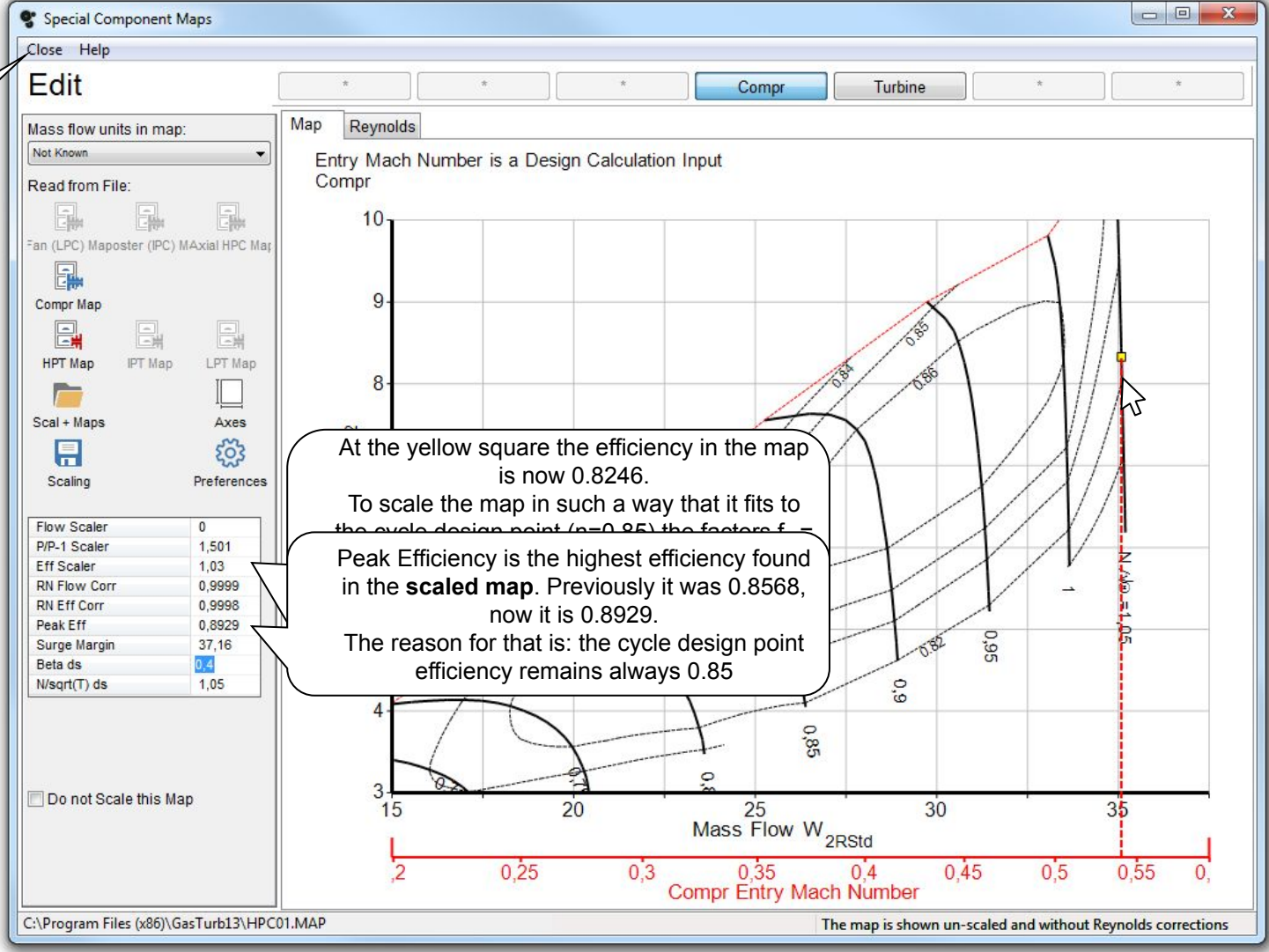
Peak Efficiency is the highest efficiency found in the map
 The coordinates of the design point in the map (the yellow square) are
 $\text{Beta, ds} = 0.5$ and $\text{N/sqrt(T), ds} = 1$

The yellow square marks the cycle design point.



Map Scaling

Close the map window



At the yellow square the efficiency in the map is now 0.8246.

To scale the map in such a way that it fits to the cycle design point ($\eta=0.85$) the factors f =

Peak Efficiency is the highest efficiency found in the **scaled map**. Previously it was 0.8568, now it is 0.8929.

The reason for that is: the cycle design point efficiency remains always 0.85



Save the data as Engine Model

Click on Operating Line

Next we run a single operating line with the default settings.

Off Design Input for a Turbojet

Cycle Design Main Window Exit Program Help

Operating Line

Task

- Operat Line
- Parametric
- Flight Envel
- Monte Carlo
- Analysis
- Sensitivity
- Init Trans
- Batchjob
- Transient

Project

- Read Engine Model **Save**
- Off-Design Point Input Data
- Read File History Save
- Additional
- Maps and Connections
- Controls
- Extras

Basic Data

- Modifiers
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 - alt, Mach, dtamb
 - T1, P1, Pamb
 - Nozzle Calculation
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Basic Data Distortion No

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Fuel Heating Value	MJ/kg	43,124	
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Rel. Overboard Bleed W_Bld/W2		0,01	
Recirculating Bleed W_reci/W2		0	
Power Offtake	kW	0	
ZXN given (1) or ZT4 given (2)		1	
HPC Spool Speed ZXN		1	
Compressor Delta VG Setting[deg]		0	inactive
d_HPT Efficiency / d_XN		0	

C:\Program Files (x86)\GasTurb13\Data\Demo_jet.CYJ (modified) Operating Line

The data can only be stored as **Engine Model File** if all data on the *Steady State* page are identical to those from the cycle design point and if all the *Modifiers* are zero.

An *Engine Model File* contains in addition to a normal data file information about the component maps and how they are scaled.



Off-Design Input Data Page

Detailed description: The screenshot shows the 'Operating Line' software window. The title bar reads 'Operating Line'. The menu bar contains 'Close' and 'Help'. The main toolbar has a green play button labeled 'Operating Line', a 'Manage' button with a downward arrow, and a 'Review' button with a magnifying glass. Below the toolbar is a 'Stop' button with a power icon. The left sidebar contains a tree view with 'Gas Generator Speed St...' expanded, showing '15 Points' and '0.025 NH Stepsize'. There are 'Incr NH' and 'Decr NH' buttons. Below are 'Thrust Steps', 'Compare', and 'Compressor Map(s)' sections. The main area has tabs for 'Compr', 'Turbine', and 'Y=f(x)'. A dialog box is open in the center with a question mark icon and the text 'More operating lines?'. It has 'Yes' and 'No' buttons. A callout box points to the 'No' button with the text 'Select No'. Another callout box points to the 'Operating Line' button with the text 'Run the Operating Line'. A third callout box points to the 'Compr' tab with the text 'Select Compr'.

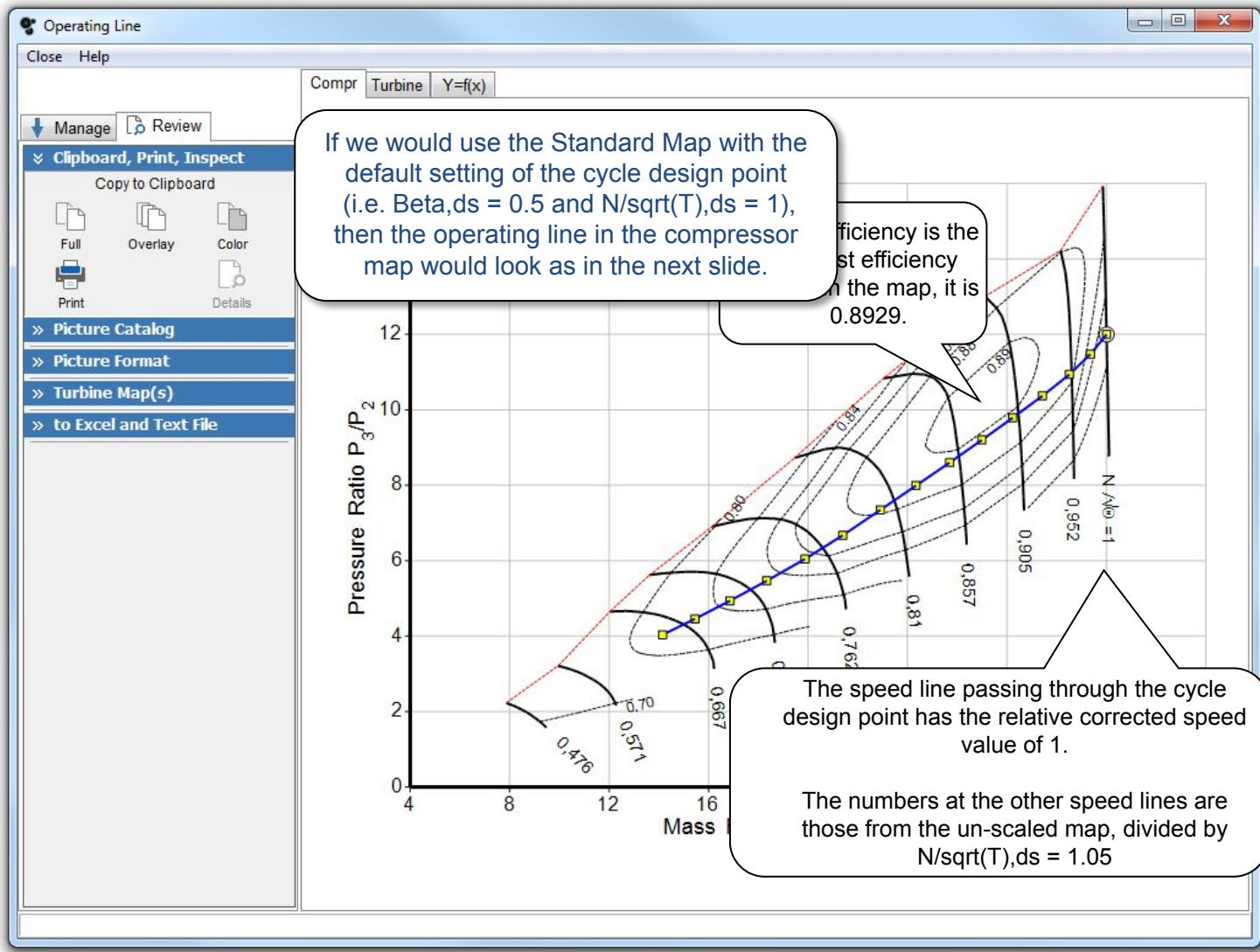
Run the Operating Line

Select Compr

Select No



Compressor Map New



If we would use the Standard Map with the default setting of the cycle design point (i.e. $\beta_{ds} = 0.5$ and $N/\sqrt{T}_{ds} = 1$), then the operating line in the compressor map would look as in the next slide.

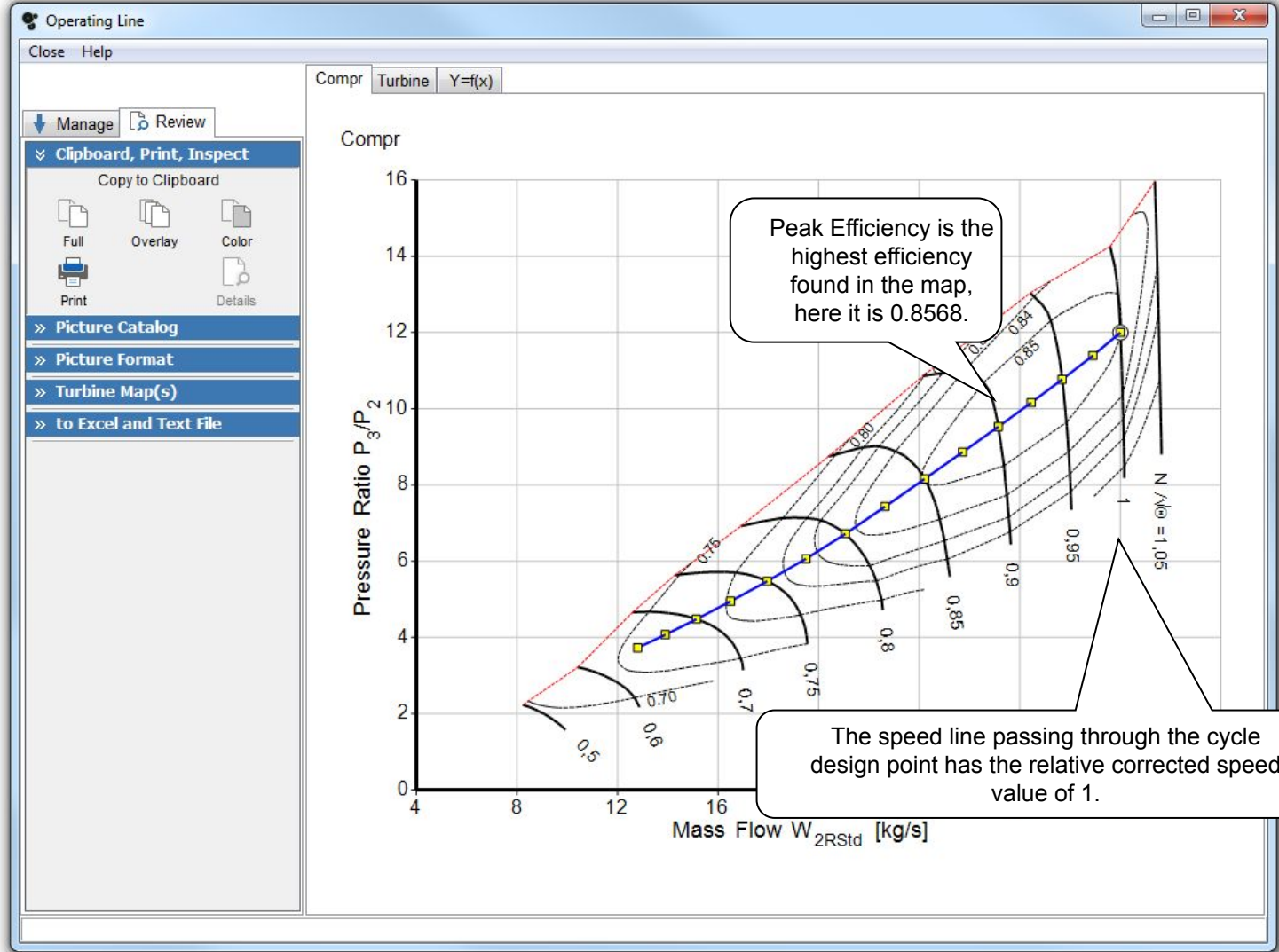
The efficiency at the design point is the best efficiency on the map, it is 0.8929.

The speed line passing through the cycle design point has the relative corrected speed value of 1.

The numbers at the other speed lines are those from the un-scaled map, divided by $N/\sqrt{T}_{ds} = 1.05$

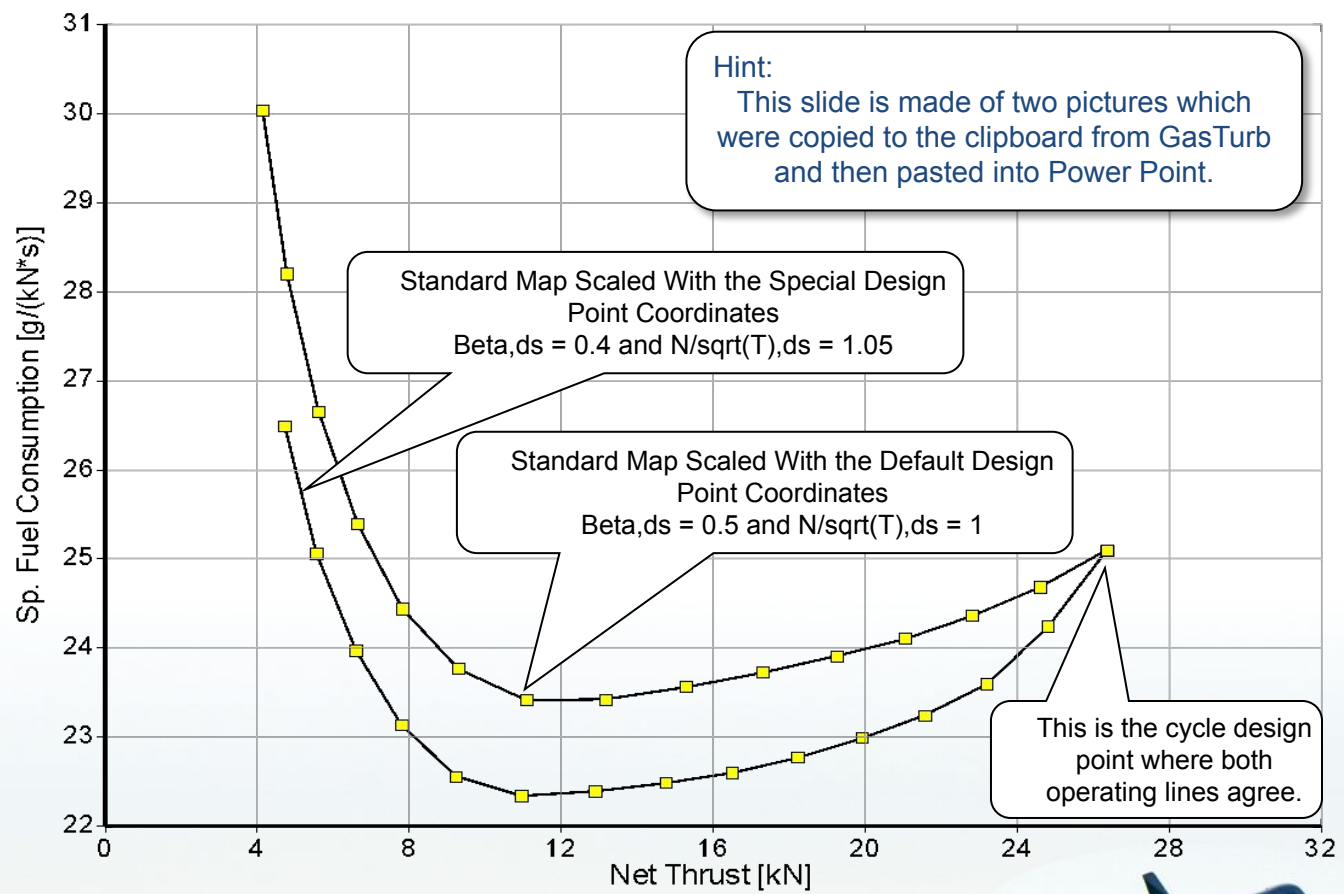


Compressor Map Old





Effect of Map Scaling on SFC





Comparing Measured Data With GasTurb

Off Design Input for a Turbojet

Cycle Design Main Window Exit Program Help

Operating Line

Task

- OD Point
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Project

Additional

Maps and Connections

- Standard
- Special
- Scaling
- Save Maps
- Intake Map

Fuel: Generic

Controls

Extras

Basic Data

Distortion No

Property	Unit	Value	Comment
Intake Pressure Ratio		0,99	
Fuel Heating Value	MJ/kg	43,124	
Overboard Bleed	kg/s	0	
Rel. Overboard Bleed W_Bld/W2		0,01	
Recirculating Bleed W_reci/W2		0	
Power Offtake	kW	0	
ZXN given (1) or ZT4 given (2)		1	
HPC Spool Speed ZXN		1	
Compressor Delta VG Setting[deg]		0	inactive
d_HPT Efficiency / d_XN		0	

C:\Program Files (x86)\GasTurb13\Data\Demo_jet.CYJ (modified) Operating Line

And run another Operating line

Switch back to Standard maps



Read Test Data

The screenshot shows the 'Operating Line' software window. On the left, there is a control panel with buttons for 'Run the Operating Line', 'Manage', 'Review', and 'Stop'. Below these are sections for 'Gas Generator Speed St...', 'Thrust Steps', 'Compare', and 'Compressor Map(s)'. The 'Compare' section has a 'Read' button highlighted with a red box. A callout points to this button with the text 'Read a file with measured data'. In the center, a file dialog window titled 'Öffnen' is open, showing a file named 'demo_jet.tst' selected. A callout points to this file with the text 'Read the file demo_jet.tst'. Below the file dialog, a dialog box asks 'More operating lines?' with 'Yes' and 'No' buttons. A callout points to the 'No' button with the text 'Select No'. At the bottom of the file dialog, the 'Öffnen' (Open) button is highlighted, with a callout pointing to it that says 'Click Open'.



Making the Comparative Data Visible

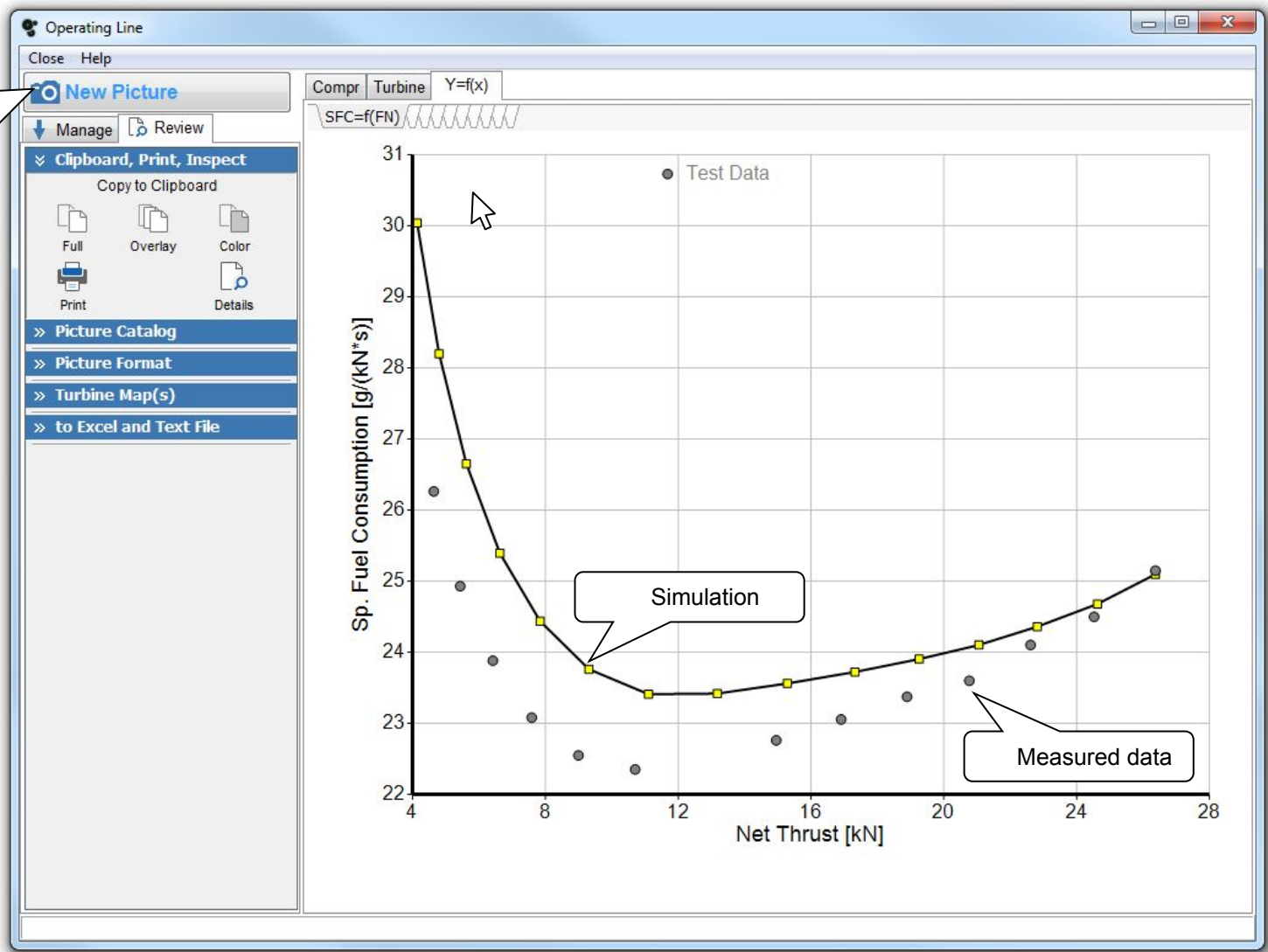
The screenshot shows the 'Operating Line' window in GasTurb. The interface includes a menu bar (Close, Help), a toolbar (Manage, Review), and a sidebar with options like 'Clipboard, Print, Inspect', 'Picture Catalog', and 'to Excel and Text File'. The main area is divided into 'Compr' and 'Turbine' tabs, with a 'Y=f(x)' plot area. A 'Draw y=f(x)' button is highlighted with a callout 'Click Plot'. A 'Show Test Data' checkbox is checked and highlighted with a callout 'Check Show Test Data'. The plot shows Specific Thrust [m/s] on the y-axis (ranging from 1271 to 1275) and Net Thrust [kN] on the x-axis (ranging from 0.92 to 1.2). The plot displays a curve with five data points.

Net Thrust [kN]	Specific Thrust [m/s]
0.95	1273.5
1.00	1274.8
1.05	1274.2
1.10	1272.8
1.15	1271.5



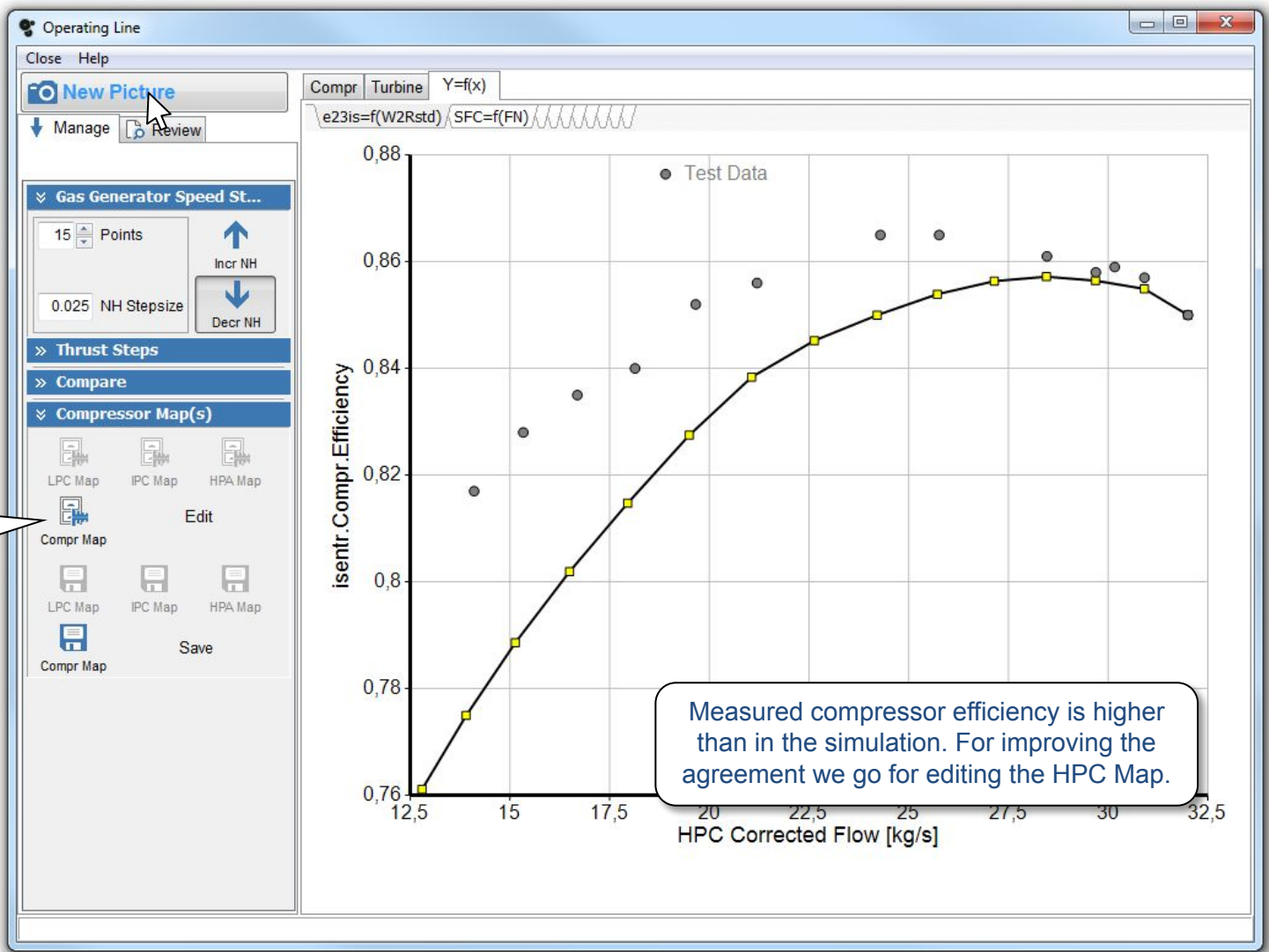
Comparing SFC

Click on New Picture and plot the isentropic compressor efficiency over the corrected compressor flow





Comparing Compressor Efficiency



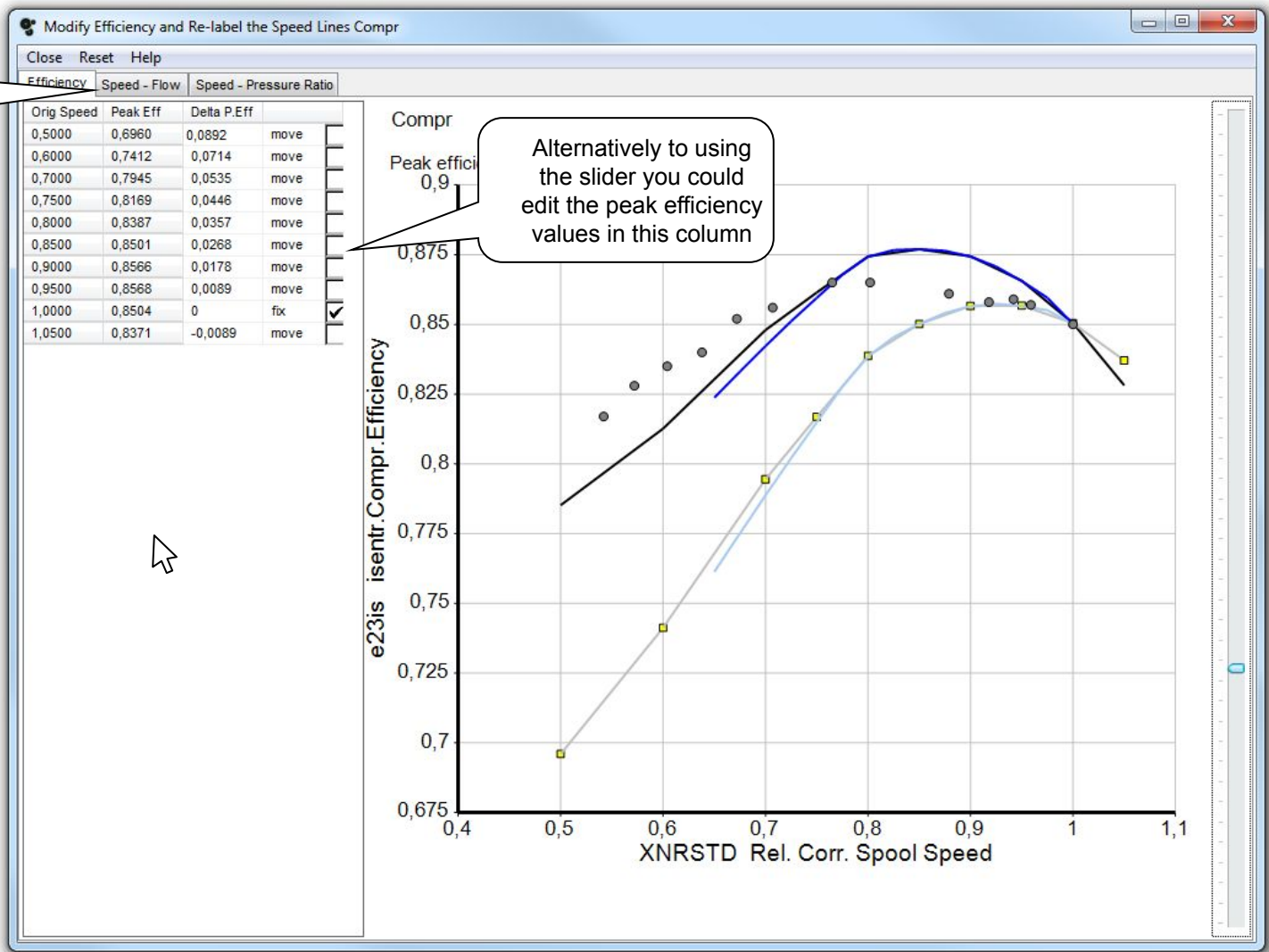
Click on Edit Compr Map

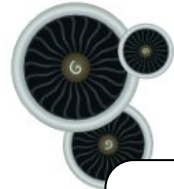
Measured compressor efficiency is higher than in the simulation. For improving the agreement we go for editing the HPC Map.



The Compressor Map Editor

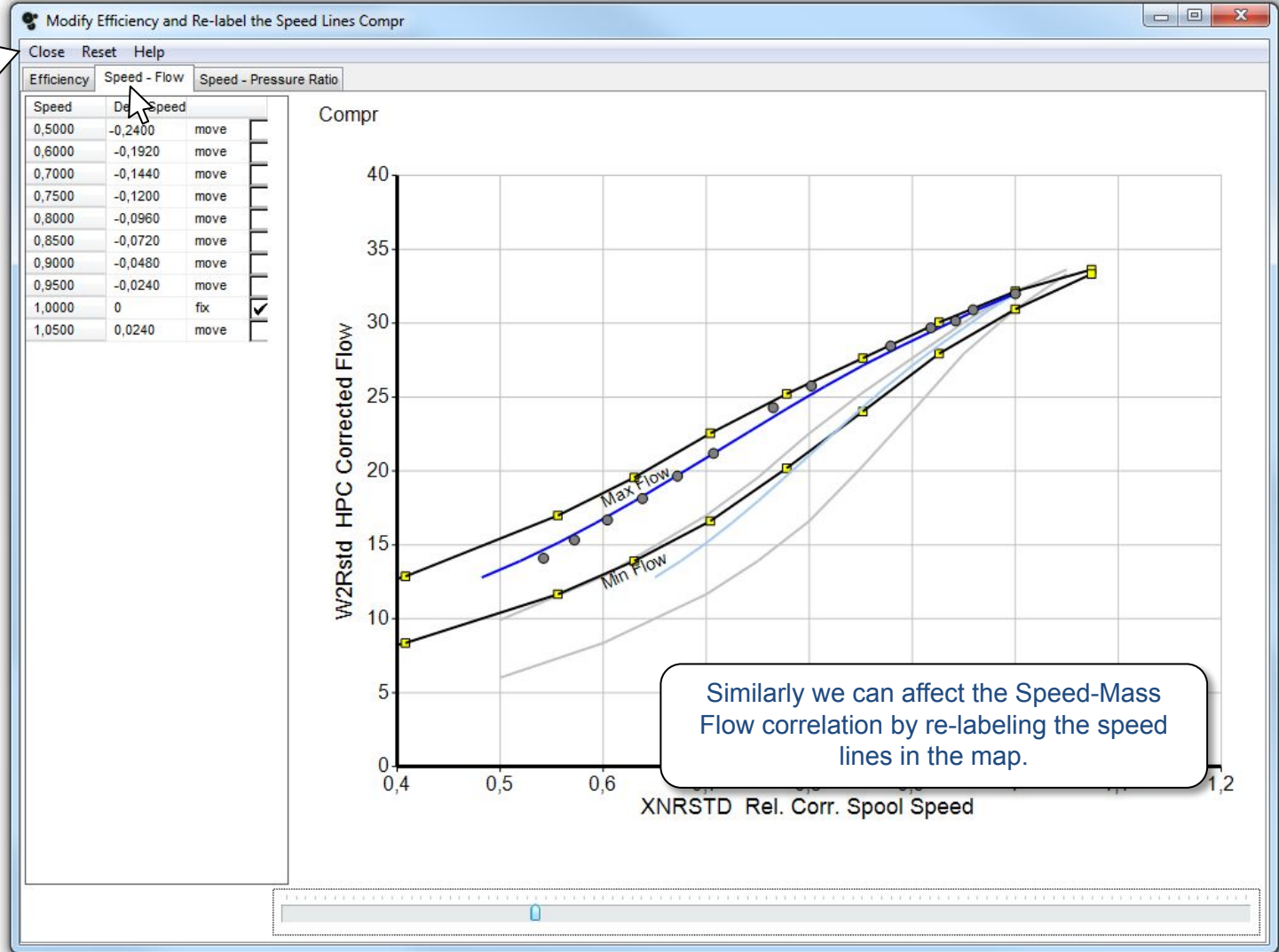
Click on Speed to modify the speed-mass flow correlation



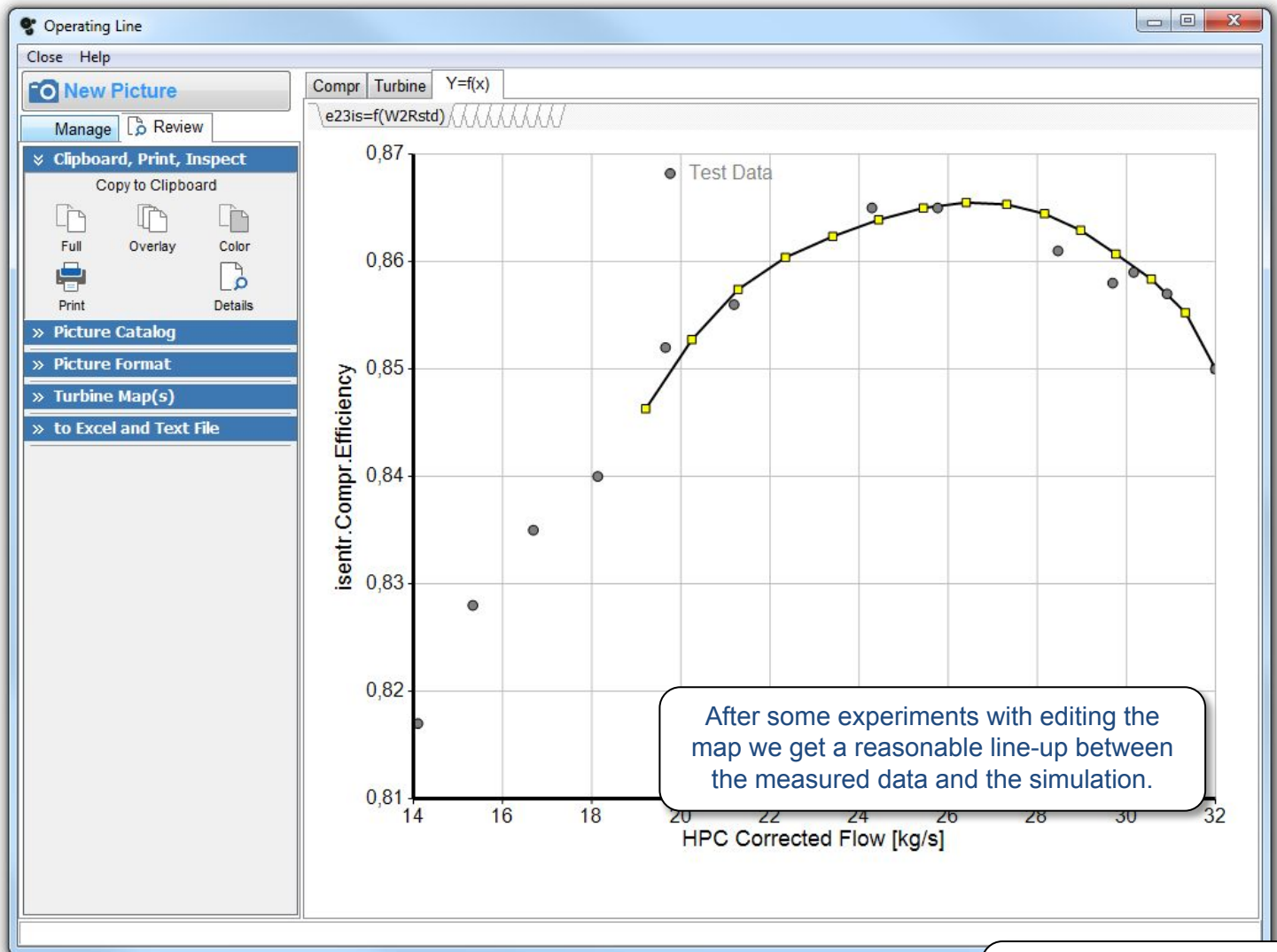


The Compressor Map Editor

The new compressor map should be saved after closing the map editor



The Simulation Agrees with the Measurements



This slide ends the **Component Maps Tutorial**