June 10th, 2015

Dear Customer,

We are pleased to enclose a new release of our software suite, Version 25, with the new features and improvements summarised below. Some of the items described here were pre-released as Version 24.1, optionally downloaded from our website.

GT PRO / GT MASTER / PEACE

(1) Multi-Point Design:

A plant operating across a range of conditions requires careful compromises in sizing its various components. In the past, we had left it entirely up to users to manage this process, and had discussed in our manuals, training, and customer support the need to make exploratory runs across the operating envelope, then use their results to adjust sizing of various components, either in GTPM (during the transition from GT PRO to GT MASTER), or directly in GT MASTER.

In version 25, we've added a new tool to better manage this process, helping you to synthesize a single GT MASTER model from a family of GT PRO designs which span the range of anticipated plant operating conditions.

We've named this tool MPD (Multi-Point Design). MPD is built into, and invoked from the MACRO. Within the Macro, you define and compute a family of GT PRO cases encompassing your "design domain", then use the MPD tool to interactively synthesize a single GT MASTER model from your family of GT PRO cases. Typically, the design domain will include different ambient conditions, duct firing levels, operation on primary and backup fuels, and, for cogeneration plants, different process steam / water flow rates.

(2) GT MASTER models imported into THERMOFLEX:

Version 25 allows you to directly import GTM models into TFX, akin to the feature that has been available for GT PRO files since 1996. This allows users who've revised plant hardware in GT MASTER, or created a GT MASTER model using the new Multi-Point Design tool, to convert that GT MASTER model to an equivalent THERMOFLEX model. Once in TFX, all components will already be in Off-Design (OD) mode, with the same hardware details as they had in GT MASTER.

(3) GT PRO & GT MASTER now include hybrid desalination systems:

In version 25, GTP & GTM include hybrid desalination systems. This augments the MSF, MED, and RO systems, which have been available since 2004. The hybrid system produces water partly in an MED or MSF unit with the balance coming from the electrically-driven RO system.

(4) GT PRO automatic cycle design logic:

Some major revisions were made in GT PRO's automatic selection of main cycle design parameters, the first such revision in over ten years. This produces automatic designs closer to a typical optimum, especially for smaller plants and those with low GT/Recip Engine exhaust temperature. Additionally, we introduced an *Intermediate* setting to the **Cost / Efficiency Balance** selection at **New Session**. These improvements were pre-released in Version 24.1 in late 2014, and remain unchanged in Version 25.

(5) New GT PRO 'Commentary' text output report:

This is available from the **System** tab in GT PRO's text outputs. Key plant design parameters are listed along with typical range for each, which is a function of cycle type and plant size, and is admittedly somewhat subjective. Comments are included when an input parameter falls outside this typical range, helping users to identify any inputs they made which may be inconsistent with good practice.

(6) Other improvements to GTPRO / GTMASTER:

(6a) Added option to duct fire combined cycles to desired net power in GT PRO.

(6b) Added option to limit duct firing to user-specified steam turbine output power in GT MASTER.

(6c) Improved PEACE size and cost estimates for small plants, those below approximately 10MW electric.

(6d) GTP/GTM now allow up to two moisture extraction ports in the steam turbine.

(6e) PEACE size and cost is now included for stand-alone deaerators, process hot water storage tanks, and district heating water storage tanks.

(6f) Several new features added for plants with inlet chillers: (1) Added ability to user-define the chiller performance curves, which previously were hard-wired. (2) New option to reduce chiller load when GT reaches its power limit to reduce auxiliary load that would otherwise be wasted. (3) New option in GT PRO to turn chiller off, with chilled water coming from storage or an external source.

(6g) Added steam turbine resizing feature to GT MASTER, available from the **Re-design in GT PRO** button, conveniently allowing the user to resize various sections of the steam turbine.

(6h) A second user-defined fuel was added to both the gas turbine and the duct burner.

(6i) Included an option to split GT generator loss into mechanical and electrical+windage components. This is used to determine the size of the two cooling circuits used to remove heat from the generator. Expanded ability to edit GT genset losses by exposing inputs for rating point mechanical and gearbox efficiencies. Included a new method to establish generator rating for user-defined GT models so it is now possible to fix the power used to establish the estimated genset cost and the genset rating-point efficiencies used to estimate losses.

(6j) Included cycles of concentration for evaporative cooler, allowing it to compute its blowdown.

(6k) Added sizing flexibility for HRSG fresh-air dilution fan.

(6l) Added option to automatically run GT inlet heater in a specific range of incoming air temperatures.

(6m) Added option to prevent condenser pressure from falling below the steam turbine choke limit in GT MASTER.

(6n) Included an option to spray water on surface of dry air-cooled condenser in GT MASTER to enhance ACC effectiveness when water is available.

(6o) Added option to allow GT fuel compressor delivery pressure to slide for physical engine models and those modeled using the linked GE APPS program.

THERMOFLEX / PEACE

(1) GT MASTER models imported into THERMOFLEX:

Version 25 allows you to directly import GTM models into TFX, akin to the feature that has been available for GT PRO files since 1996. This allows users who've revised plant hardware in GT MASTER, or created a GT MASTER model using the new Multi-Point Design tool, to convert that GT MASTER model to an equivalent THERMOFLEX model. Once in TFX, all components will already be in Off-Design (OD) mode, with the same hardware details as they had in GT MASTER.

(2) New Smoke Tube Evaporator component:

This new icon is located on the **Boilers / HRSGs** tab. Sometimes called a "fire-tube" boiler, this component is used to model evaporators where flue gases pass through tubes submerged in water contained in a cylindrical pressure vessel. These are often utilized together with an economizer to raise steam in smaller single pressure combined cycle or waste heat recovery plants where the required steam pressures don't exceed approximately 35 bar (500 psi).

(3) New exhaust-driven and direct-fired absorption chiller components:

These new icons are located in the **General** tab, beside the other absorption chillers. The exhaust driven chiller is fed hot gases from an engine or other flow-determining icon and can be fired to augment energy input if desired. The direct-fired chiller is usually fed fresh air and uses fuel to supply all the energy. These chillers have options and modes similar to the single stage and two stage steam-heated absorption chillers.

(4) Two new storage tank components:

These new icons are located in the **General** tab. The simple liquid storage tank with one inlet and one discharge node is used to provide capacitance for unbalanced network flows. The thermally-stratified liquid storage tank is used to store fluids for use in chilling and district heating networks. These components calculate the rate of change of the stored commodity to facilitate their use in conjunction with a user-defined time-step analysis done in ELINK. Both tanks handle water and heat transfer fluids, can be constructed from steel or concrete and include size, weight, and estimated cost.

(5) New model of a Ruths steam accumulator:

This new icon is located in the **Water / Steam** tab. The accumulator is charged using steam and stores energy as pressurized saturated water that is flashed to provide steam at lower pressure, usually to supplement another source with insufficient capacity. This component includes size, weight, and estimated cost.

(6) Improved Management of Assemblies:

Modifications were made to the Steam Turbine and HRSG Assemblies to make it easier to define, re-define, and manage them: (1) Assemblies are now identified graphically on the flowsheet using a colored circular icon we call a 'Charm' that acts in many ways as the Assembly's "icon". Assembly inputs and outputs can be accessed through the charm which has a dropdown menu and default behavior when double-clicked. (2) Assembly definitions are preserved when all icons in an assembly are copied and then pasted to create a duplicate assembly. Previously, the icons and connections would be preserved but the assembly definitions would be lost. (3) Definition of steam turbine assembly casing configuration was revised and streamlined to make possible configurations easier to identify and select.

(7) Improved flowsheet graphic editing:

A number of flowsheet handling improvements were introduced to make it easier to edit the drawing: (1) Icons can be deleted without losing the stream connections attached to the icon's nodes. This is the new default behavior when using the [DEL] key for a single highlighted icon. The old delete method, which killed both icon and all its connections, is still available but is accomplished using [SHIFT]+[DEL]. The [BACKSPACE] key disconnects highlighted icons but preserves the connection paths to previously connected nodes. A key benefit of these changes is that tagged connections are now preserved, by default, when deleting icons connected via tags. (2) Selected items can be moved using the [ARROW] keys, and they can be "nudged" using the [CTRL]+[ARROW] keys. (3) Potential stream display snap points along the stream path are displayed whenever a stream display is relocated.

(8) Other Improvements to THERMOFLEX:

(8a) The Flowsheet Title Block was overhauled. The Title Block, available from **Define** menu or Print Preview mode, can now include an image to allow inclusion of your company logo on the printout. The title block definition can be exported from one model and imported to another so a consistent design can be easily utilized for all models. The block can now include a value table with outputs from the current model, for example Net power, Net LHV efficiency, etc. The title block definition menu was improved to make it easier to format and manipulate the layout.

(8b) You can now copy and paste icon model data from any icon to any other "like" icon in the current model, or any other TFX model that is currently open on your computer. Model data is the collection of inputs used to define the icon. "Like" icons are those with the same icon type and sharing the same connection configuration.

(8c) The Water/Steam Logical Header was generalized so it now also works with brine, heat transfer fluid, and refrigerants. It also was given optional "makeup" and "blowdown" nodes so it has the new ability to balance supply/demand mismatches in the network. The icon retains its ability to estimate installed cost for the pipe and associated fittings. It is now called simply "Logical Header" and is located on the **General** tab.

STEAM PRO / STEAM MASTER / PEACE

(1) Desalination models for thermal, electric, and hybrid thermal-electric systems is now available:

This is implemented in the same proven way it has been in GT PRO since 2004, and as revised for hybrid systems in Version 25. The choice to include desalination is made at the **New Session** topic. Thermal systems (MSF and MED) are heated using a steam source from the plant and produce water in amounts based on available steam supply, or desired water production. Desalination models for MED, MSF, RO, MSF+RO, and MED+RO are available and provide size, weight, and estimated cost outputs in addition to the thermodynamic performance results.

(2) Steam turbines with or without reheat may now exhaust to process:

This selection, made at the **New Session** topic allows the plant to deliver steam turbine exhaust to a process with all types of steam turbines, not just smaller "back-pressure" types.

(3) Other Improvements to STP/STM:

(3a) Boiler can be designed to produce saturated steam.

(3b) Cost models for fuel handling systems, fabric filters, and ESP systems were revised. These changes result in lower cost estimates in all cases relative to previous versions.

(3c) Seawater FGD system is now available in plants that use fresh water for cooling.

(3d) CO2 capture can now be included in plants that use seawater cooling.

PEACE

The USD/EUR factor was change to 1.2 and the regional cost multipliers were adjusted accordingly for Europe. Other currency conversion factors and cost multipliers were left unchanged. Ongoing monetary policy actions around the world has made it exceptionally difficult to establish factors that can apply for even one month, let alone an entire year.

Cost functions and automated sizing procedures in both GTP/M & STP/M PEACE modules were revised with an emphasis on smaller plants; those in the sub-25 MW range. As a result estimated plant cost for models in this size range will be generally lower, and in some cases significantly lower than in Revisions to TFLOW24 that pre-date July 15, 2014.

(1) Modified automatic site configuration logic for plants nominally rated at 5MW and below. New logic removes buildings, parking lots, roads, and sidewalks for these small plants based on the assumption the plant is being co-located with another facility that will provide this support.

(2) Reduced the cost of gas turbine inlet chillers and the chiller coils by about 20%.

(3) Reduced the cost of cooling towers by about 5%.

(5) Cost for smaller head multi-stage boiler feedpumps was reduced by an amount that depends on nameplate pump head.

(5) Fuel gas compressor cost function was revised.

(6) Estimated cost for plant engineering was reduced by an amount that depends on plant size.

(7) Cost and installation hours estimates for small tanks, generally those below 25,000 gallons, were revised to reduce installed costs for these tanks which are often shipped to site rather than field-erected.

(8) The default length for process steam, condensate return, and cooling water supply, and raw water supply pipes is now a dynamic function of plant size as specified on the [New Session] topic.

(9) Revised internal assumptions affecting the amount of cable tray needed for plant auxiliary loads.

(10) Reduced length of some of the miscellaneous pipes accounted for automatically such as service water, service air, feedwater, boiler vents, and liquid fuel.

Plant Design Expert (PDE) & webPDE

These programs include a new User-defined Plant Configuration mode for pure power plants. This allows the user to explicitly choose allowable cycle type(s) and whether the plant may include duct firing, or not. An option was added to use GT inlet air chilling to reduce compressor inlet air temperature from the specified ambient temperature. A new input was added to specify fuel line pressure. This is used to first decide if the plant needs a fuel compressor, and when needed, to set the suction side pressure.

GAS TURBINE DATABASE

The gas turbine database was updated as shown below. Some of these engine models have been previously released in revisions to TFLOW24.

Engines added to the database

530 - GE LM6000 PG SPT 60 Hz
531 - GE LM6000 PG SPT 50 Hz
537 - GE Jenbacher recip J920 (50Hz)
538 - GE Jenbacher recip J920 (60Hz)
547 - GE LM6000 PC VIGV (60 Hz)
548 - GE LM6000 PC Fix IGV (60 Hz)
549 - GE LM6000 PC VIGV (50 Hz)
550 - GE LM6000 PC Fix IGV (50 Hz)
551 - GE LM6000 PC SPT VIGV (60 Hz)
552 - GE LM6000 PC SPT Fix IGV (60 Hz)
553 - GE LM6000 PC SPT VIGV (50 Hz)
554 - GE LM6000 PC SPT Fix IGV (50 Hz)
555 - GE LM6000 PD (60 Hz)
556 - GE LM6000 PD (50 Hz)
557 - GE LM6000 PD SPRINT (60 Hz)
558 - GE LM6000 PD SPT (50 Hz)
559 - GE LM6000 PF (60 Hz)
560 - GE LM6000 PF (50 Hz)
561 - GE LM6000 PF SPT 25 (60 Hz)
562 - GE LM6000 PF SPT 25 (50 Hz)
563 - GE LM6000 PF SPT 15 (60 Hz)
564 - GE LM6000 PF SPT 15 (50 Hz)
565 - GE LM6000 PG (60 Hz)
566 - GE LM6000 PG (50 Hz)
567 - GE LM6000 PG SPT (60 Hz)
568 - GE LM6000 PG SPT (50 Hz)
569 - GE GT-9E.04
570 - GE GT-6F.01
571 - GE GT-7H.02
572 - GE LM2500 PJ25 (60 Hz)
573 - GE LM2500 PJ 25 (50 Hz)
574 - GE LM2500 PJ15 (60 Hz)
575 - GE LM2500 PJ15 (50 Hz)
576 - GE LM2500+ PK (60 Hz)
577 - GE LM2500+ PR (60 Hz)
578 - GE LM2500+ PK (50 Hz)
579 - GE LM2500+ PR (50 Hz)
580 - GE LM2500+ (60 Hz)
581 - GE LM2500+ (60 Hz)
582 - GE LM2500+ (50 Hz)
583 - GE LM2500+ (50 Hz)
584 - GE 9H.02
585 - GE LM2500PE (60 Hz)
586 - GE LM2500PE (50 Hz)

587 - AnsaldoEnergia 94.2
589 - AnsaldoEnergia 64.3A
588 - AnsaldoEnergia 94.3A

534 – Siemens SGT5-4000F (25MAC)
535 – Siemens SGT5-8000H
536 – Siemens SGT6-8000H
590 - Siemens SGT800-50

539 – MHPS 701F4
540 – MHPS 501JAC
541 – MHPS 501J
542 – MHPS GAC
543 – MHPS 501GAC (Fast)
544 MHPS 701J
545 – MHPS 701JAC
546 – MHPS 701F5

532 – Kawasaki GPB80
533 Kawasaki GPB80D (DLN)

Existing engines with modified performance

151 - Vericor VPS4
399 - Siemens SGT6-2000E (51MAC)
506 - Siemens SGT5-2000E (33MAC)
267 - Siemens SGT-100 (5.05MW)
481 - Siemens SGT6-5000F (enh. eff.)
507 - Siemens SGT5-2000E (25MAC)
298 - Siemens SGT-400 (12.9MW)
483 - Siemens SGT6-5000F
508 - Siemens SGT5-4000F (33MAC)
398 - Siemens SGT6-2000E (33MAC)
505 - Siemens SGT5-2000E (51MAC)
290 - Solar Mars 90-1300