



Welcome!

Webinar #12: Different ways of modelling GT's in the TF Program Suite
27 September 2017

Agenda:

- * Introduction
- * Modelling Different GTs' in GT PRO/GT MASTER
- * Modelling Different GTs' in THERMOFLEX
- * Examples
- * Q & A Session

(pls. send Q's anytime during the presentation to both the presenter & host)

Thermoflow Training and Support

- Standard Training
- On-site Training course
- Advanced Workshop
- Webinars when new version is released
- Help, Tutorials, PPT, Videos
- Technical Support

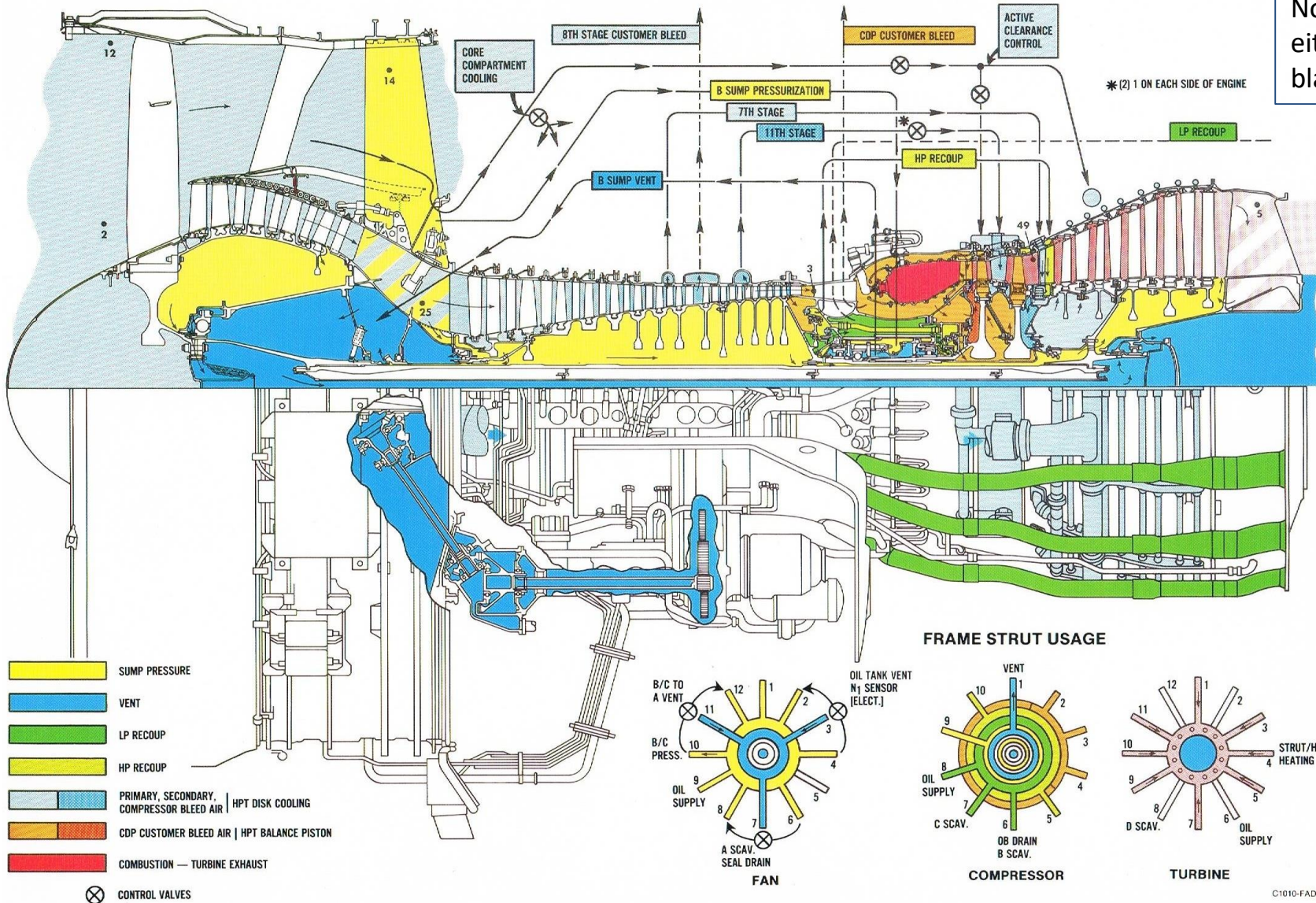
→ Feature Awareness Webinars

Feature Awareness Webinars

- 1- Assemblies in THERMOFLEX
- 2- Scripts in Thermoflow programs
- 3- Multi Point Design
- 4- Reciprocating Engines
- 5- Simplified Annual & TIME
- 6- Matching ST Performance
- 7- Modelling Solar Systems
- 8- Combining Thermoflex & Application Specific
- 9- Methods and Methodology explained
- 10- Supplementary Firing & Control Loops in GT PRO/GT MASTER
- 11- The Wind Turbine Feature in Thermoflex
- 12 -Different ways of modelling GT's in the TF Program Suite

The Gas Turbine- An Example

Note the number of compressor bleeds, either for HPT stator cooling or for turbine blade clearance control



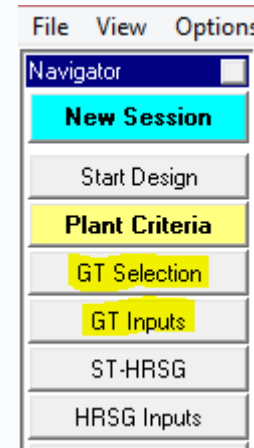
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Different GT Models in – GT PRO

- 2 tabs are available to the user in GT PRO ie.

GT Selection: the GT is selected at this point

GT Inputs : 8 input tabs for details of fuel, pressure drops, performance tuning, fuel heating, inlet cooling/chilling etc.



GT PRO - GT Selection Tab

File View Options Window Excel Link Compare Files Scripts Custom Variable List Help

Number of gas turbines: Single shaft GT/ST configuration

Did you know that if you cannot find a particular engine:
 -> its nominal power may be outside the power range set below
 -> it may be filtered out by 'Show new specs only' switch
 -> it may be filtered out by 'Show 50/60 Hz' switch
 -> it may be listed under a different name, click 'Show other names' checkbox
 Click the red button to see the whole list, or the white one to use the filter.

Display Entire GT Library (Red button) | Display Partial GT Library (White button)

Engine Selection Filter

Show engines rated from MWe Up to MWe

Sort by:
 Manufacturer Smallest to largest power Largest to smallest power ID #

Show new specs only
 Show 50 Hz engines
 Show 60 Hz engines
 Show other name(s)

*** Reference price for basic genset with included appurtenances, excluding stack. It is not a cost estimate for a Simple Cycle plant.

ID	Manufacturer & Model	Shafts	RPM	PR	TIT C	TET C	Air Flow t/h	Gen Power kWe	LHV HR kJ/kWh	LHV Eff %	Price*** MM\$
Other GT Model Options											
-3	GE engine computed using GE APPS										
-2	GT Template Defined Gas Turbine Model										
-1	User-defined Gas Turbine Performance										
0	No Gas Turbine										
1	GE 5371PA	1	5100	10.0	963	485	444	26555	12449	28.9	10.8
2	GE 6541B	1	5100	11.8	1104	534	497	39615	11067	32.5	15.3
5	GE LM500	2	7000	14.5	1127	513	57	3880	12059	29.9	2.5
6	GE LM1600	3	7000	21.7	1227	487	161	13430	10086	35.7	6.4
14	Solar Saturn	1	22120	6.7	888	499	23	1080	15493	23.2	0.9
15	Solar Taurus	1	14950	11.2	1016	497	74	4370	12924	27.9	2.8
16	Solar Mars 90	2	8568	15.7	1057	466	134	8824	11500	31.3	4.8
18	Siemens Industrial 501-KB5	1	14250	9.3	1035	560	56	3725	12995	27.7	2.5
19	Siemens Industrial 501-KH	1	14600	9.3	1010	549	57	3740	13043	27.6	2.5
20	Siemens Industrial 570KA	2	11500	12.0	1166	566	67	4610	12897	27.9	2.9
21	Siemens Industrial 571-KA	2	11500	12.7	1166	538	70	5590	11236	32.0	3.3
22	Siemens SGT-900	1	5420	14.2	1093	504	568	42300	11183	32.2	16.1

Guidance

GE 9E 3-ser - Revised 06-29-2010, estimated price updated September 2016. This machine specification is no longer available new.
 [***] -> 'Curve fit OEM' model; performance results come from a GT Template model which uses vendor data at selected conditions and interpolation in between.
 [***] -> Review following comments for any restrictions on scope of validity of this model. Press F1 for more information.
 Source : GE GTP 3.9.0 06/2010
 No change to nominal data
 Dry Low NOx Combustor (15/42)

GT PRO - GT Selection Tab (continued)

No of gas turbines – select as required

Single shaft- tick if appropriate

Display entire/partial GT library – 50/60 Hz GT's etc – order as required

ID No. – note this column . ID numbers range from minus 3 to 645 and this is an indication of how many unique GT models are resident in GTPro ie.

ID No. -3 : GE Engine Computed Using GE APPS

This is an option for GE internal use & is not available to non GE employees. The APPS program provides performance data for the GE aeroderivative engines (LM2500, LM6000 etc)

ID No. -2: GE Template Defined Gas turbine model

Ref the GT Template xx tool from within the TF program suite. GT Template models are stored in c:\TFlow xx\GTDU

ID No. -1: User Defined Gas Turbine Performance

Enables the user to characterise the GT at one unique operating point in terms of generator power, heat rate, exhaust mass flow and exhaust temperature. This data needs to be provided by a program such as the GE APPS or Siemens SIEPEP in house programs.

ID No. 0: No gas turbine. Self evident & a useful option when just need to focus on the bottoming cycle

No Asterisk Type Engines – Physical Model
ie. ID no. 378

ID	Manufacturer & Model	Shafts	RPM	PR	TIT C	TET C	Air Flow t/h	Gen Power kWe	LHV HR kJ/kWh	LHV Eff %	Price*** MM\$
378	Ansaldo AE64.3A	1	5413	17.6	1421	563	763	74550	10065	35.8	28.6

Guidance

AE64.3A - Revised 11-18-2009, estimated price updated September 2016. This machine specification is no longer available new (superseded by engine ID #457).
 Source : Ansaldo Energia data recd 11/09
 Dry Low NOx Combustor
 No change to nominal data
 Max model errors in test range: Mex<0.5% kW<0.5% HR<0.5% Tex<5F (2.8C)
 Test range : 0 to 120 F (-18 to 49 C) full load dry
 Part load model with variable IGV control included

Ref the guidance box for important information regarding limitations on use of the GT model and basic configuration data (ie. combustor type). None Asterisk type engines typically have the least limitations imposed on their operation. The model is a reverse-engineered, detailed, physical engine model to calculate gas turbine performance. Ref GTPro Help Menu ch. 5.2.

Physical model type engines reside in c:\TFlow xx\GTD as a MACHnnn.GTD file where the nnn equates to the GT id number in the GT Library ie. MACH378.GTD is the physical model for the id. No. 378 GT noted above – these files are not available for manipulation

Engines Having 1 Asterisk – Data Defined
ie. ID no. 192

ID	Manufacturer & Model	Shafts	RPM	PR	TIT C	TET C	Air Flow t/h	Gen Power kWe	LHV HR kJ/kWh	LHV Eff %	Price*** MM\$
192	GE LM6000 PC SPRINT (*)	2	3000	29.4	-	459	455	42497	9055	39.8	18.1

Guidance

GE LM6000SPT - Revised 06-08-2000, estimated price updated September 2016. This machine specification is no longer available new (superseded by engine ID #236).

(*) -> 'Data-defined' engine model; performance results come from a database of vendor data at selected conditions and interpolation in between.

(*) -> Review following comments for any restrictions on scope of validity of this model. Press F1 for more information.

Geared version of 60Hz engine

Standard Combustor

Source : GE data rcvd 5/00 Standard Combustor

Model limited to compressor inlet temperature above 40F (4C)

Model capable of full load only

Max model errors in test range: Mex<0.5% kW<0.5% HR<0.5% Tex<5F (2.8C)

The (*) adjacent to the GT name identifies the GT as being a Data Defined Model for which operational limitations will apply. Ref the guidance box for important information regarding limitations on use of the GT model and basic configuration data (ie. combustor type). Ref GTPro Help Menu ch. 5.3. The model data is resident in GTPro as a .GTD file, in this case MACH192.GTD . These files are not available for manipulation

Engines Having 2 Asterisks – Curve Fit OEM
ie. ID no. 388

ID	Manufacturer & Model	Shafts	RPM	PR	TIT C	TET C	Air Flow t/h	Gen Power kWe	LHV HR kJ/kWh	LHV Eff %	Price*** MM\$
388	GE 6F 3-series (**)	1	5100	15.5	-	596	750	78250	10053	35.8	26.4

Guidance

GE 6F 3-ser - Revised 06-29-2010, estimated price updated September 2016. This machine specification is no longer available new.

(**) -> 'Curve fit OEM' model; performance results come from a GT Template model which uses vendor data at selected conditions and interpolation in between.

(**) -> Review following comments for any restrictions on scope of validity of this model. Press F1 for more information.

Source : GE GTP 3.9.0 06/2010

No change to nominal data

Dry Low NOx Combustor (15/42)

The (**) adjacent to the GT name identifies the GT as being a Curve-Fit OEM Data Model for which operational limitations may apply. Ref the guidance box for important information regarding limitations on use of the GT model and basic configuration data (ie. combustor type). The model uses the same structure as the GT Template model, hence the file for the machine has a .GTT extension ie. in this case MACH388.GTT. These files are not available for manipulation

In some cases the User may wish to generate their own GT model which can be used at various operating points repeatedly. In this case the user may generate a GT performance file by means of the GT Template program resident in the TF Program suite. Ref Help Volume 4, GT Template and the example files for the GE 6541B and the Solar Mercury 50 GT's resident in c:\TF26\GTDU\

Screen 1 of 5: Gas Turbine Nameplate Rating (Primary Fuel)

Primary Fuel: Natural Gas | Secondary Fuel: Distillate Oil

Gas Turbine Performance

Name and model: GE6541B-GTT

Gross power at generator terminals: 38974 kW

Gross heat rate (LHV): 10620 BTU/kWh

Exhaust temperature: 1000 F

Exhaust flow: 309 lb/s

Generator power factor: 0.9

Compressor pressure ratio: 12.9

Gross efficiency (LHV): 32.13 %

Fuel flow: 5.377 lb/s

Fuel LHV @ 77F (25C): 21381 BTU/lb

Ambient Conditions

Pressure: 14.7 psia

Temperature: 59 F

Relative humidity: 60 %

Compressor Inlet Temperature Table (Screen 2 of 5):

Compressor Inlet Temperature	Gross Power	Gross Heat Rate	Exhaust Temp.	Exhaust Flow
1	1.217	0.9629	0.965	1.114
20	1.145	0.972	0.977	1.081
30	1.072	0.986	0.988	1.042
40	1	1	1	1
50	0.92	1.0217	1.012	0.951
60	0.845	1.0426	1.024	0.908
70	0.77	1.0719	1.035	0.868
80				
90				
100				
110				
120				

Screen 3 of 5: Gas Turbine Part Load Curves (Screens 3 and 4)

Data For: Primary fuel (selected), Secondary fuel

Number of Part Load Curves: 5

Basis of Part Load Data: Nameplate data (selected), Corresponding compressor inlet temperature

Compressor Inlet Temperature, CIT, °F

Curve 1: 0

Curve 2: 30

Curve 3: 59

Curve 4: 90

Curve 5: 120

GT PRO - GT Inputs Tab

Have eight input screens as follows:

- Gas Turbine Main Inputs: main inputs entered on this screen include water and steam injection and also the GT fuel definition. If the GT is a User Defined type, then the key performance parameters are also entered on this screen
- Inlet heating & cooling: inputs available on six sub-tabs include compressor recirculation.
- Model Adjustments: allows the GT to be tuned to specific performance parameters. A useful feature when tuning a library GT to OEM supplied performance data. Feature may be limited in application if GT chosen likewise has performance limitations applied (ie. full load operation only).
- Controls, margins and genset losses: allows further manipulation of how the GT behaves, particularly how the exhaust temperature trends during part load operation. Care is required in manipulating these variables. Ref the Help menu, Ch. 6.4
- Fuel Heating and GT Cooling: in most part self explanatory, some options such as GT Heat Rejection will be available depending on the GT selected (ref next slide)
- Bleeds & Injections: whether these inputs are available depends at the New Session screen, specifically whether or not the plant includes IGCC.
- Auxiliaries & Miscellaneous: enables fine tuning of these parameters influencing the plant aux loads
- Equipment Options PEACE tab: inputs made here will influence the final plant cost

Assume that receive the following OEM data:

GT: 6fa, DLN combustor, air cooled generator with 0.8 pf, GT operates at base load, 5231 rpm

Site Conditions: 323 m asl, 10.1 degC, 67.2% RH

GT Performance : HR 10060 kJ/kW-hr, generator output 76410 kW, 747.9×10^3 kg/hr , exhaust temp 593.2 degC,

Fuel : Natural Gas @ 20degC

Fuel Composition by volume (%): C1@ 91.34, C2 @3.5, C3 @0.86, C4 @0.37, C5 @0.01, N2 @0.49, CO2 @3.41, H2S @0.02

Losses: inlet loss =7.47 mBar, exhaust loss = 24.28 mBar , generator losses = 1173.3kW, fixed aux load =400.37kW, gear losses = 1079.6kW

How best to model this?

Choose based on given task ie. if an accurate cycle design is required which will dictate major item selection for the bottoming cycle, the User Defined GT may be the best way to go.

On the other hand, if it is required to do a quick economic analysis of two similar CCGT's, then a tuned library selected GT may be best...

GT PRO – GT Model Tuning & OEM Performance Data

The User Defined GT

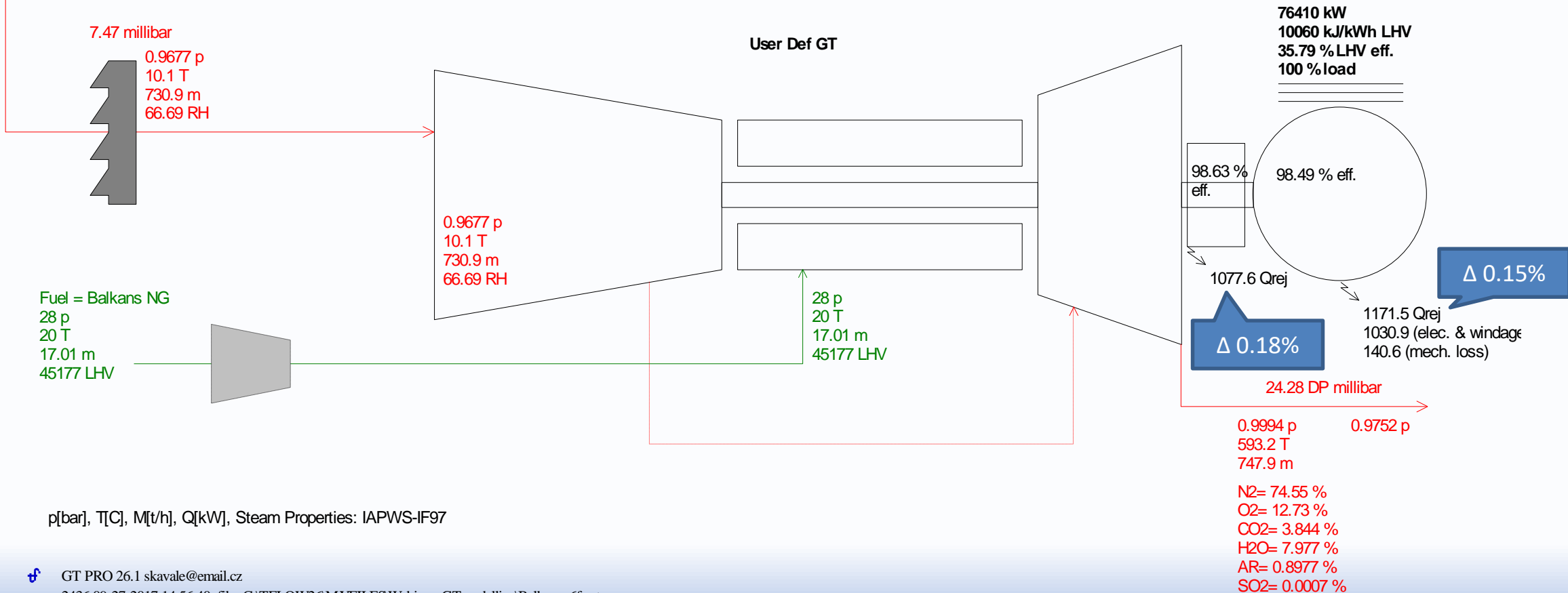
Using the OEM data provided, build the User Defined GT in GTPro. The result is shown below

Ambient air in

0.9752 p
10.1 T
730.9 m

67.2 %RH
323 m elev.

GT generator power = 76410 kW
GT Heat Rate @ gen term = 10060 kJ/kWh
GT efficiency @ gen term = 32.31% HHV = 35.79% LHV



GT PRO – GT Model Tuning & OEM Performance Data

The Tuned GT from the Library (ID no. 258)

Using the OEM data provided to tune the ID no. 258 Library GT. The result is shown below

Ambient air in

0.9752 p
10.1 T
730.9 m

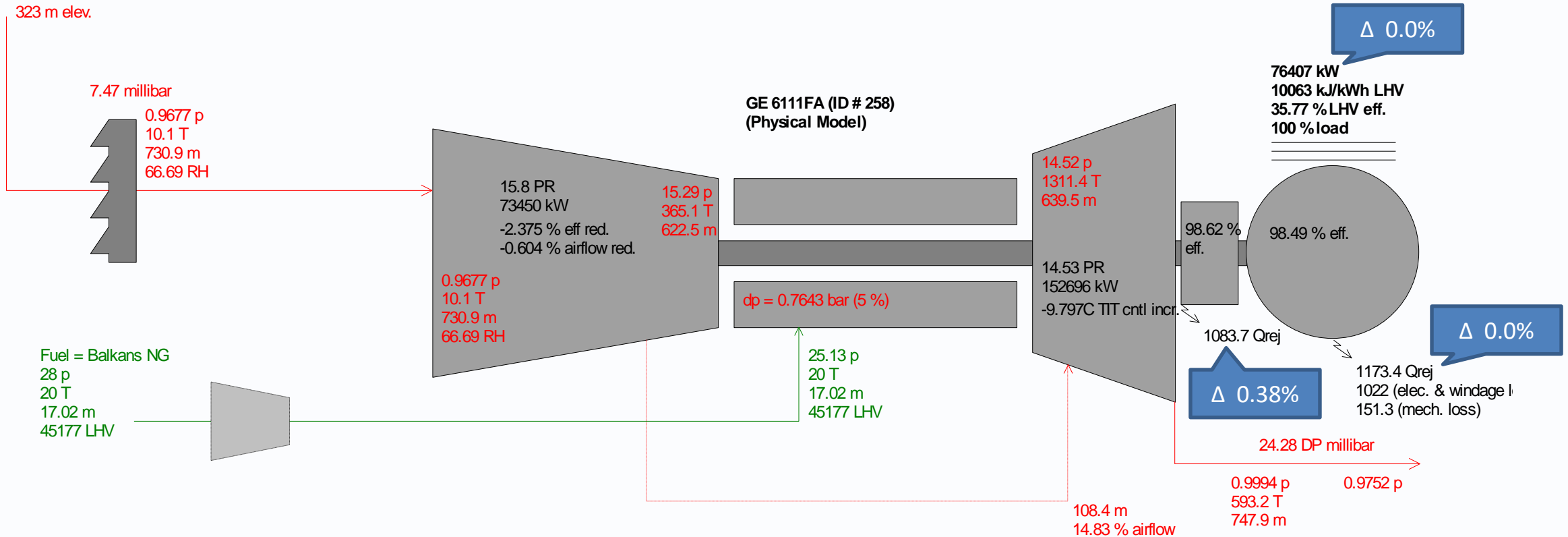
67.2 %RH
323 m elev.

7.47 millibar

0.9677 p
10.1 T
730.9 m
66.69 RH

Fuel = Balkans NG
28 p
20 T
17.02 m
45177 LHV

GT generator power = 76407 kW
GT Heat Rate @ gen term = 10063 kJ/kWh
GT efficiency @ gen term = 32.3% HHV = 35.77% LHV
GT @ 100 % rating, inferred TIT control model, CC limit

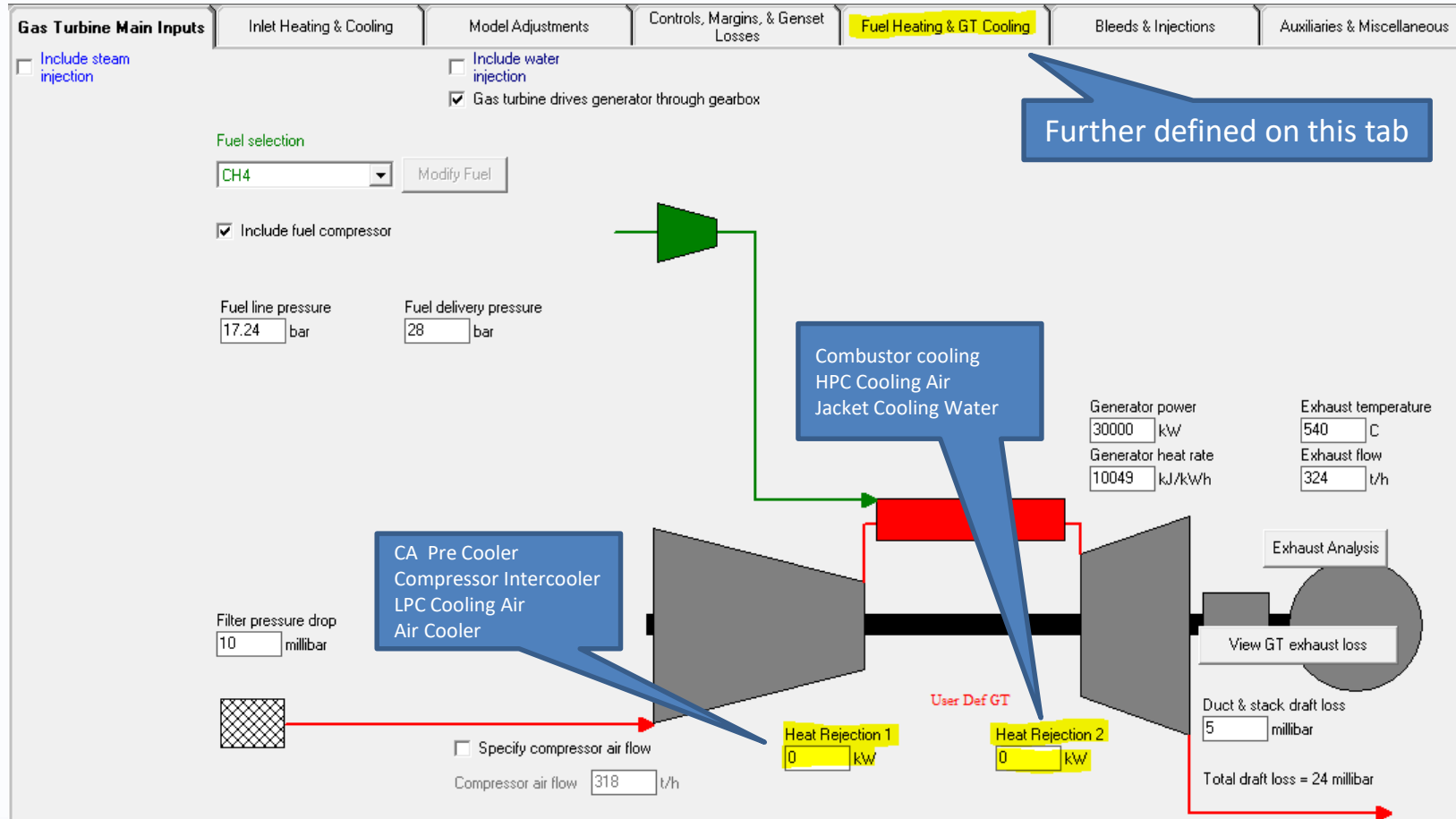


p[bar], T[C], M[t/h], Q[kW], Steam Properties: IAPWS-IF97

GT PRO - GT Inputs Tab – Heat Rejection

This menu item allows heat rejection hardware to be incorporated into the GT cooling circuit which normally bleeds compressor air to the turbine stages for cooling purposes. Additional heat rejection can be realised via combustor cooling . Hence two schemes for heat rejection are possible ie.

Care is required when manipulating these parameters with User Defined GT's. Ref Help > GTPro > ch.6.1.2



The screenshot displays the 'Fuel Heating & GT Cooling' tab in the software. Key elements include:

- Navigation Tabs:** Gas Turbine Main Inputs, Inlet Heating & Cooling, Model Adjustments, Controls, Margins, & Genset Losses, **Fuel Heating & GT Cooling**, Bleeds & Injections, Auxiliaries & Miscellaneous.
- Checkboxes:**
 - Include steam injection
 - Include water injection
 - Gas turbine drives generator through gearbox
 - Include fuel compressor
 - Specify compressor air flow
- Fuel Selection:** CH4 (with Modify Fuel button)
- Pressures:** Fuel line pressure (17.24 bar), Fuel delivery pressure (28 bar)
- Temperatures:** Exhaust temperature (540 C)
- Performance Metrics:** Generator power (30000 kW), Generator heat rate (10049 kJ/kWh), Exhaust flow (324 t/h)
- Heat Rejection:** Heat Rejection 1 (0 kW), Heat Rejection 2 (0 kW)
- Callouts:**
 - Combustor cooling: HPC Cooling Air, Jacket Cooling Water
 - CA Pre Cooler, Compressor Intercooler, LPC Cooling Air, Air Cooler
- Other Parameters:** Filter pressure drop (10 millibar), Compressor air flow (318 t/h), Duct & stack draft loss (5 millibar), Total draft loss = 24 millibar.

Further defined on this tab

Combustor cooling
HPC Cooling Air
Jacket Cooling Water

CA Pre Cooler
Compressor Intercooler
LPC Cooling Air
Air Cooler

Exhaust Analysis

View GT exhaust loss

Duct & stack draft loss

Total draft loss = 24 millibar

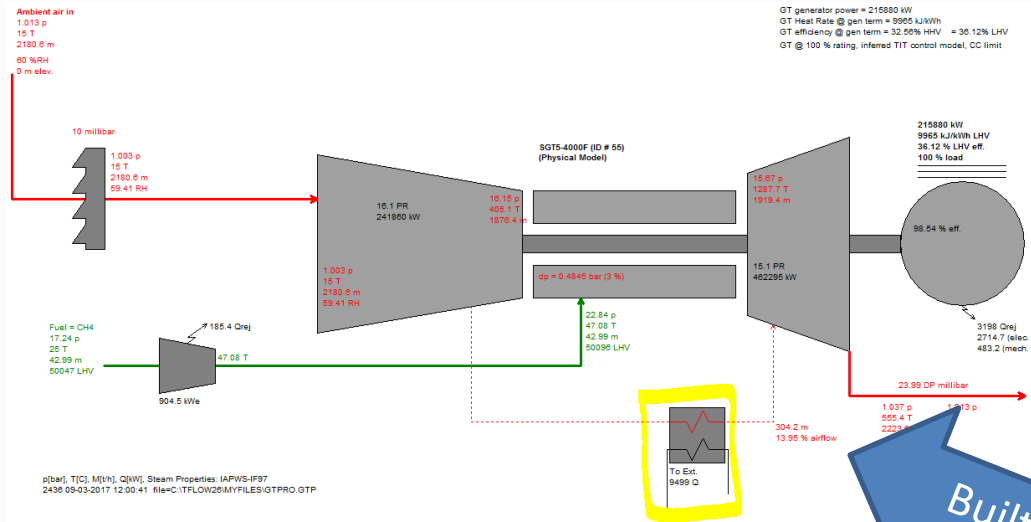
User Def GT

Heat Rejection 1
0 kW

Heat Rejection 2
0 kW

GT PRO - GT Inputs Tab – Heat Rejection

For some GT library models, heat rejection is built in- the user then has the choice of defining the disposition of the rejected heat (either to an external source or to the cycle) ie. GT ID no. 55 - in either case the quantity of rejected heat is the same...



Gas Turbine Main Inputs | Inlet Heating & Cooling | Model Adjustments | Controls, Margins, & Genset Losses | **Fuel Heating & GT Cooling** | Bleeds & Injections | Auxiliaries & Miscellaneous

Fuel Heating & GT Heat Rejection Model
 Built-in User-defined

Fuel Heating | GT Heat Rejection 1 (e.g. CA Precooling) | GT Heat Rejection 2 (e.g. Steam Cooling)

% of CA heat rejected to external sink %

% of CA heat rejected to HRSG stream %

HRSG source

Return to

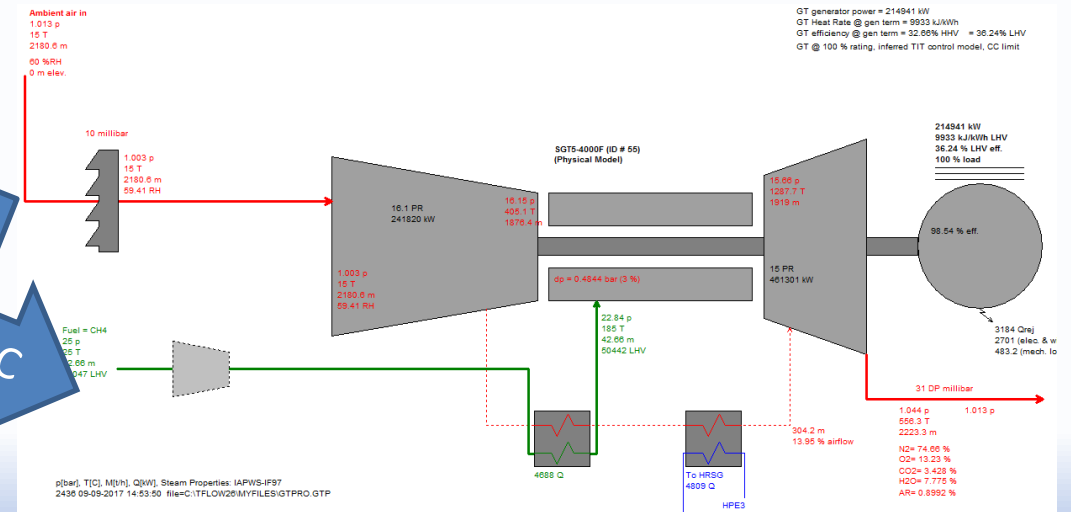
CA Precooling Heat Exchanger

HRSG

CAUTION: The program does not check to ensure that heat from the GT heat rejection 1 (e.g. cooling air) is at a sufficiently high temperature to make steam at the user-defined pressure/temperature combination. The user must ascertain, by consulting with the GT manufacturer, that any steam generated by recovering heat from the GT heat rejection 1 is at conditions that can indeed be achieved.

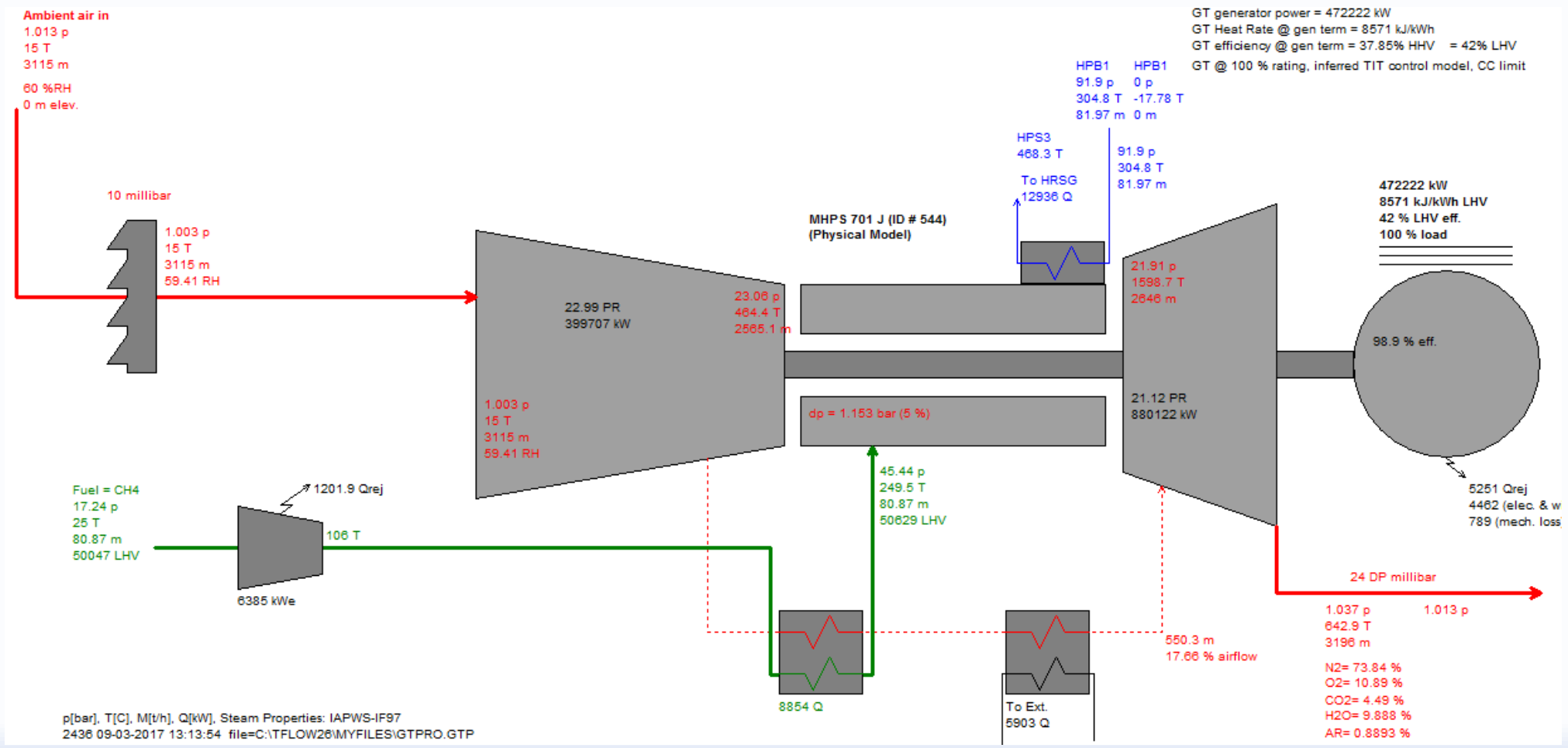
Built in - SC

User defined - CC



GT PRO - GT Inputs Tab – Features Included By Default

Depending on the GT model, a number of heat rejection schemes may be a feature of the machine. By choosing the “Built In” option, all heat rejection schemes are accounted for. By choosing the “User defined” option, all heat rejection schemes are still accounted for but the user has more control over the sources and sinks in the heat rejection scheme ie. GT ID no. 544



Thermoflow GT PRO - GT Inputs Tab – Features Included By Default

Some Library GT models will also include model streams which the user has no control over. An example is GT ID no. 553 which includes intercooling of the compressor air by means of water injected as a fine mist, this improving cycle efficiency ie. Have the given set of conditions:

GT: LM6000PC SPRINT, std combustor, air cooled generator with 0.9 pf, GT operates at base load, LPT rpm 3627

Site Conditions: 474 m asl, 8.7 degC, 75.4% RH

GT Performance : HR 9134 kJ/kW-hr, generator output 48682 kW, 469.139×10^3 kg/hr , exhaust temp 446 degC,

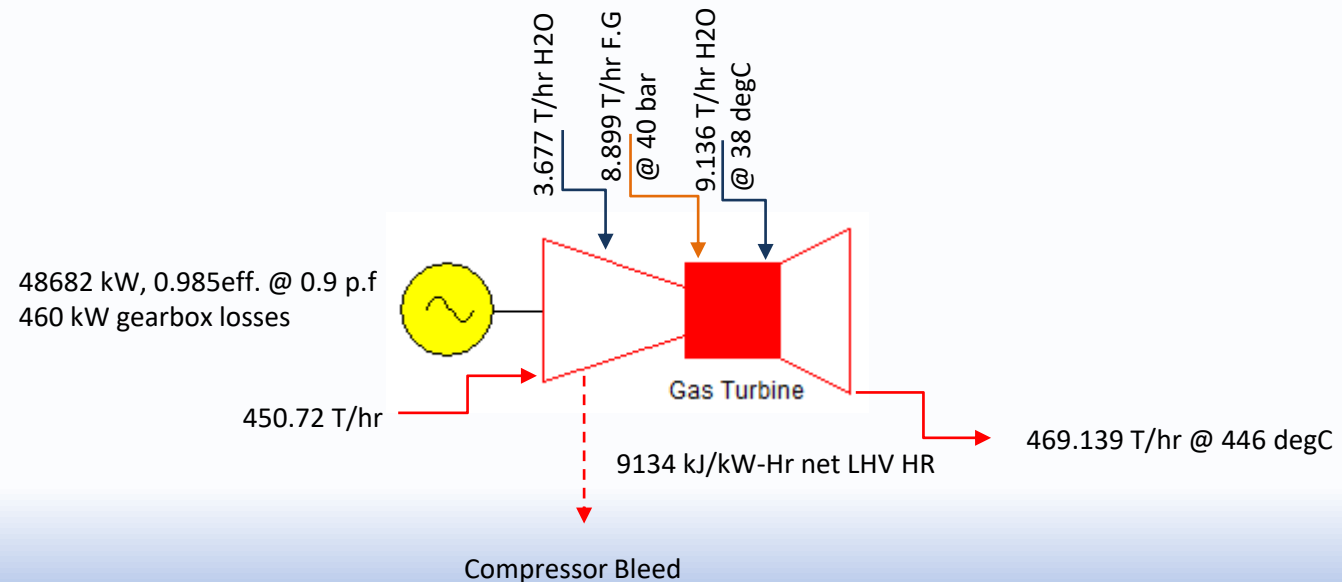
Fuel : Natural Gas @ 20degC

Fuel Composition by volume (%): C1@ 91.34, C2 @3.5, C3 @0.86, C4 @0.37, C5 @0.01, N2 @0.49, CO2 @3.41, H2S @0.02

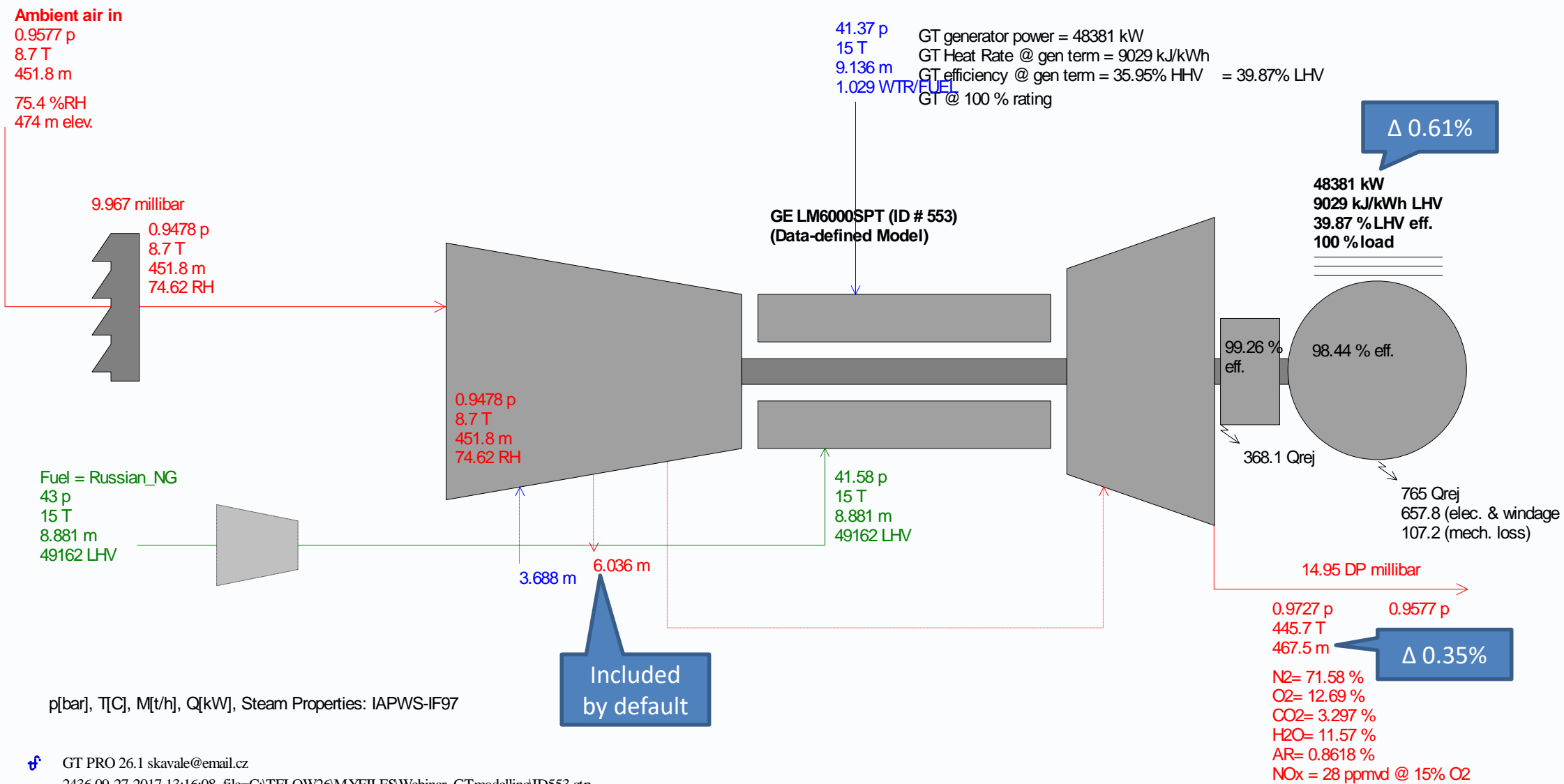
Losses: inlet loss =9.967 mBar, exhaust loss = 14.95 mBar , generator losses = 662kW, gear losses = 460kW

Mass Balance: Fuel in @ 8.899 t/hr, NOx water spray @ 9.136 t/hr, SPRINT spray @ 3.677 t/hr, exhaust (as above), air inlet flow @ 450.72 t/hr.

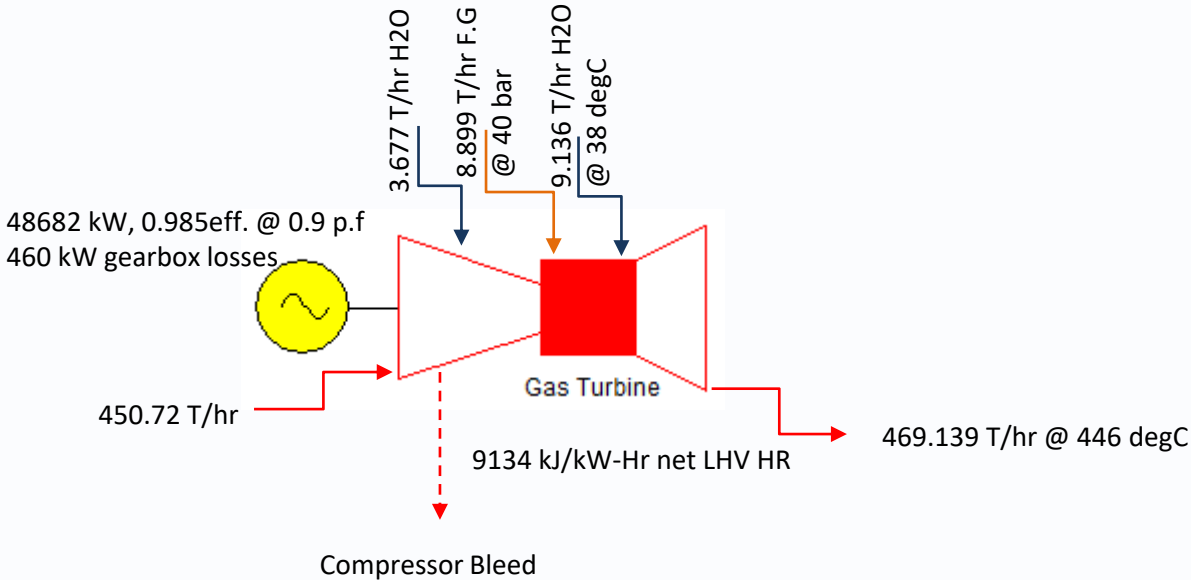
Ref next slide for GTPro simulation result



GT PRO - GT Inputs Tab – Features Included By Default



GT PRO 26.1 skavale@email.cz
 2436 09-27-2017 13:16:08 file=C:\TFLOW26\MYFILES\Webinar_GTmodelling\ID553.gtp



Performing a simple mass balance around the engine:
 Have 472.432 T/hr flowing into the machine
 Have 469.139 T/hr flowing out of the machine

This leaves a difference of + 3.293 T/hr ie. more is flowing into the machine than is flowing out. This difference is assigned to the compressor bleed air (unloading the compressor at this condition).

The GT Pro Inputs are shown on the following slides

GT PRO Inputs – Main GT Inputs Tab

Ambient air in
 0.9577 p
 8.7 T
 450.7 m
 75.4 %RH
 474 m elev.

9.967 millibar
 0.9478 p
 8.7 T
 450.7 m
 74.62 RH

Fuel = Russian_NG
 40 p
 15 T
 9.041 m
 49162 LHV

45 p
 38 T
 9.136 m
 1.011 WTR/FUEL

GT generator power = 48682 kW
 GT Heat Rate @ gen term = 9134 kJ/kWh
 GT efficiency @ gen term = 35.53% HHV = 39.41% LHV

As required

48682 kW
 9134 kJ/kWh LHV
 39.41 % LHV eff.
 100 % load

User Def GT

0.9478 p
 8.7 T
 450.7 m
 74.62 RH

40 p
 15 T
 9.041 m
 49162 LHV

Δ 1.6%

3.677 m
 3.435 m
 Δ 4.3%

99.18 %
 eff.



409.8 Qrej

662 Qrej
 582.6 (elec. & windage)
 79.44 (mech. loss)

14.95 DP millibar

0.9727 p
 446 T
 469.1 m
 N2= 71.56 %
 O2= 12.59 %
 CO2= 3.344 %
 H2O= 11.64 %
 AR= 0.8615 %

As required

p[bar], T[C], M[t/h], Q[kW], Steam Properties: IAPWS-IF97

GT MASTER – Different GT Models

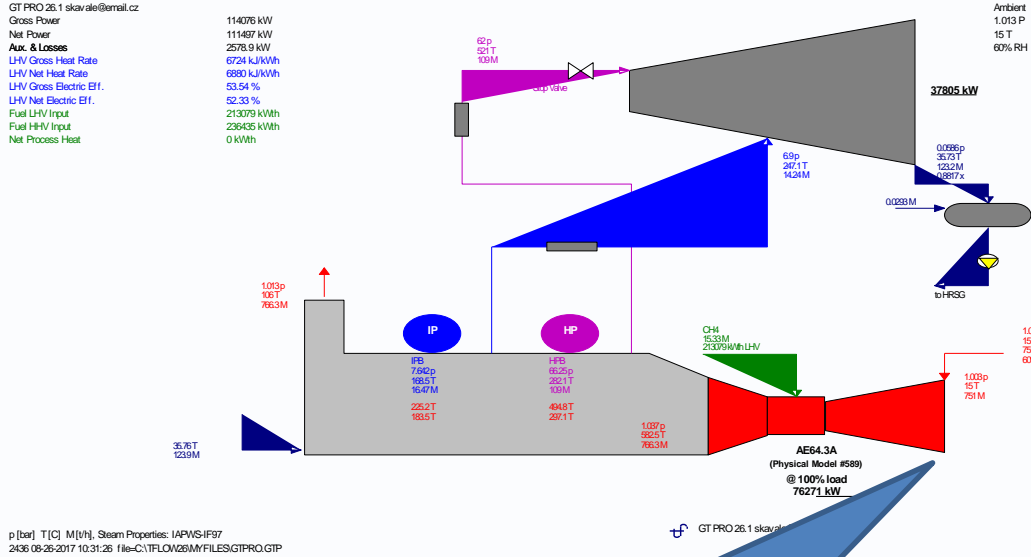
In transitioning the GTPro model to GTMaster, the user has the following features available:

- for a GT from the GT Library: Manipulation of the GT load (assuming that the model is the *physical model* type or has no part load restrictions if it is either a Data Defined type or Curve Fit OEM type model

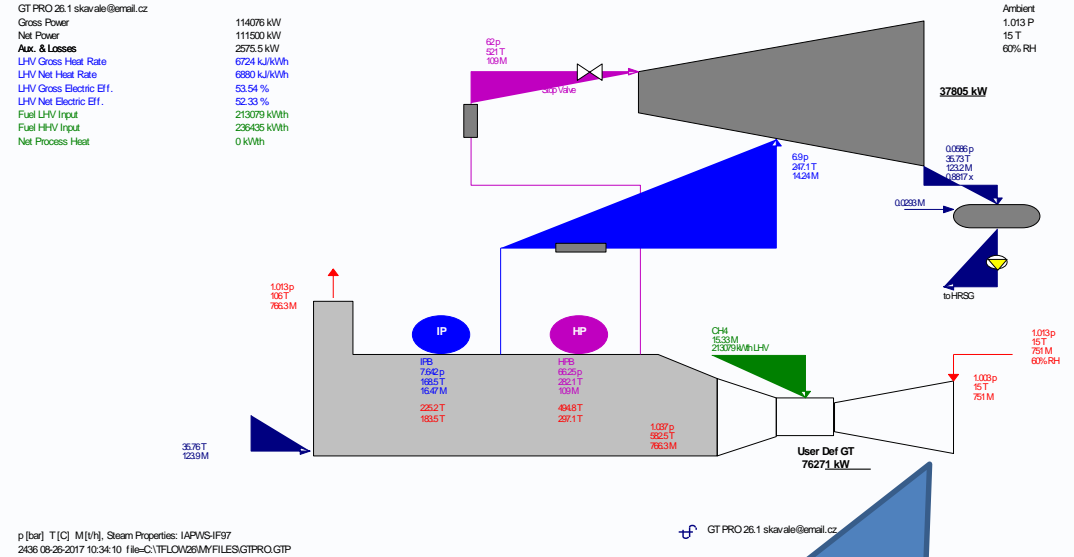
- Reselect GT : the user can select to power the cycle already defined with another (similar performance) GT. A useful feature in the case of a repowering type study. If the *No GT* option is selected then the GT Inputs screen becomes the same as the HRSG Inlet screen from GTPro

GT Master - GT Inputs tab : same as in GTPro with the same sub tabs except for the Equipment Options PEACE tab which is omitted. Note that significant hardware items that were not defined in GTPro can not now be defined in GTMaster. Hence if inlet air chilling was not defined in GTPro, it cannot be subsequently defined in GTMaster. Compressor air recirculation is however still able to be defined in GTMaster even though in GTPro it may have been ignored.

Visual Cues from Heat Balances



Red GT always denotes a GT selected from the GT library resident in GT PRO- the ID No.



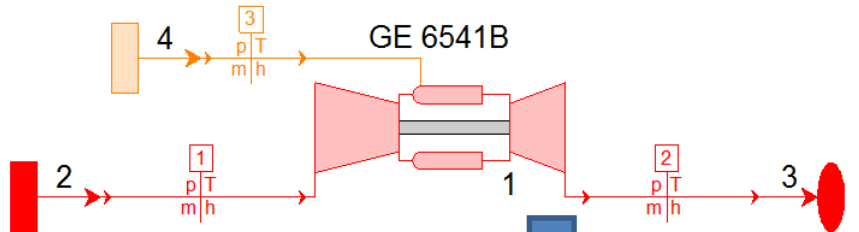
A white GT denotes the user defined type GT No.

Note: In GT PRO v.26 all inputs defining the gas turbine heat balance are preserved when changing from a built-in model to the User Defined Gas Turbine model. Previously (GT PRO v.25) only the heat rate, power, exhaust flow, and exhaust temperature were preserved.

GT's & GT Modelling - THERMOFLEX

A couple of methods are available to the THERMOFLEX user in which to model the GT.

Method 1- By selecting the GT PRO Gas Turbine option from the gas/air group & connecting the appropriate sources & sinks (air, fuel, steam injection etc). The completed component appears as:



Edit Inputs

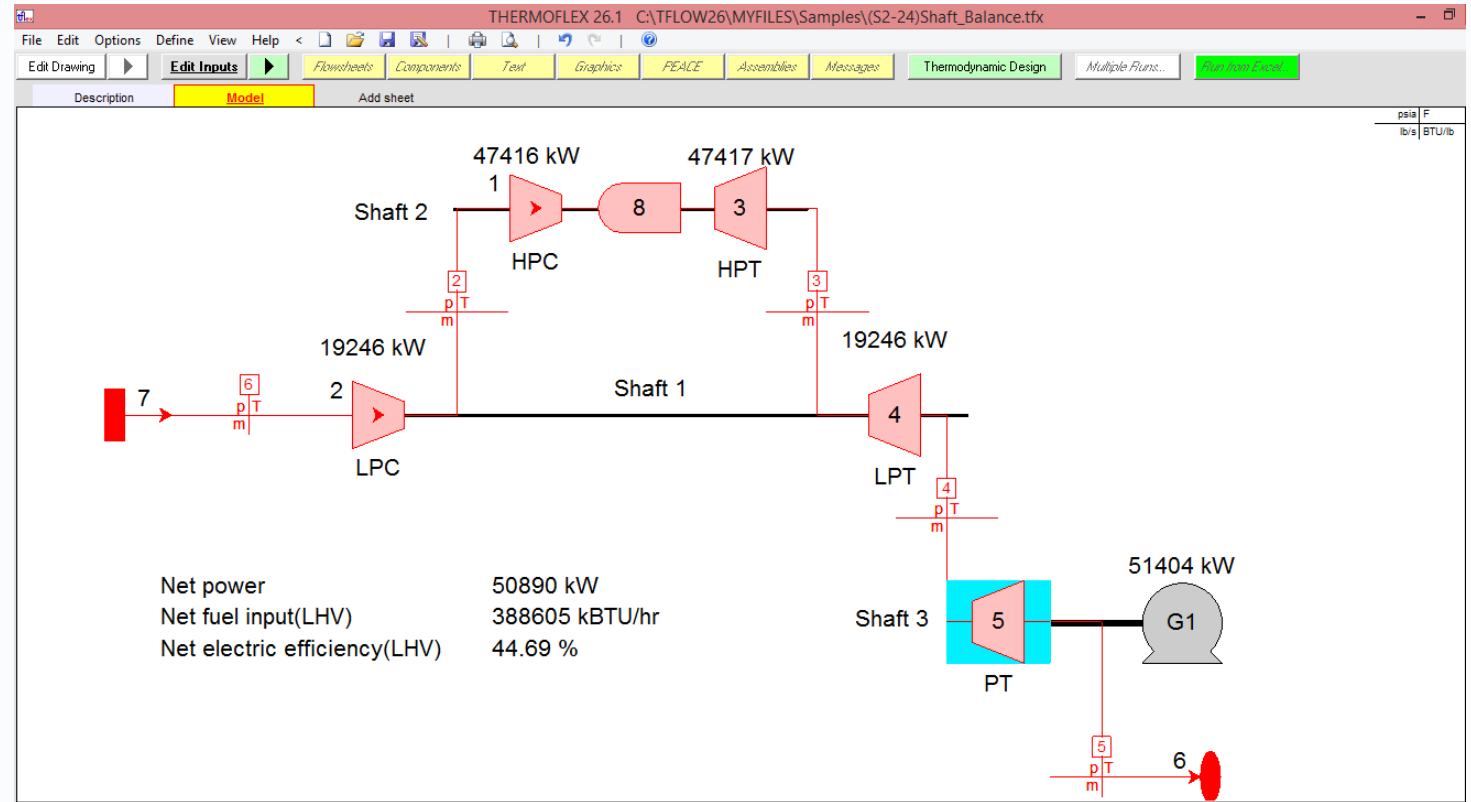
Clicking into the GT icon opens up its input screen – note the similarity to the normal GT PRO GT Input screen. The GT can be reselected from ID No. -3 to XX (with the exception of ID . 0)

The screenshot shows the software interface for configuring a GE 6541B gas turbine. The main window is titled 'Turbine (GT PRO) [1]' and has several tabs: 'Turbine Main Inputs', 'Inlet Heating', 'Model Adjustments', 'Controls, Margins, & Genset Losses', 'GT Heat Rejection', 'Compressor Bleed', and 'Auxiliaries & Miscellaneous'. The 'Thermodynamic Design' tab is selected, showing a 3D model of the turbine with various components labeled, including 'Air filter', 'ID2 - GE 6541B Physical Model', and 'Exhaust duct draft loss'. Input fields include 'Number of GT's present' (set to 1), 'Filter pressure drop' (9.963 millibar), and 'Specify GT Load Percentage' (set to 100%). Buttons for 'Reselect GT' and 'GT Emissions' are visible. The interface also shows a 'Use water injection' checkbox which is currently unchecked.

Method 2- By building up the gas turbine from discrete components. The completed GT appears as:

Example of aeroderivative multi-shaft GT, ref sample file S2-24

Note: care is required when taking this type of model into off design mode since this type of GT model does not incorporate the required performance correction curves



GT's & GT Modelling – THERMOFLEX (continued)

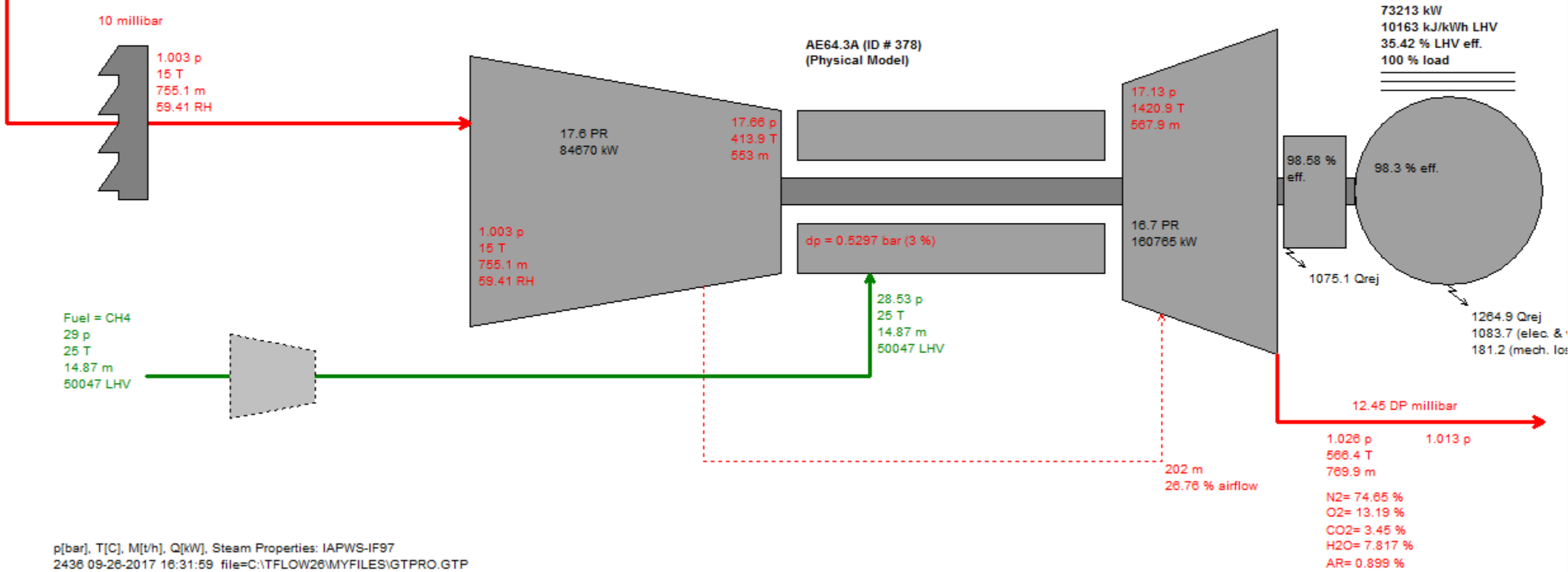
Additional factors to bear in mind when modelling GT's by the 2nd method

- Neither the compressor icon, turbine icon and combustor icon are a flow dictating device, hence the correct flow for the model needs to be defined, usually by **fix a flow** at the air source.
- Even the simplest GT uses compressor bleed air for turbine cooling (typically the 1st stage NGV's), hence a cooled turbine stage icon will need to be included. Partially this IS a flow dictating device since the cooling flow stream is a function of the design metal temperature.
- The Turn Rubber On, Control Loop and Shaft Balancing features in TFX all make the GT modelling exercise fairly straight forward.

GT's & GT Modelling – THERMOFLEX (continued)

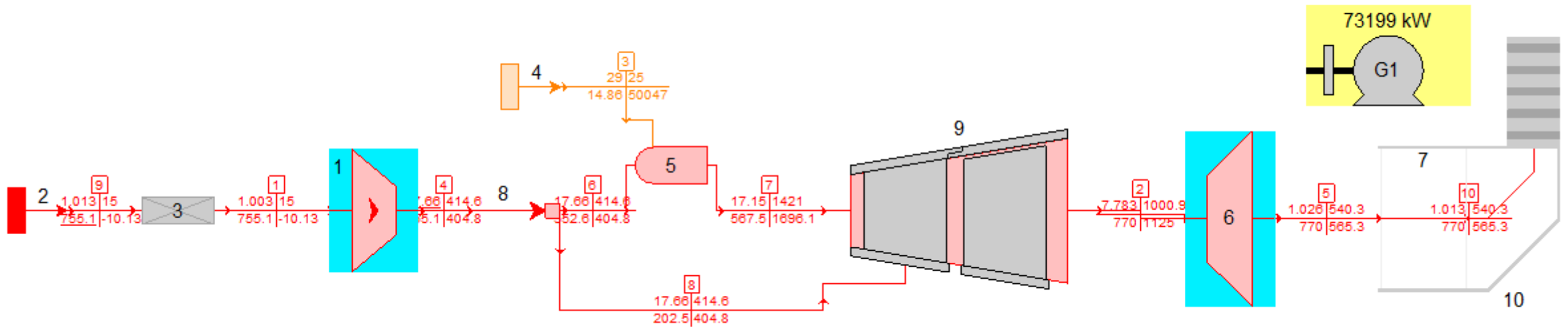
GT generator power = 73213 kW
 GT Heat Rate @ gen term = 10163 kJ/kWh
 GT efficiency @ gen term = 31.92% HHV = 35.42% LHV
 GT @ 100 % rating, inferred TIT control model, CC limit

GT Modelling exercise to illustrate some of the points from the previous page: the ID 378 engine GT PRO results provide the THERMOFLEX model input data



GT's & GT Modelling – THERMOFLEX (continued)

GT Modelling exercise to illustrate some of the points from the previous page: the ID 378 engine THERMOFLEX equivalent model



The THERMOFLEX GT in Off Design Mode

Main points to note are that:

- if the GT model is from the GT library, then the normal GT MASTER type off design inputs are available to the user when in TFX OD mode

- if the GT model has been built up from discrete icons, then off design operation will likely require reference to OEM performance data. Part load runs can be achieved either by manipulating the compressor inlet airflow or by applying control loops to manage various parameters at once (caution required)

Q & A Time....