



Welcome!

Webinar #10. Supplementary Firing &
Control Loops in GT PRO/GT MASTER

August 31, 2017

The webinar will be starting on time (10:00 EDT)

Host: Meritt Elmasri (US office)

Presenter: Evgeny Zakharenkov

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

Agenda

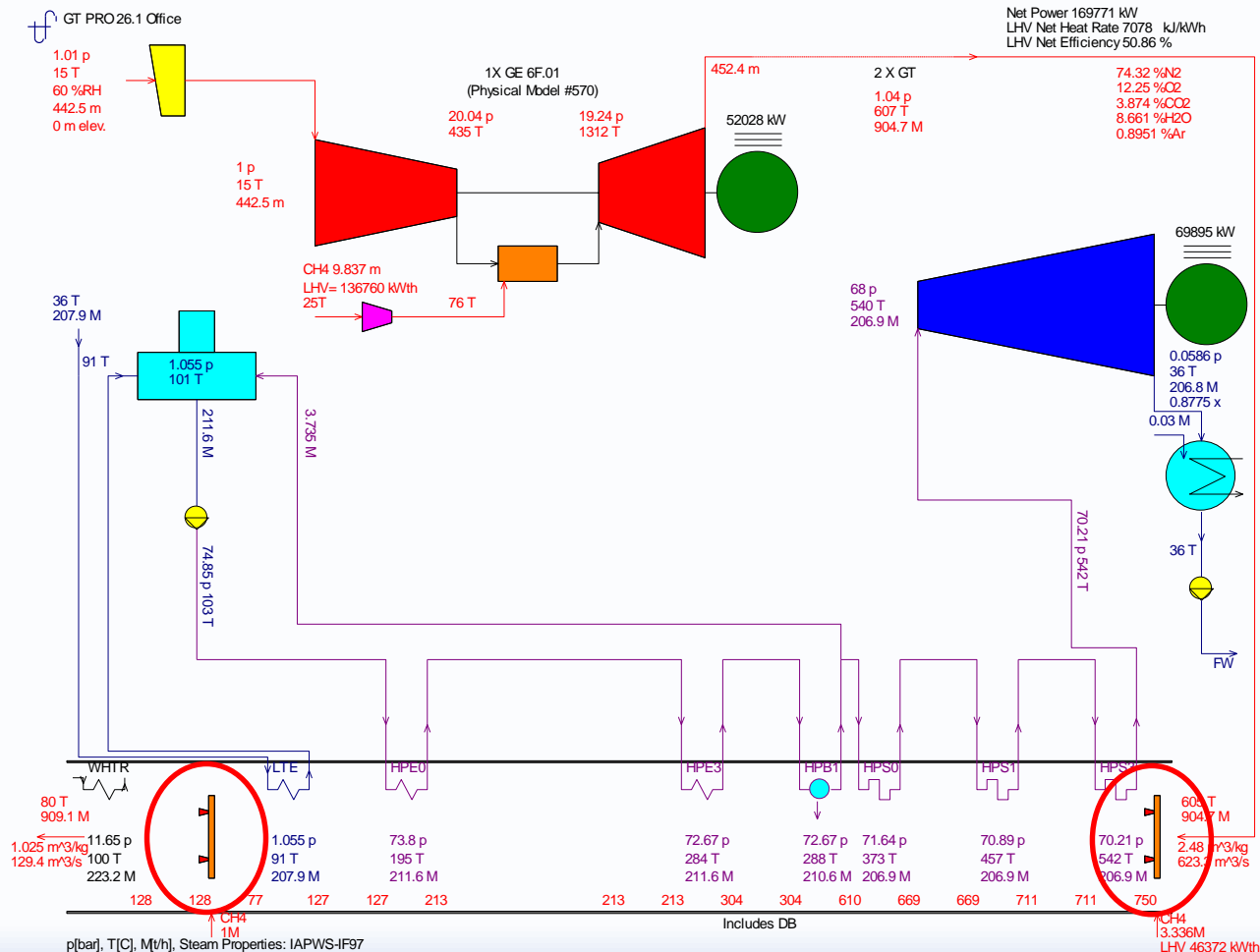
- Designing plants with supplementary firing
- HRSG with radiant surfaces
- Control Loops in GT MASTER

Designing plants with supplementary firing

When supplementary firing is used

- Flexible steam production and power output of the steam turbine.
- Flexible cogeneration plants for steam and hot water production.
- Compensation for changing ambient conditions (stabilizing steam temperature and mass flow rate).

GT PRO / GT MASTER allows to have up to two duct burners



GT PRO 26.1 - C:\TFlow26\MYFILES\GTPRO.GTP

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

Navigator

New Session

Start Design

Plant Criteria

GT Selection

GT Inputs

ST-HRSG

HRSG Inputs

Water Circuits

HRSG Layout

Cooling System

ST Inputs

Environment

Other PEACE

Economics

Gasification

Desalination

HRSG Main Inputs

Duct Burner Fuel
 Gas turbine fuel
 Modify fuel

Duct Burner
 1. Included, specify exit temperature
 0. Not in plant
 1. Included, specify exit temperature
 2. Included, specify fuel flow
 3. Included, specify LHV heat input
 4. Included, specify HHV heat input
 5. Included, specify gas temperature rise
 6. Included, specify plant net output

Min. stack temperature
 Min. approach to sulphur dewpoint 10 C

Thermodynamic Design Assumptions

Hardware Design

Radiant Boiler / Additional Duct Burner
 Included, specify fuel flow
 Fuel flow (plant total) 1 t/h


Steam Generation Dictated By
☒ Pinch ☐ Mass flow

Radiant Boiler

HP Evaporator Circulation
 Natural

HPE Exit T Specification
 Approach subcooling

HP



Changing location of the duct burner

GT PRO 26.1 - C:\TFlow26\MYFILES\GTPRO.GTP

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 - Environment
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 - Economics
 - Gasification
 - Desalination
- Compute
 - Text Output
 - Graphics Output
 - PEACE Output
- Carrying on...
 - Multiple Designs (MACRO)
 - Run from Excel (ELINK)
 - Off Design Simulation (GT MASTER)
 - Fully-Flexible Design (THERMOFLEX)

HX Locations & Duties

Select the 'User-defined' Method to edit the HRSG layout. You may then drag heat exchangers to new locations, and edit heat exchanger exit temperatures where an input box is provided.

Method: ☒ Automatic ☐ User-defined

Main DB Location: ☒ Automatic ☐ User-defined

Design Point Desuperheating

Path	15	14	13	Zone 12	11	10	Zone 9	8	7	6	5	Zone 4	3	2	1	Zone 0
2				HPE0 194.7 C 101.1 C		HPE1 194.7 C 194.7 C	HPE2 194.7 C 194.7 C		HPE3 284.4 C 194.7 C		HPB1 288.4 C 288.4 C	HPS0 372.9 C 288.4 C		HPS1 457.4 C 372.9 C	HPS2 457.4 C 457.4 C	HPS3 542 C 457.4 C
1																
0																

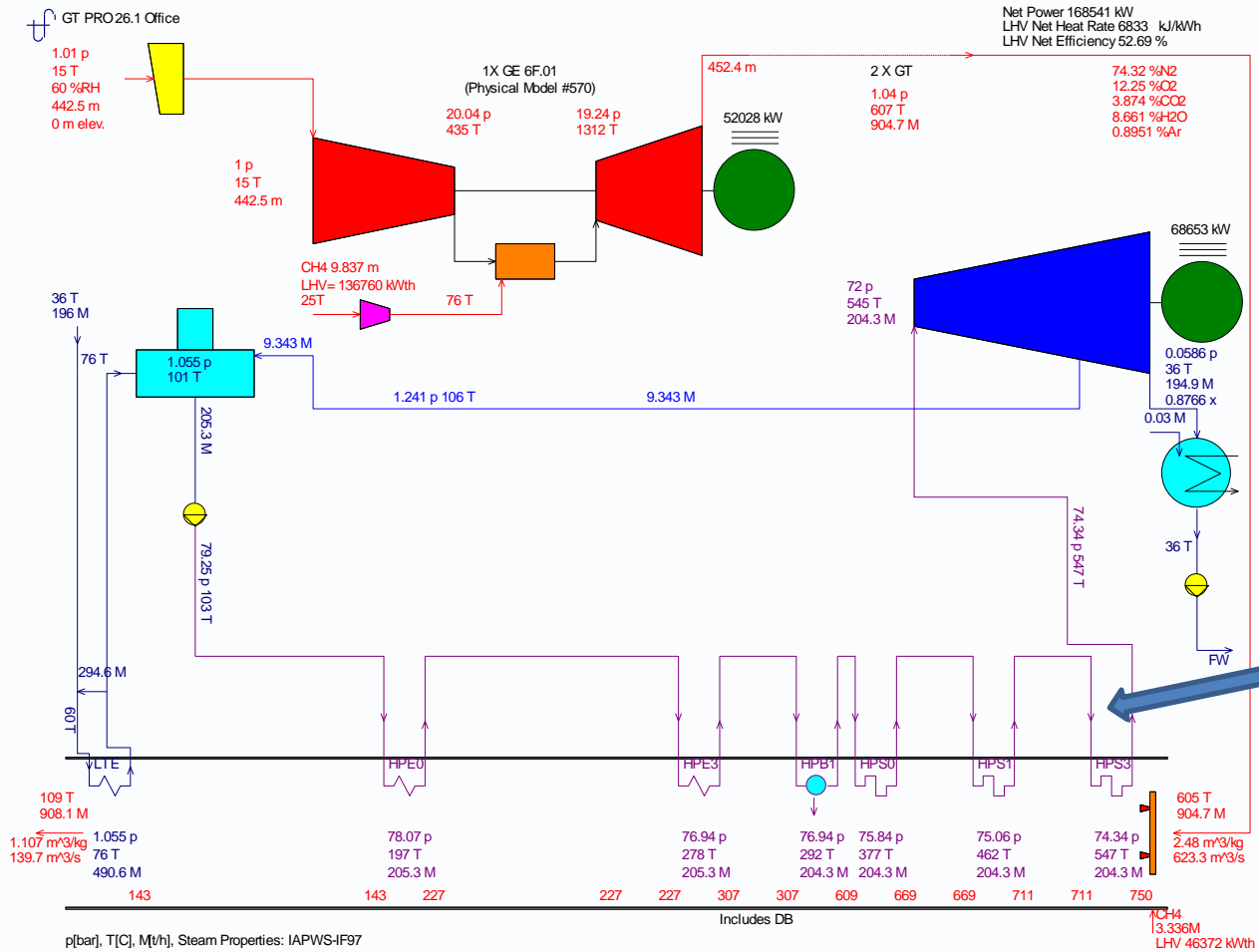
Duct Burner

*Switch to user-defined and drag duct burners to new locations

Plant model sample with supplementary firing

- Combined cycle based on 2xGE 6F.01.
- Supplementary firing (up to 750 C) to produce more power when electricity price is high.

Plant model sample with supplementary firing



Super Heaters
undersized

Plant model sample with supplementary firing

Thermoflow Multi-Point Design 26.1 - C:\TFlow26\MYFILES\GTPRO.MGP

File Edit Options Help

< Review / Edit Designs SUMMARY **HRSR** STEAM TURBINE COOLING SYSTEM GT INLET PUMPS PIPES OTHER Build and Run GT MASTER Model Build and Save GT MASTER Model

☐ Use HRSR from specific design: Nominal Design

☒ Use sizing options below

Model Determining HX & DB Location and Sequence
Nominal Design

Duct Width & Tube Length
☐ Average ☒ From range: Min plus 1 * (Max - Min)

Superheater Areas
☐ Average ☒ From range: Min plus 0.7 * (Max - Min)

Evaporator Areas
☐ Average ☒ From range: Min plus 1 * (Max - Min)

Economizer Areas
☐ Average ☒ From range: Min plus 1 * (Max - Min)

Duct Burner Capacity
☐ Average ☒ From range: Min plus 1 * (Max - Min)

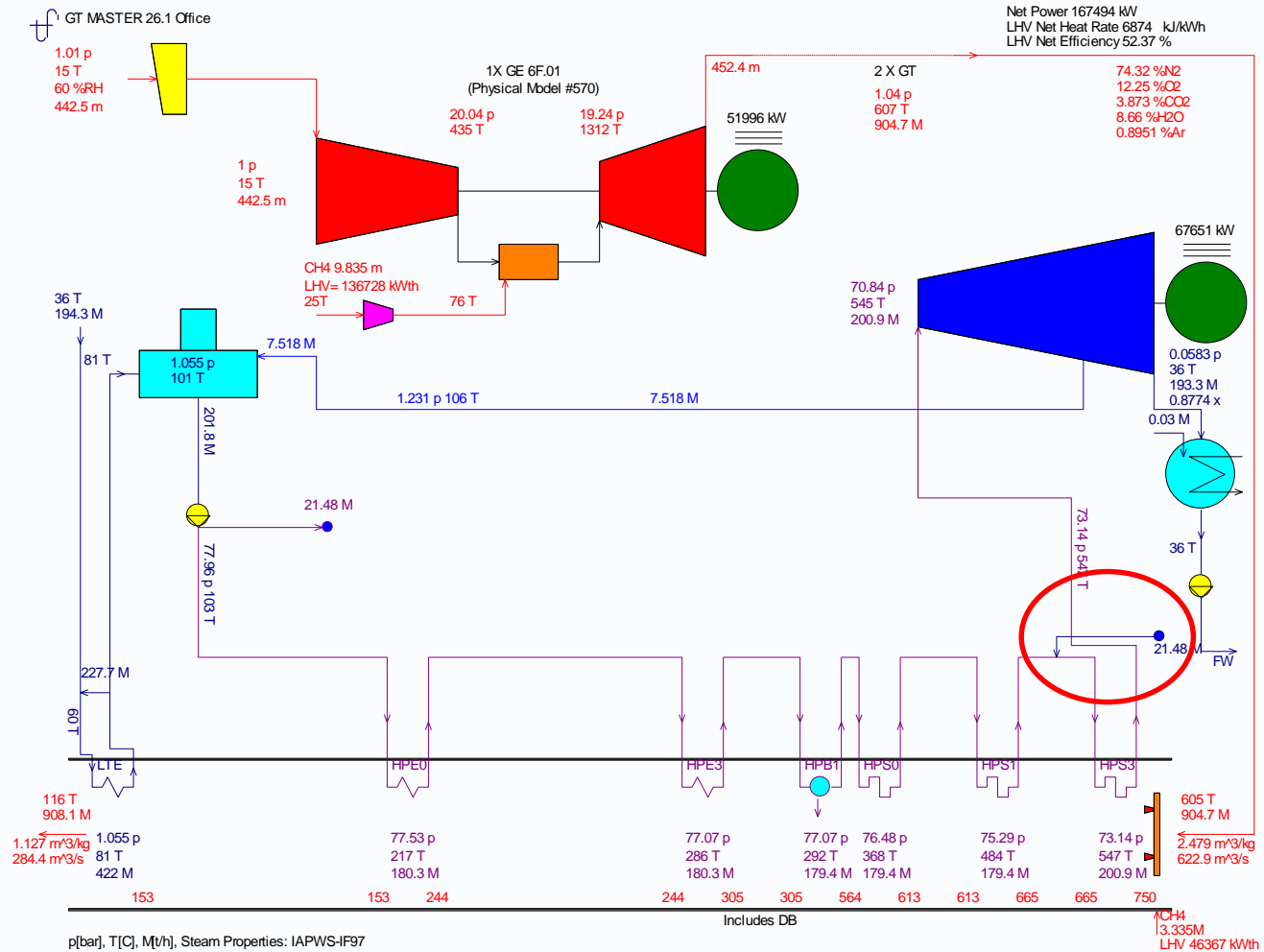
Drum Dimensions
☐ Average ☒ From range: Min plus 0.75 * (Max - Min)

Stack Dimensions
☐ Average ☒ From range: Min plus 0.75 * (Max - Min)

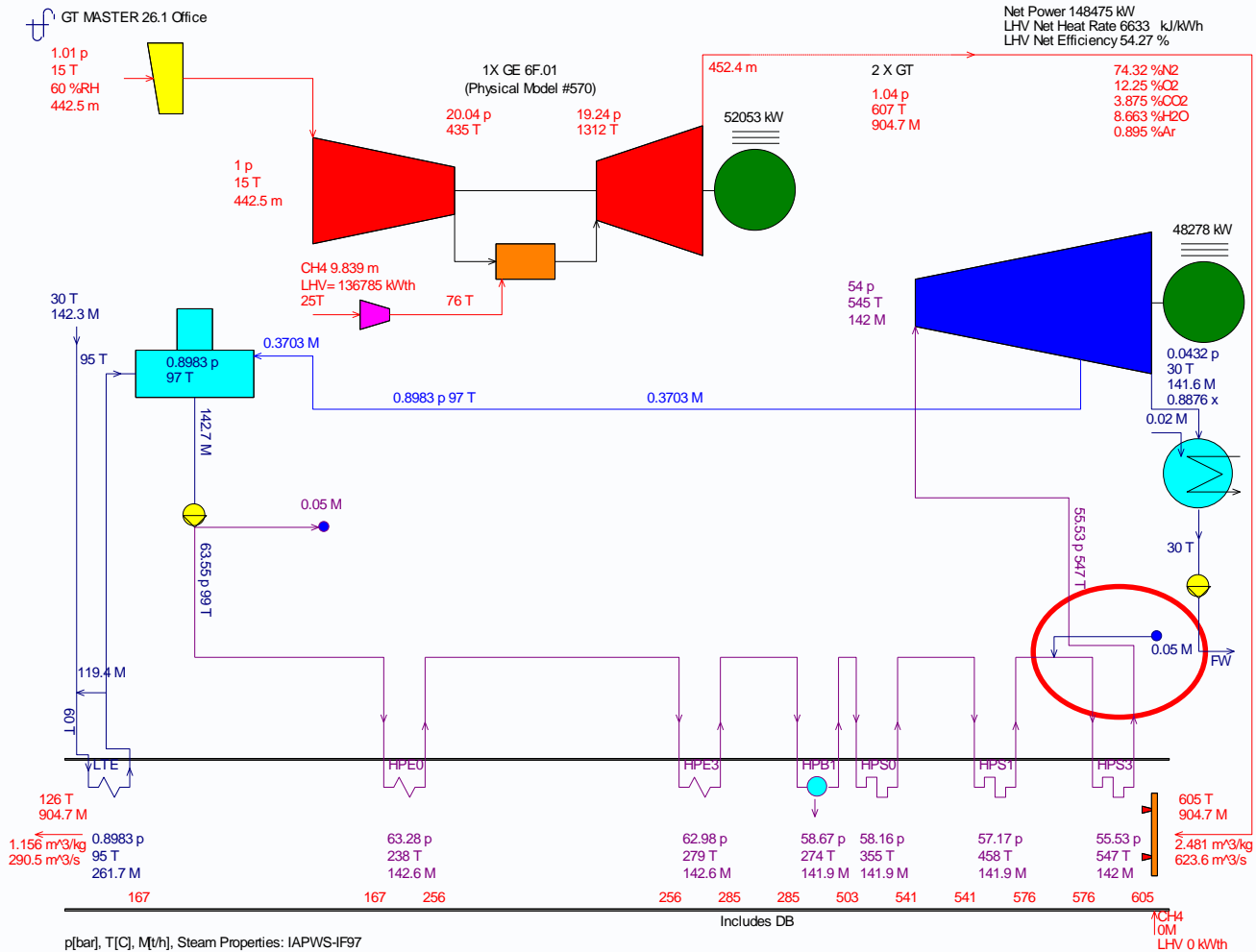
SCR & CO Catalyst Effectiveness
☐ Average ☒ From range: Min plus 1 * (Max - Min)

Radiant Boiler Projected Areas
☐ Average ☒ From range: Min plus 1 * (Max - Min)

		Nominal Design	Design 1
User excluded this design entirely		no	no
HRSR compatible with HRSR in nominal design		yes	yes
Gas temperature reaching HRSR	C	604.6	604.6
Gas temperature after duct burner (if present)	C	750	604.6
Duct burner nameplate LHV capacity	kW	23,186	20,723
Overall heat transfer surface	m ²	23,919	12,994
Economisers	m ²	15,933	5,415
Evaporators	m ²	6,719	5,728
Superheater/Reheaters	m ²	1266.7	1,850
Duct width	m	3.547	3.254
Tube length	m	10.33	9.463
Main stack height	m	22.73	20.82
Main stack diameter	m	2.981	2.976
HP drum length	m	5.172	4.744
HP drum diameter	m	1.222	1.036
HP drum thickness	mm	51.37	43.56

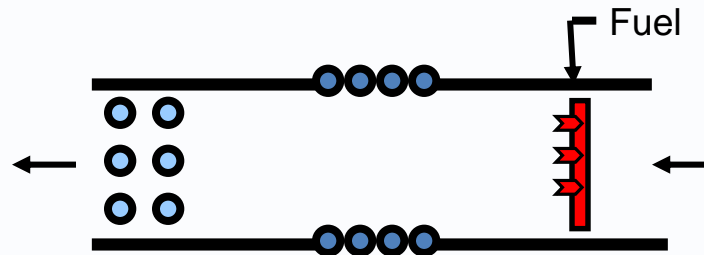


website: www.Thermoflow.ir
 Telegram: @Thermoflow_users
No supplementary firing



HRSG with radiant surfaces

- When the gas temperature is higher than 800 C the radiant heat exchange takes place.
- Radiant heat exchanges have to be used in this case (screens).



HRSG with radiant surfaces

GT PRO 26.1 - C:\TFlow26\MYFILES\GTPRO.GTP

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Carrying on...

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HRSG Main Inputs

Thermodynamic Design Assumptions

Hardware Design

Radiant Boiler

1. Fuel flow to radiant zone burner (per plant)	0	t/h
2. Steam production in water wall region (per plant)	105	t/h
3. Steam production in screen region (per plant)	45	t/h
4. Screen radiation surface area/screen surface area per row	0	
5. Radiation beam length correction factor	1	
6. Water wall surface emissivity	0.8	
7. Wall metal conductivity @ 500 F (260 C)	46.73	W/m-C
8. Wall metal conductivity slope	-0.0249	W/m-C ²
9. Wall thickness	5.08	mm
10. Water side fouling factor	1.761E-4	m ² -C/W
11. Gas side fouling factor	1.761E-4	m ² -C/W
12. Gas side convective h.t.c. correction factor	1	
13. Soot emissivity exponent correction factor	1	
14. Correction factor for radiant flux	1	
15. Aspect ratio of radiant section frontal area (0=automatic estimate)	0	
16. Radiant section frontal area / HRB frontal area	1	

HRSG with radiant surfaces

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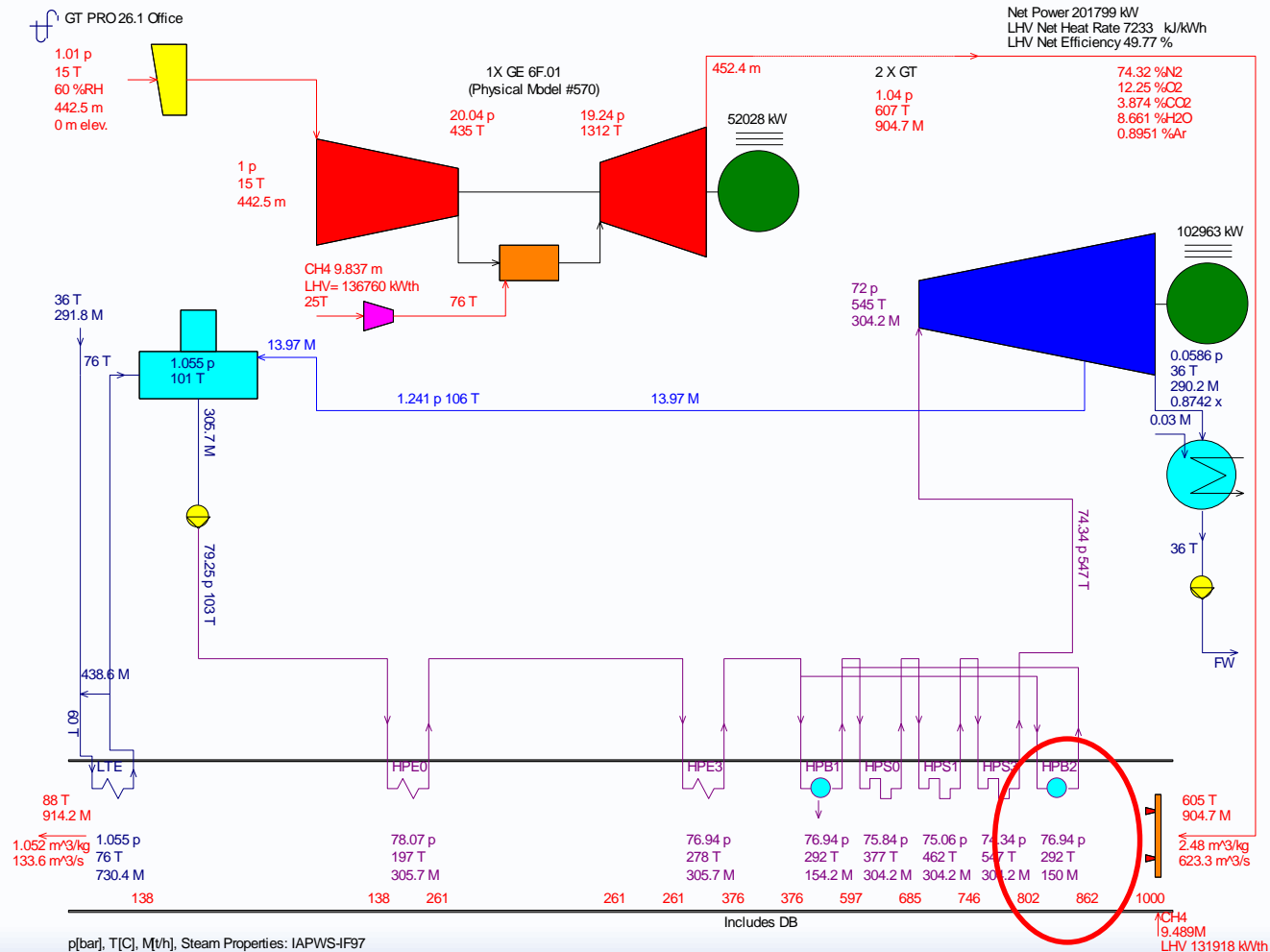
Path	15	14	13	Zone 12	11	Zone 10	9	Zone 8	7	6	5	Zone 4	3	2	Zone 1	0	Path
2				HPE0 196.7 C		HPE1 196.7 C	HPE2 196.7 C		HPE3 278.3 C		HPB1 292.3 C	HPS0 377.2 C		HPS2 462.1 C			2
1				101.1 C		196.7 C	196.7 C		196.7 C			292.3 C		462.1 C			1
0													HPS1 377.2 C	HPS3 462.1 C	HPB2 292.3 C		0

HPB2

Duct Burner

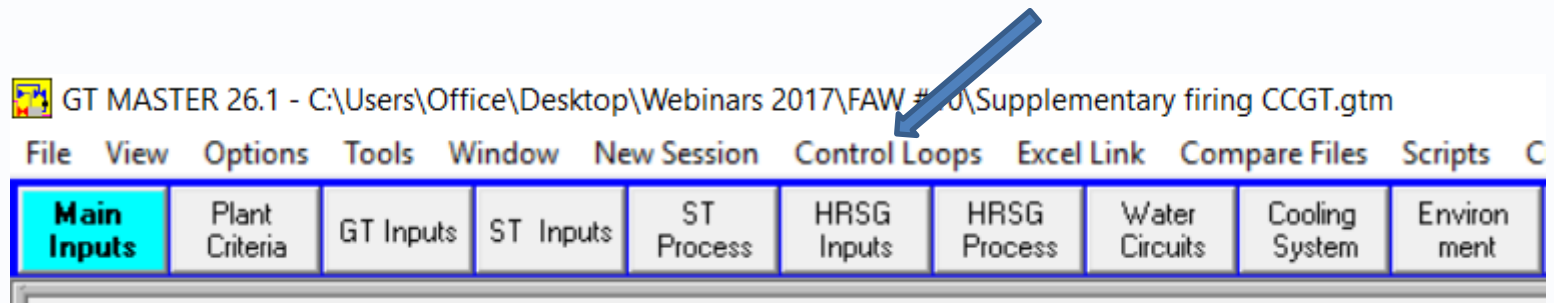
Placing into radiant zone

HRSG with radiant surfaces



Control Loop in GT MASTER

- Control Loop is a tool for automatically searching for the values of inputs to the GT MASTER model that cause an output of the GT MASTER model to attain a certain, desired value.



Control Loop in GT MASTER

Control Loop Menu

GT MASTER 26.1 - Control Loop Menu

Control loop: ☒ Enabled ☐ Disabled Toggle lower window display OK

Current Control Loop Configurations

☒ **Set Point => Plant net output** Tolerance %

Desired value [kW]

☐ **Primary control => GT load percentage** from ^{X1} to ^{X2} [%]

☐ **Upper control => Duct Burner exit temperature** from to [C]

☐ **Lower control => None** from to

Select Set Point or Control Variables

☒ **Set Point variables**

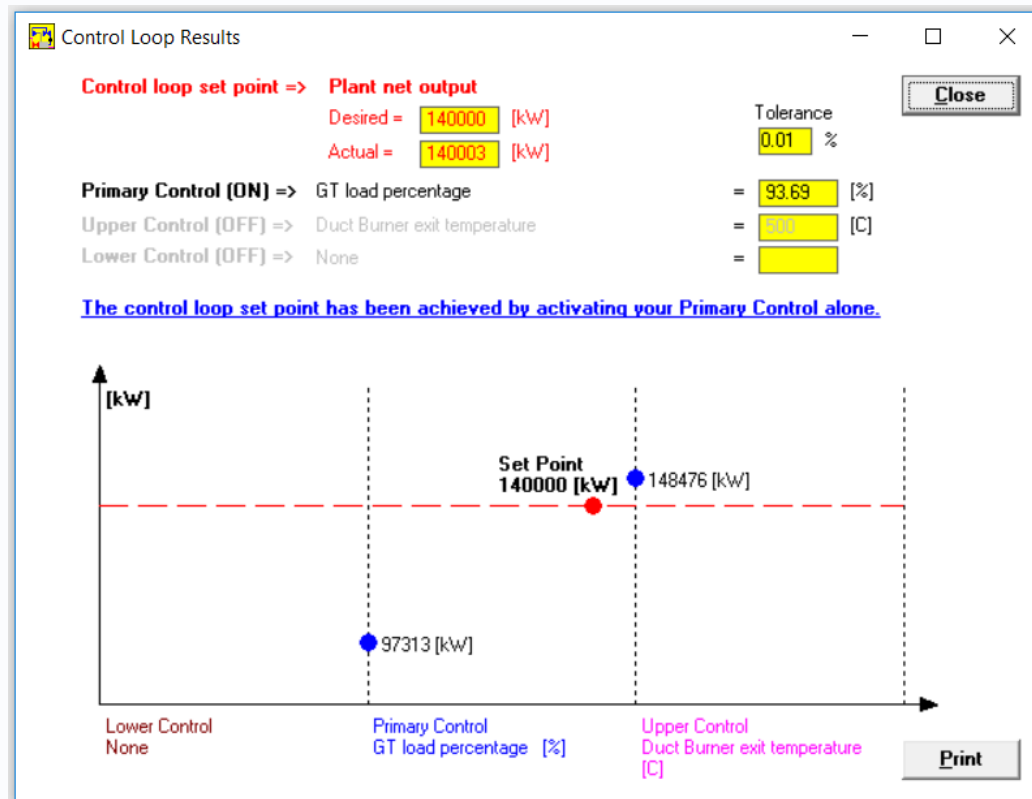
☐ Plant operating variables ☐ Process streams ☐ HRSG massflow additions/extractions

None
Plant gross output
Plant net output
Steam turbine generator output
Plant gross heat rate
Plant net heat rate
Plant gross electric eff
Plant net electric eff
Gas turbine gross output
PURPA efficiency

Click on the list box to select Set Point variable. GT MASTER will iterate on Primary Control variable, and Upper or Lower Control variable if necessary, to achieve the desired set point value.

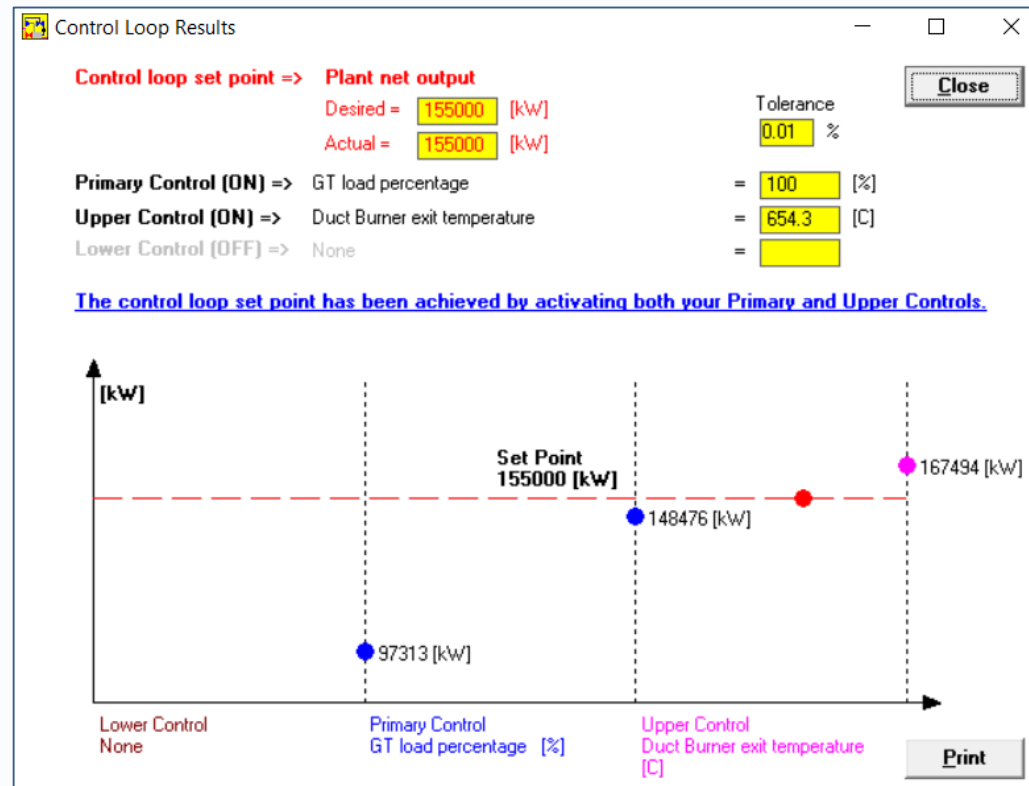
Control Loop in GT MASTER

Control Loop Results (140 MW)




Control Loop in GT MASTER

Control Loop Results (155 MW)



Control Loop in GT MASTER

Control Loop is available input for ELINK

 ELINK 26.1 (Save-ALL) ? Copyright (c) 1999 - 2017 Base Case: C:\TFLOW26\MYFILES\GTPRO.gtm Loaded: 08-31-2017 : 10:53:39		Base Case	Case 1	Case 2	Case 3	Case 4	Case 5
Computation Message ->		Messages	OK	OK	OK	OK	Messages
INPUT VARIABLE DESCRIPTION	Units	Input	Input	Input	Input	Input	Input
Plant net output		170000	90000	110000	130000	150000	170000
OUTPUT VARIABLE DESCRIPTION	Units	Output	Output	Output	Output	Output	Output
Plant net output	kW	167,494	89,995	110,005	129,994	149,999	167,494
GT load	%	100.0	54.47	69.98	85.9	100.0	100.0
GT fuel flow	t/h	9.835	6.502	7.583	8.696	9.839	9.835
Total duct burner fuel flow	t/h	3.335	0	0	0	0.2547	3.335
Duct burner exit temperature	C	750.0	647.1	638.2	620.7	616.0	750.0

Q & A session

Please send your questions to the
presenter in the webinar chat!

For further questions:
zakharenkov@thermoflow.com

Thank you!