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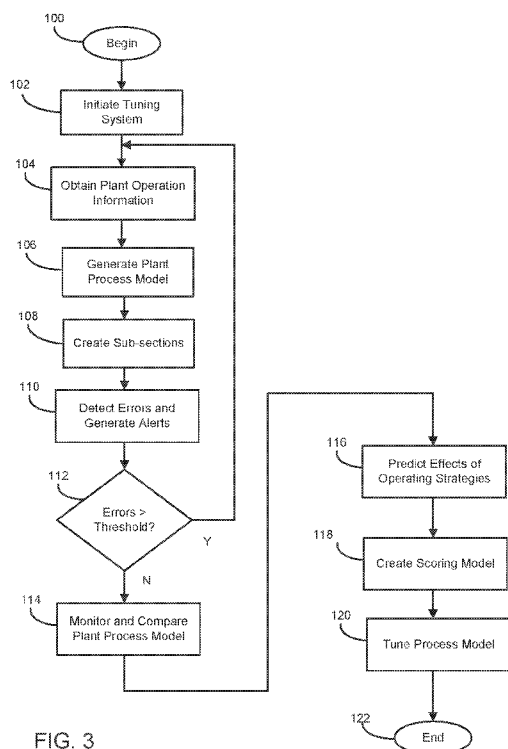


FIG. 3

(57) **Abstract:** A refinery or petrochemical plant may include a fractionation column and related equipment, such as one or more condensers, receivers, reboilers, feed exchangers, and pumps. The equipment may have boundaries or thresholds of operating parameters based on existing limits and/or operating conditions. Illustrative existing limits may include mechanical pressures, temperature limits, hydraulic pressure limits, and operating lives of various components. There may also be relationships between operational parameters related to particular processes. For example, the boundaries on a naphtha reforming reactor inlet temperature may be dependent on a regenerator capacity and hydrogen-to-hydrocarbon ratio, which in turn may be dependent on a recycle compressor capacity. Operational parameters of a final product may be determined based on actual current or historical operation, and implemented in one or more models to determine adjustments for enhanced operational efficiency.

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REFINERY OR PETROCHEMICAL PLANT PROCESS PERFORMANCE IMPROVEMENTS

CROSS-REFERENCE

[0001] This application claims priority to U.S. Patent Application No. 15/665,042, filed July 31, 2017, entitled, “IDENTIFYING AND IMPLEMENTING REFINERY OR PETROCHEMICAL PLANT PROCESS PERFORMANCE IMPROVEMENTS,” which is incorporated herein by reference in its entirety.

FIELD

[0002] The present disclosure is related to improving operating processes of a plant, such as a chemical plant or refinery. Specifically, refinery operations may be optimized to, for example, result in improved yields, chemical product properties, and/or coke production rates by tuning process models for threshold analysis and implementing resulting recommendations in operations.

BACKGROUND

[0003] Companies operating refineries and petrochemical plants typically face tough challenges in today’s environment. These challenges may include increasingly complex technologies, a reduction in workforce experience levels, and constantly changing environmental regulations.

[0004] Furthermore, companies seek to continually increase production and efficiency of existing operations. In response, catalyst, adsorbent, equipment, and control system suppliers develop more complex systems that may increase performance. Maintenance and operations of these advanced systems generally requires increased skill levels that may be difficult to develop, maintain, and transfer, given the time pressures and limited resources of today’s technical personnel. This means that these increasingly complex systems are not always operated at their

highest potential. In addition, when existing assets are operated close to and beyond their design limits, reliability concerns and operational risks may increase.

[0005] Plant operators typically respond to these challenges with one or more strategies, such as, for example, availability risk reduction, working the value chain, and continuous optimization. Availability risk reduction generally places an emphasis on achieving adequate plant operations as opposed to maximizing performance. Working the value chain typically places an emphasis on improving the match of feed and product mix with operational capabilities and other demands. Continuous optimization often employs tools, systems, and models to continuously monitor and bridge gaps in plant performance.

[0006] There are multiple levels of gaps (or performance deficits) that refinery operators typically experience:

1) Events or “Lost Opportunities” Gap

Most refinery operators may sufficiently track the results of unplanned events in their refineries: unplanned shutdowns, equipment availability problems, or the like. The impact associated with these gaps may be large, but the duration is normally short. Well-operated refineries may keep these events to a minimum through effective process and mechanical reliability programs.

2) Backcasting Gap

Some refineries focus on a backcasting (historical) gap in which the operator compares the monthly refinery production plan against the actual achieved operations, and conducts an analysis to understand and resolve the cause(s) for any gap(s). This is typically done on a monthly basis. Refinery operators may often uncover substantial improvement if they resolve the root causes for deviation from refinery production process plans.

[0007] But when root causes are embedded in poor process performance, they are often difficult to identify. This historical backcasting analysis also may be costly, in that it leaves

issues unidentified and un-resolved until the end of the month. Early identification of this gap and resolution of the problems may avoid significant losses. It is important to maintain continuous and consistent levels of desired performance when optimizing a particular process based on various plant process models to ensure consistent and viable results.

[0008] Therefore, there is a need for an improved, automated tuning system that utilizes a strategy of optimization that employs tools, systems, and models to enable operators to monitor and successfully bridge the gaps in plant performance.

SUMMARY

[0009] A general object of the disclosure is to improve operational efficiency of chemical plants and refineries. A more specific object of this disclosure is to overcome one or more of the problems described herein. A general object of this disclosure may be attained, at least in part, through a method for improving operation of a plant. The method includes obtaining plant operation information from the plant.

[0010] The present disclosure further comprehends a method for improving operation of a plant that includes obtaining plant operation information from the plant and generating a plant process model using the plant operation information. The disclosure further comprehends a method for improving operation of a plant. The method may include receiving plant operation information over a network and generating a plant process model using the plant operation information.

[0011] A simulation engine may be systematically tuned to provide a sound basis for plant optimization. Key matching parameters may be defined and reconciled based on associated reference points, and differences of one or more parameters may be iteratively or cumulatively assessed to determine a fitness of the simulation compared to actual plant operations. As described in greater detail below, a threshold value may be defined and

determined to assess the need for additional tuning of the simulation engine based on the fitness of the simulation.

[0012] The present disclosure may utilize configured process models to monitor, predict, and/or optimize performance of individual process units, operating blocks and/or complete processing systems. Routine and frequent analysis of predicted versus actual performance may allow early identification of operational discrepancies that may be acted upon to optimize impact.

[0013] The present disclosure may utilize process measurements, such as, for example, measurements from pressure sensors, differential pressure sensors, orifice plates, venturi, other flow sensors, temperature sensors (e.g., thermocouples, temperature probes, thermal cameras, infrared cameras), capacitance sensors, weight sensors, gas chromatographs, moisture sensors, and/or other sensors commonly found in the refining and petrochemical industry. Further, the process may utilize laboratory measurements from, for example, gas chromatographs, liquid chromatographs, distillation measurements, octane measurements, and/or other laboratory measurements commonly found in the refining and petrochemical industry.

[0014] The process may be used to monitor the performance of equipment, such as pumps, compressors, heat exchangers, fired heaters, control valves, fractionation columns, reactors and/or other process equipment commonly found in the refining and petrochemical industry.

[0015] The method may be implemented using a web-based computer system. The benefits of executing work processes within a web-based platform may include improved plant performance due to an increased ability by operations to identify and capture opportunities, a sustained ability to bridge performance gaps, an increased ability to leverage personnel expertise, and/or improved enterprise tuning. Advanced computing technology, in combination

with other parameters, may thus be used to change the way plants, such as refineries and petrochemical facilities, are operated.

[0016] The present disclosure may use a data collection system at a plant to capture data that may be automatically sent to a remote location, where it may be reviewed to, for example, eliminate errors and biases, and/or used to calculate and report performance results. The performance of the plant and/or individual process units of the plant may be compared to the performance predicted by one or more process models to identify any operating differences, or gaps.

[0017] A report (e.g., a daily report) showing actual performance compared to predicted performance may be generated and delivered to a plant operator and/or a plant or third party process engineer via one or more computer networks (e.g., the internet). The identified performance gaps may allow the operators and/or engineers to identify and resolve the cause of the gaps. The method may further use the process models and plant operation information to run optimization routines that converge on an optimal plant operation for given values.

[0018] The method may provide plant operators and/or engineers with regular advice that may enable recommendations to adjust setpoints or reference points, which may allow the plant to run continuously at or closer to optimal conditions. The method may provide the operator alternatives for improving or modifying the future operations of the plant. The method may regularly or periodically maintain and tune the process models to correctly represent the true potential performance of the plant. In some embodiments, the method may include optimization routines configured per the operator's specific criteria, which may be used to identify optimum operating points, evaluate alternative operations, and/or evaluate feed.

[0019] The present disclosure provides a repeatable method that may help refiners bridge the gap between actual and achievable performance. The method may utilize process

development history, modeling and stream characterization, and/or plant automation experience to address the critical issues of ensuring data security as well as efficient aggregation, tuning, and/or movement of large amounts of data. Web-based optimization may enable achieving and sustaining maximum process performance by connecting, on a virtual basis, technical expertise and the plant process operations staff.

[0020] The enhanced workflow may utilize configured process models to monitor, predict, and/or optimize performance of individual process units, operating blocks, or complete processing systems. Routine and frequent analysis of predicted versus actual performance may allow early identification of operational discrepancies, which may be acted upon to optimize impact.

[0021] As used herein, references to a “routine” are to be understood to refer to a sequence or sequences of computer programs or instructions for performing a particular task. References herein to a “plant” are to be understood to refer to any of various types of chemical and petrochemical manufacturing or refining facilities. References herein to a plant “operators” are to be understood to refer to and/or include, without limitation, plant planners, managers, engineers, technicians, and others interested in, overseeing, and/or running the daily operations at a plant.

[0022] In some embodiments, a tuning system may be provided for improving operation of a plant. One or more servers may be coupled to the tuning system for communicating with the plant via a communication network. A computer system may include a web-based platform for receiving and sending plant data related to the operation of the plant over the network. A display device may interactively display the plant data. A reconciliation unit may be configured for reconciling actual measured data from the plant in comparison with a performance process model result from a simulation engine based on a set of predetermined reference or set points.

The reconciliation unit may perform a heuristic analysis against the actual measured data and the performance process model result using a set of predetermined threshold values.

[0023] In some embodiments, a tuning method may be provided for improving operation of a plant, and may include providing one or more servers coupled to a tuning system for communicating with the plant via a communication network; providing a computer system having a web-based platform for receiving and sending plant data related to the operation of the plant over the network; providing a display device for interactively displaying the plant data, the display device being configured for graphically or textually receiving the plant data; obtaining the plant data from the plant over the network; generating a plant process model based on the plant data for estimating plant performance expected based on the plant data; monitoring a health of the plant based on the plant process model; reconciling actual measured data from the plant in comparison with a performance process model result from a simulation engine based on a set of predetermined reference or set points; creating a scoring model for determining a degree of trustworthiness of the plant process model based on the plant data; and tuning the plant process model based on the scoring model for representing a potential performance of the plant.

[0024] The foregoing and other aspects and features of the present disclosure will become apparent to those of reasonable skill in the art from the following detailed description, as considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] FIG. 1 depicts an illustrative use of a tuning system in a cloud computing infrastructure in accordance with one or more embodiments of the present disclosure;

[0026] FIG. 2 depicts an illustrative functional block diagram of a tuning system featuring functional units in accordance with one or more embodiments of the present disclosure; and

[0027] FIG. 3 depicts an illustrative tuning method in accordance with one or more embodiments of the present disclosure.

DETAILED DESCRIPTION

[0028] Referring now to FIG. 1, an illustrative tuning system, generally designated 10, using an embodiment of the present disclosure may be provided for improving operation of one or more plants (e.g., Plant A . . . Plant N) 12a-12n, such as a chemical plant or refinery, or a portion thereof. The present tuning system 10 uses plant operation information obtained from at least one plant 12a-12n.

[0029] As used herein, the term “system,” “unit” or “module” may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, memory (shared, dedicated, or group) and/or a processor (shared, dedicated, or group) that executes computer-readable instructions (e.g., software or firmware programs), a combinational logic circuit, and/or other suitable components that provide the described functionality. The system, unit, or module may be stored on one or more non-transitory computer-readable media. Thus, while this disclosure includes particular examples and arrangements of the units, the scope of the present system should not be so limited, since other modifications will become apparent to the skilled practitioner.

[0030] The tuning system 10 may reside in or be coupled to one or more servers or computing devices 14 (including, e.g., database and video servers), and may be programmed to perform tasks and display relevant data for different functional units via a communication network 16, e.g., using a secured cloud computing infrastructure. Other suitable networks may be used, such as the internet, a wired network, a wireless network (e.g., Wi-Fi), a corporate Intranet, a local area network (LAN), a wide area network (WAN), and/or the like, using dial-in connections, cable modems, high-speed ISDN lines, and/or other types of

communication methods known in the art. Some or all relevant information may be stored in one or more databases for retrieval by the tuning system 10 or the computing device 14 (e.g., as a data storage device and/or a non-transitory machine-readable data-storage medium carrying computer programs or instructions).

[0031] Further, the present tuning system 10 may be partially or fully automated. In some embodiments, the tuning system 10 may be performed by a computer system, such as a third-party computer system, local to or remote from the plant 12a-12n and/or the plant planning center. The present tuning system 10 may include a web-based platform 18 that obtains or receives and sends information over a communication network, such as the internet. Specifically, the tuning system 10 may receive signals and parameters from at least one of the plants 12a-12n via the communication network 16, and display, (e.g., in real time or substantially in real time), related performance information on an interactive display device 20 accessible to an operator or user.

[0032] Using a web-based system for implementing the method may provide benefits, such as improved plant performance due to an increased ability by plant operators to identify and capture opportunities, a sustained ability to bridge plant performance gaps, and/or an increased ability to leverage personnel expertise and improve training and development. The method may allow for automated daily or other regular evaluation of process performance, thereby increasing the frequency of performance review with less time and effort from plant operations staff.

[0033] The web-based platform 18 may allow one or more users to work with the same information, thereby creating a collaborative environment for sharing best practices or for troubleshooting. The method may provide more accurate prediction and optimization results due to fully configured models, which may include, for example, catalytic yield representations, constraints, degrees of freedom, and the like. Routine automated evaluation of plant planning and operation models may allow timely plant model tuning to reduce or eliminate gaps between

plant models and the actual plant performance. Implementing the method using the web-based platform 18 may also allow for monitoring and updating multiple sites, thereby better enabling facility planners to propose realistic optimal targets.

[0034] Referring now to FIG. 2, the present tuning system 10 may include a reconciliation unit 22 configured for reconciling actual measured data from the respective plants 12a-12n in comparison with performance process model results from a simulation engine based on a set of reference or set points. In some embodiments, a heuristic analysis may be performed against the actual measured data and the performance process model results using a set of predetermined threshold values. A statistical analysis and/or other suitable analytic techniques may be used to suit different applications.

[0035] As an example only, operating plant parameters or plant data, such as temperatures, pressure levels, feed compositions, fractionation column product compositions, and the like, may be received from the respective plants 12a-12n. These plant parameters may represent actual measured data from selected pieces of equipment in the plants 12a-12n during a predetermined time period. Comparisons of plant operational parameters may be performed with the performance process model results from the simulation engine based on the predetermined threshold values.

[0036] As an example of measuring operating plant parameters or plant data, temperature data may be sensed by various temperature sensors, including thermocouples, resistance temperature detectors (RTD), thermistors, and/or thermal imaging techniques. Temperature sensing devices may be directly connected to the target equipment (e.g., a knife-edge skin thermocouple), or may be sheathed in a protective device (e.g., a thermowell). The temperatures these devices measure may result in a variable voltage signal, a resistance, or may be transmitted as a video image. In one example, a knife-edge skin thermocouple directly welded to the heater tube may be used to generate a voltage signal, which may be interpreted by

the control system in the plant as a specific temperature. This temperature data may be sent from the plant (12a – 12n) to the system.

[0037] As another example of measuring operating plant parameters or plant data, pressures, differential pressures, some levels and/or some flows may be measured using pressure or differential pressure sensors. These sensors may use a capacitive and/or piezoresistive primary sensor to measure the force of the fluid and convert this signal to an electric signal that may be interpreted by the control system. In one example, the electric signal would be a 4 – 20 mA signal.

[0038] To measure flows, a primary device may be used to create a differential pressure that is proportional to the flow through the device. The differential pressure sensor may be connected to the inlet and outlet sides of the primary device to measure the differential pressure at specific locations in the flow profile. The primary device may be a restriction orifice, a venturi, and/or an averaging pitot device.

[0039] As another example of measuring operating plant parameters or plant data, compositions may be measured through a variety of analytical techniques. The analyzers used in these techniques may be dedicated instruments closely coupled to the process that analyze continuously or periodically, or they may be shared instruments in a remote laboratory, and may be operated on a regular or irregular schedule. Analytical techniques used to determine compositions may include using gas chromatographs, liquid chromatographs, infrared, nuclear magnetic resonance, and/or other techniques. Analyzers may be designed to measure the partial or entire contents of the sampled fluid, or may be designed to measure the quantity of one or more specific components.

[0040] The tuning system 10 may include an interface module 24 for providing an interface between the tuning system 10, one or more internal or external databases 26, and/or the network 16. The interface module 24 may receive data from, for example, plant sensors

via the network 16, and other related system devices, services, and applications. The other devices, services, and applications may include, but are not limited to, one or more software or hardware components related to the respective plants 12a-12n. The interface module 24 may also receive the signals and/or parameters, which may be communicated to the respective units and modules, such as the tuning system 10, and associated computing modules or units.

[0041] A prediction unit 28 may be provided for predicting a trustworthiness of a current process model of the simulation engine based on the comparisons of the plant operational parameters. The prediction unit 28 may generate or calculate a trustworthiness score of the process model based on the comparisons using a partial least squares (PLS) analysis, an orthogonal PLS (OPLS) analysis, and/or other suitable analytic techniques, as known in the art.

[0042] For example, a scoring model may be created for determining a degree of trustworthiness of the current process model based on the plant operational parameters. Further, the trustworthiness score may be weighted based on an amount of difference between the plant operational parameters and the corresponding predetermined threshold values. The scoring model may be updated with the weighted trustworthiness scores, and the current process model may be adjusted or tuned based on the scoring model.

[0043] More specifically, at least one plant parameter or a subset of the plant parameters may be selected as a key matching parameter, and a difference between the selected plant parameter and the corresponding performance model result may be assessed cumulatively during a predetermined time period to determine the fitness of the simulation to the related actual plant operations. When the difference is greater than a predetermined threshold value, an additional tuning of the process model may be performed. For example, when an error margin of the difference is greater than a predetermined percentage (%) value, the current process model may be further evaluated and tuned accordingly.

[0044] An optimization unit 30 may be provided for optimizing at least a portion of the refining or petrochemical process of at least one plant 12a-12n based on the trustworthiness score of the performance or plant process model. It may be difficult for operators in the refining and petrochemical field to optimize at the level of an entire complex of the plant 12a-12n because there are various parameters and measurements that might not provide a cohesive basis for process simulation and optimization. In some embodiments, the trustworthiness score may be a sum of weighted differences between the measured values from the plant and the matching calculated values in the process model. The weighting factors may be dependent on the trustworthiness of the individual measurements. The weighting factors may be calculated based on various aspects of the measurements, which may, for example, include accuracy of the primary measuring sensor or age of the measurement.

[0045] In operation, the optimization unit 30 may receive the actual measured data from a customer site or plant 12a-12n on a recurring basis (e.g., every 100 milliseconds, every second, every ten seconds, every minute, every two minutes). Data cleansing may be performed. For example, the data may be analyzed for completeness and corrected for gross errors by the optimization unit 30. Then, the data may be corrected for measurement issues (e.g., an accuracy problem for establishing a simulation steady state) and overall mass balance closure to generate a duplicate set of reconciled plant data.

[0046] The corrected data may be used as an input to a simulation process, in which the process model may be tuned to ensure that the simulation process matches the reconciled plant data. An output of the reconciled plant data may be input into a tuned flowsheet, and then may be generated as a predicted data. Each flowsheet may be a collection of virtual process model objects as a unit of process design. A delta value, which is a difference

between the reconciled data and the predicted data, may be validated to ensure that a viable optimization case is established for a simulation process run.

[0047] As a result, the tuned simulation engine may be used as a basis for the optimization case, which may be run with a set of the reconciled data as an input. The output from this step is a new set of data, namely an optimized data. A difference between the reconciled data and the optimized data may provide an indication as to how the operations should be changed to reach a greater efficiency. In this configuration, the optimization unit 30 may provide a user-configurable method for minimizing objective functions, thereby maximizing efficiency of the plants 12a-12n.

[0048] In some embodiments, the optimization unit 30 may define an objective function as a calculation of multiple operational factors for a particular process, such as materials consumed, products produced, and/or utilities utilized, subject to various constraints. For example, a maximum fractionation column capacity may be determined by a flooding limit of the internal components. In some embodiments, the maximum capacity of a fractionation column may be determined by estimating the liquid and vapor flow rates and properties (density, viscosity, surface tension) on one or more stages of a fractionation column. The optimization unit 30 may use the design of the fractionation column internal devices (tray size, number of holes, downcomer dimensions, weir heights) and/or the vapor and liquid flow rates and properties to calculate the fraction of the available column capacity that is currently being used. The maximum capacity is the capacity above which the efficiency of the column is drastically reduced and is commonly called “flooding.” Flooding can manifest as excessive liquid flow or excessive vapor flow.

[0049] In another example, a maximum capacity of a furnace may be determined based on a surface temperature of a tube inside the furnace. The surface temperature may be measured by one or more temperature sensors, such as a thermocouple, temperature probe,

thermal imaging camera, or the like. Specifically, in some embodiments, the maximum capacity of a furnace may be based on one or more indicators. The heater tubes may be designed for a maximum external temperature, above which the life of the tube may be in jeopardy and/or at risk of failure. The tube wall temperature may be related to the heat flow capacity of the heater (e.g., the higher the heat flow, the higher the tube wall temperature). The actual furnace tube wall temperature may be measured using one or more temperatures sensors. These sensors may be placed at specific places on the tube wall, and in some instances, might not always be accurate. In some embodiments, one or more alternative methods of estimating tube wall temperature may include calculating the heat flow of the heater and/or calculating, using the emissivity of the tubes and various geometrical factors, the estimated maximum tube wall temperature. In some embodiments, measured values may be used during the reconciliation process to determine the geometrical factors used in the estimated values.

[0050] Thus, the optimization unit 30 may use analytical calculations to modify parameters in the model that best fit the measured data from the plant. In some embodiments, this may include data reconciliation. For example, in some embodiments, the optimization unit 30 may correlate the surface temperatures that are calculated by the process calculations with measured temperatures that are measured from the plant. Through those correlations, the optimization unit 30 may tune the process calculations such that the process model better reflects what is actually happening in the plant. From that, the system may be better able to predict where the future limits of the equipment (e.g., fired heater) may be in future modes of operation. Other suitable objective functions may suit different applications.

[0051] The tuning system 10 may include an analysis unit 32 configured for determining an operating status of the refinery or petrochemical plant to ensure robust operation of the plant 12a-12n. The analysis unit 32 may determine the operating status based on at least one

of a kinetic model, a parametric model, an analytical tool, related knowledge, and/or a best practice standard.

[0052] In some embodiments, the analysis unit 32 may receive historical or current performance data from one or more of the plants 12a-12n to proactively predict future actions to be performed. To proactively predict various limits of a particular process and stay within the acceptable range of limits, the analysis unit 32 may determine target operational parameters of a final product based on actual current and/or historical operational parameters, e.g., from a flow of steam, a heater, a temperature set point, a pressure signal, or the like.

[0053] For example, in using the kinetic model or other detailed calculations, the analysis unit 32 may establish boundaries or thresholds of operating parameters based on existing limits and/or operating conditions. Exemplary existing limits may include mechanical pressures, temperature limits, hydraulic pressure limits, and/or operating lives of various components. Other suitable limits and conditions may suit different applications.

[0054] In using the knowledge and best practice standard, based upon, for example, specific know-how, the analysis unit 32 establishes relationships between operational parameters related to the specific process. For example, the boundaries on a naphtha reforming reactor inlet temperature may be dependent on a regenerator capacity and hydrogen-to-hydrocarbon ratio, which is itself dependent on a recycle compressor capacity.

[0055] Referring now to FIG. 3, a simplified flow diagram is depicted for an illustrative method of improving operation of a plant, such as the plant 12a-12n of FIGs. 1 and 2, according to some embodiments. Although the following steps are primarily described with respect to the embodiments of FIGs. 1 and 2, the steps within the method may be modified and executed in a different order or sequence, one or more additional steps may be performed, and/or one or more depicted steps may be omitted.

[0056] The method begins at step 100. In step 102, the tuning system 10 may be initiated by a computer system that is inside or remote from the plant 12a-12n. The method may be automatically performed by the computer system, but the disclosure is not so limited. One or more steps may include manual operations or data inputs from the sensors and other related systems, as desired.

[0057] In step 104, the tuning system 10 obtains plant operation information or plant data from the plant 12a-12n over the network 16. The plant operation information may include plant operational parameters, plant process condition data, plant lab data, and/or information about plant constraints. The plant data may include one or more of: the plant operational parameter, the plant lab data, the plant constraint, and/or the plant process condition data. As used herein, “plant lab data” refers to the results of periodic laboratory analyses of fluids taken from an operating process plant. As used herein, “plant process data” refers to data measured by sensors in the process plant.

[0058] In step 106, a plant process model may be generated using the plant operation information. The plant process model may estimate or predict plant performance that is expected based upon the plant operation information (e.g., how the plant 12a-12n is operated). The plant process model results may be used to monitor the health of the plant 12a-12n and/or to determine whether any upset or poor measurement occurred. The plant process model may be generated by an iterative process that models plant performance at various plant constraints to determine the desired plant process model.

[0059] In step 108, a process simulation unit may be utilized to model the operation of the plant 12a-12n. Because the simulation for the entire unit may be large and complex to solve in a reasonable amount of time, each plant 12a-12n may be divided into smaller virtual sub-sections consisting of related unit operations. An exemplary process simulation unit 10, such as a UniSim® Design Suite, is disclosed in U.S. Patent Publication No. 2010/0262900, now U.S.

Patent No. 9,053,260, which is incorporated by reference in its entirety. The process simulation unit 10 may be installed in the optimization unit 30. Other illustrative related systems are disclosed in commonly assigned U.S. Patent Application Nos. 15/084,291 and 15/084,319 (Attorney Docket Nos. H0049323-01-8500 and H0049324-01-8500, both filed on March 29, 2016), which are incorporated by reference in their entirety.

[0060] For example, in one embodiment, a fractionation column and its related equipment such as its condenser, receiver, reboiler, feed exchangers, and pumps may make up a subsection. Some or all available plant data from the unit, e.g., temperatures, pressures, flows, and/or laboratory data may be included in the simulation as measured variables. Multiple sets of the plant data may be compared against the process model. Model fitting parameters and/or measurement offsets may be calculated that generate the smallest errors.

[0061] In step 110, fit parameters or offsets that change by more than a predetermined threshold, and measurements that have more than a predetermined range of error, may trigger further action. For example, changes in offsets or fit parameters beyond a threshold amount of change may indicate the model tuning may be inadequate. Overall data quality for the set of data may then be flagged as questionable.

[0062] In step 112, when the change, difference, or range of error is greater than a predetermined value, control returns to step 104. Otherwise, control proceeds to step 114. Individual measurements with large errors may be eliminated from the fitting algorithm. In some embodiments, an alert message or warning signal may be raised to have the measurement inspected and rectified.

[0063] In step 114, the tuning system 10 may monitor and compare the plant process model with actual plant performance to ensure the accuracy of the plant process model. Typically, more effective process models are ones that more accurately reflect the actual operating capabilities of the commercial processes. This may be achieved by calibrating models to the reconciled data.

For example, the model parameters may be manipulated (e.g., based on the reconciled data) so that the model agrees with the plant measurements. One or more operating variables, such as cut points and tray efficiencies, may be adjusted to minimize differences between measured and predicted performance. A cut point may include one or more column product compositions, which may be measured as a component contaminant in one or more products or as a fractional recovery of a particular component in one or more products. For example, a benzene product purity may consider the contamination of benzene by toluene or other contaminating components. The fractionation column may also be controlled to recovery a certain fraction of the benzene in its to the benzene product. A tray efficiency may include the performance (e.g., degree of separation) of an actual fractionation column stage compared to a theoretical one. This calculation may be measured as a percentage. For example, in some embodiments, the tray efficiency may range from 20% to 90%. In some embodiments, upon a predetermined difference between the plant process model and actual plant performance, the plant process model may be updated, and the updated plant process model may be used during the next cycle of the method. The updated plant process model may also be used to optimize the plant processes.

[0064] In step 116, the plant process model may be used to accurately predict the effects of varying feedstocks and operating strategies. Consequently, regular updating or tuning of the plant process model using reconciled data may enable the refiner to assess changes in process capability. A calibrated, rigorous model of this type may enable refinery operations engineers and planning personnel to identify process performance issues, so that they may be addressed before they have a serious impact on operating efficiencies and/or performance.

[0065] For example, calculations such as yields, product properties, and/or coke production rate may be key indicators of process problems when examined as trends over time. Regular observation of such trends may indicate abnormal declines in performance or mis-operations. For example, if a rapid decline in C₅+ hydrocarbon yields in a naphtha reforming unit is

observed, this may indicate an increasing rate of coke production, which then may be traced back to an incorrect water-chloride balance in the reactor circuit or incorrect platforming feed pre-treatment. Alternatively or additionally, the plant process model may support improvement studies that consider short-term operational changes and/or long-term revamp modifications to generate improved performance of the unit.

[0066] In step 118, a scoring model may be created for determining a degree of trustworthiness of the current process model based on the plant operational parameters. Specifically, a trustworthiness score of the process model is generated based on comparisons between the plant operational parameters using a partial least squares (PLS) analysis, an orthogonal PLS (OPLS) analysis, and/or other suitable analytic techniques. As discussed above, the plant operational parameters may be compared with the performance process model results from the simulation engine based on the predetermined threshold values.

[0067] During operation, an output interface may be designed to directly relate operational performance (e.g., cost of production per ton of product)—which may be the concern of the plant tuning—to the primary operating variables of the plant (e.g., a flow of steam to a heat exchanger or set point on a column composition controller). This may be accomplished by relating the performance to the plant operation through a cascade of more detailed screens, each of which may be designed to allow the user to quickly view what variables are causing the departure from the target performance.

[0068] A benefit of the method is its long-term sustainability. Often, projects to improve plant performance may achieve reasonable benefits for a modest duration, but these improvements decay over time. This decay is usually the result of inadequate time and expertise of available in-house technical personnel. Web-based optimization using the method may help operators bridge existing performance gaps and better leverage the expertise of their personnel in a way that may be sustained in the long term.

[0069] Some plant operators have attempted to use locally installed process models to address the optimization needs of a refinery. While several such process model offerings exist in the marketplace, these tools lose value over time, as there are inadequate methods for keeping them tuned (e.g., modeling catalyst deactivation, temporary equipment limitations, and the like) and configured to take into account plant flow scheme and equipment modifications. In this configuration, over time, the investment made in acquiring such models does not deliver the intended value. Additionally, the cost associated with performing the model maintenance function may be relatively large and the expertise difficult to maintain or replace. The web-enabled platform specifically addresses these shortcomings by remotely hosting and maintaining the models.

[0070] Beyond the technical benefits, implementation of the web-based method of the present tuning system 10 may deliver tangible benefits that address the customer's managerial challenges. Such a service may aid in improving training and development of technical personnel, automation of business processes, and/or development of operational excellence. Training of new engineers and operators may be simplified, as there is a central repository of knowledge about the individual process units. Furthermore, engineers may more easily be rotated among several process units to give them broader experience. This rotation may be done with the assurance that consistency of knowledge is transferred by highly repeatable remote performance monitoring processes and by professionals interacting with skilled technical services personnel.

[0071] In step 120, the current process model may be tuned to correctly represent the true potential performance of the plant based on the scoring model. The process model is further tuned to ensure that the simulation process matches the reconciled plant data. The tuned simulation engine is used as a basis for the optimization case, which may be run with a set of the reconciled data as an input. The output from this step is the optimized data. As a result,

future operations of the plants 12a-12n may be optimized, and productions may be maximized.

[0072] A business optimization work process may be made more predictable by providing a common platform for viewing results to the various stakeholders, such as planners, managers, engineers, and technicians. For example, the tuning system 10 may be used to provide a simplified and robust look at process units at various locations, thereby allowing quick allocation of resources to process units that either have the highest feed processing opportunity or the most need for maintenance and upgrade.

[0073] Further advantage may be achieved by utilizing a common infrastructure that establishes links between the plant process and performance. Some or all process, analytical, and/or performance data may be used to generate and/or provide reports that are linked through process models. Thus, operators may effectively communicate and make decisions from a common set of information, thereby driving the whole organization to focus on continuous performance maximization. The method ends at step 122.

[0074] While a particular embodiment of the present tuning system has been described herein, it will be appreciated by those skilled in the art that changes and modifications may be made thereto without departing from the disclosure in its broader aspects and as set forth in the following claims.

SPECIFIC EMBODIMENTS

[0075] While the following is described in conjunction with specific embodiments, it will be understood that this description is intended to illustrate and not limit the scope of the preceding description and the appended claims.

[0076] A first embodiment is a system for improving operation of a plant, the tuning system including a server coupled to the tuning system for communicating with the plant via a communication network; a computer system having a web-based platform for receiving and sending plant data related to the operation of the plant over the network; a display device for interactively displaying the plant data; and a reconciliation unit configured for reconciling actual measured data from the plant in comparison with a performance process model result from a simulation engine based on a set of predetermined reference or set points, wherein the reconciliation unit performs a heuristic analysis against the actual measured data and the performance process model result using a set of predetermined threshold values. An embodiment is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the reconciliation unit receives the plant data from the plant via the computer system, and the received plant data represent the actual measured data from equipment in the plant during a predetermined time period. An embodiment is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, further including an interface module configured for providing an interface between the tuning system, a database storing the plant data, and the network. An embodiment is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, further including a prediction unit configured for predicting a trustworthiness of a current process model of the simulation engine based on the comparison of the plant data. An embodiment is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the prediction unit calculates a trustworthiness score of the corresponding process

model based on the comparison of the plant data using an analytic technique. An embodiment is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the prediction unit creates a scoring model for determining a degree of trustworthiness of the corresponding process model based on at least one plant operational parameter. An embodiment is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the trustworthiness score is weighted based on an amount of difference between the plant data and the corresponding predetermined threshold values. An embodiment is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the scoring model is updated with a weighted trustworthiness score, and the current process model is adjusted or tuned based on the scoring model. An embodiment is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the prediction unit cumulatively calculates a difference between a selected plant parameter and the corresponding performance model result during a predetermined time period to determine a fitness of a simulation related to the operation of the plant. An embodiment is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, further including an optimization unit configured for optimizing at least a portion of the plant based on a trustworthiness score of a plant process model. An embodiment is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the optimization unit defines an objective function as a user-defined calculation of a total cost of the operation during a particular process, including materials consumed, products produced, and utilities utilized, subject to at least one constraint. An embodiment is one, any or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, further including an analysis unit configured for determining an operating status of the plant based on at least one of a kinetic model, a parametric model, an analytical tool, and a related knowledge and best practice standard. An embodiment is one, any

or all of prior embodiments in this paragraph up through the first embodiment in this paragraph, wherein the analysis unit determines a target operational parameter of a final product of the plant based on at least one of an actual current operational parameter and a historical operational parameter.

[0077] A second embodiment is a method for improving operation of a plant, the tuning method including providing a server coupled to a tuning system for communicating with the plant via a communication network; providing a computer system having a web-based platform for receiving and sending plant data related to the operation of the plant over the network; providing a display device for interactively displaying the plant data, the display device being configured for graphically or textually receiving the plant data; obtaining the plant data from the plant over the network; generating a plant process model based on the plant data for estimating plant performance expected based on the plant data; monitoring a health of the plant based on the plant process model; reconciling actual measured data from the plant in comparison with a performance process model result from a simulation engine based on a set of predetermined reference or set points; creating a scoring model for determining a degree of trustworthiness of the plant process model based on the plant data; and tuning the plant process model based on the scoring model for representing a potential performance of the plant. An embodiment is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph, further including performing a heuristic analysis against the actual measured data and the performance process model result using a set of predetermined threshold values. An embodiment is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph, further including detecting an error in the tuning of the plant process model based on a predetermined threshold or range. An embodiment is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph, further including monitoring and comparing the plant process model with actual plant

performance to ensure an accuracy of the plant process model. An embodiment is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph, further including predicting an effect of an operating strategy of the plant based on the tuning of the plant process model. An embodiment is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph, further including calculating a trustworthiness score of the plant process model based on the comparison of the plant data using an analytic technique. An embodiment is one, any or all of prior embodiments in this paragraph up through the second embodiment in this paragraph, further including generating a set of reconciled plant data of the simulation engine based on the tuned plant process model.

[0078] One or more embodiments may include a method for enhancing operational efficiency of a chemical plant, the method comprising: receiving, by a computing device and from one or more thermocouples affixed to one or more tubes inside a furnace of a chemical plant, measured surface temperature data for the one or more tubes inside the furnace; providing, by the computing device, the measured surface temperature data to a database configured to store the measured surface temperature data; analyzing, by the computing device, the measured surface temperature data for completeness by identifying gaps in the measured surface temperature data based on a measurement interval; correcting, by the computing device, the measured surface temperature data for overall mass balance closure; generating, by the computing device, reconciled surface temperature data; using, by the computing device, the measured surface temperature data to determine whether an upset occurred; determining, by the computing device, a model fitting parameter for a process model for the chemical plant based on the reconciled surface temperature data; adjusting, by the computing device, a cut point of the chemical plant or a tray efficiency of the chemical plant to minimize differences between measured performance of the chemical plant and predicted performance of the chemical plant; optimizing, by the computing device, the process model using the model fitting parameter for

the process model for the chemical plant; determining, by the computing device, a maximum capacity of the furnace based on the measured surface temperature data for the one or more tubes inside the furnace; and using, by the computing device, a design of a device of the chemical plant to calculate a fraction of an available capacity of the device of the chemical plant that is currently being used; generating, by the computing device and for interactive display, one or more detail screens relating the reconciled surface temperature data to operational performance of the one or more tubes inside the furnace; sending, by the computing device, a report showing actual performance of the chemical plant compared to predicted performance of the chemical plant; providing, by the computing device, alternatives for improving or modifying future operations of the chemical plant, the alternatives comprising operational changes and revamp modifications to generate improved performance of the chemical plant; and recommending, by the computing device, target operational parameters of a final product of the chemical plant.

[0079] In one or more embodiments, a method may include using a partial least squares (PLS) analysis or an orthogonal PLS (OPLS) analysis to generate a trustworthiness score of the process model for the chemical plant based on a comparison between the operational parameters related to the process of the chemical plant.

[0080] In one or more embodiments, a method may include creating a scoring model that is used for generating the trustworthiness score of the process model.

[0081] In one or more embodiments, a method may include weighting the trustworthiness score using one or more factors and based on a difference between the operational parameters related to the process of the chemical plant and corresponding one or more threshold values, wherein the one or more factors comprise an accuracy of a primary measuring sensor or an age of a measurement.

[0082] In one or more embodiments, a method may include updating the scoring model with the weighted trustworthiness score; and adjusting the process model for the chemical plant based on the scoring model.

[0083] In one or more embodiments, a method may include creating, by the computing device, a scoring model; and using the scoring model to generate, by the computing device, a trustworthiness score of the process model for the chemical plant based on a comparison between operational parameters related to a process of the chemical plant.

[0084] In one or more embodiments, a method may include weighting, by the computing device, the trustworthiness score using one or more factors and based on a difference between the operational parameters related to the process of the chemical plant and corresponding one or more threshold values, the one or more factors comprising an age of a measurement; updating, by the computing device, the scoring model with the weighted trustworthiness score; and adjusting, by the computing device, the process model for the chemical plant based on the scoring model.

[0085] In one or more embodiments, a method may include performing a heuristic analysis against the measured surface temperature data and performance process model results from the process model.

[0086] One or more embodiments may include a computer program comprising instructions arranged such that when executed by one or more computers, the instructions cause the one or more computers to perform one or more methods described herein. One or more embodiments may include a computer-readable medium storing the computer program.

[0087] One or more embodiments may include a system for enhancing operation of a chemical plant, the system comprising: a furnace comprising one or more tubes inside the furnace; one or more thermocouples affixed to the one or more tubes inside the furnace; a fractionation column; a reboiler associated with the fractionation column; a receiver associated

with the fractionation column; a feed exchanger associated with the fractionation column; an interface platform; an optimization platform; an analysis platform; and/or an interaction platform.

[0088] In one or more embodiments, an interface platform may include: one or more processors of the interface platform; a communication interface of the interface platform and in communication with the one or more thermocouples affixed to the one or more tubes inside the furnace; and non-transitory computer-readable memory storing executable instructions that, when executed by the one or more processors of the interface platform, cause the interface platform to: receive, from the one or more thermocouples, measured surface temperature data for the one or more tubes inside the furnace; and provide the measured surface temperature data to a database configured to store the measured surface temperature data.

[0089] In one or more embodiments, an optimization platform may include: one or more processors of the optimization platform; a communication interface of the optimization platform and in communication with the interface platform; and non-transitory computer-readable memory storing executable instructions that, when executed by the one or more processors of the optimization platform, cause the optimization platform to: receive, via the interface platform, the measured surface temperature data; analyze the measured surface temperature data for completeness by identifying gaps in the measured surface temperature data based on a measurement interval; correct the measured surface temperature data for overall mass balance closure; generate reconciled surface temperature data; use the measured surface temperature data to determine whether an upset occurred; determine a model fitting parameter for a process model for the chemical plant based on the reconciled surface temperature data; adjust a cut point of the chemical plant or a tray efficiency of the chemical plant to minimize differences between measured performance of the chemical plant and predicted performance of the chemical plant; optimize the process model using the model fitting parameter for the process model for the

chemical plant; determine a maximum capacity of the furnace based on the measured surface temperature data for the one or more tubes inside the furnace; and use a design of a device of the chemical plant to calculate a fraction of an available capacity of the device of the chemical plant that is currently being used.

[0090] In one or more embodiments, an analysis platform may include: one or more processors of the analysis platform; a communication interface of the analysis platform and in communication with the interface platform; and non-transitory computer-readable memory storing executable instructions that, when executed by the one or more processors of the analysis platform, cause the analysis platform to: receive historical performance data for the chemical plant; establish relationships between operational parameters related to a process of the chemical plant; analyze the historical performance data for the chemical plant as trends over time to identify key indicators of process problems for the process of the chemical plant; determine target operational parameters of a final product of the chemical plant based on the historical performance data for the chemical plant; and predict a limit of the process of the chemical plant based on the target operational parameters of the final product of the chemical plant.

[0091] In one or more embodiments, an interaction platform may include: one or more processors of the interaction platform; a communication interface of the interaction platform and in communication with the interface platform; and non-transitory computer-readable memory storing executable instructions that, when executed by the one or more processors of the interaction platform, cause the interaction platform to: generate, for interactive display to a plant operator of the chemical plant, one or more detail screens relating the reconciled surface temperature data to operational performance of the one or more tubes inside the furnace; send a report showing actual performance of the chemical plant compared to predicted performance of the chemical plant; provide, to the plant operator of the chemical plant, alternatives for improving or modifying future operations of the chemical plant, the alternatives comprising

operational changes and revamp modifications to generate improved performance of the chemical plant; and recommend, to the plant operator of the chemical plant, the target operational parameters of the final product of the chemical plant.

[0092] In one or more embodiments, a system may include a prediction platform comprising: one or more processors of the prediction platform; a communication interface of the prediction platform and in communication with the interface platform; and non-transitory computer-readable memory storing executable instructions that, when executed by the one or more processors of the prediction platform, cause the prediction platform to: use a partial least squares (PLS) analysis or an orthogonal PLS (OPLS) analysis to generate a trustworthiness score of the process model for the chemical plant based on a comparison between the operational parameters related to the process of the chemical plant.

[0093] In one or more embodiments, the non-transitory computer-readable memory of the prediction platform may store executable instructions that, when executed by the one or more processors of the prediction platform, cause the prediction platform to: create a scoring model that is used for generating the trustworthiness score of the process model; and weight the trustworthiness score using one or more factors and based on a difference between the operational parameters related to the process of the chemical plant and corresponding one or more threshold values, wherein the one or more factors comprise an accuracy of a primary measuring sensor or an age of a measurement.

[0094] In one or more embodiments, the non-transitory computer-readable memory of the prediction platform may store further executable instructions that, when executed by the one or more processors of the prediction platform, cause the prediction platform to: update the scoring model with the weighted trustworthiness score; and adjust the process model for the chemical plant based on the scoring model.

[0095] In one or more embodiments, a system may include a reconciliation platform comprising: one or more processors of the reconciliation platform; a communication interface of the reconciliation platform and in communication with the interface platform; and non-transitory computer-readable memory storing executable instructions that, when executed by the one or more processors of the reconciliation platform, cause the reconciliation platform to: receive the measured surface temperature data for the one or more tubes inside the furnace; and perform a heuristic analysis against the measured surface temperature data and performance process model results from the process model.

[0096] Without further elaboration, it is believed that using the preceding description that one skilled in the art may utilize the present disclosure to its fullest extent and easily ascertain the essential characteristics of this disclosure, without departing from the spirit and scope thereof, to make various changes and modifications of the disclosure and to adapt it to various usages and conditions. The preceding embodiments are, therefore, to be construed as merely illustrative, and not limiting the remainder of the disclosure in any way whatsoever, and that it is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims.

[0097] In the foregoing, all temperatures are set forth in degrees Celsius and, all parts and percentages are by weight, unless otherwise indicated.

CLAIMS

What is claimed is:

1. A method for enhancing operational efficiency of a chemical plant, the method comprising:

receiving, by a computing device and from one or more thermocouples affixed to one or more tubes inside a furnace of a chemical plant, measured surface temperature data for the one or more tubes inside the furnace;

providing, by the computing device, the measured surface temperature data to a database configured to store the measured surface temperature data;

analyzing, by the computing device, the measured surface temperature data for completeness by identifying gaps in the measured surface temperature data based on a measurement interval;

correcting, by the computing device, the measured surface temperature data for overall mass balance closure;

generating, by the computing device, reconciled surface temperature data;

using, by the computing device, the measured surface temperature data to determine whether an upset occurred;

determining, by the computing device, a model fitting parameter for a process model for the chemical plant based on the reconciled surface temperature data;

adjusting, by the computing device, a cut point of the chemical plant or a tray efficiency of the chemical plant to minimize differences between measured performance of the chemical plant and predicted performance of the chemical plant;

optimizing, by the computing device, the process model using the model fitting parameter for the process model for the chemical plant;

determining, by the computing device, a maximum capacity of the furnace based on the measured surface temperature data for the one or more tubes inside the furnace;

using, by the computing device, a design of a device of the chemical plant to calculate a fraction of an available capacity of the device of the chemical plant that is currently being used;

generating, by the computing device and for interactive display, one or more detail screens relating the reconciled surface temperature data to operational performance of the one or more tubes inside the furnace;

sending, by the computing device, a report showing actual performance of the chemical plant compared to predicted performance of the chemical plant;

providing, by the computing device, alternatives for improving or modifying future operations of the chemical plant, the alternatives comprising operational changes and revamp modifications to generate improved performance of the chemical plant; and

recommending, by the computing device, target operational parameters of a final product of the chemical plant.

2. The method of claim 1, comprising:

using a partial least squares (PLS) analysis or an orthogonal PLS (OPLS) analysis to generate a trustworthiness score of the process model for the chemical plant based on a comparison between the operational parameters related to the process of the chemical plant.

3. The method of claim 2, comprising:

creating a scoring model that is used for generating the trustworthiness score of the process model.

4. The method of claim 3, comprising:

weighting the trustworthiness score using one or more factors and based on a difference between the operational parameters related to the process of the chemical plant and corresponding one or more threshold values, wherein the one or more factors comprise an accuracy of a primary measuring sensor or an age of a measurement.

5. The method of claim 4, comprising:

updating the scoring model with the weighted trustworthiness score; and
adjusting the process model for the chemical plant based on the scoring model.

6. The method of claim 1, comprising:

creating, by the computing device, a scoring model; and
using the scoring model to generate, by the computing device, a trustworthiness score of the process model for the chemical plant based on a comparison between operational parameters related to a process of the chemical plant.

7. The method of claim 6, comprising:
 - weighting, by the computing device, the trustworthiness score using one or more factors and based on a difference between the operational parameters related to the process of the chemical plant and corresponding one or more threshold values, the one or more factors comprising an age of a measurement;
 - updating, by the computing device, the scoring model with the weighted trustworthiness score; and
 - adjusting, by the computing device, the process model for the chemical plant based on the scoring model.
8. The method of any of claims 1-7, comprising:
 - performing a heuristic analysis against the measured surface temperature data and performance process model results from the process model.
9. A computer program comprising instructions arranged such that when executed by one or more computers, the instructions cause the one or more computers to perform the method of any of claims 1-8.
10. A computer-readable medium storing the computer program according to claim 9.
11. A system for enhancing operation of a chemical plant, the system comprising:
 - a furnace comprising one or more tubes inside the furnace;
 - one or more thermocouples affixed to the one or more tubes inside the furnace;
 - a fractionation column;
 - a reboiler associated with the fractionation column;
 - a receiver associated with the fractionation column;
 - a feed exchanger associated with the fractionation column;
 - an interface platform comprising:
 - one or more processors of the interface platform;
 - a communication interface of the interface platform and in communication with the one or more thermocouples affixed to the one or more tubes inside the furnace; and

non-transitory computer-readable memory storing executable instructions that, when executed by the one or more processors of the interface platform, cause the interface platform to:

- receive, from the one or more thermocouples, measured surface temperature data for the one or more tubes inside the furnace; and

- provide the measured surface temperature data to a database configured to store the measured surface temperature data;

an optimization platform comprising:

- one or more processors of the optimization platform;

- a communication interface of the optimization platform and in communication with the interface platform; and

non-transitory computer-readable memory storing executable instructions that, when executed by the one or more processors of the optimization platform, cause the optimization platform to:

- receive, via the interface platform, the measured surface temperature data;

- analyze the measured surface temperature data for completeness by identifying gaps in the measured surface temperature data based on a measurement interval;

- correct the measured surface temperature data for overall mass balance closure;

- generate reconciled surface temperature data;

- use the measured surface temperature data to determine whether an upset occurred;

- determine a model fitting parameter for a process model for the chemical plant based on the reconciled surface temperature data;

- adjust a cut point of the chemical plant or a tray efficiency of the chemical plant to minimize differences between measured performance of the chemical plant and predicted performance of the chemical plant;

- optimize the process model using the model fitting parameter for the process model for the chemical plant;

- determine a maximum capacity of the furnace based on the measured surface temperature data for the one or more tubes inside the furnace; and

use a design of a device of the chemical plant to calculate a fraction of an available capacity of the device of the chemical plant that is currently being used;

an analysis platform comprising:

one or more processors of the analysis platform;

a communication interface of the analysis platform and in communication with the interface platform; and

non-transitory computer-readable memory storing executable instructions that, when executed by the one or more processors of the analysis platform, cause the analysis platform to:

receive historical performance data for the chemical plant;

establish relationships between operational parameters related to a process of the chemical plant;

analyze the historical performance data for the chemical plant as trends over time to identify key indicators of process problems for the process of the chemical plant;

determine target operational parameters of a final product of the chemical plant based on the historical performance data for the chemical plant; and

predict a limit of the process of the chemical plant based on the target operational parameters of the final product of the chemical plant; and

an interaction platform comprising:

one or more processors of the interaction platform;

a communication interface of the interaction platform and in communication with the interface platform; and

non-transitory computer-readable memory storing executable instructions that, when executed by the one or more processors of the interaction platform, cause the interaction platform to:

generate, for interactive display to a plant operator of the chemical plant, one or more detail screens relating the reconciled surface temperature data to operational performance of the one or more tubes inside the furnace;

send a report showing actual performance of the chemical plant compared to predicted performance of the chemical plant;

provide, to the plant operator of the chemical plant, alternatives for improving or modifying future operations of the chemical plant, the alternatives comprising operational changes and revamp modifications to generate improved performance of the chemical plant; and

recommend, to the plant operator of the chemical plant, the target operational parameters of the final product of the chemical plant.

12. The system of claim 11, comprising:

a prediction platform comprising:

one or more processors of the prediction platform;

a communication interface of the prediction platform and in communication with the interface platform; and

non-transitory computer-readable memory storing executable instructions that, when executed by the one or more processors of the prediction platform, cause the prediction platform to:

use a partial least squares (PLS) analysis or an orthogonal PLS (OPLS) analysis to generate a trustworthiness score of the process model for the chemical plant based on a comparison between the operational parameters related to the process of the chemical plant.

13. The system of claim 12, wherein the non-transitory computer-readable memory of the prediction platform stores further executable instructions that, when executed by the one or more processors of the prediction platform, cause the prediction platform to:

create a scoring model that is used for generating the trustworthiness score of the process model; and

weight the trustworthiness score using one or more factors and based on a difference between the operational parameters related to the process of the chemical plant and corresponding one or more threshold values, wherein the one or more factors comprise an accuracy of a primary measuring sensor or an age of a measurement.

14. The system of claim 13, wherein the non-transitory computer-readable memory of the prediction platform stores further executable instructions that, when executed by the one or more processors of the prediction platform, cause the prediction platform to:

update the scoring model with the weighted trustworthiness score; and

adjust the process model for the chemical plant based on the scoring model.

15. The system of claim 11, comprising:

a reconciliation platform comprising:

one or more processors of the reconciliation platform;

a communication interface of the reconciliation platform and in communication with the interface platform; and

non-transitory computer-readable memory storing executable instructions that, when executed by the one or more processors of the reconciliation platform, cause the reconciliation platform to:

receive the measured surface temperature data for the one or more tubes inside the furnace; and

perform a heuristic analysis against the measured surface temperature data and performance process model results from the process model.

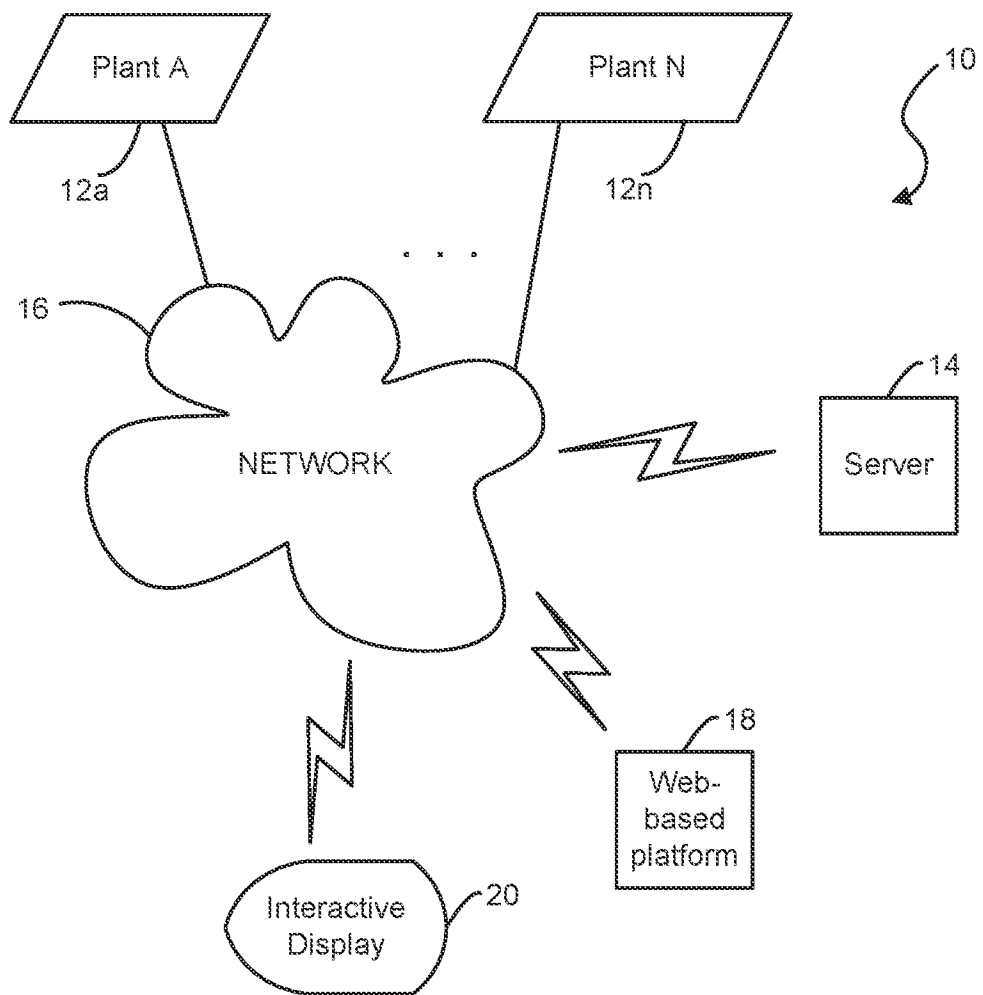


FIG. 1

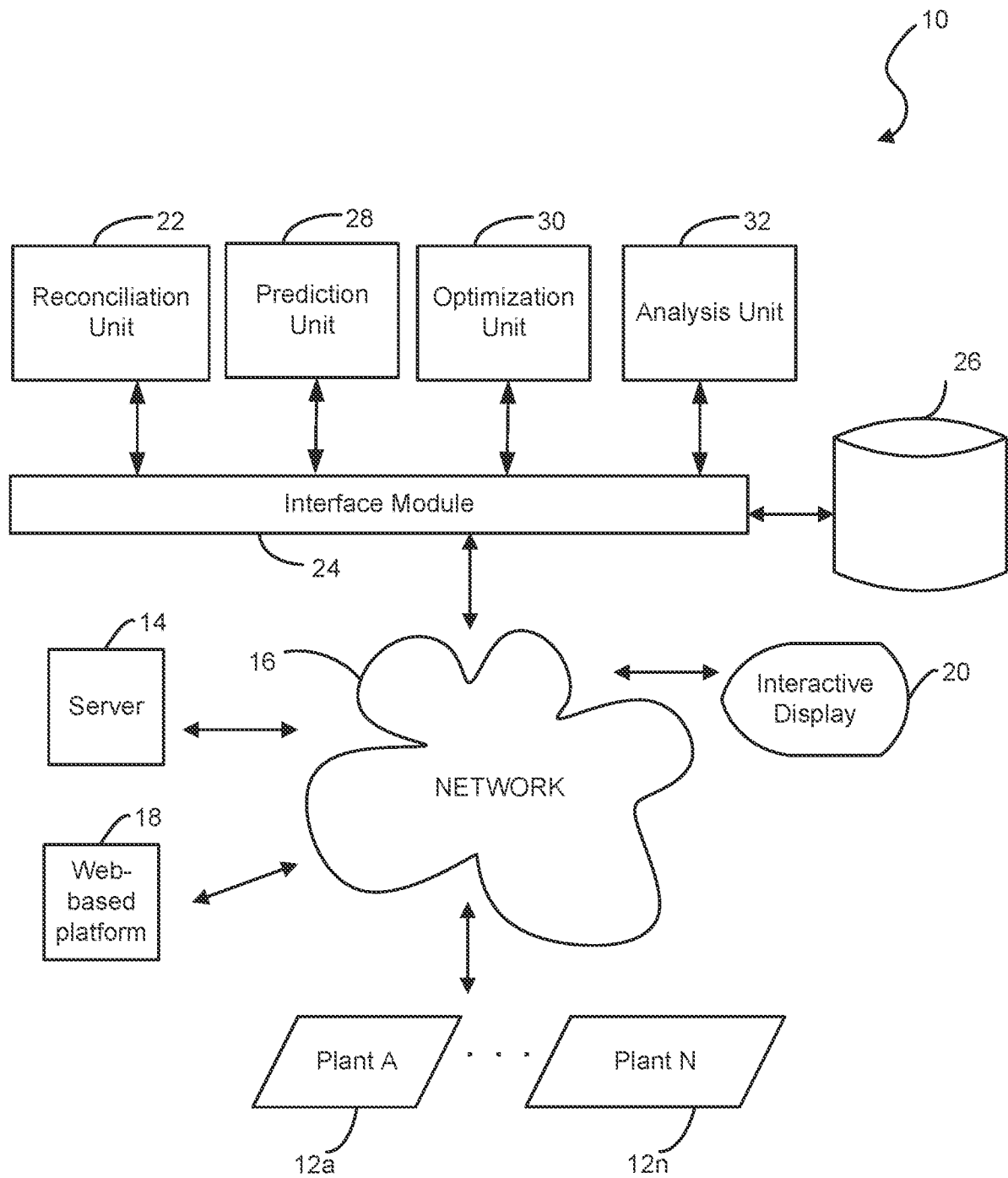


FIG. 2

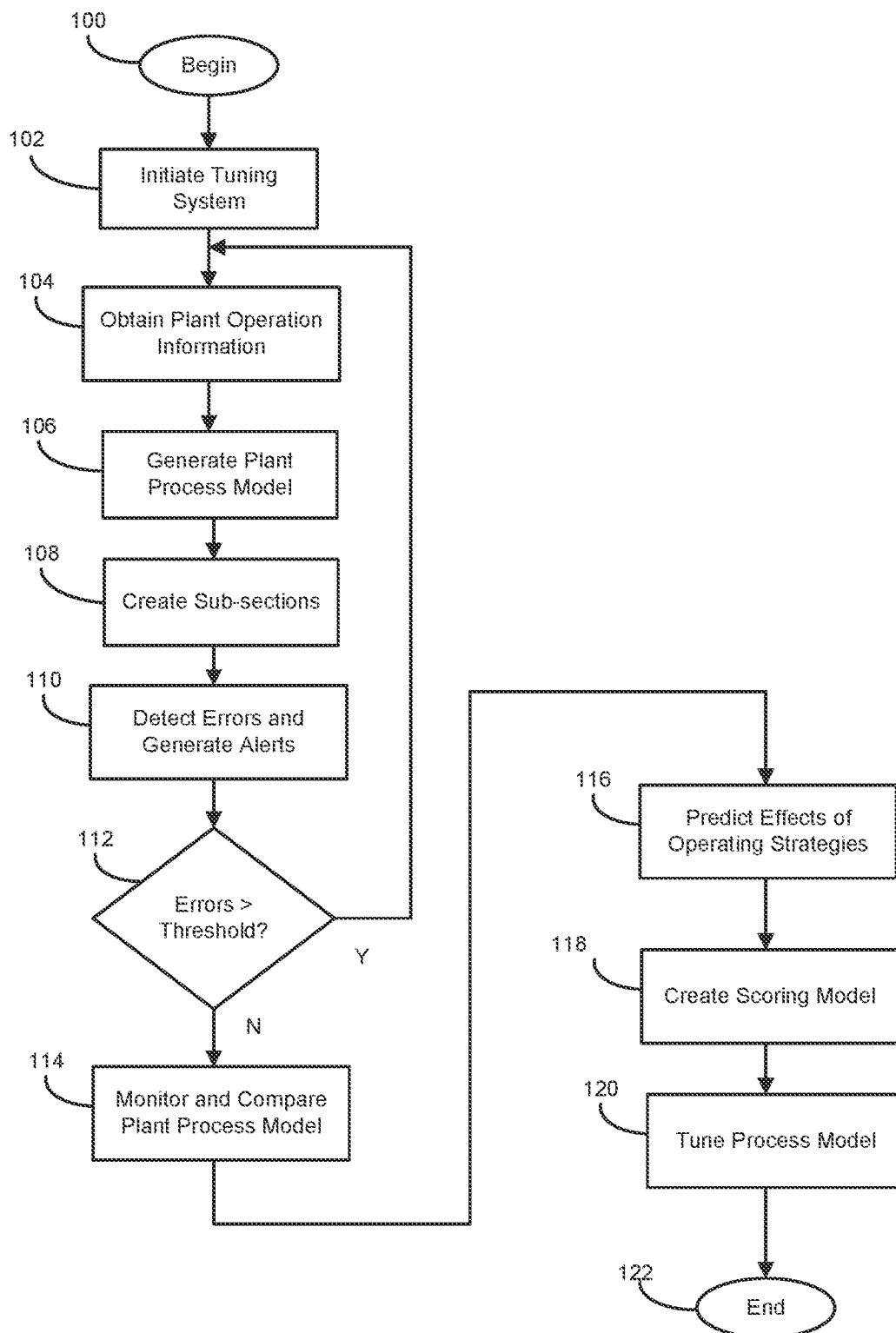


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2018/044601

A. CLASSIFICATION OF SUBJECT MATTER		
G05B 19/418 (2006.01) G06Q 10/04 (2012.01)		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
G05B 1/00-1/08, 11/00-11/60, 13/00-13/04, 19/00, 19/19-19/43, G06F 15/00, 15/16-15/82, 17/00, 17/17-17/20, 17/40-17/50, G06Q 10/040-10/08, 50/00, 50/04-50/06		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2016/0291584 A1 (UOP LLC) 06.10.2016, abstract, [0009], [0011]-[0014], [0016]-[0017], [0020]-[0021], [0024]-[0026], [0032]-[0068], [0070], [0073]-[0074], claims 1, 3, 7-8, 14, fig. 1-3	1-15
A	US 2002/0123864 A1 (EVREN ERYUREK et al.) 05.09.2002	1-15
A	US 6038540 (THE DOW CHEMICAL COMPANY) 14.03.2000	1-15
A	US 2006/0259163 A1 (SMITHS DETECTION INC.) 16.11.2006	1-15
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “E” earlier document but published on or after the international filing date “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) “O” document referring to an oral disclosure, use, exhibition or other means “P” document published prior to the international filing date but later than the priority date claimed “T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention “X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone “Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art “&” document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
05 October 2018 (05.10.2018)		18 October 2018 (18.10.2018)
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37		Authorized officer I. Meshkova Telephone No. 8 499 240 25 91