Welcome!

Webinar #28: On Line & Off line Simulation of a Coal Plant

30 May 2018

Agenda:

* Introduction
* Philosophy of Thermoflow
* Replicating an existing coal plant, STP-PCE
* Off-Line OD Simulation, STM / TFX-PCE
* On-Line OD Simulation, Elink, U-Link
* Data Reconciliation (DRS) and System Optimization (TOPS)
* Q & A Session

Presenter: IGNACIO MARTIN (SPAIN) – GLEN GUO (CHINA)
Support: Meritt Elmasri (U.S. HQ)

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Thermoflow Training and Support

- Standard Training
- On-site Training Course
- User's Meetings / Advanced Workshops
- Webinars when new version is released
- Help, Tutorials, PPT, Videos
- Technical Support

→ **Feature Awareness Webinars**

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Feature Awareness Webinars

1- Assemblies in TFX, June 2016
2- Scripts in Thermoflow programs, GTP-GTM-TFX
3- Multi Point Design in GTP-GTM
4- Reciprocating Engines in TFX
5- TIME in GTM
6- Matching ST Perfromance in STP
7- Modeling Solar Systems in TFX
8- Combining THERMOFLEX & Application-Specific Programs
9- Methods & Methodology in GT PRO & STEAM PRO
10- Supplementary Firing & Control Loops in GT PRO & GT MASTER
11- The Wind Turbine Feature in Thermoflex
12- Modelling GT's in Thermoflow programas-1

13- Thermoflex for on line and off line performance monitoring

14- Tflow 27, what's new
15- Modelling GT's in Thermoflow programas-2
16- Multi Point Design in GTP-GTM
17- Total Plant Cost in TFX
18- Steam Turbine Tunning
19- User Defined Components in TFX
20- Cooling System Optimization

…………………………

28- OD Simulation of a Coal Plant

Simulation of an existing Plant: Philosophy of Thermoflow

- Clear Definition: → What we want
  → What we can achieve
- Plant Engineers involvement @ the Development and Operation
- Plant operating regime & environment (regulation, prices, …)
- Plant specific concerns
- Availability – Reliability comes first!!!
- Pay back?

→ Realistic Expectations

→ Unique solution for each plant

Monitoring an existing Plant: Options

1. Data acquisition system + simple data processing → Trends
2. " + use of correction curves
3. " + Thermodynamic Model
4. " + Detailed Engineered model → Thermoflow

Complexity

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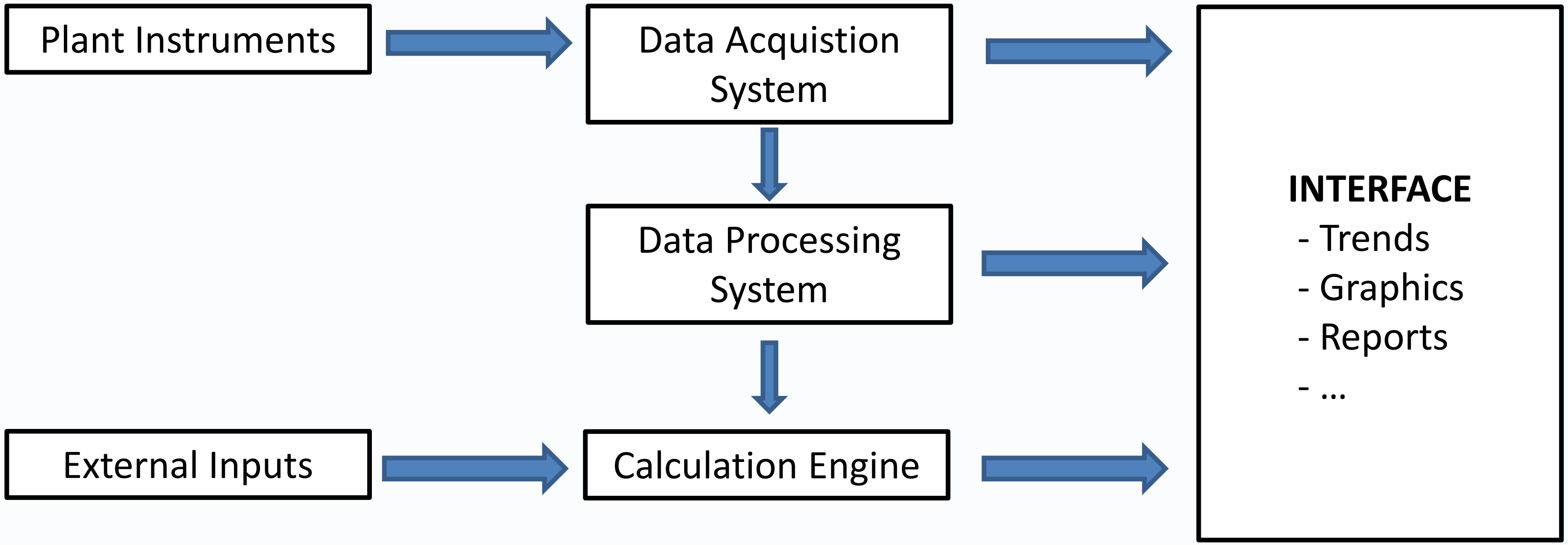
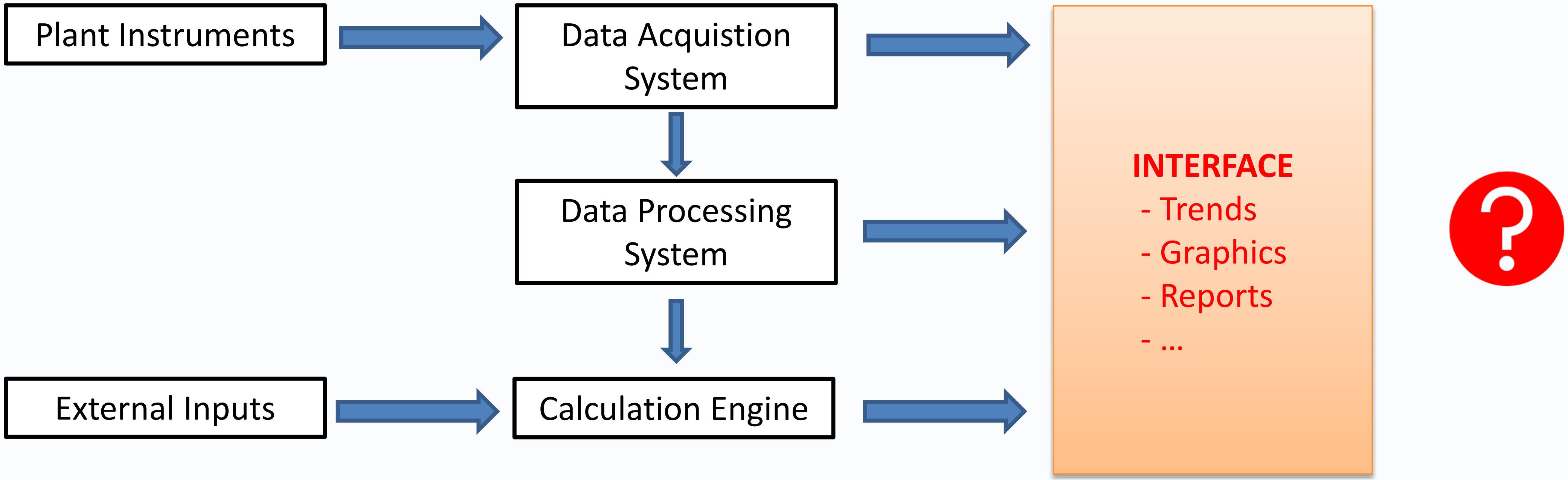
Simulation of an existing Plant: Structure



Simulation of an existing Plant: Focus?



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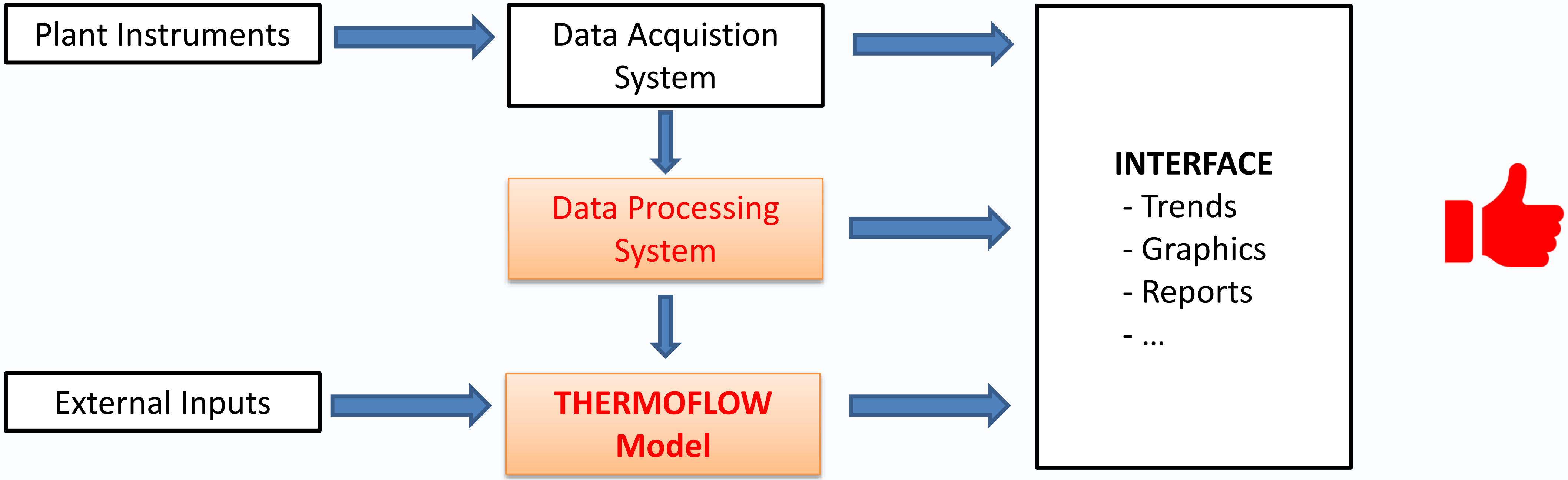
Simulation of an existing Plant: Focus?



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Simulation of an existing Coal Plant: Limitations

- Instrumentation available & accuracy
- Flow rates measurement: coal, air, gas, water-steam flows, CW flow
- Real Time Coal properties
- ST expansion on the wet region, steam properties
- Unburnt carbon in ash measurement
- Uncounted Boiler losses (Manufacturer Margin)
- Others: PA/SA distribution
  Fly/Bottom Ash distribution
  …

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Simulation of an existing Plant in Thermoflow: Steps

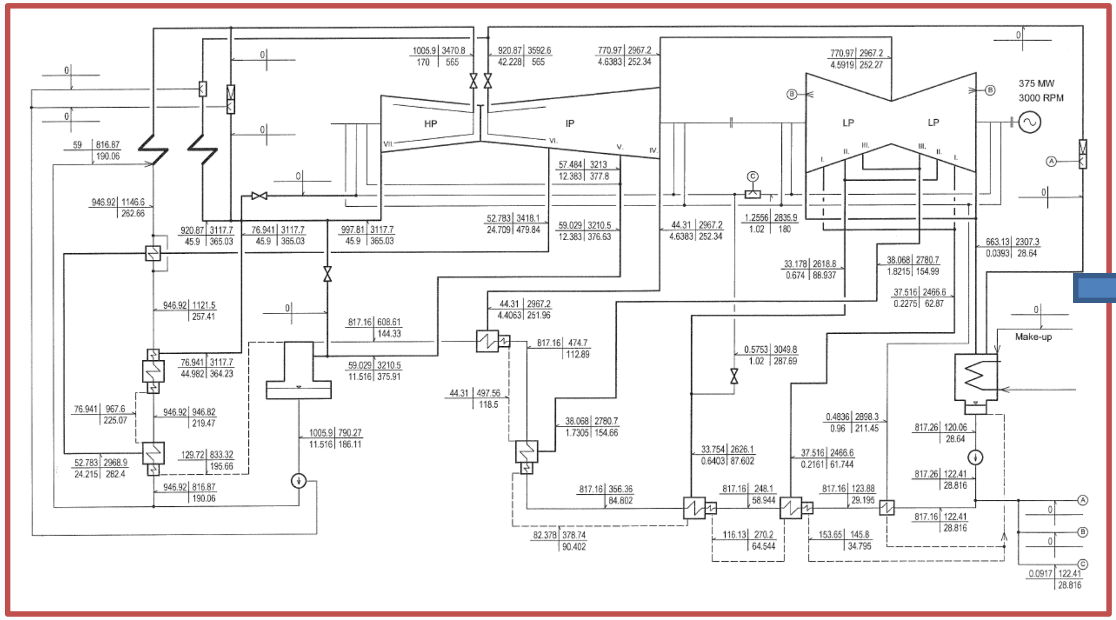
1. Replicating the Original HB → Steam Pro-PEACE
2. “As built” model in STM / TFX-PCE
3. Hardware in STM / TFX-PCE
4. Controls in STM / TFX-PCE
5. Degradation in STM / TFX-PCE: “Current Status” vs “Clean Status”
6. OD Simulation Off Line
7. OD Simulation On Line, Performance Monitoring

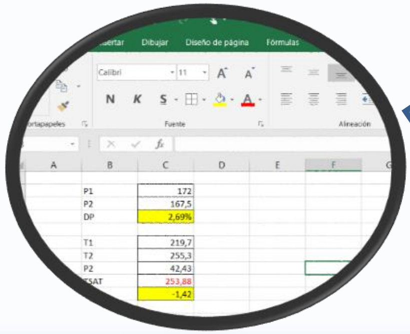
Simulation of an existing Plant in Thermoflow: Steps

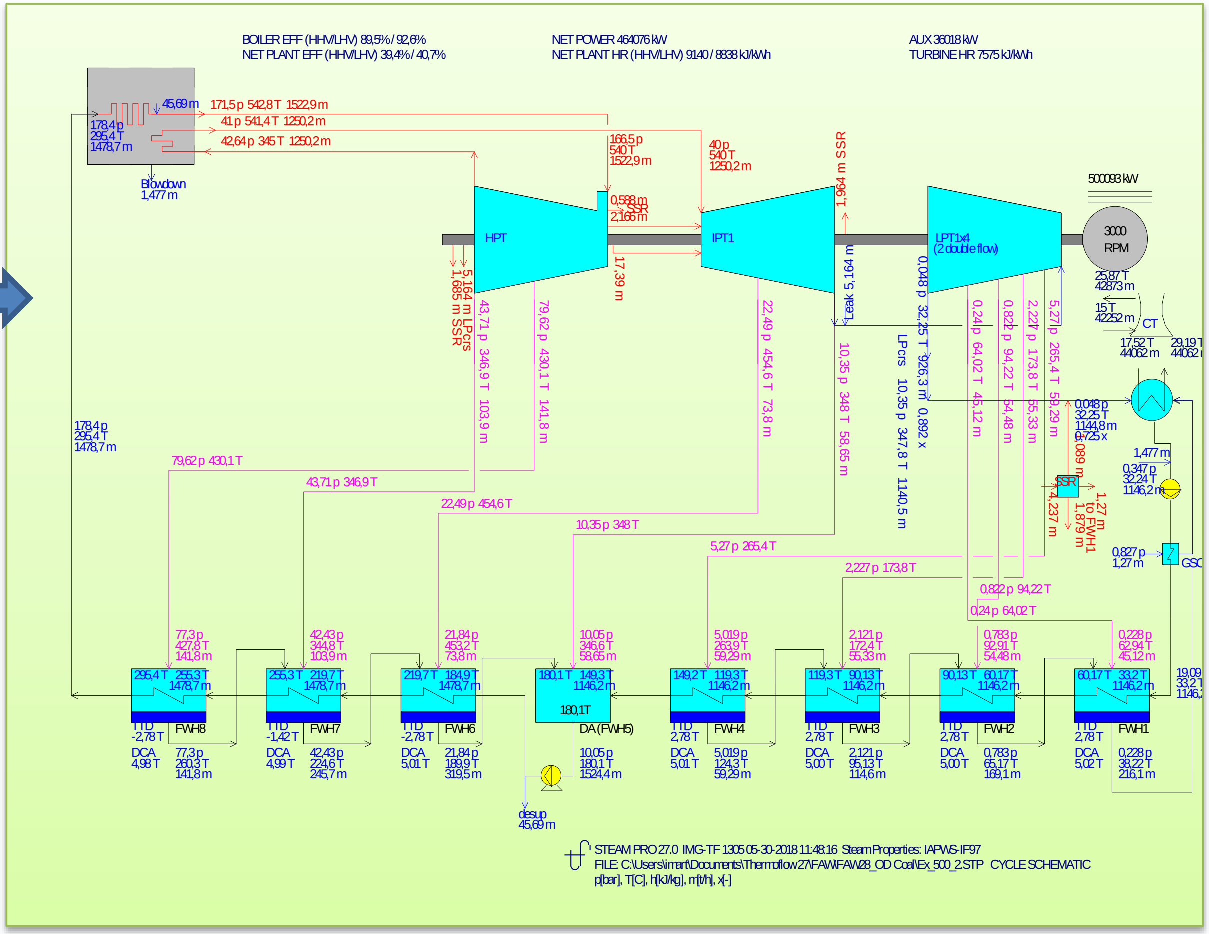
Example

1. Design in 1999 → "Original Heat Balance"
2. Start Up in May 2002 → "As Built" HB and first "real data"
3. Last Overhaul in Sep 2016 → "Current Clean Status"
4. Now, May 2018 → "Current Status"

Replicating an existing plant STP, Original HB, Steam Cycle



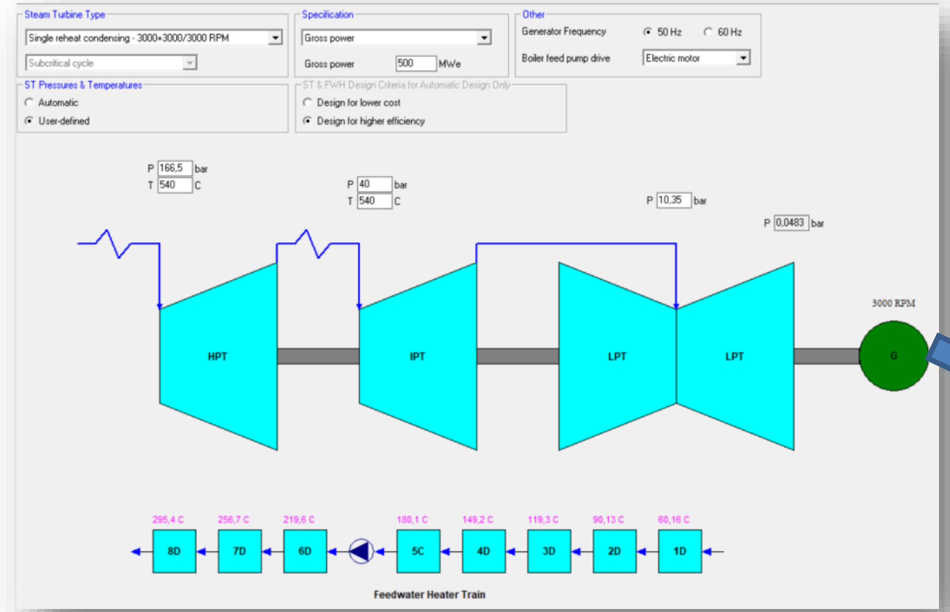


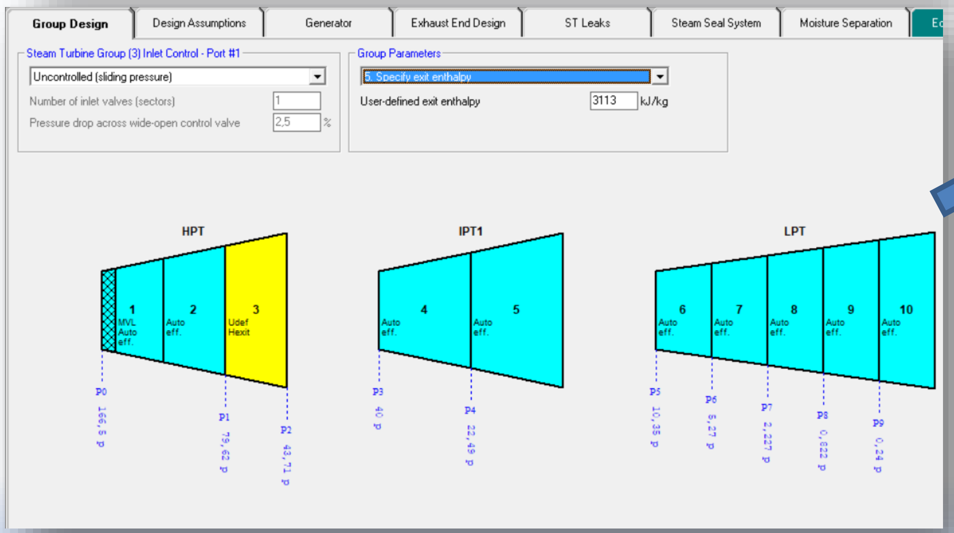


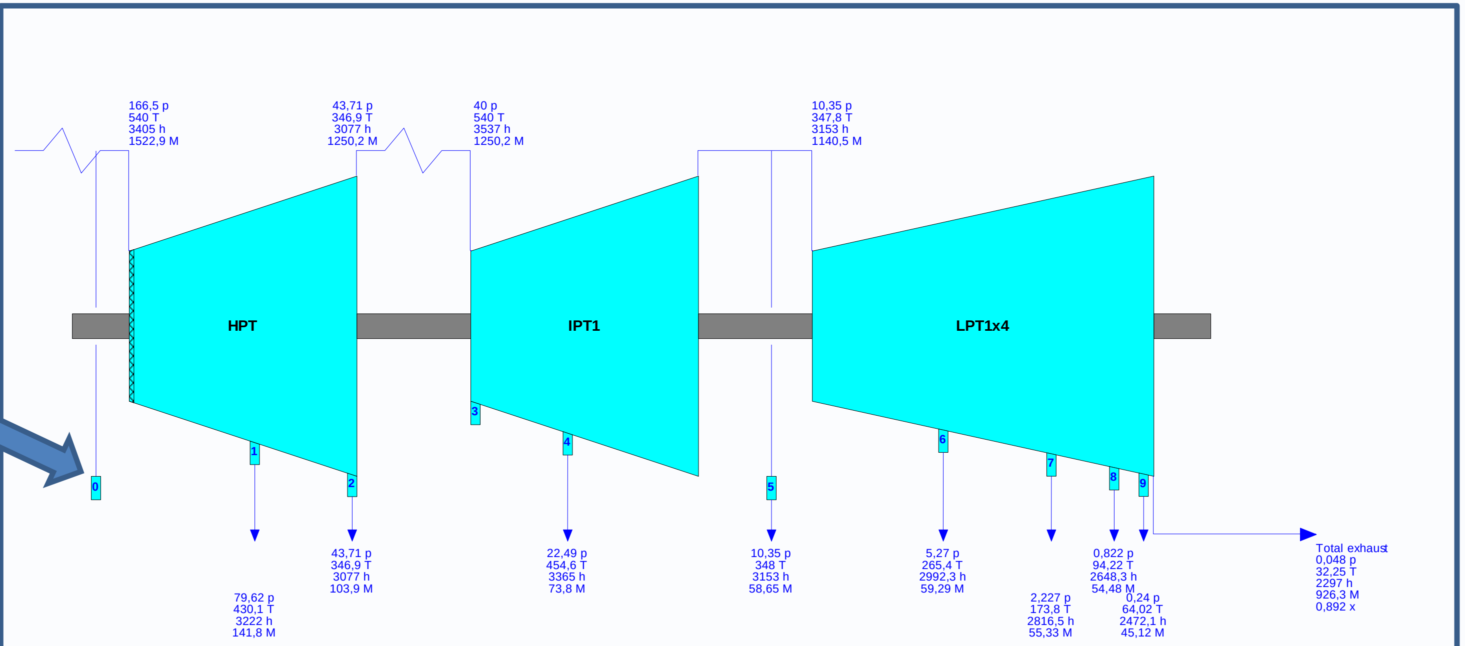
Replicating an existing plant STP, Original HB, Steam Cycle

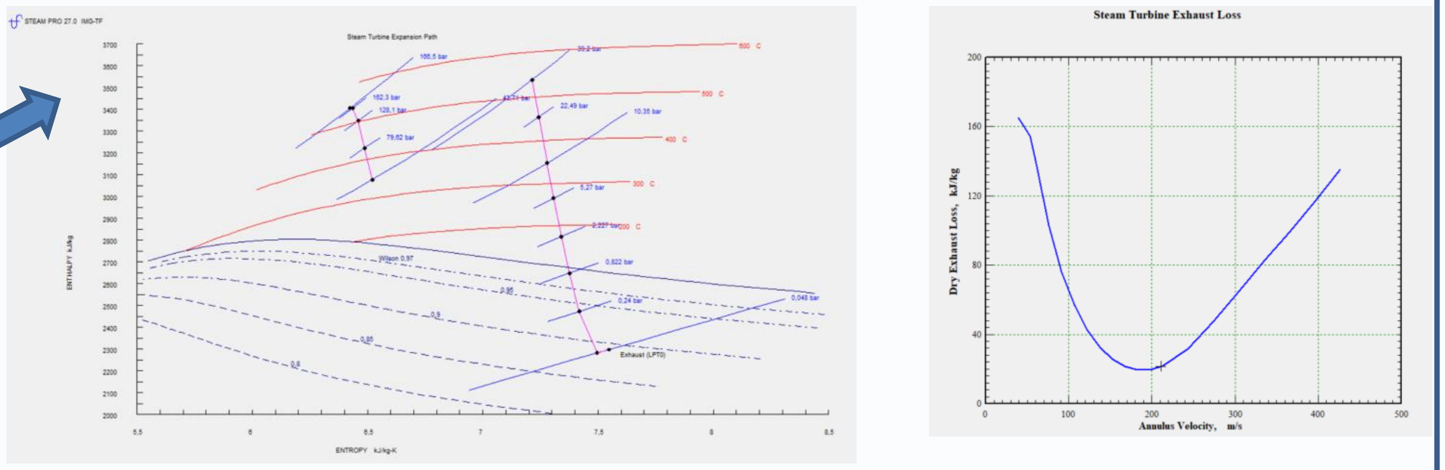
- Plant Criteria & Site Conditions
- Cycle type: Subcritical, Single Reheat Condensing
- Plant Size: HPT Flow, Gross Power, Net Power
- Steam Cycle conditions, Pressures & Temperatures
- Steam Turbine, Casing configuration, group efficiencies, leakage system, exhaust end-EL, losses
- FWH: number, type & connections
    - Thermal parameters, TTD, DCA, DP
    - Parallel trains
    - hardware definitions
- Cooling System: type, Condenser Pressure, CW DT, other parameters, hardware definitions
- Pipe pressure drops
- Boiler Feed Pump: electric motor or steam turbine
- Pumps, type, margins-curve, number operating & stand by
- Auxiliary Streams: aire preheater, jet ejector, auxiliary steam, steam to sootblowers, blowdown, desuperheating

Replicating an existing plant STP, Original HB, ST

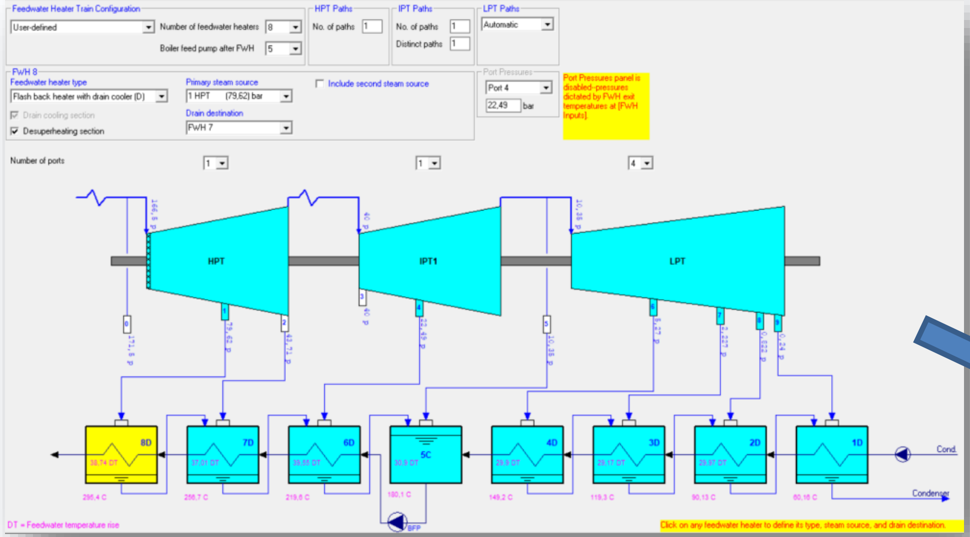


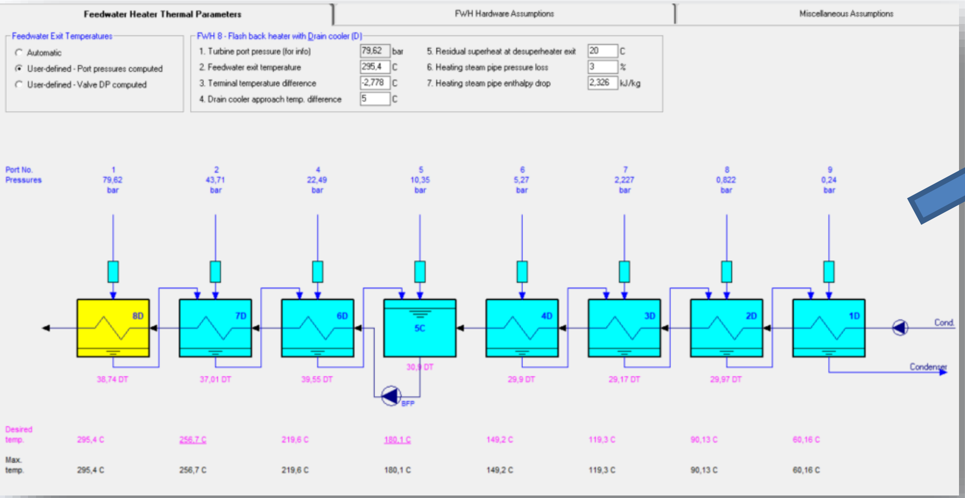


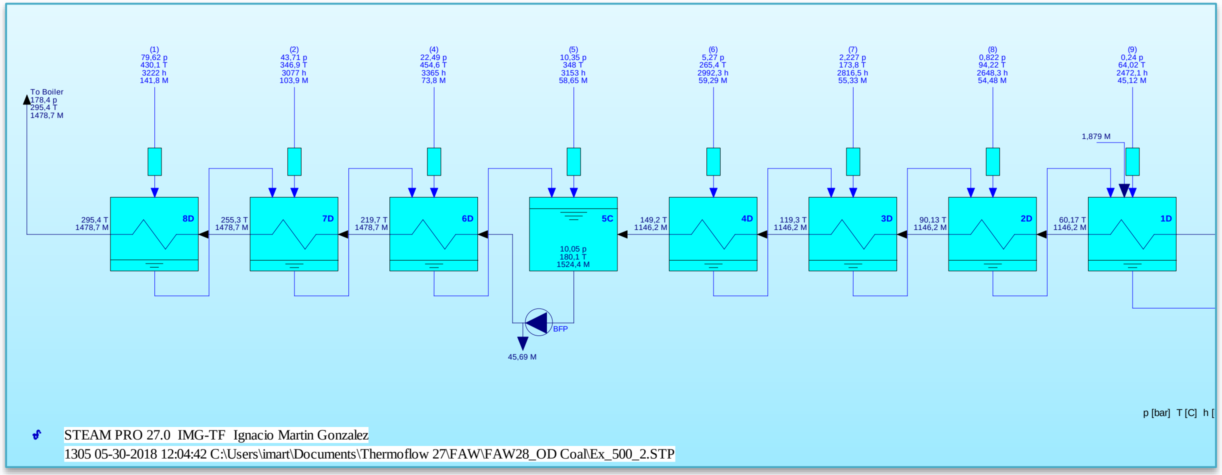


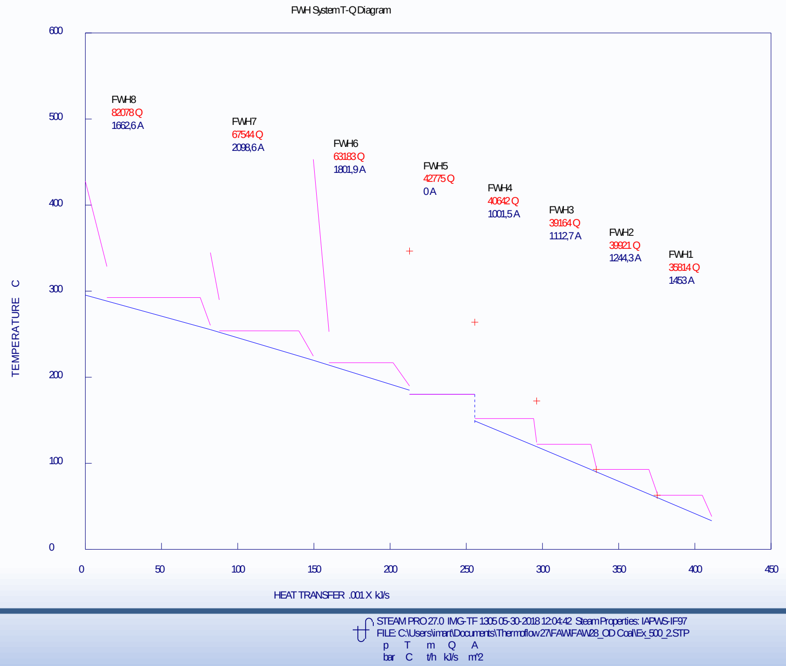


Replicating an existing plant STP, Original HB, FW Heaters

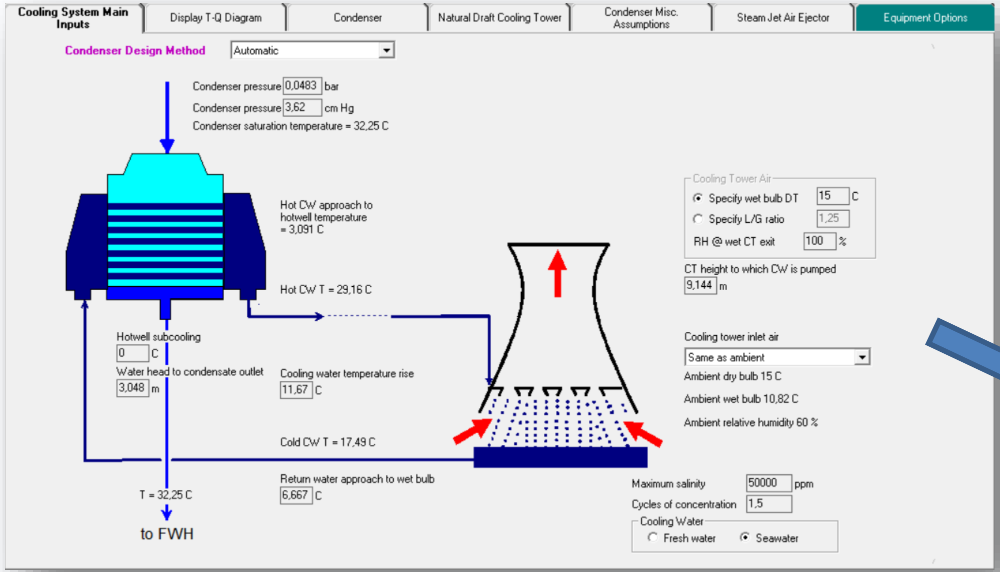


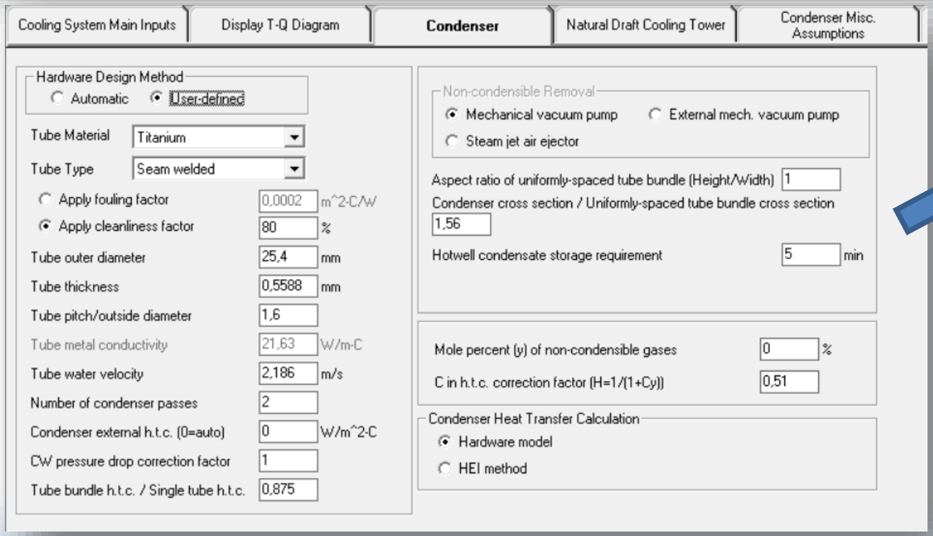


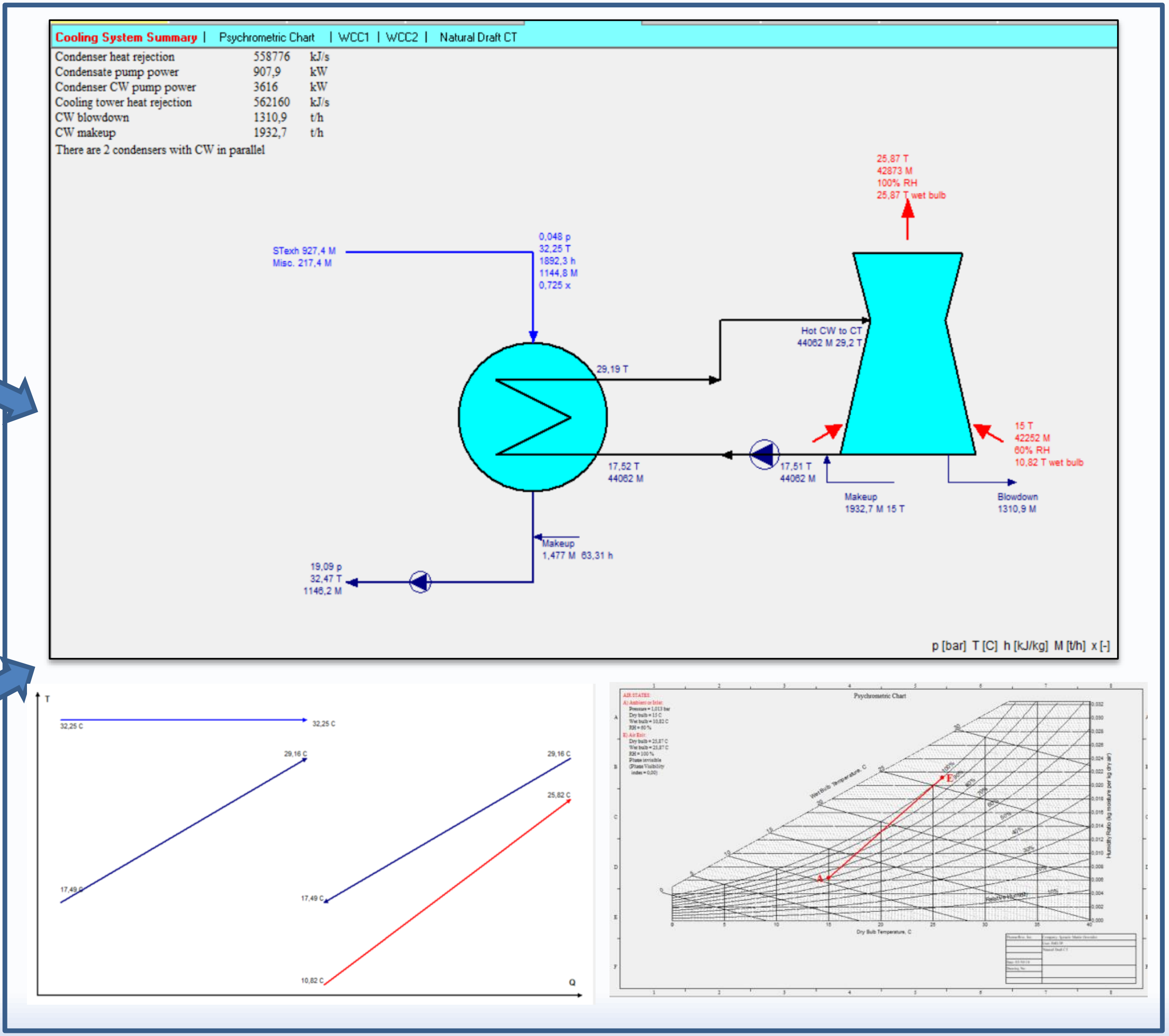




Replicating an existing plant STP, Original HB, Cooling Syst







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Replicating an existing plant STP: Boiler design

- Fuel type, fuel preparation
- Boiler Thermal: configuration, circulation, excess air, minor losses, blowdown
- Air Handling: PA-SA, Air Pre-heating, DP, fans
- Desuperheating
- Boiler sizing: Furnace exit T, SH load, RH load, Eco load
- Furnace parameters: unburnt carbon in ash
- Stack
- Convective HX DP and hardware definition

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Replicating an existing plant STP: Boiler design

No.	Parameter	Base	MTBU Barat		
			Min	Max	Average
1	Total Moisture (TM)	% AR	21.70	33.90	28.61
2	Proximate Analysis	% AR			
	- Innerent Moisture		9.30	21.20	16.04
	- Volatile Matter		30.22	56.33	33.45
	- Fixed Carbon		29.19	36.50	32.35

S/N	Name	Unit	Design Coal Type
1	Basic carbon collected [Car]	%	48.05
2	Basic hydrogen collected [Har]	%	3.51
3	Basic oxygen collected [Oar]	%	12.94
4	Basic nitrogen collected [Nar]	%	0.63
5	Basic sulfur collected [Sar]	%	0.67
6	Basic ash collected [Aar]	%	5.59
7	Whole water content [Mar]	%	28.61
8	Inherent Moisture [Mad]	%	16.04
9	Basic volatile collected [Var]	%	33.45
10	Received basis gross calorific [Qgr.ar]	kCal/kg	4632
11	As received basis calorific value [Qnet.ar]	kCal/kg	4271
12	Hardgrove grindability coefficient [HGI]		54

Ash components

S/N	Name	Unit	Design Coal
1	Silicon dioxide (SiO_2)	%	52.96
2	Alumina (Al_2O_3 0)	%	19.72
3	Ferric oxide (Fe_2O_3)	%	5.88
4	Titanium dioxide (TiO_2)	%	0.64
5	Mangano-manganic oxide (Mn_3O_4)	%	0.11
6	Calcium oxide (CaO)	%	6.54
7	Magnesia (MgO)	%	3
8	Sodium oxide (Na_2O)	%	3.31
9	Kali (K_2O)		0.33
10	Phosphorus pentoxide (P_2O_5)		0.25
11	Sulfur trioxide (SO_3)		6.12

Performance coal 100%B-MCR condition

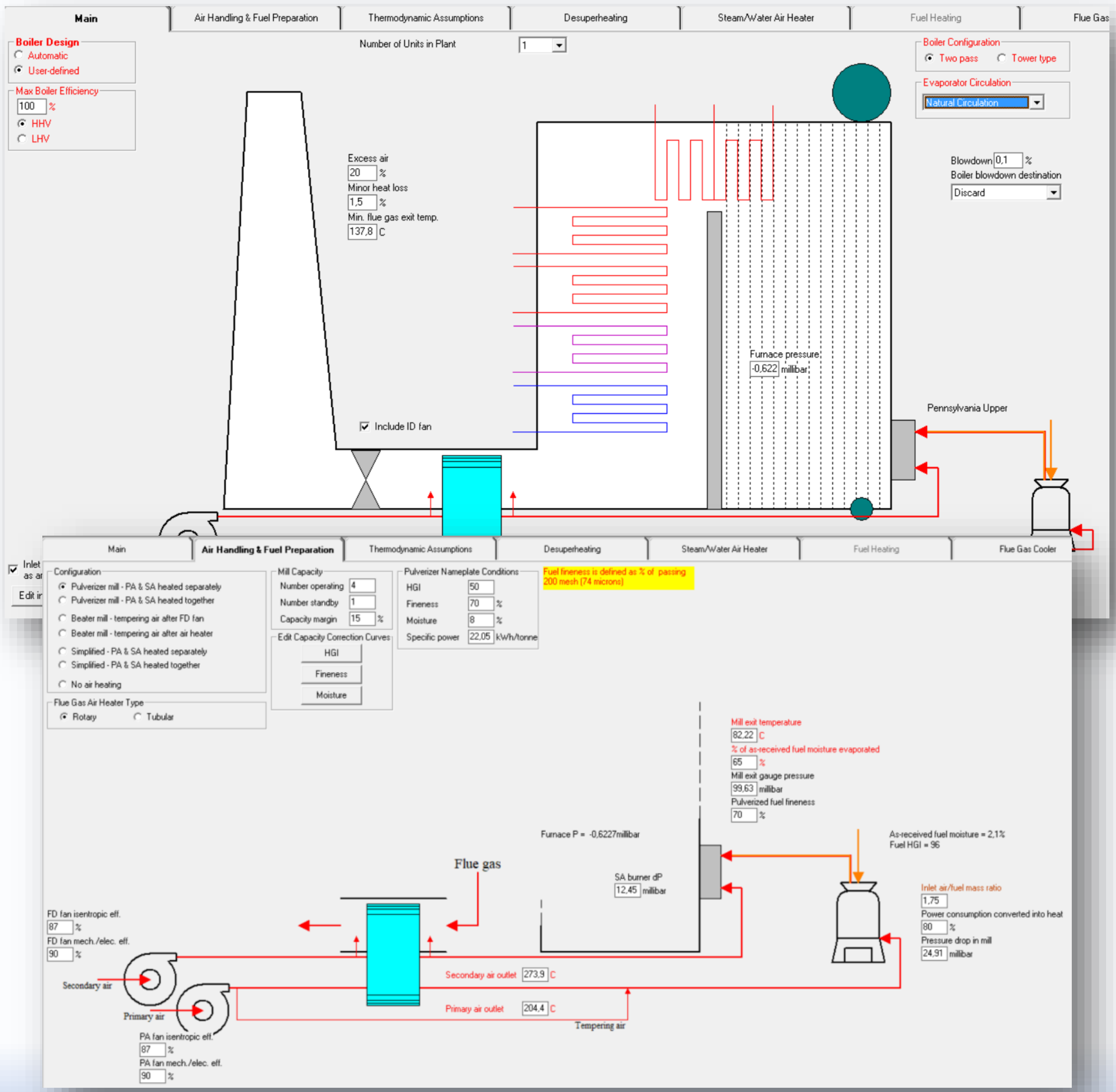
Boiler Parameters			
SH steam flow	√ Dgr	t/h	440
SH steam temp.	Tgr	℃	540
SH steam outlet pressure	Pgr	MPa .g	13.8
Feed water temp.	Tgs	℃	249
Inlet Temp. at Air Heater	Ta	℃	35
Drum operation pressure	Pgt	MPa .g	15.05
RH steam flow	Dzr	t/h	359
RH steam outlet temp.	Tzr	℃	326
RH steam outlet pressure	Pzr	MPa .g	2.59
RH steam inlet pressure	Pjk	MPa .g	2.44
RH steam inlet temp.	Tjk	℃	540

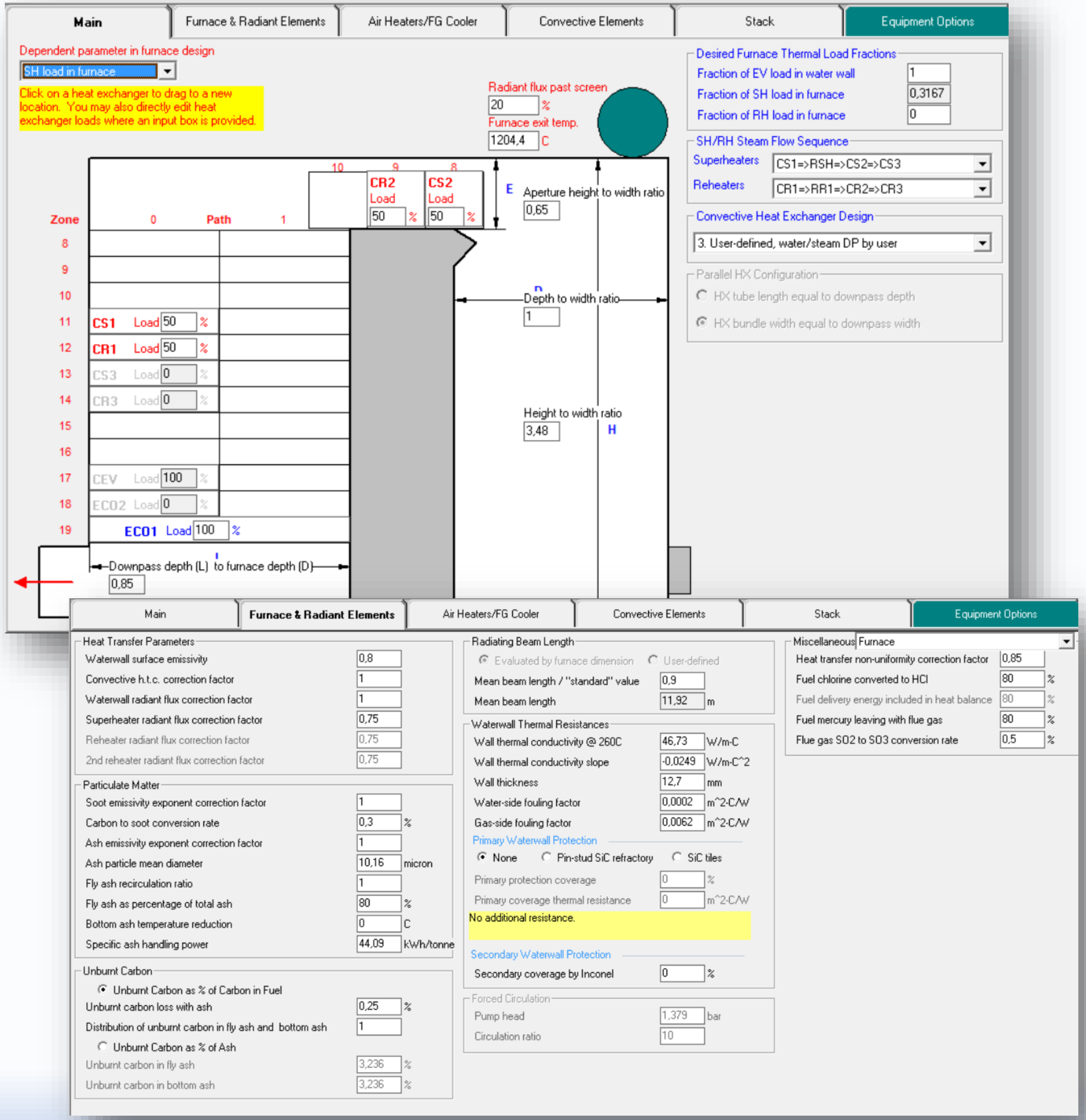
Desuperheating type of SH: Spray water			
Primary stage	D1	t/h	14.76
Secondary stage	D2	t/h	7.92
Spray water temp.		℃	168
Desuperheating type of RH: Damper regulating			

Gas, air and steam temperature profile

Item	Sym.	unit	Furnace	Cyclone	Enclosure	LTS	Platen SH	HTS	Cold RH	Platen RH	Eco.	Air Heater
Fluegas inlet temp.	T_{in}	℃	/	883	882	669	/	829	857	/	532	305
Fluegas outlet temp.	T_{out}	℃	/	883	/	531	/	669	534	/	305	149
Media inlet temp.	T_{in}	℃	343	/	341	351	360	483	326	433	249	35
Media outlet temp.	t_{out}	℃	343	/	352	373	500	540	435	540	322	263

Replicating an existing plant STP: Boiler design





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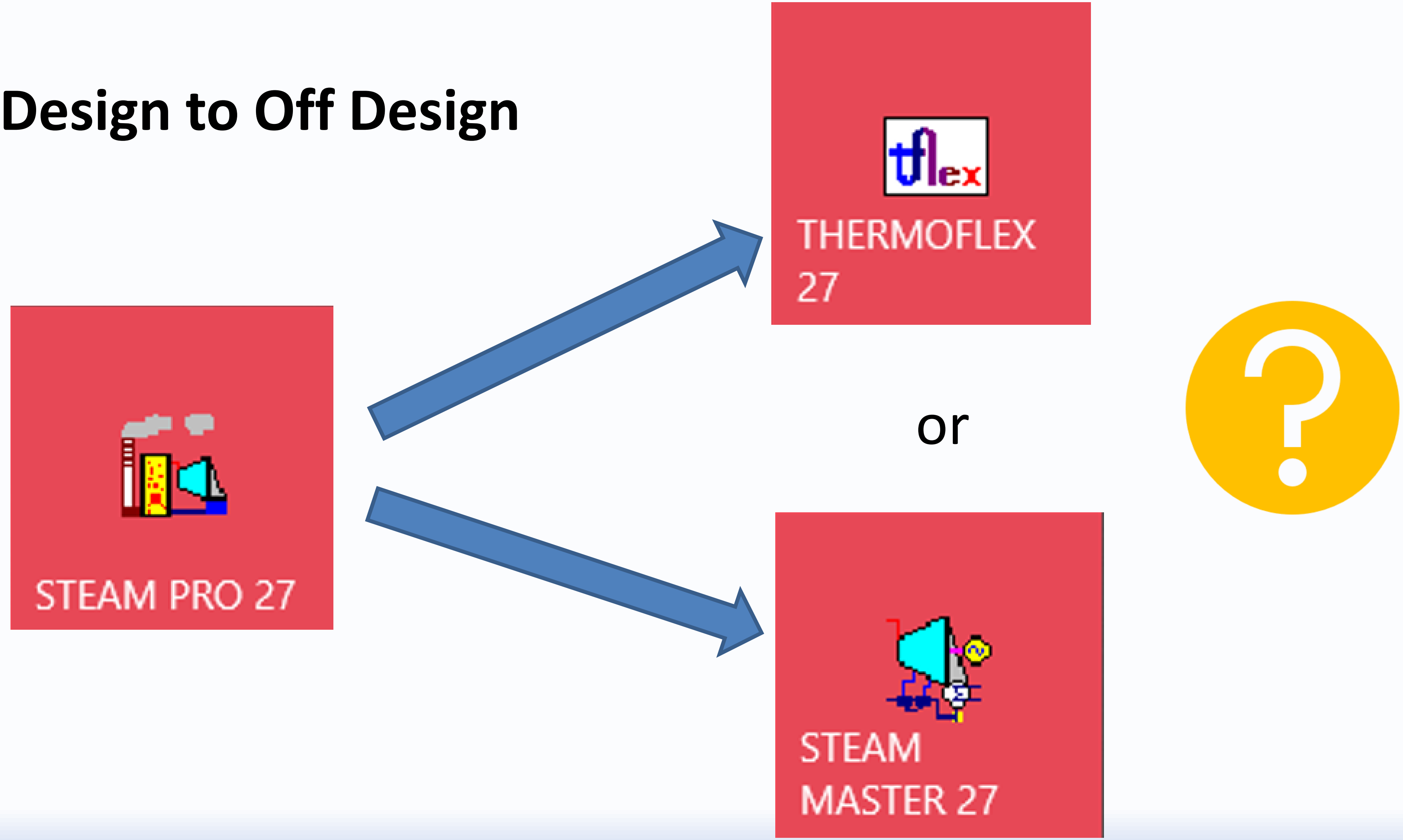
Replicating an existing plant STP: Environment

- NOx: SCR-SNCR
- Particles: Fabric Filter-ESP
- Sulfur: FGD wet/dry
- Mercury: activated carbon injection

Replicating an existing plant STP: Auxiliary Power

- Pumps
- Fans
- Fuel Delivery, Ash Handling
- Emission Control equipment
- Transformer Losses
- Other PEACE
- Miscellaneous

From Design to Off Design



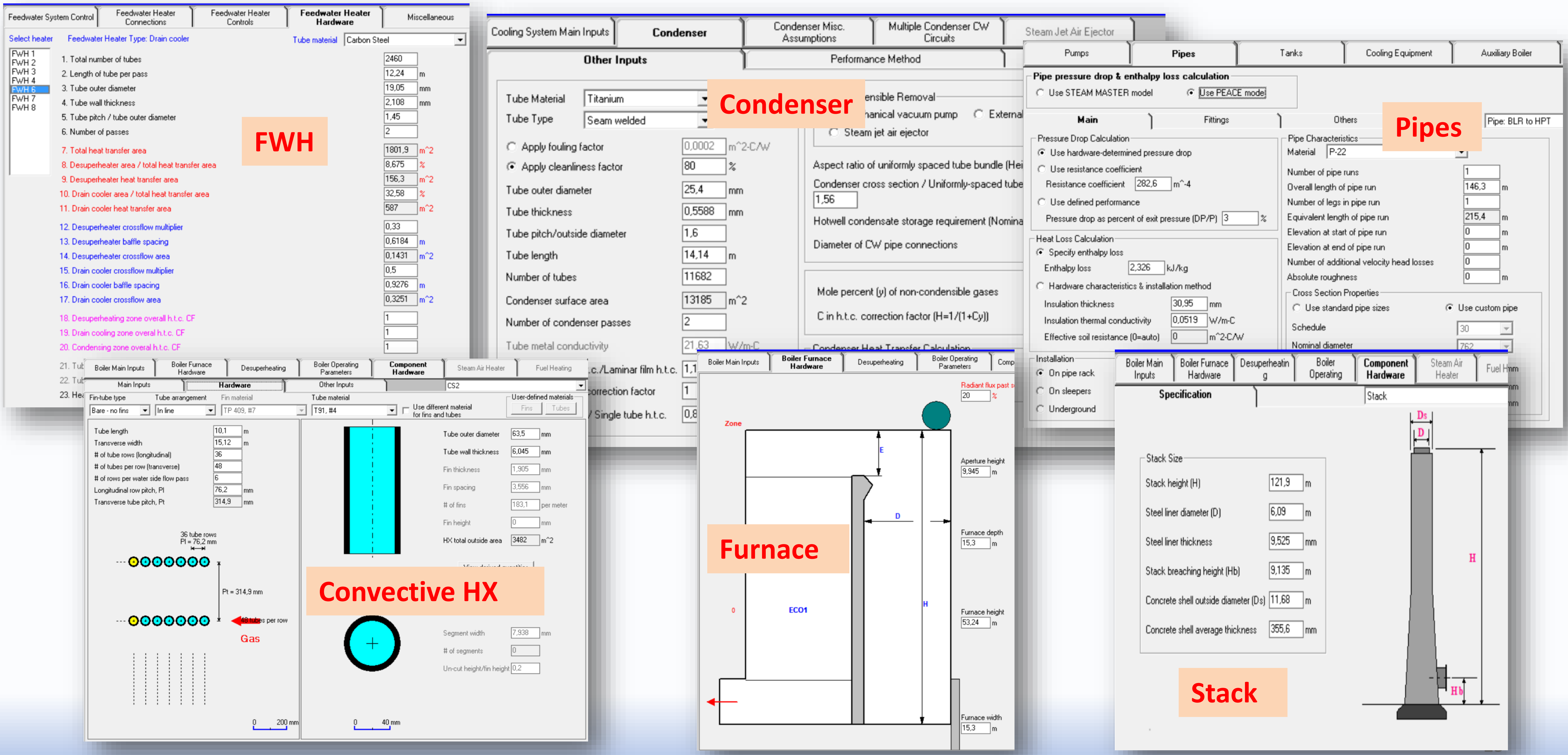
When in Off Design mode, STM or TFX

- Tune the Hardware
- Set the Controls
- Introduce Degradation

Tuning the Design in STM / TFX: Hardware

- Pipes
- FW Heaters
- Condenser / Cooling Tower
- ST: Inlet Nozzle Area
- Furnace Dimensions
- Boiler Convective HX
- Air Heaters
- Stack

Tuning the Design in STM / TFX: Hardware



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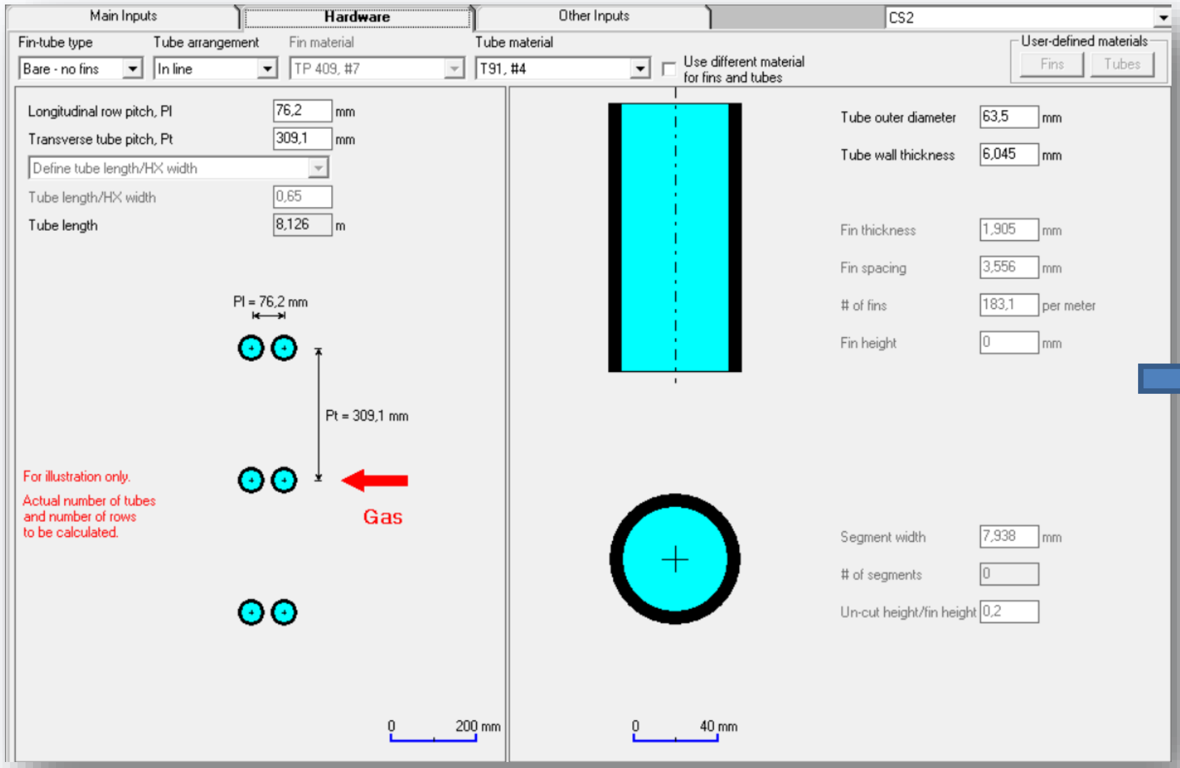
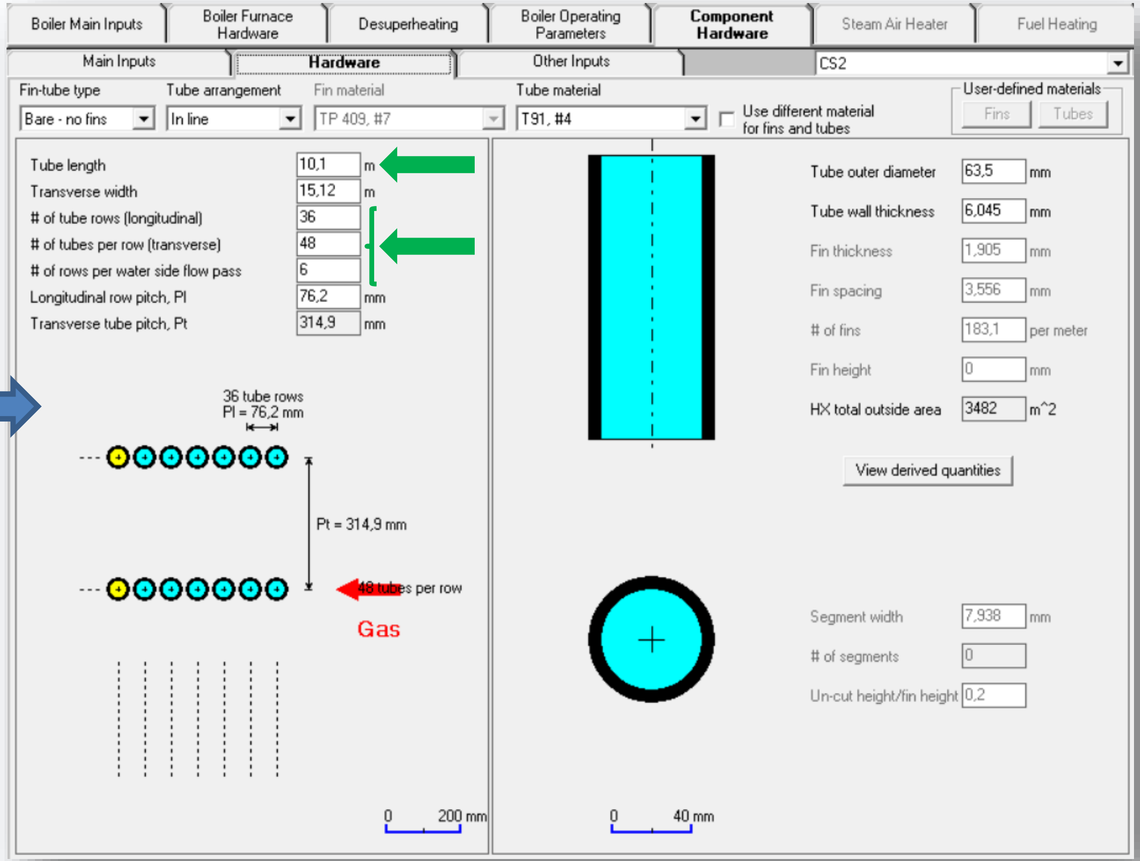
Tuning the Design in STM / TFX: Hardware

Steam Pro



Steam Master



Tuning the Design in STM / TFX: Controls

- Plant
- ST
- Boiler
- FWH
- Condenser

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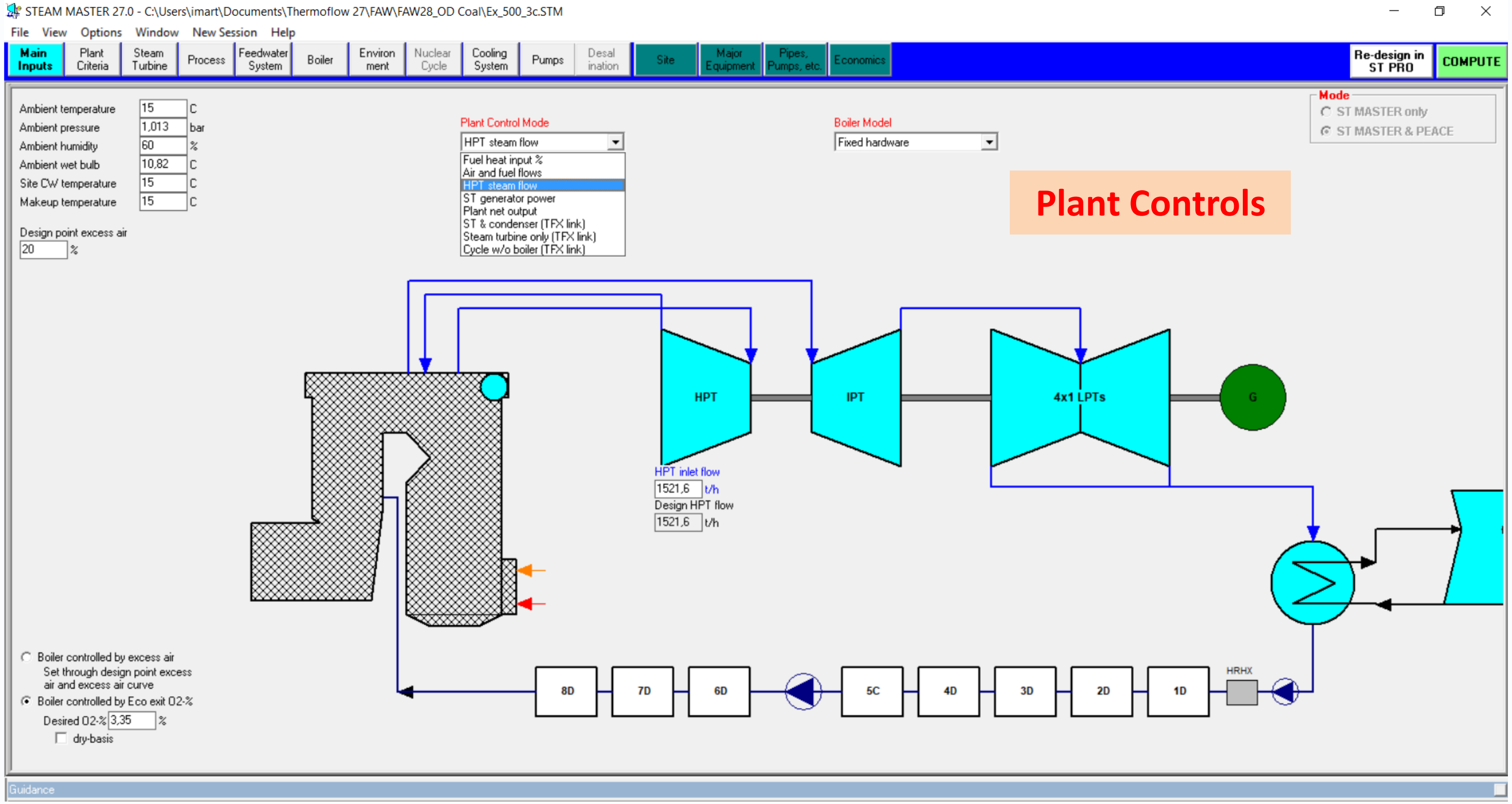
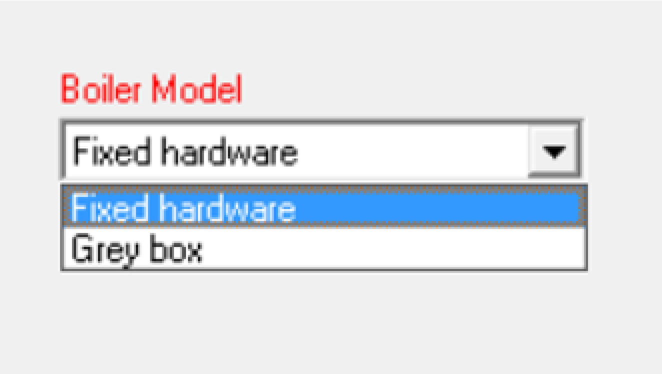
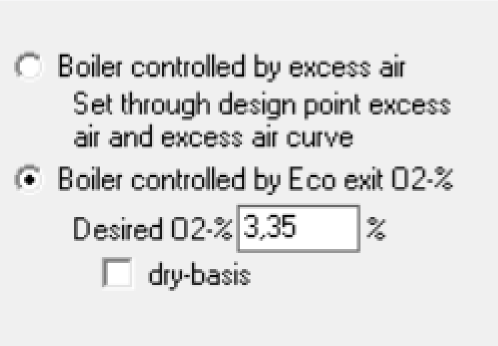
Tuning the Design in STM / TFX: Controls

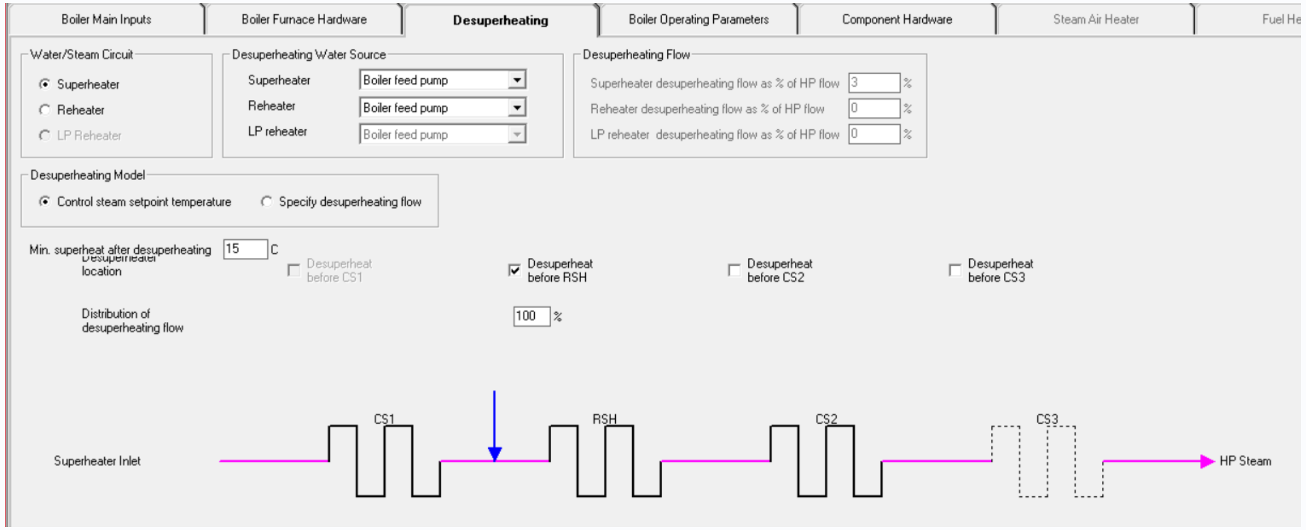


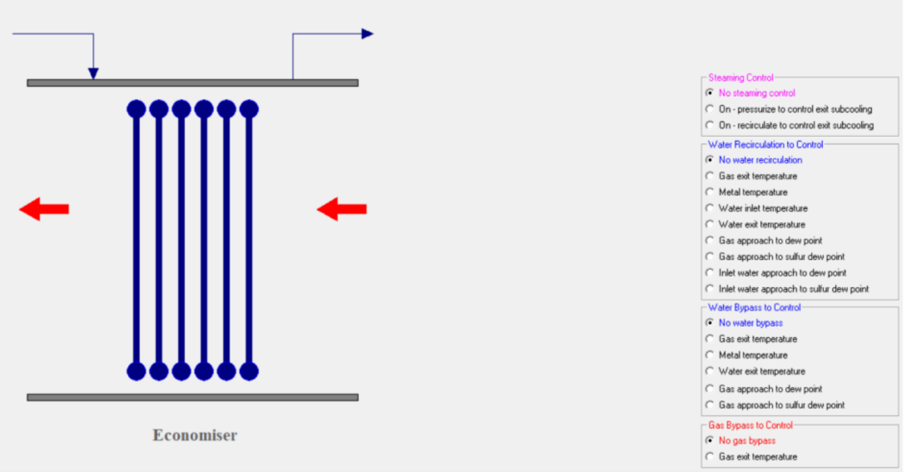
Tuning the Design in STM / TFX: Controls

Boiler Controls

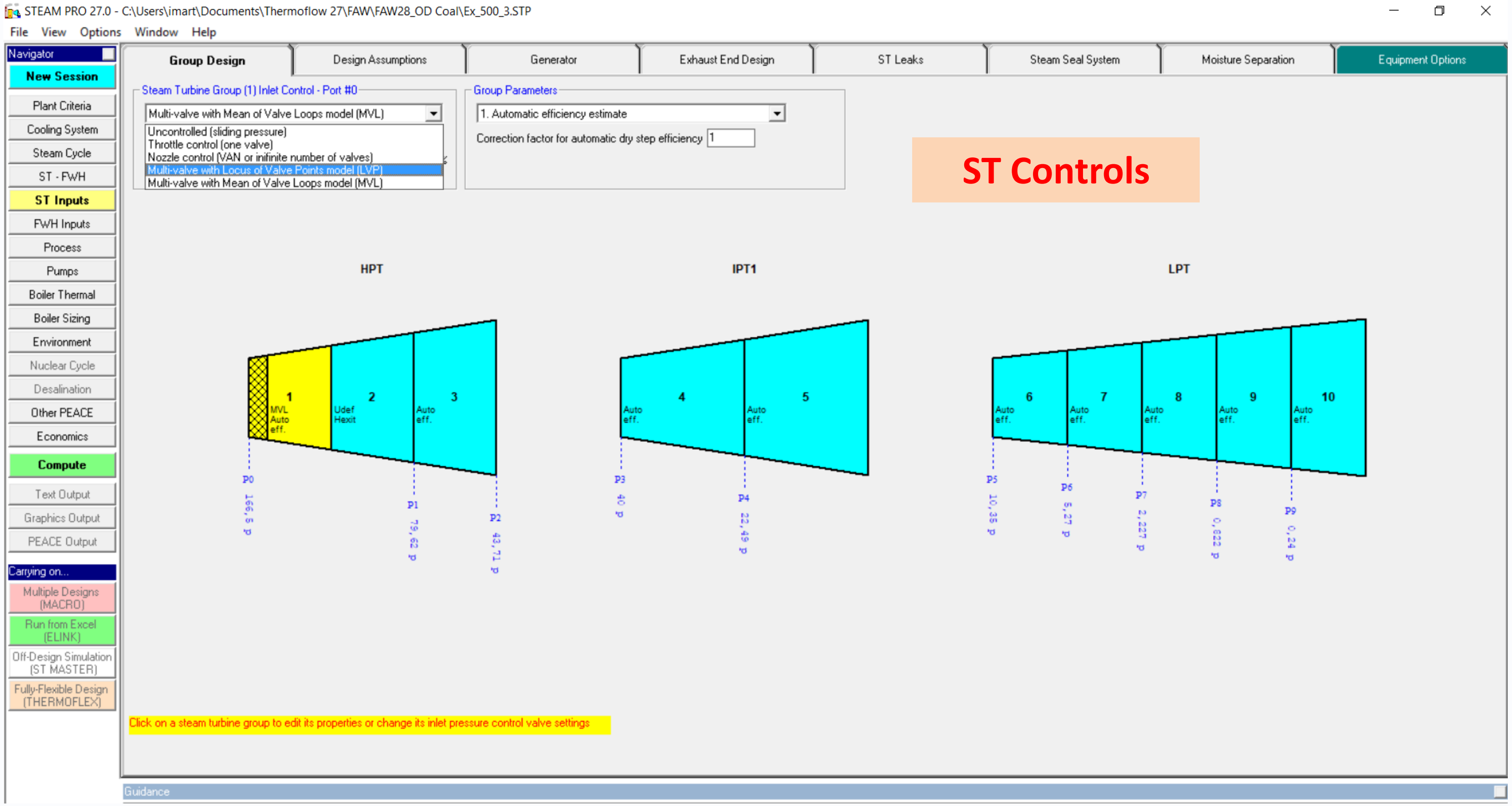








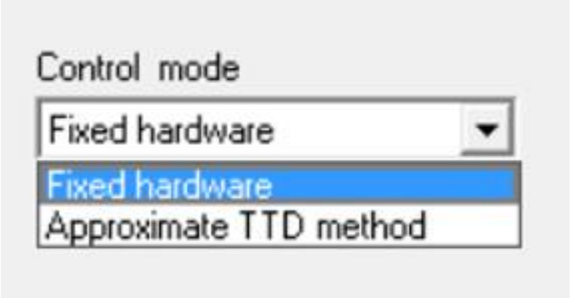
Tuning the Design in STM / TFX: Controls

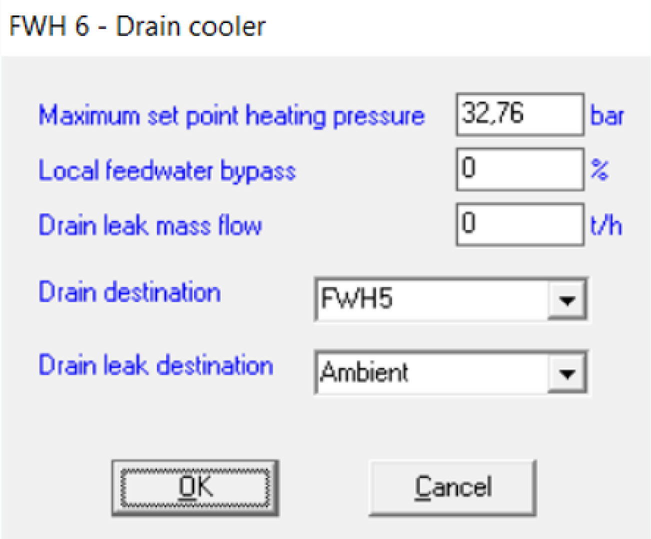


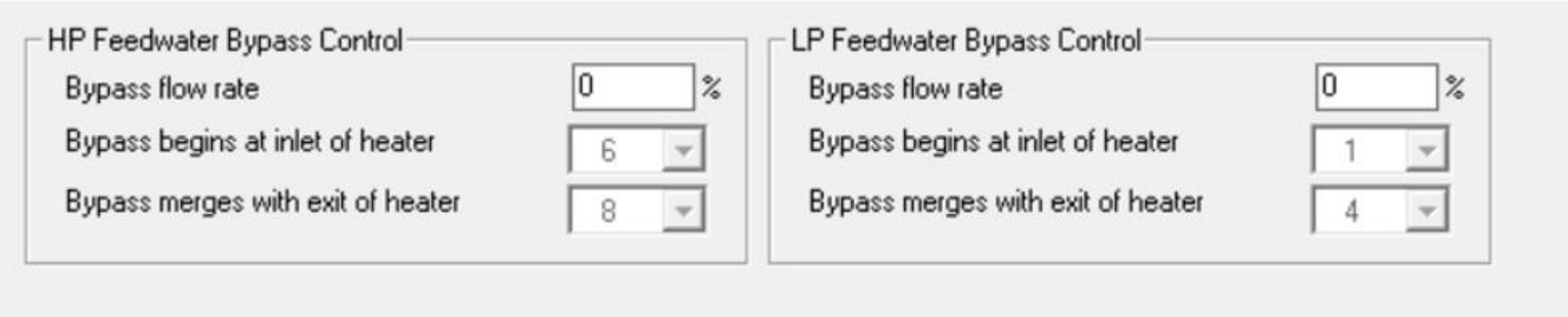
ST Controls

Tuning the Design in STM / TFX: Controls

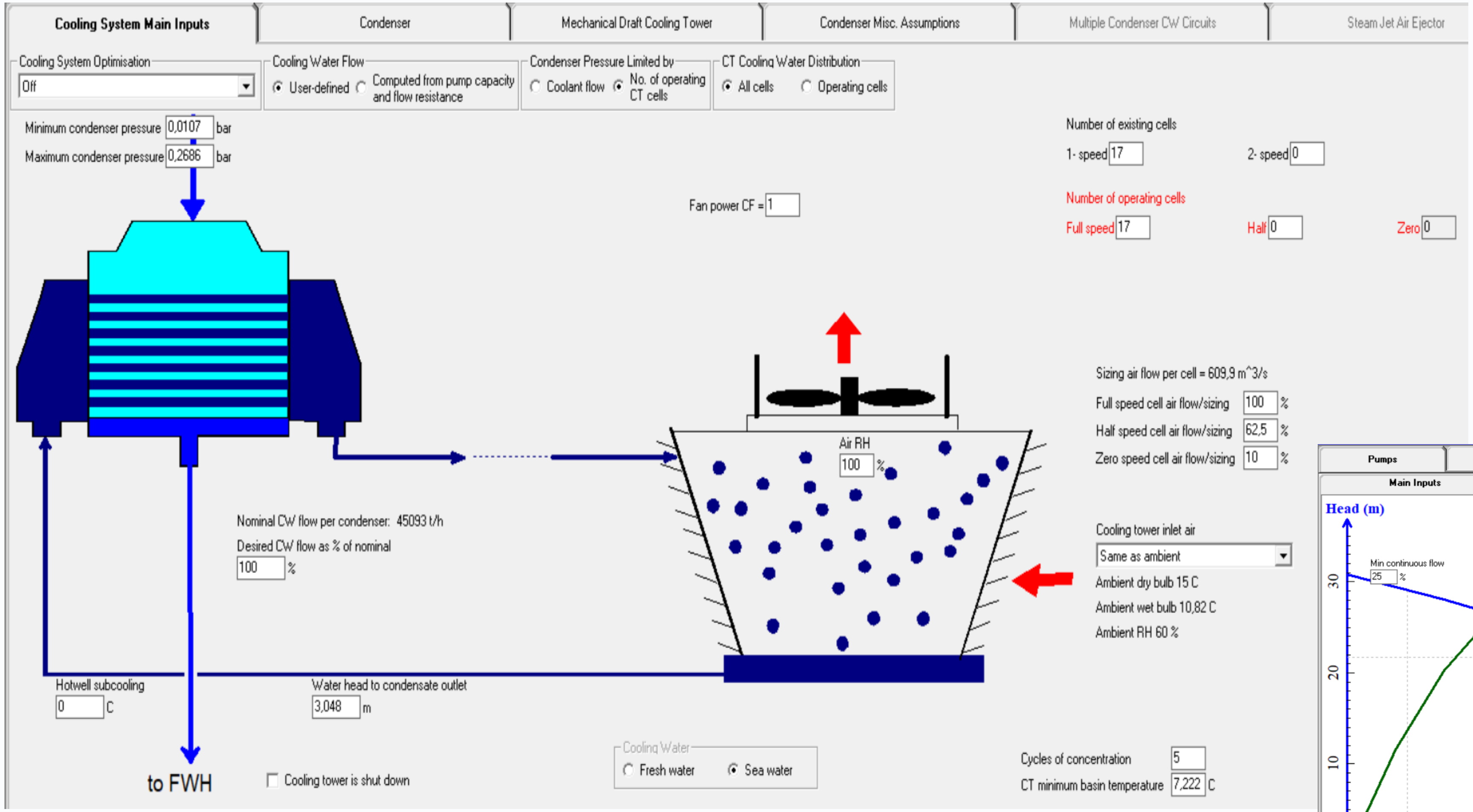
FWH Controls



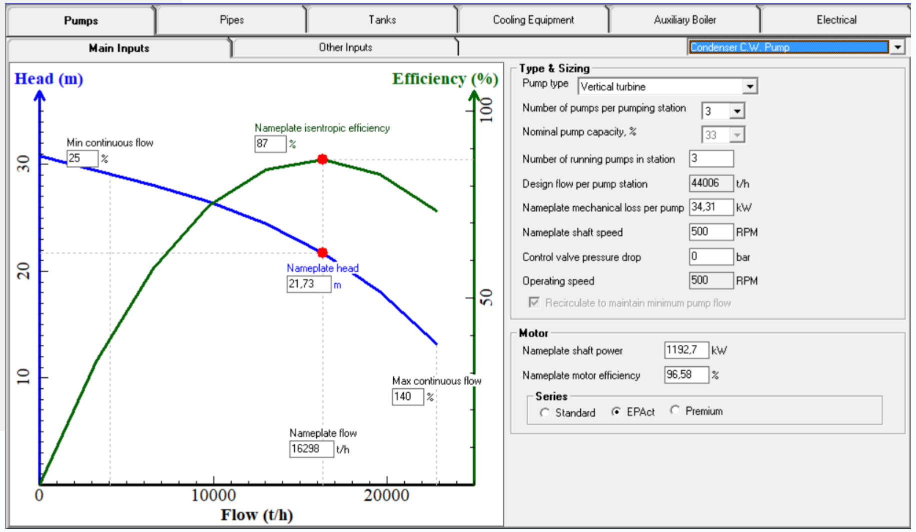




Tuning the Design in STM / TFX: Controls



Cooling System Controls



Tuning the Design in STM / TFX: Degradation

- ST:	Efficiency Degradation
- FWH:	Blocked Tubes, Fouling, Leaks
- Condenser:	Cleanliness Factor, Air intake
- Boiler:	HX Fouling
- Others	

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OD Simulation Off Line

- Typical Correction curves (Elink)
- Other correction curves (steam out, steam to sootblowing, desuperheating, …)
- Effect of Operation alternatives
  - Bypass FWH
  - CW Pumps / CT-ACC cells on
  - Excess Air-Unburnt Carbon in Ash
  - Steam Air pre heating
- Effect of Degradation
  - FWH blocked tubes
  - AH leakage / Dirtyness
  - Boiler fouling
  - Condenser fouling

OD Simulation Off Line STM, Correction Curves

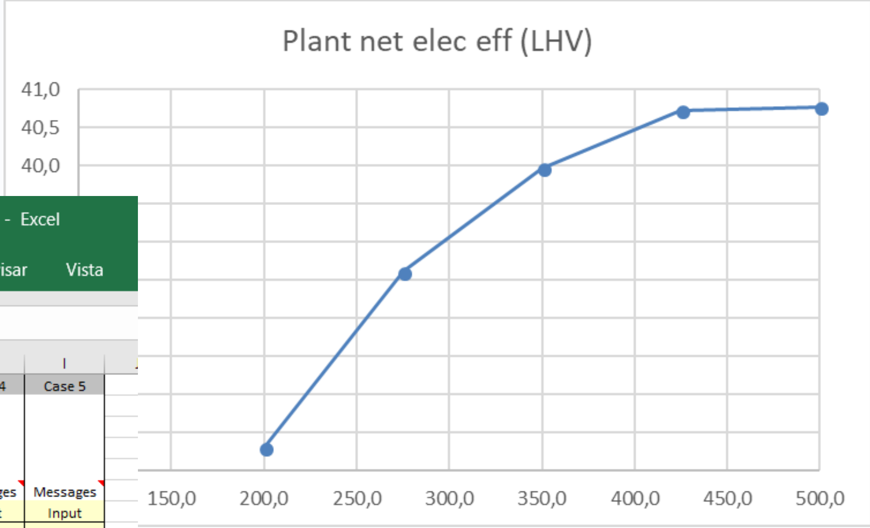
Part Load Curves

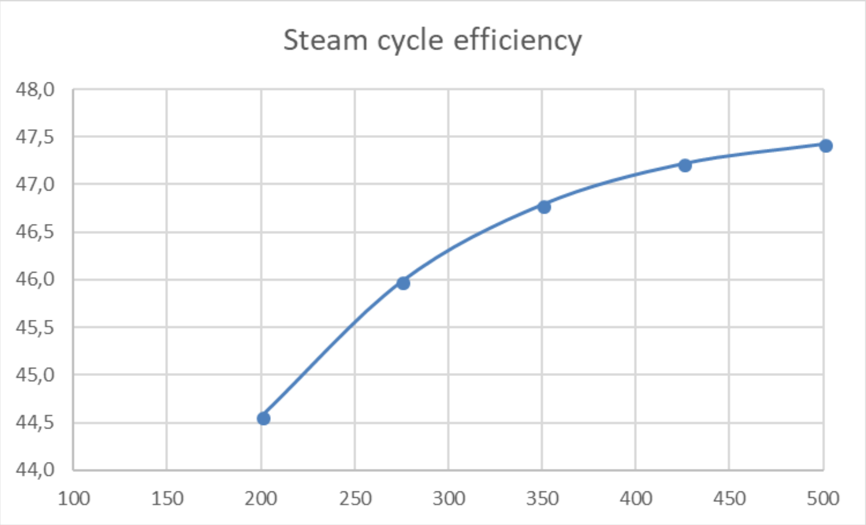
Autoguardado | TFELINKx1 - Excel

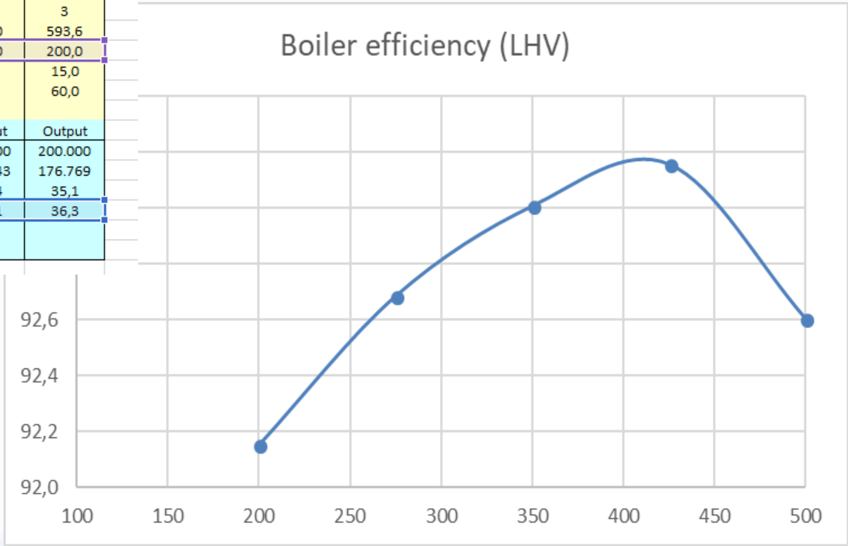
Archivo | Inicio | Insertar | Dibujar | Diseño de página | Fórmulas | Datos | Revisar | Vista

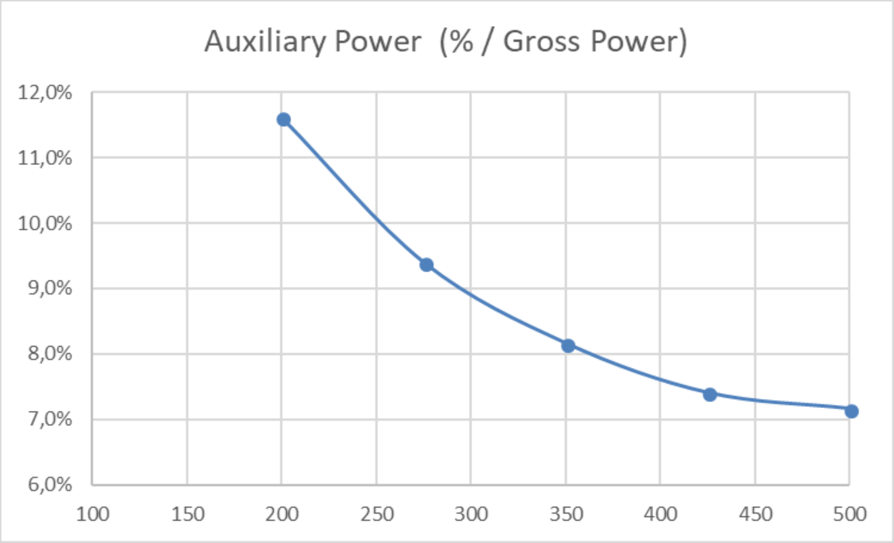
Gráfico 1

	B	C	D	E	F	G	H	I
1	ELINK 27.0 (Save-ALL		Base Case	Case 1	Case 2	Case 3	Case 4	Case 5
2								
3	Copyright (c) 1999 - 2017							
4	Base Case:							
5	C:\Users\imart\Documents\Thermoflo							
6	Computation Message ->		Messages	Messages	Messages	Messages	Messages	Messages
7	**INPUT VARIABLE DESCRIPTION**	**Units**	Input	Input	Input	Input	Input	Input
8	Plant control mode (choose first!): 0=fuel heat input percentage, 1=air+fuel flows, 2=HPT steamflow, 3=ST generator power, 4=Plant net power		0	3	3	3	3	3
9	Desired HPT inlet steam flow rate	t/h	1522,0	1522,2	1279,3	1035,6	809,0	593,6
10	Desired ST generator power	MWe	499,9	500,0	425,0	350,0	275,0	200,0
11	Ambient temperature	C	15,0	15,0	15,0	15,0	15,0	15,0
12	Ambient relative humidity	%	60,0	60,0	60,0	60,0	60,0	60,0
13								
14	**OUTPUT VARIABLE DESCRIPTION**	**Units**	Output	Output	Output	Output	Output	Output
15	Plant gross output	kW	499.930	500.000	425.000	350.000	275.000	200.000
16	Plant net output	kW	464.090	464.156	393.496	321.409	249.143	176.769
17	Plant net elec eff (HHV)	%	39,42	39,43	39,38	38,64	37,34	35,1
18	Plant net elec eff (LHV)	%	40,77	40,77	40,73	39,96	38,61	36,3
19								
20								
21								









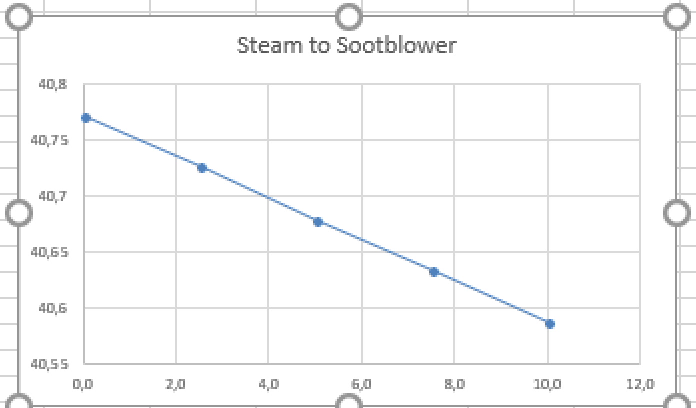
OD Simulation Off Line, STM

Steam to Sootblowers vs HX cleaning

Case 1 to 5: Steam mf to Sootblowers, 0 to 10 t/h

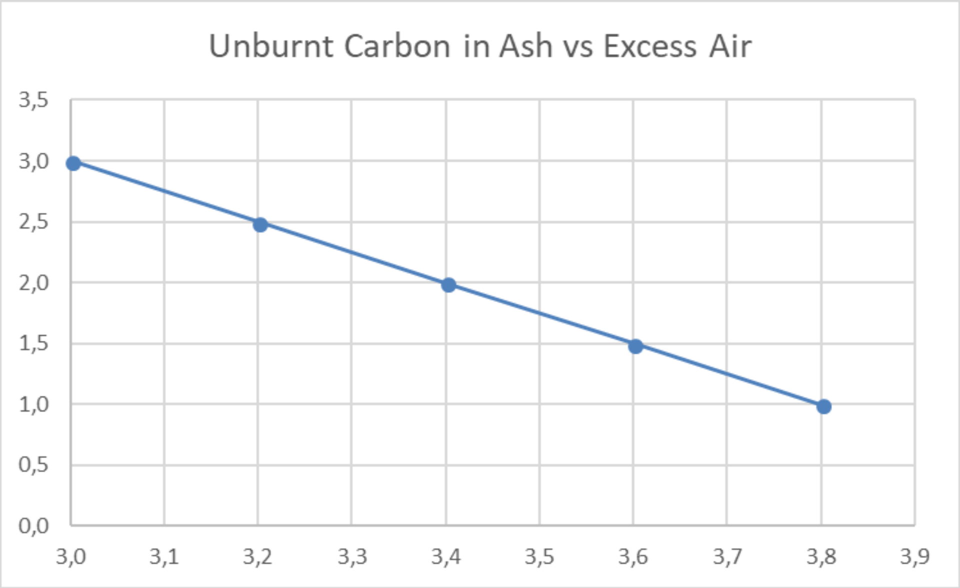
Cases 6 & 7: Effect of cleaning SH2, HTC adjustment factor 0,75→0,95

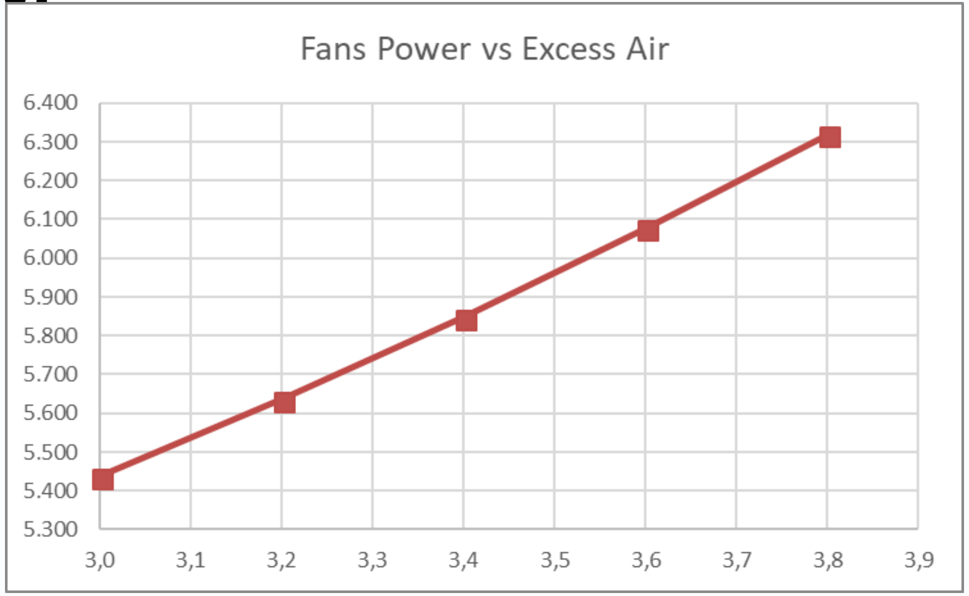
	B	C	D	E	F	G	H	I	J	K
1	ELINK 27		Base Case	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
3	Copyright (c) 199									
6		Computation Message ->	Messages	Messages	Messages	Messages	Messages	Messages	Messages	Messages
7	INPUT VARIABLE DESCRIPTION	Units	Input	Input	Input	Input	Input	Input	Input	Input
8	Plant control mode (choose first!): 0=fuel heat input percentage, 1=air+fuel flows, 2=HPT steamflow, 3=ST generator power, 4=Plant net power		0	3,0	3,0	3,0	3,0	3,0	0	0
9	Desired HPT inlet steam flow rate	t/h	1521,9	1522,2	1523,9	1525,7	1527,5	1529,2	1511,5	1519,8
10	Desired ST generator power	MWe	498,9	500,0	500,0	500,0	500,0	500,0	498,2	498,7
11	Ambient temperature	C	15,0	15,0	15,0	15,0	15,0	15,0	15,0	15,0
12	Ambient relative humidity	%	60,0	60,0	60,0	60,0	60,0	60,0	60,0	60,0
13	Process steam1 mass flow	t/h	5,0	0,0	2,5	5,0	7,5	10,0	5,0	5,0
14	CS2: Gas/air-side convective h.t.c. adjustment factor		1,0	1,0	1,0	1,0	1,0	1,0	0,75	0,95
16	OUTPUT VARIABLE DESCRIPTION	Units	Output	Output	Output	Output	Output	Output	Output	Output
17	Plant gross output	kW	498.870	500.000	500.000	500.000	500.000	500.000	498.161	498.741
18	Plant net output	kW	463.034	464.156	464.126	464.094	464.063	464.031	462.312	462.903
19	Plant net elec eff (HHV)	%	39,33	39,43	39,38	39,34	39,29	39,25	39,27	39,32
20	Plant net elec eff (LHV)	%	40,68	40,77	40,73	40,68	40,63	40,59	40,61	40,67

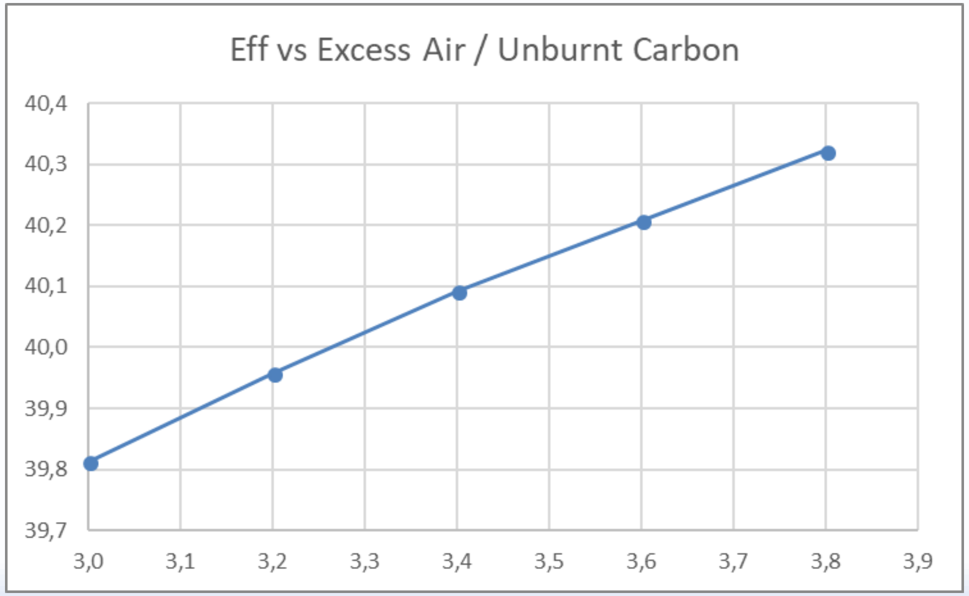


OD Simulation Off Line, STM

Excess Air / Unburnt Carbon in Ash

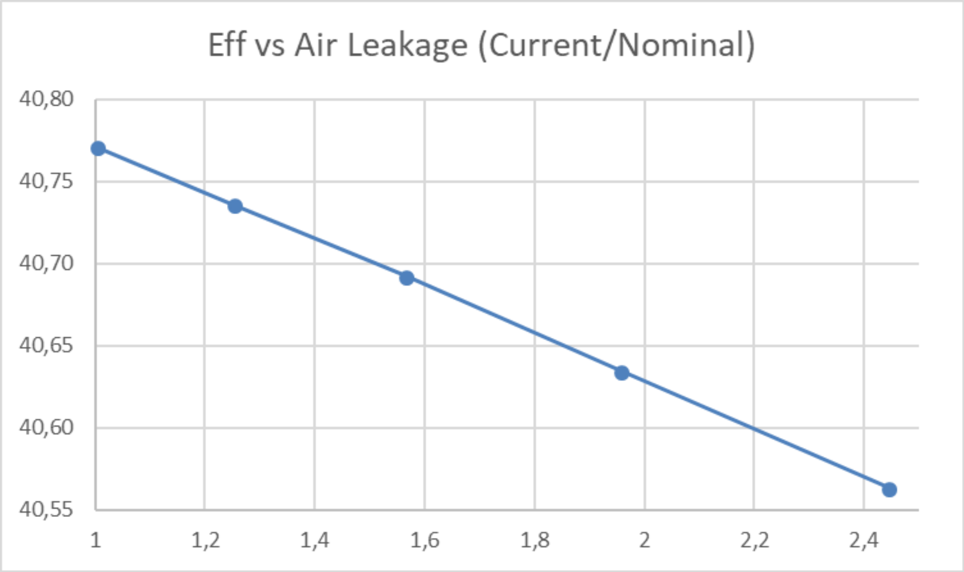


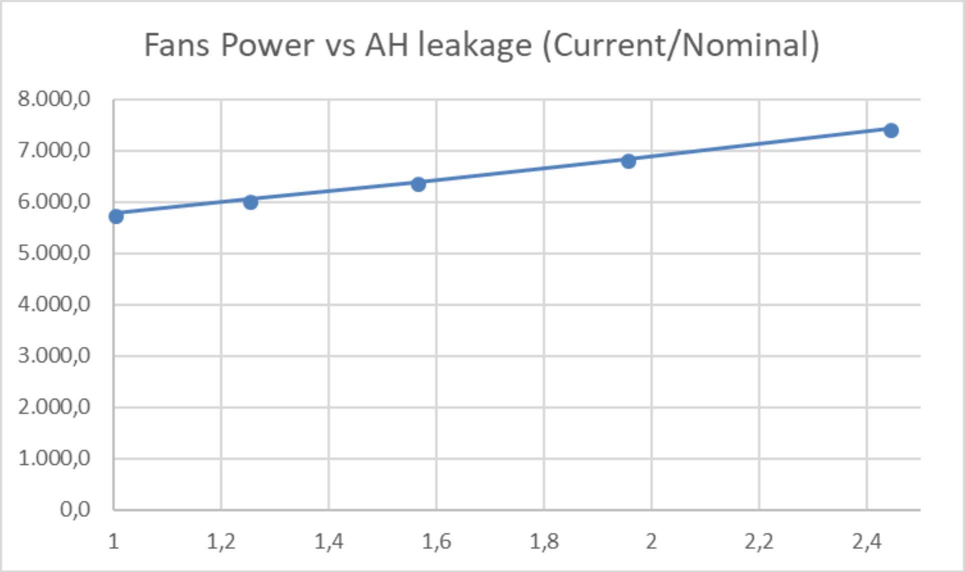




OD Simulation Off Line, STM

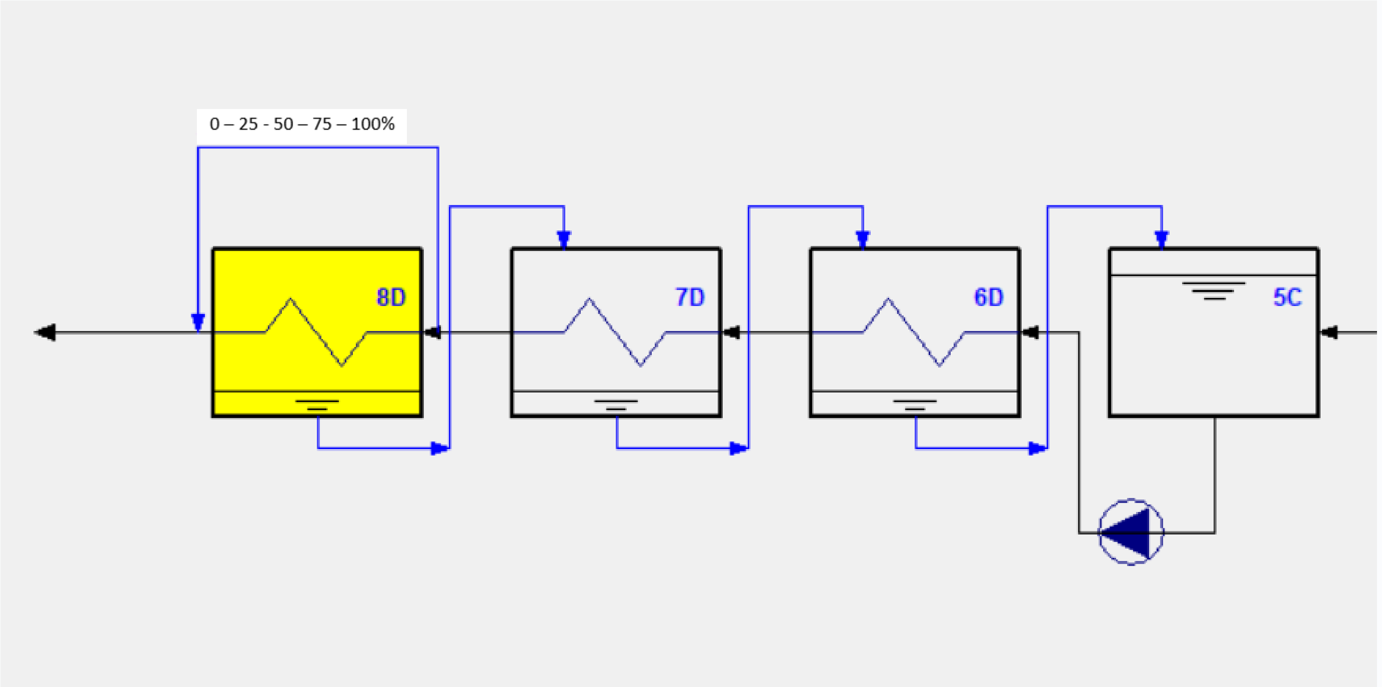
Air Heater Leakage / DP

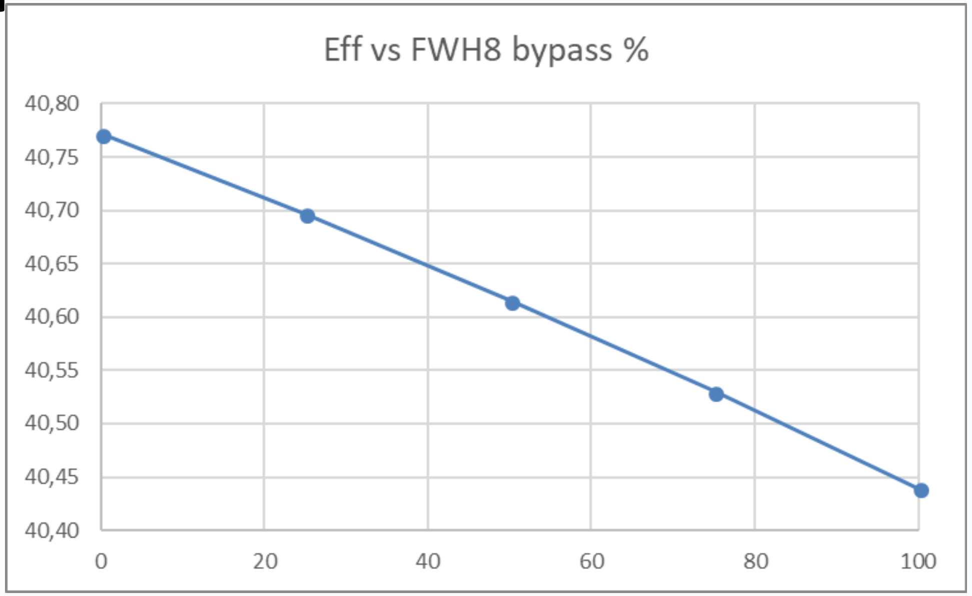


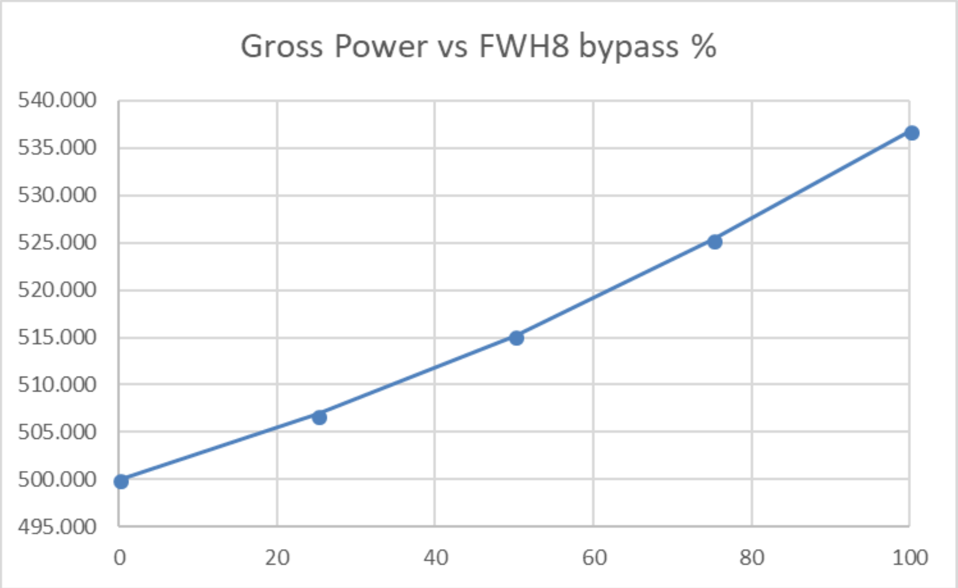


OD Simulation Off Line, STM

FWH Bypass







OD Simulation On Line, Performance Monitoring

- Tune Thermoflex+PEACE Model
- Connect to the DCS (Elink - ULink)
- Select Inputs & Outputs to be considered as Inputs / Outputs
- Select Inputs & Outputs to be reconciled
- Calculate degradation parameters
- Enter external inputs
- Set and Admin. the User Interface

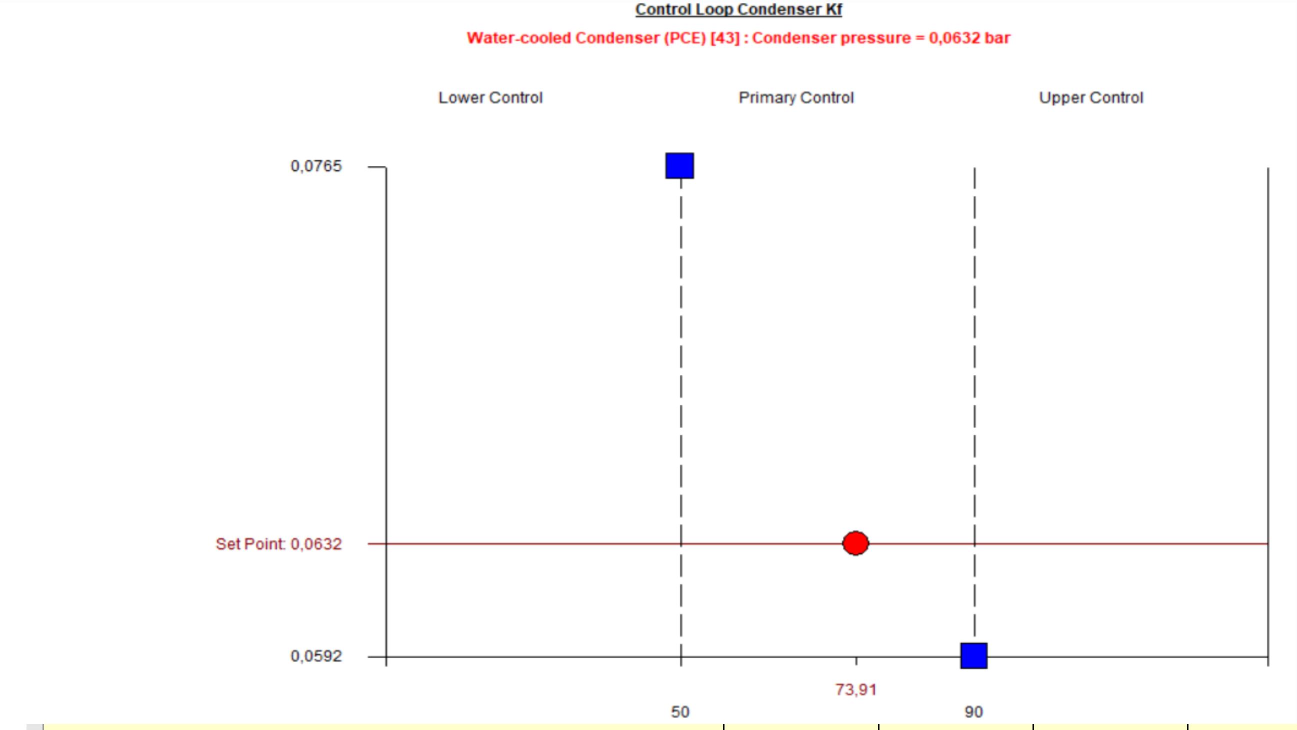
See Webinar n. 13, June 2017

TFX: Control Loop to find degradation parameters

Condenser Fouling

@ Current Conditions (Ambient, Load, CW Pumps, …):

	Cond P mbar	*Cleanliness Factor*
Expected from TFX	61,4	80%
Measured	63,2	???

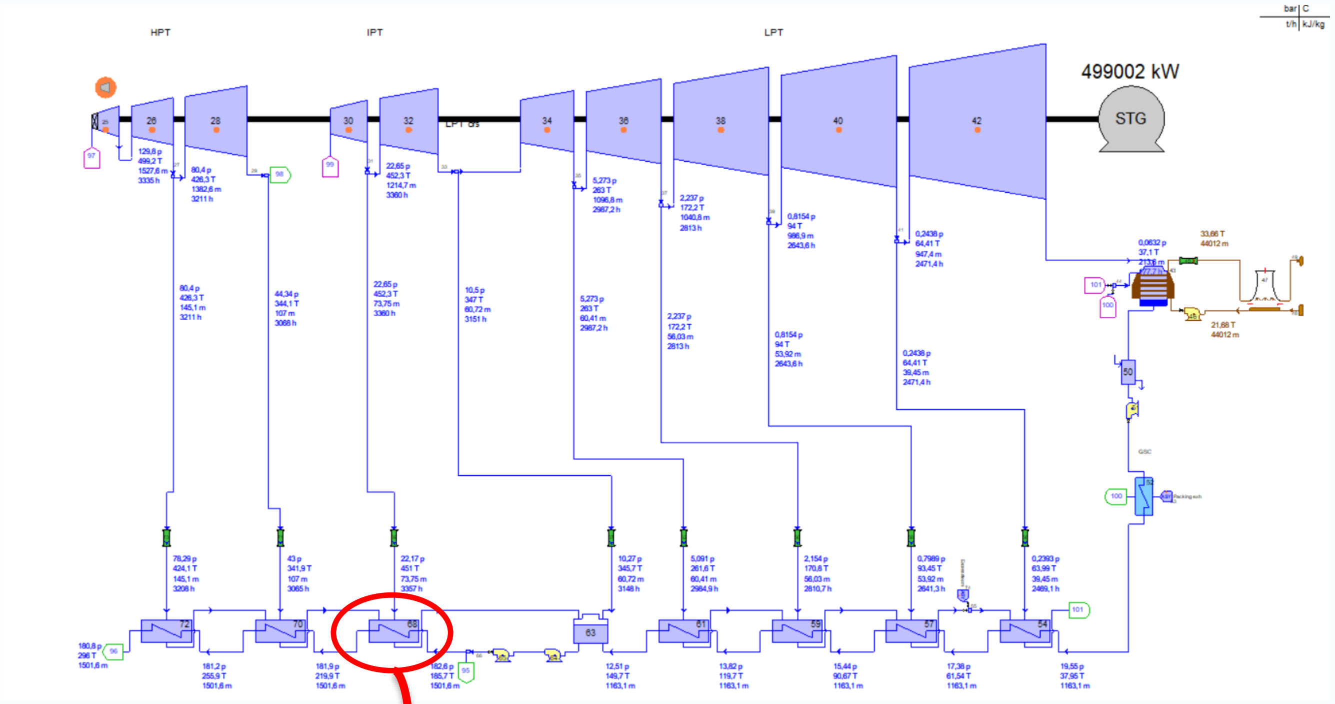


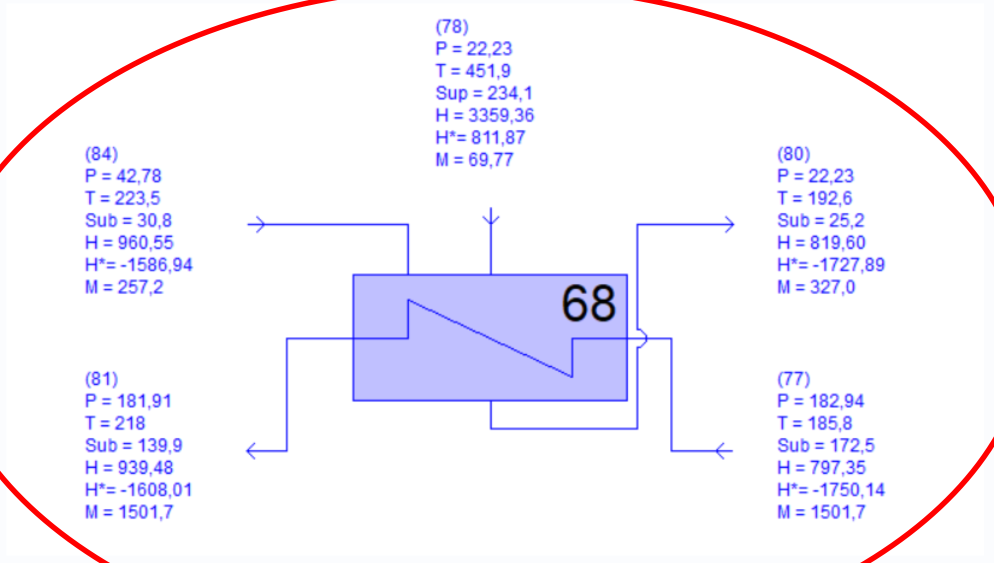
Water-cooled Condenser (PCE) [43] Cleanliness factor	%	**73,91**	80,0	73,91
Boiler Assembly: Furnace w/ Pulverizer [1] Steam production rate	t/h	**1500**	1500	1500
OUTPUT VARIABLE DESCRIPTION	**Units**	**Output**	Output	Output
Gross power	kW	**499.005**	499.906	499.005
Net power	kW	**462.868**	463.765	462.868
Net electric efficiency(LHV)	%	**40,13**	40,21	40,13
Water-cooled Condenser (PCE) [43] Condenser pressure	bar	**0,0632**	0,0614	0,0632

TFX: Degradation

FWH blocked tubes / fouling

2	Feedwater Heater (PCE) [68] Total number of tubes		**2458**	2458	1917
6	Feedwater Heater (PCE) [68] Condensing zone overall h.t.c. correction factor		**0,95**	1,0	0,9375
1					
2	**OUTPUT VARIABLE DESCRIPTION**	**Units**	**Output**	Output	Output
7	Feedwater Heater (PCE) [68] Feedwater temperature rise (overall)	C	**34,2**	34,55	32,15
8	81 - Feedwater outlet of Feedwater Heater (PCE) [68] -> Feedwater inlet of Feedwater Heater (PCE) [70] Temperature	C	**219,9**	220,3	218,0
9					





OD Simulation On-Line, other TF tools

- DRS: Data Reconciliation System
- TOPS: Optimizer

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Computation Tools

Introduce four types of computation tool:

* Control Loops
* Searcher
* Data Reconciliation System (DRS)
* Thermoflow's Optimization System(TOPS)

These tools must be used together with our programs such as GT Master, Thermoflex etc.

Presenter: Glen GUO(CHINA)
Support: Meritt Elmasri (U.S. HQ)

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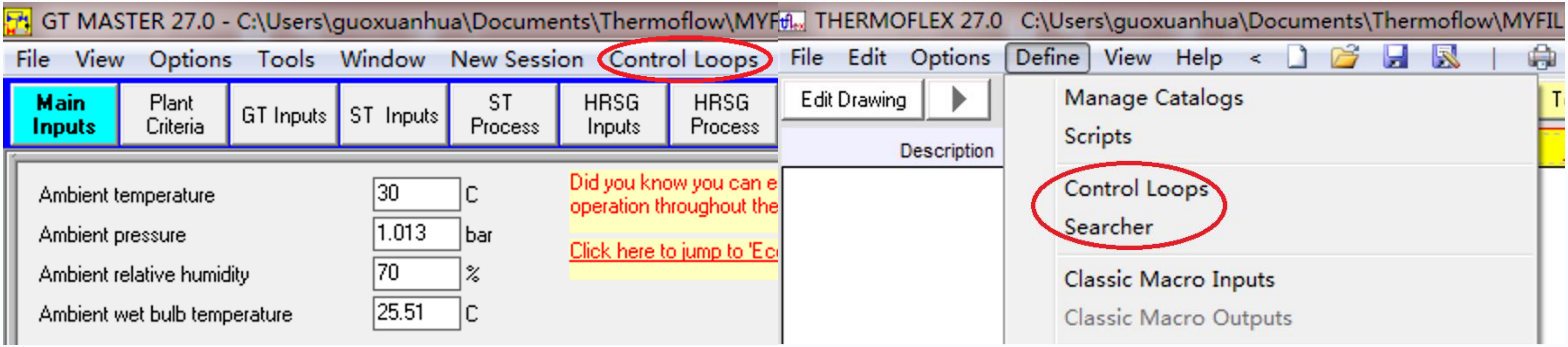
Where to find these tools?

* Control Loops (GT Master, Thermoflex)

* Searcher (Thermoflex)



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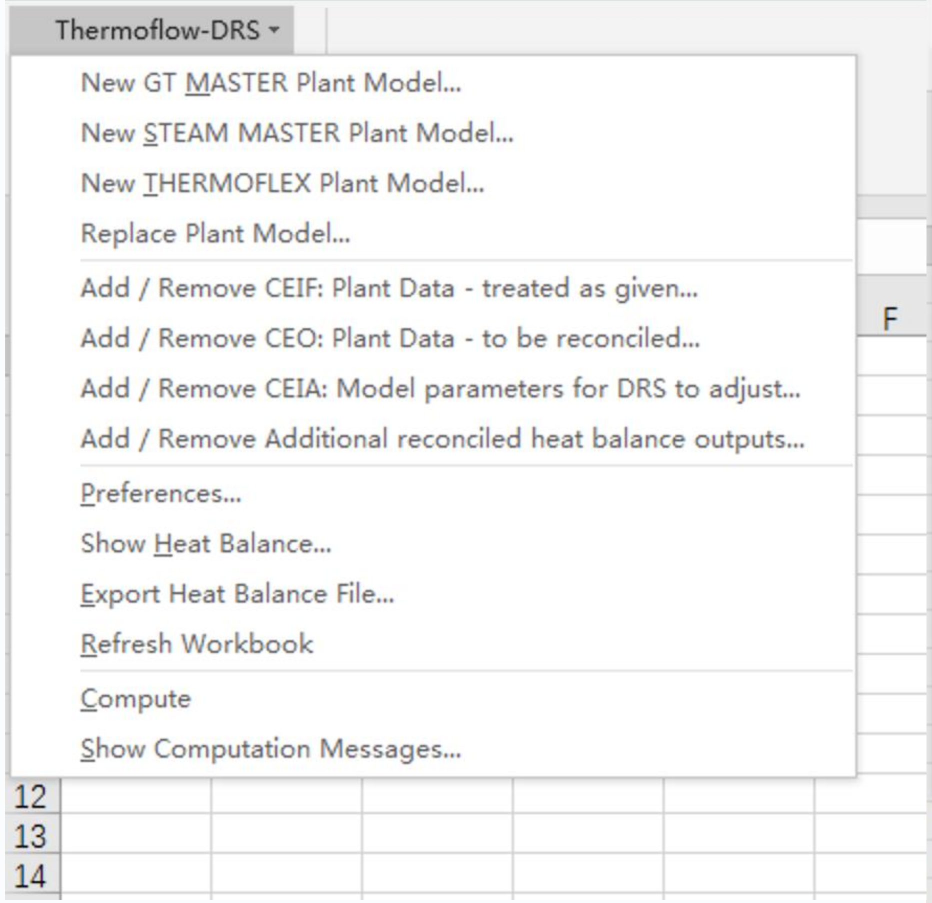
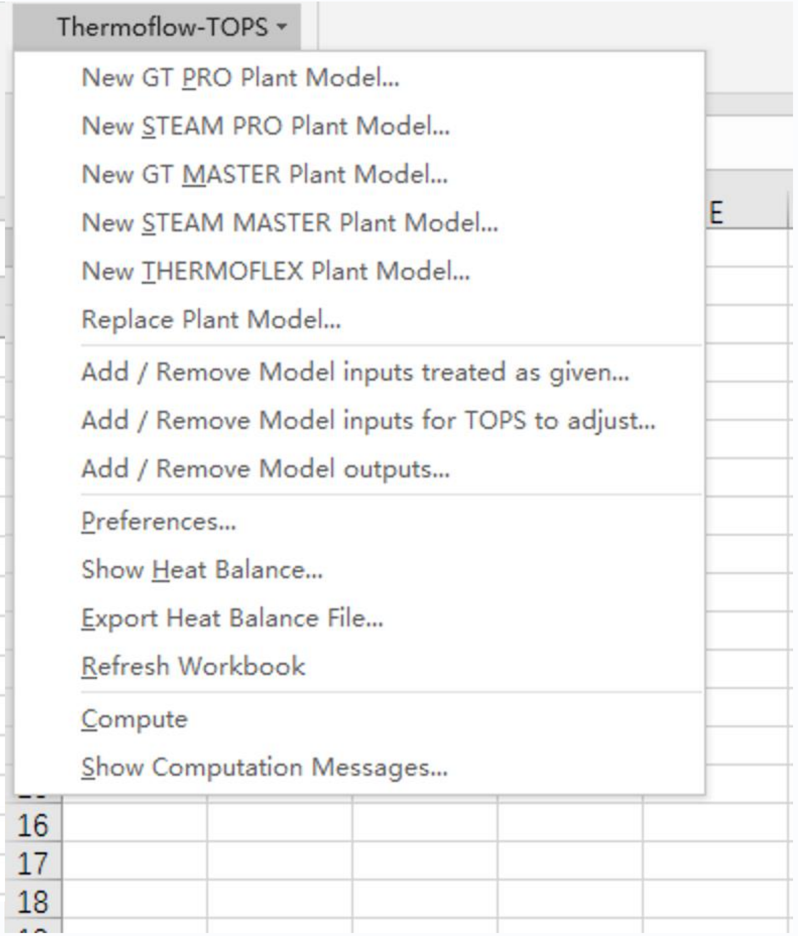
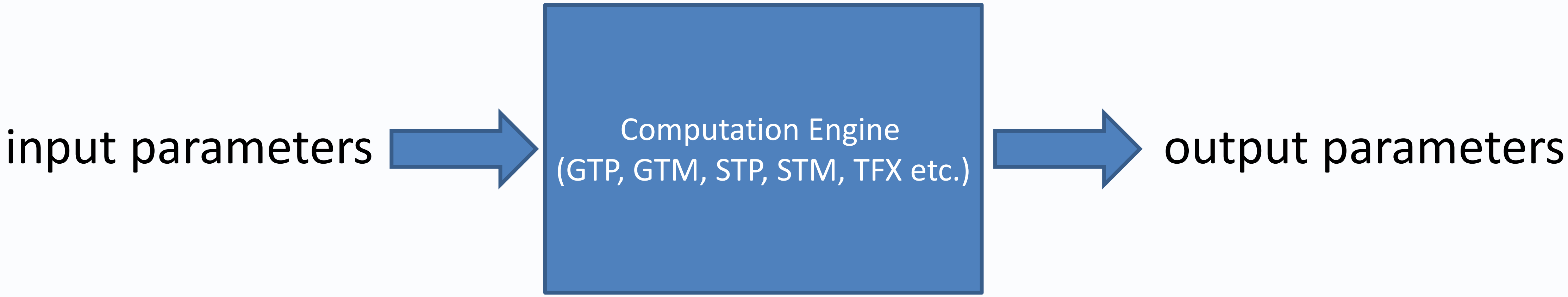
Where to find these tools?

* DRS (Excel Addin)
* TOPS (Excel Addin)





To be adjusted & to be matched



E.g. To achieve a certain net power in GTM, we adjust GT load percentage.

We can use trial method manually, but it’s tedious/time-consuming.

Control loops is automatical trial method, save your time!

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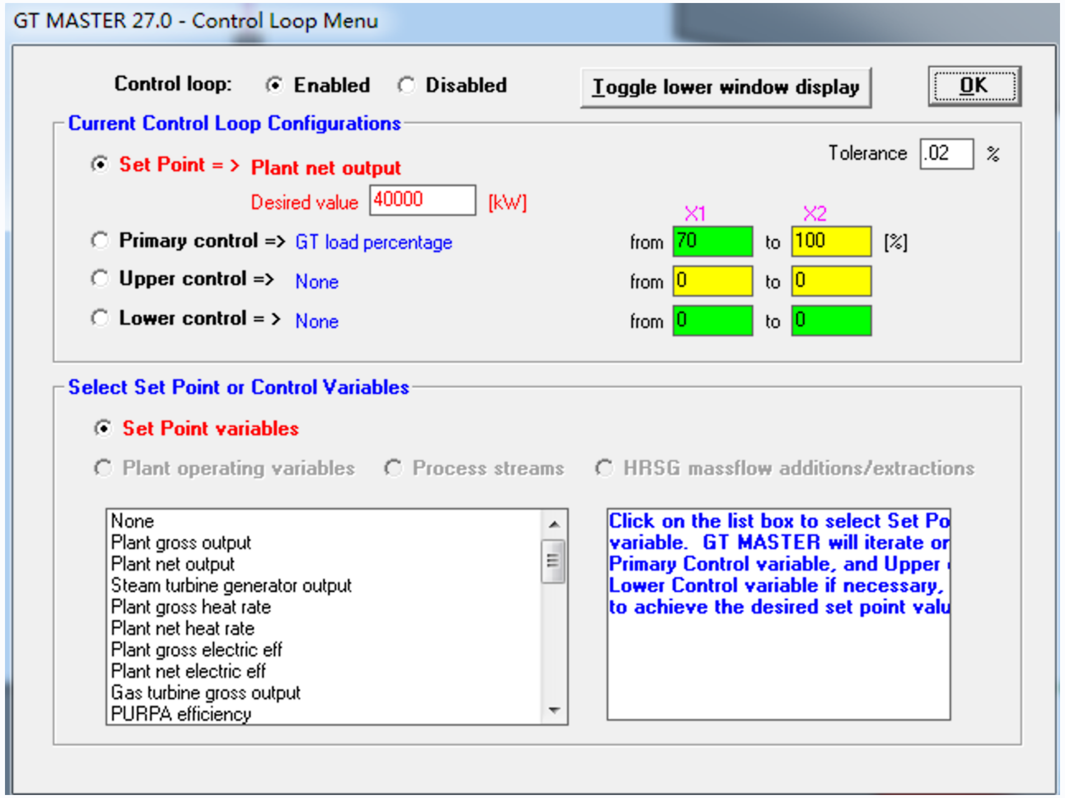
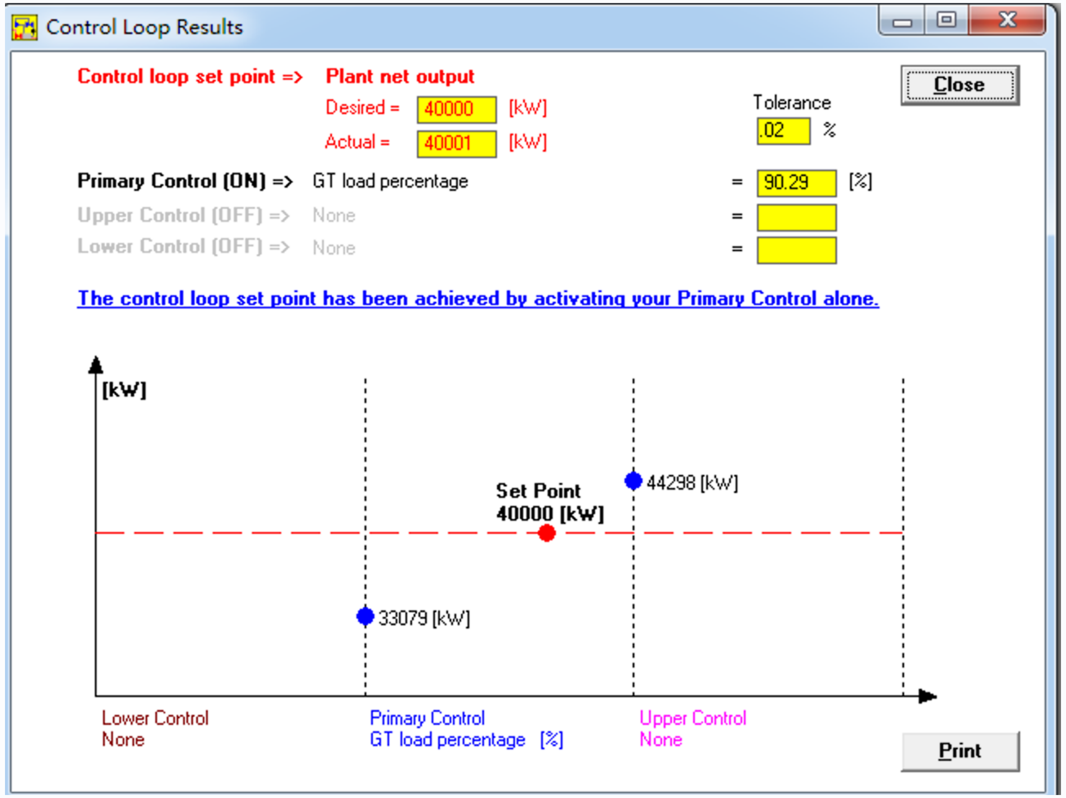
Control Loops Interface in GTM





At one time, there is only one input parameter to be adjusted although you may pick up to three inputs in control loops.

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How to choose computation tools

Adjust One
Input Parameter

Computation Engine

Match One
Output Parameter

Control Loops

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How to start work with data reconciliation

Imagine that you get hundreds of gauge measurements from DCS.

A small part of these measurements are inaccurate.

But you don’t know which ones are faulty.

Theoretically every measurement is suspicious.

How to start your work since you trust none of them?

We don’t trust any individual measurement, but we trust the whole of them, so we’ll match many parameters simultaneously.

How to choose computation tools

Adjust Many
Input Parameters

Computation Engine

Match Many
Output Parameters

DRS

DRS background

DRS is useful in online/offline monitoring for data reconciliation.

Measurements always include uncertainty caused by random and systematic errors. In operating power plants various levels of effort are dedicated to accurately measuring the quantities used to monitor and control the plant. The DRS uses a model-based approach to help isolate faulty sensors, quantify the accuracy of other measurements, and fill-in unmeasured quantities.

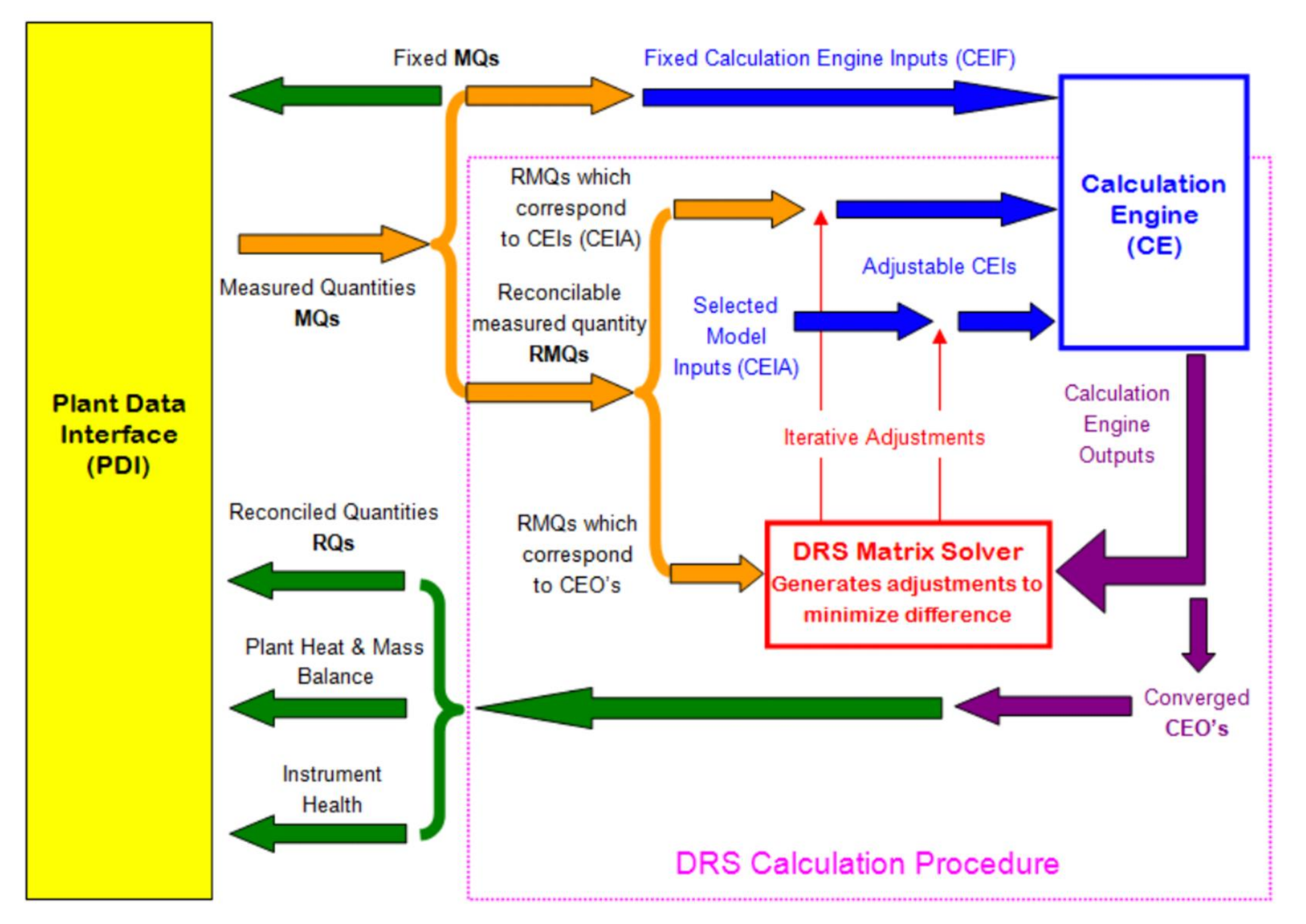
Least square method

Minimize the sum of the squares of the weighted error signals. The error signals are defined as the difference between the MQs and the corresponding CEOs at the current nominal point.

Full Name	Abbreviation	Description
Calculation Engine	CE	The calculation engine is any one of Thermoflow's GT PRO, GT MASTER, STEAM PRO, STEAM MASTER, or THERMOFLEX modeling programs. It uses a base model file together with input parameters to compute model output parameters.
Measured Quantity	MQ	Data values measured by plant sensors, or imputed from measured values.
Reconciled Quantity	RQ	Reconciled quantities are outputs from the computation engine. Each RQ has an equivalent MQ, for example generator power is both a measurement value and a computation result. The DRS final step produces the complete set of RQs.
Calculation Engine Input	CEI	Parameter that is an input to the program that the interactive user normally enters to make a calculation. Examples include site ambient temperature, duct burner fuel flow, cooling water source temperature, condenser cooling water flow, etc.
Calculation Engine Output	CEO	Parameter that is a computed result from the program that the interactive user typically finds in the text and graphics displays following computation. Examples for a gas turbine are generator power, fuel flow, exhaust flow and exhaust temperature.
Fixed Calculation Engine Input	CEIF	This is a particular type of CEI. It comes directly from the measurements and is not adjusted by the DRS. Any CEI can be included in this category. Part of DRS configuration is to judiciously select which MQs to include in the CEIF category. Typically, ambient temperature is one of the MQs on the CEIF list.
Adjustable Calculation Engine Input	CEIA	This is a particular type of CEI. It is a model input that is adjusted by the DRS as it tries to minimize the difference between the measurement values and the model output values. Some CEIAs correspond directly to measured quantities. Other CEIAs, such as condenser fouling factor, or steam turbine efficiency, do not correspond to physical measurements. These are model parameters chosen during DRS configuration and assigned nominal starting values by default.

Table 3-1 Summary of DRS terminology

DRS Process


Plant Data Interface (PDI)
Fixed MQs
Fixed Calculation Engine Inputs (CEIF)
Calculation Engine (CE)
RMQs which correspond to CEIs (CEIA)
Measured Quantities MQs
Reconcilable measured quantity RMQs
Selected Model Inputs (CEIA)
Adjustable CEIs
Iterative Adjustments
Calculation Engine Outputs
Reconciled Quantities RQs
RMQs which correspond to CEO's
DRS Matrix Solver
Generates adjustments to minimize difference
Plant Heat & Mass Balance
Converged CEO's
Instrument Health
DRS Calculation Procedure

DRS example

There are four DRS example files in the sample directory.

Show (DRS4)RHTGTCC.xls

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How to choose computation tools

Adjust One
Input Parameter

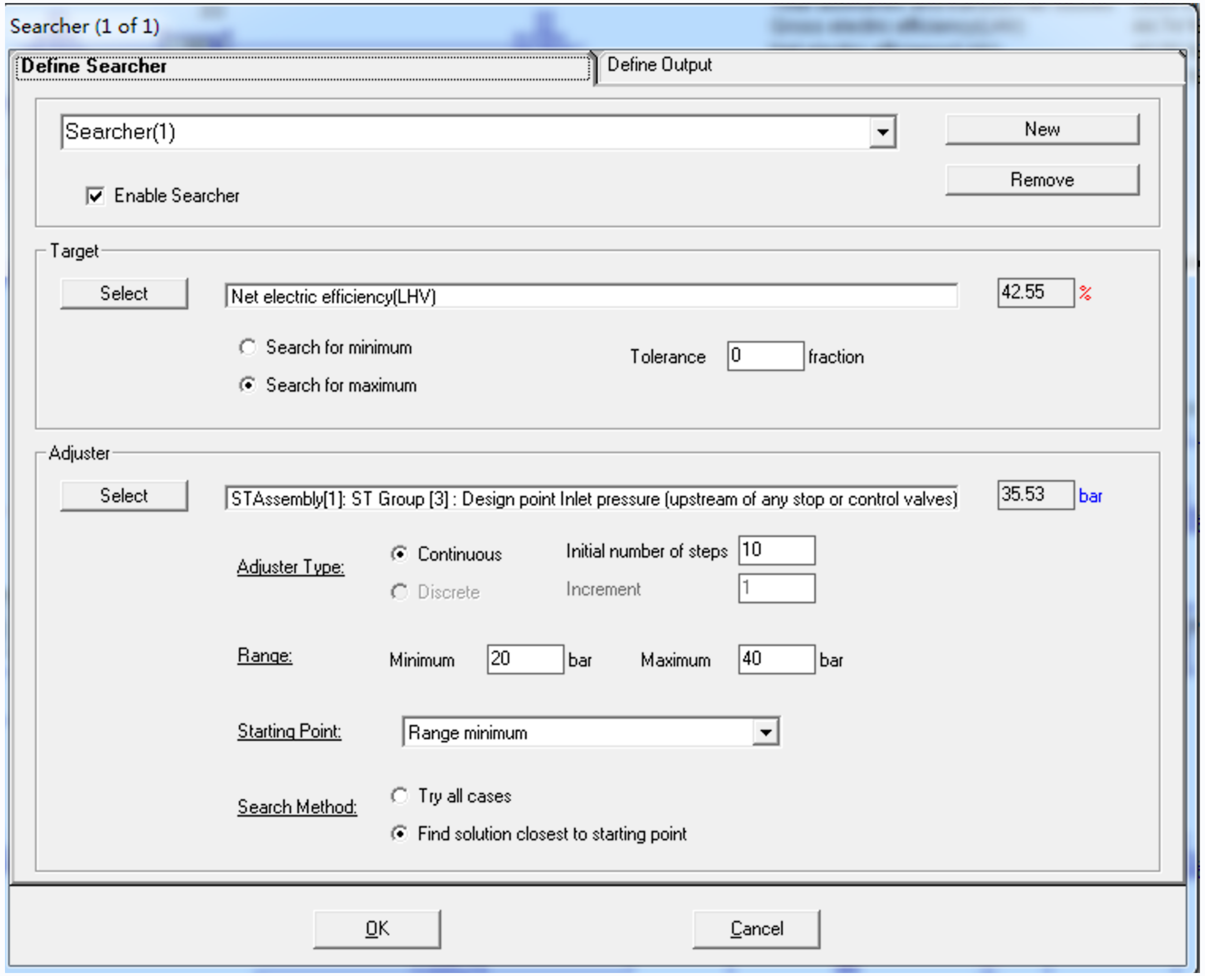
Computation Engine

Find One Extreme
Output Parameter

No idea of the value in advance

Searcher

Searcher interface



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How to choose computation tools

Adjust Many Parameters

Computation Engine

Find One Extreme Parameter

No idea of the value in advance

TOPS

TOPS example

Full Name	Abbreviation	Description
Objective Function	OBJ	This is the function to optimize. It may simply be an output value computed by the core program, or it can be a function of one or more program outputs and other input values you define and declare.
Calculation Engine	CE	The calculation engine is any one of Thermoflow's GT PRO, GT MASTER, STEAM PRO, STEAM MASTER, or THERMOFLEX modeling programs. It uses a base model file together with input parameters to compute model output parameters.
Calculation Engine Output	CEO	Parameter that is a computed result from the program that the interactive user typically finds in the text and graphics displays following computation. Examples for a gas turbine are generator power, fuel flow, exhaust flow and exhaust temperature.
Calculation Engine Input	CEI	Parameter that is an input to the program that the interactive user normally enters to make a calculation. Examples include site ambient temperature, duct burner fuel flow, cooling water source temperature, condenser cooling water flow, steam turbine section efficiency degradation, etc.
Fixed Calculation Engine Input	CEIF	This is a particular type of CEI. For each TOPS run these inputs are unchanged. They come from user input directly. Any CEI can be included in this category. Typically, boundary conditions like ambient conditions and cooling water temperature are in this category. Additionally, any fixed constraints like steam flow to process are on the CEIF list.
Adjustable Calculation Engine Input	CEIA	This is a particular type of CEI. It is a model input that is adjusted by TOPS as it searches for an optimum in the objective function. The number of independent CEIAs defines the degrees of freedom in the system. There must be at least one CEIA, but there may be many depending on the nature of the model and objective function.

Table 3-1 Summary of TOPS Terminology

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TOPS example

There are two TOPS example files in the sample directory.
Show (TOPS2)CCGTLoadOptimization.xls

If you run TOPS for design models of our programs, you optimize the design;

If you run TOPS for OFF-design models of our programs, you optimize the operating for existing power plants.

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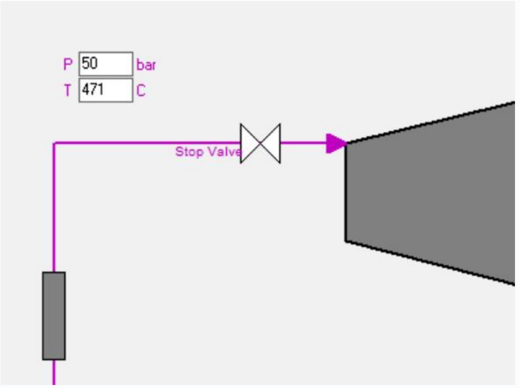
TOPS example

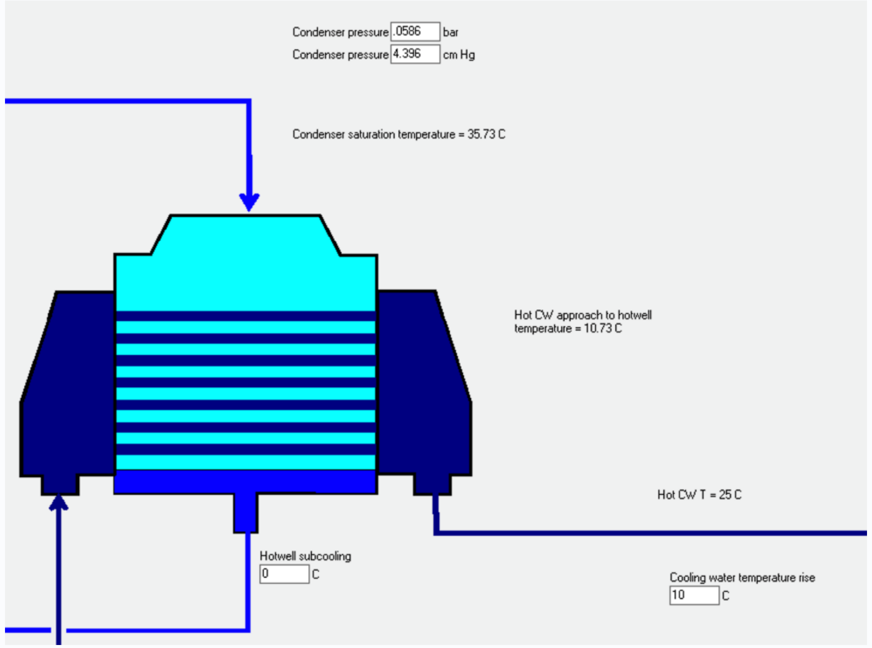
Optimum Equipment Load Levels Versus Power Price						
Power Price, $/MWhr	**15**	**25**	**35**	**55**	**75**	**175**
Gas Turbine Load, %	30	100	100	100	100	100
Chiller Load, %	0	0	88	100	100	100
Duct Burner Load, %	0	0	92%	100	100	100
Steam Injection Level, %	0	0	0	0	0	0
Cooling Tower Utilization, %	100	100	100	100	100	100
Circ pump Utilization, %	33	100	100	100	100	100
Net Power, MW	22.1	55.1	68.4	69.6	69.6	69.6
Net Electric Efficiency, %	34.9	45.7	44.3	44.1	44.1	44.1
Operating Profit, $/hr	-506	-219	350	1,737	3,130	10,093

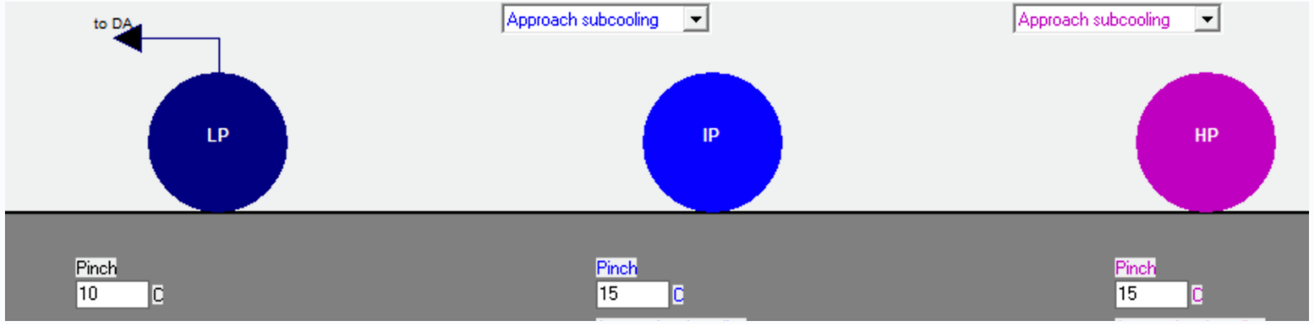
TOPS vs Elink(Multiple design)



If you want to optimize 10 parameters simultaneously and each parameter has 5 trials.

5^10= 9,765,625 combinations!





With Elink, if your PC computes one combination within 10 seconds, it will cost you 3 years to find the optimized solution! With TOPS you can find it within minutes!

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Computation Tools Summary

1) Both control loops and searcher are “1 adjustable vs 1 target” tools. When you want to match the target value in advance please use control loops otherwise use searcher to find the unknown extreme value.
2) DRS is “N vs N” tool, much powerful than 1 vs 1 control loops when matching output values.
3) TOPS is “N vs 1” tool, much powerful than searcher when finding one extreme/optimized value.

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DRS and TOPS for online/offline simulation

Our customers may build up online/offline monitoring system with accurate hardware model plus DRS & TOPS modules.

In this way, they will master the real status of existing plants and get operating optimization suggestions.

Q & A Session

- Please forward your questions on the WebEx Chat
- Further questions by email to: **info@thermoflow.com**

- PP Presentation will be available on the Website / Tutorials
- Video will be available on the Service Center

Thank you!

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IGNACIO MARTIN - SPAIN martin@thermoflow.com