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(54) **INTEGRATED SMOKE MONITORING AND CONTROL SYSTEM FOR FLARING OPERATIONS**

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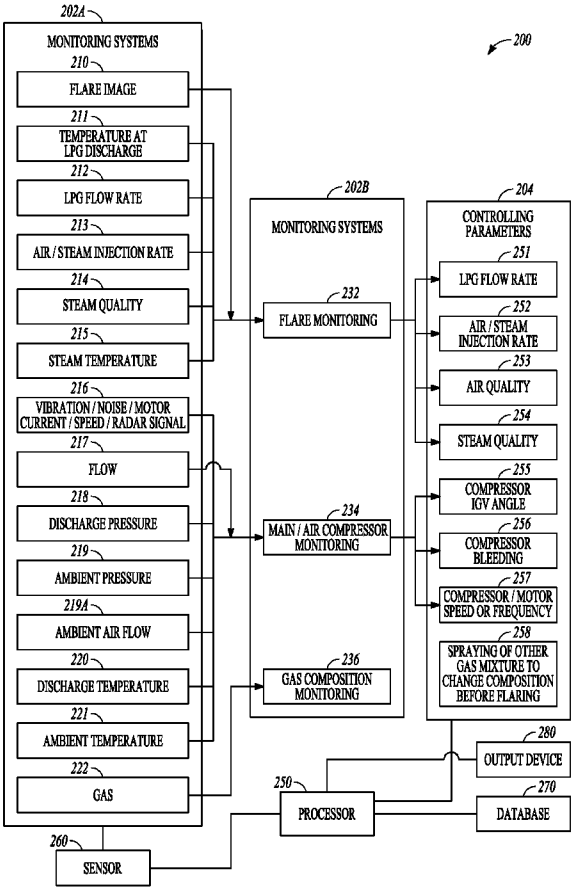
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(57) **ABSTRACT**

A flare monitoring and control system monitors parameters that affect the amount of smoke generated during a flaring operation. The system receives data relating to the parameters, and analyzes the data relating to the parameters. The system predicts an impending increase in the amount of smoke generated during the flaring operation, and varies a value of one or more parameters to prevent the impending increase in the amount of smoke generated during the flaring operation.



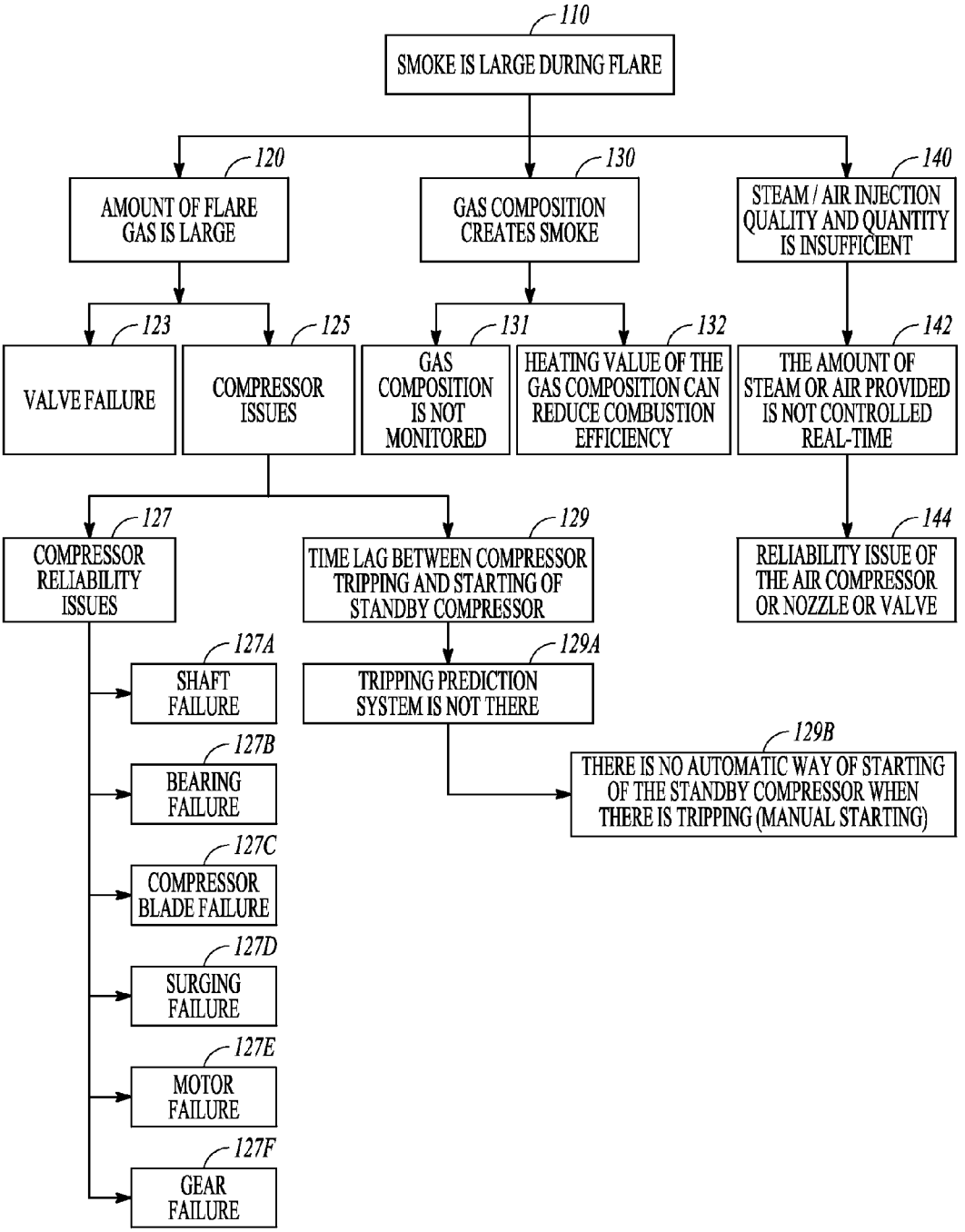

110
SMOKE IS LARGE DURING FLARE
120
AMOUNT OF FLARE GAS IS LARGE
130
GAS COMPOSITION CREATES SMOKE
140
STEAM / AIR INJECTION QUALITY AND QUANTITY IS INSUFFICIENT
123
VALVE FAILURE
125
COMPRESSOR ISSUES
131
GAS COMPOSITION IS NOT MONITORED
132
HEATING VALUE OF THE GAS COMPOSITION CAN REDUCE COMBUSTION EFFICIENCY
142
THE AMOUNT OF STEAM OR AIR PROVIDED IS NOT CONTROLLED REAL-TIME
127
COMPRESSOR RELIABILITY ISSUES
129
TIME LAG BETWEEN COMPRESSOR TRIPPING AND STARTING OF STANDBY COMPRESSOR
144
RELIABILITY ISSUE OF THE AIR COMPRESSOR OR NOZZLE OR VALVE
127A
SHAFT FAILURE
129A
TRIPPING PREDICTION SYSTEM IS NOT THERE
127B
BEARING FAILURE
129B
THERE IS NO AUTOMATIC WAY OF STARTING OF THE STANDBY COMPRESSOR WHEN THERE IS TRIPPING (MANUAL STARTING)
127C
COMPRESSOR BLADE FAILURE
127D
SURGING FAILURE
127E
MOTOR FAILURE
127F
GEAR FAILURE

FIG. 1

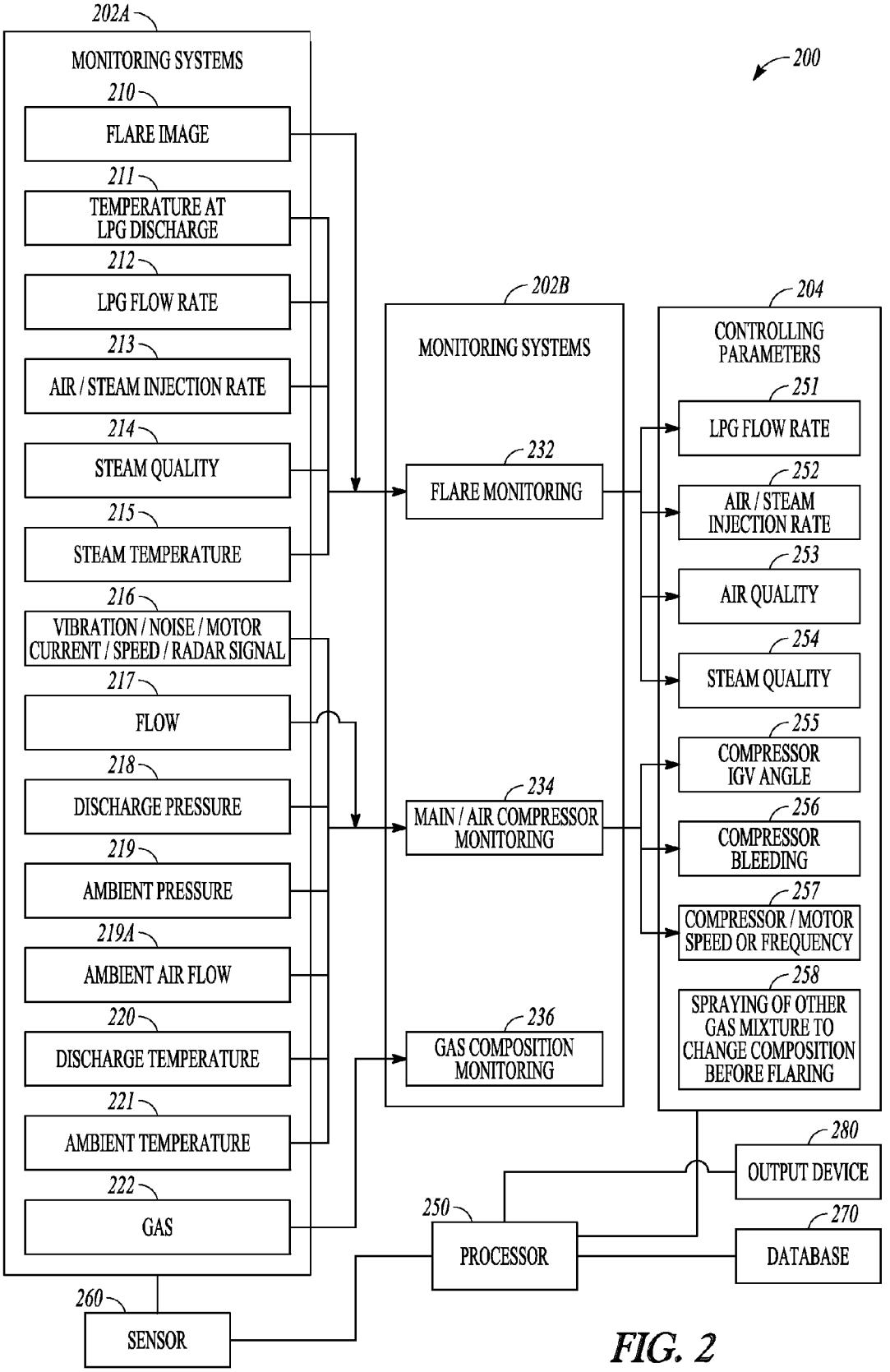

202A
MONITORING SYSTEMS
200
210
FLARE IMAGE
211
TEMPERATURE AT LPG DISCHARGE
212
LPG FLOW RATE
213
AIR / STEAM INJECTION RATE
214
STEAM QUALITY
215
STEAM TEMPERATURE
216
VIBRATION / NOISE / MOTOR CURRENT / SPEED / RADAR SIGNAL
217
FLOW
218
DISCHARGE PRESSURE
219
AMBIENT PRESSURE
219A
AMBIENT AIR FLOW
220
DISCHARGE TEMPERATURE
221
AMBIENT TEMPERATURE
222
GAS
260
SENSOR
202B
MONITORING SYSTEMS
232
FLARE MONITORING
234
MAIN / AIR COMPRESSOR MONITORING
236
GAS COMPOSITION MONITORING
204
CONTROLLING PARAMETERS
251
LPG FLOW RATE
252
AIR / STEAM INJECTION RATE
253
AIR QUALITY
254
STEAM QUALITY
255
COMPRESSOR IGV ANGLE
256
COMPRESSOR BLEEDING
257
COMPRESSOR / MOTOR SPEED OR FREQUENCY
258
SPRAYING OF OTHER GAS MIXTURE TO CHANGE COMPOSITION BEFORE FLARING
280
OUTPUT DEVICE
250
PROCESSOR
270
DATABASE

FIG. 2

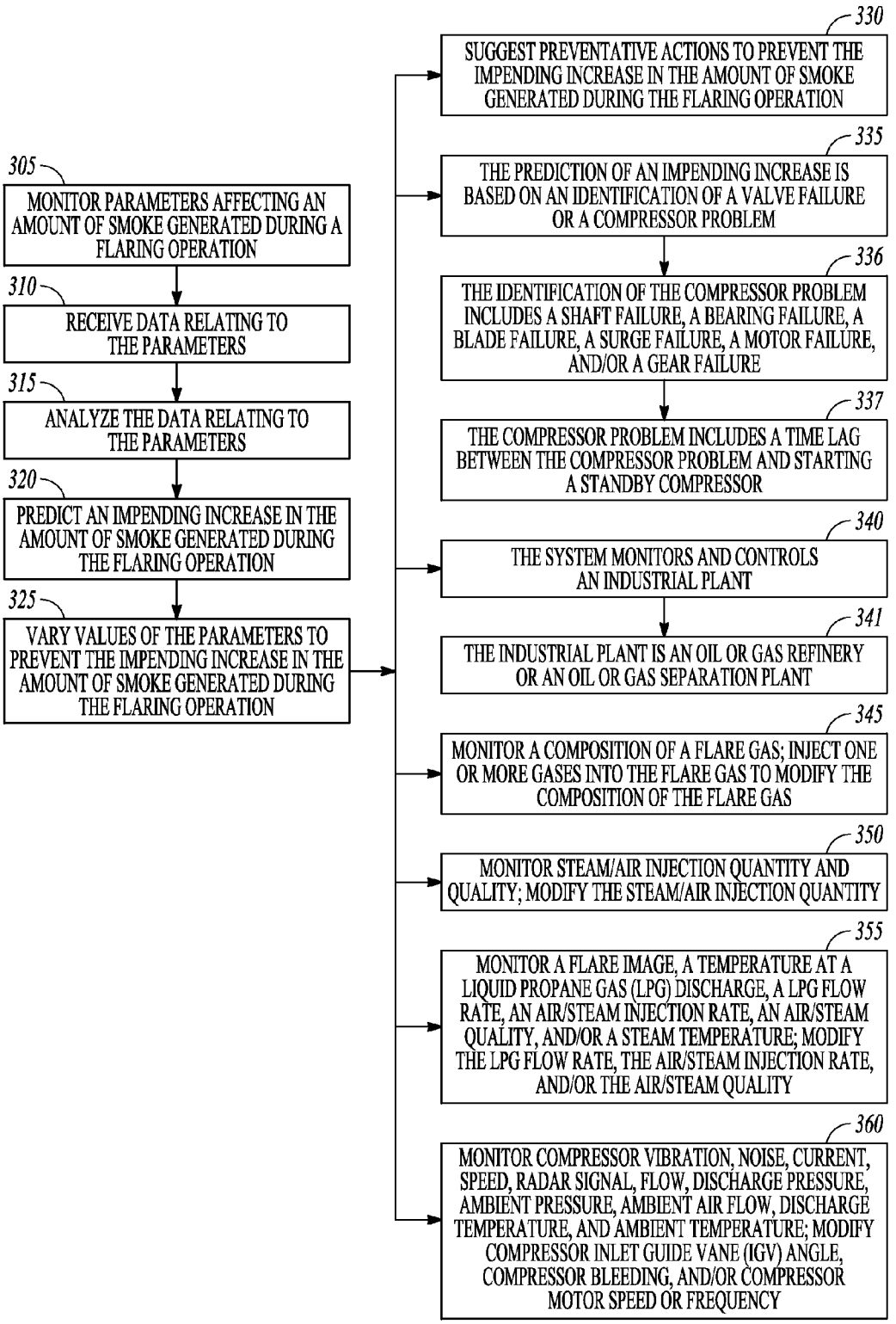

305
MONITOR PARAMETERS AFFECTING AN AMOUNT OF SMOKE GENERATED DURING A FLARING OPERATION
310
RECEIVE DATA RELATING TO THE PARAMETERS
315
ANALYZE THE DATA RELATING TO THE PARAMETERS
320
PREDICT AN IMPENDING INCREASE IN THE AMOUNT OF SMOKE GENERATED DURING THE FLARING OPERATION
325
VARY VALUES OF THE PARAMETERS TO PREVENT THE IMPENDING INCREASE IN THE AMOUNT OF SMOKE GENERATED DURING THE FLARING OPERATION
330
SUGGEST PREVENTATIVE ACTIONS TO PREVENT THE IMPENDING INCREASE IN THE AMOUNT OF SMOKE GENERATED DURING THE FLARING OPERATION
335
THE PREDICTION OF AN IMPENDING INCREASE IS BASED ON AN IDENTIFICATION OF A VALVE FAILURE OR A COMPRESSOR PROBLEM
336
THE IDENTIFICATION OF THE COMPRESSOR PROBLEM INCLUDES A SHAFT FAILURE, A BEARING FAILURE, A BLADE FAILURE, A SURGE FAILURE, A MOTOR FAILURE, AND/OR A GEAR FAILURE
337
THE COMPRESSOR PROBLEM INCLUDES A TIME LAG BETWEEN THE COMPRESSOR PROBLEM AND STARTING A STANDBY COMPRESSOR
340
THE SYSTEM MONITORS AND CONTROLS AN INDUSTRIAL PLANT
341
THE INDUSTRIAL PLANT IS AN OIL OR GAS REFINERY OR AN OIL OR GAS SEPARATION PLANT
345
MONITOR A COMPOSITION OF A FLARE GAS; INJECT ONE OR MORE GASES INTO THE FLARE GAS TO MODIFY THE COMPOSITION OF THE FLARE GAS
350
MONITOR STEAM/AIR INJECTION QUANTITY AND QUALITY; MODIFY THE STEAM/AIR INJECTION QUANTITY
355
MONITOR A FLARE IMAGE, A TEMPERATURE AT A LIQUID PROPANE GAS (LPG) DISCHARGE, A LPG FLOW RATE, AN AIR/STEAM INJECTION RATE, AN AIR/STEAM QUALITY, AND/OR A STEAM TEMPERATURE; MODIFY THE LPG FLOW RATE, THE AIR/STEAM INJECTION RATE, AND/OR THE AIR/STEAM QUALITY
360
MONITOR COMPRESSOR VIBRATION, NOISE, CURRENT, SPEED, RADAR SIGNAL, FLOW, DISCHARGE PRESSURE, AMBIENT PRESSURE, AMBIENT AIR FLOW, DISCHARGE TEMPERATURE, AND AMBIENT TEMPERATURE; MODIFY COMPRESSOR INLET GUIDE VANE (IGV) ANGLE, COMPRESSOR BLEEDING, AND/OR COMPRESSOR MOTOR SPEED OR FREQUENCY

FIG. 3

INTEGRATED SMOKE MONITORING AND CONTROL SYSTEM FOR FLARING OPERATIONS

TECHNICAL FIELD

[0001] The present disclosure relates to the monitoring and controlling of flaring operations in industrial plants.

BACKGROUND

[0002] A flare is a pressure safety relief device used to ensure that emergencies occurring in a plant (e.g., process upsets, compressor failures, etc.) do not compromise the safety and integrity of the plant. Such emergencies may require disposal of large volumes of hydrocarbons, and flaring is the best and practically the only option in these situations. Furthermore, at times, as part of a refining process, more fuel gas (e.g., propane, butane) is produced than needed by the plants. Flaring eliminates this excess process gas by burning it off rather than venting potentially damaging hydrocarbons to the atmosphere.

[0003] In industry today, as far as it is possible, flaring is avoided to prevent loss of valuable hydrocarbons as well as to minimize environmental damage. The flaring process introduces two major sources of pollution—smoke and noise. These two pollutants are strictly monitored by various environmental agencies, and there is an economical and societal need to reduce this significantly through improved monitoring and control.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** is a block diagram of a root cause analysis for smoke formation in a flaring operation.

[0005] FIG. **2** is a block diagram illustrating a monitoring system and various monitoring parameters for flare monitoring, compressor monitoring, and gas composition monitoring.

[0006] FIG. **3** is a flowchart of a monitoring and control system for a flaring operation in an industrial plant.

DETAILED DESCRIPTION

[0007] In the following description, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific embodiments which may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural, electrical, and optical changes may be made without departing from the scope of the present invention. The following description of example embodiments is, therefore, not to be taken in a limited sense, and the scope of the present invention is defined by the appended claims.

[0008] The present disclosure presents a comprehensive solution for monitoring and controlling flaring operations. A root cause analysis of various factors that necessitate flaring and the specific factors that cause extensive environmental damage is presented. An embodiment reduces the effects of the variables (or sub systems) that are responsible for flaring and pollution.

[0009] There are several issues that many industrial plants have to deal with today. One is the generation of heavy smoke during flaring operations. Because of this heavy smoke, many industrial plants are unable to meet strict environmental regulations. At least one cause of the heavy smoke is an ineffective smoke control system. Another issue is a lack of an automated monitoring solution for compressors, valves, etc. In an embodiment, compressors are monitored so as to prevent compressor failures, which will minimize flaring. Another issue is the lack of online gas composition estimation tools as part of the overall smoke control. In an embodiment, gas composition is monitored, and if the composition is detected as suboptimal (for good combustibility), an appropriate gas mixture is added. Another issue is the significant financial losses due to flaring and compressor problems.

[0010] In an embodiment, several modules can be integrated into a flare monitoring and control system. The system can include a monitoring module, relating to at least health monitoring and asset monitoring. The system can also include a machinery control system. The system can further include a field advisor that can monitor the performance of various process and equipment parameters.

[0011] In many industrial plants today, existing smoke control systems include steam injection. Such systems are automated, and the smoke detection is performed using infrared (IR) cameras. Some plants use air-assisted control. However, such control systems are not efficient for several reasons. One reason is that such systems do not take any inputs from other parts of the plant, for example, compressors, valves, etc. Also, for systems that use IR cameras, the control system takes input from the IR camera, which examines the flare (controller is tuned with a simple rule that large flares imply large smoke, and the converse), and releases an appropriate amount of steam. Such a control action is reactive in the sense that excess flaring or smoke is caused due to various processes/equipment behaving sub-optimally—and the smoke is the end result of complex failures in the plant or refinery. Also, the control system can react only after smoke detection. Consequently, there is a significant delay in control after the plant upsets, which usually renders control ineffective. Thus, there is a need for advanced monitoring techniques which can predict critical failures in industrial and refinery processes and equipment, and inform the control system of impending failures so that the control system can respond better.

[0012] Consequently, one or more goals of one or more embodiments include that the smoke that is generated during flaring should be reduced and/or eliminated, compressor reliability should be improved, and compressor tripping should be capable of prediction so that lag time (usually about thirty minutes to an hour) between the compressor tripping and a standby compressor starting should be reduced. Addressing the issues of compressor reliability and trip prediction will also help in reducing the smoke problem. Further, one or more embodiments include that the gas composition monitoring be made online and included in the overall smoke control loop.

[0013] A root cause analysis (with top-down approach) of smoke formation can be used to investigate the generation of smoke during flaring operations. The results of the root cause analysis can then be used to address the issues enumerated in the previous paragraph. FIG. **1** is a block diagram for a root cause analysis for smoke formation during a flaring operation.

[0014] Referring to FIG. **1**, the analysis begins at **110** with the premise that there is a good deal of smoke and indeed too much smoke during flaring operations. This large amount of smoke during flaring can be contributed to and/or caused by at least three major causes. First, at **120**, the amount of flare gas can be large. Of course, the more gas that there is to flare off,

then the more smoke will be generated. Second, at **130**, the composition of the particular gas that is being flared could create more or less smoke than other gases. Third, at **140**, in systems that use steam/air injection, the quantity and quality of the steam/air could be insufficient, thereby leading to unacceptable levels of smoke.

[0015] There are several reasons the amount of flare gas could be large at **120**. The large amount of flare gas could be the result of a valve failure as indicated at **123**, or it could be the result of issues with a compressor at **125**. The compressor issues at **125** could further be the result of compressor reliability issues at **127**, which in turn could be the result of a shaft failure (**127**A), a bearing failure (**127**B), a compressor blade failure (**127**C), a surging failure (**127**D), a motor failure (**127**E), and/or a gear failure (**127**F). The compressor issues at **125** could also be the result of a time lag between a compressor tripping and the starting of a standby compressor, as indicated at **129**. As illustrated at **129**A, this lag time could be because a tripping prediction system is not in place. Additionally, as indicated at **129**B, there may be no automatic way of starting the standby compressor when there is tripping. That is, the standby compressor must be manually started.

[0016] Regarding smoke creation from the gas composition at **130**, the gas composition may not be monitored as indicated at **131**, and the heating value of the gas could reduce combustion efficiency as indicated at **132**. Both the gas composition and heating value of the gas can contribute to increased smoke during flaring.

[0017] Finally, the quantity and quality of the steam/air in an injection system could be insufficient. As illustrated at **142**, the amount of steam or air that is provided may not be controlled in real time. Additionally, as indicated at **144**, there may be reliability issues with an air compressor, a nozzle, or a valve.

[0018] The root cause analysis of FIG. **1** shows that there are at least three reasons for (excessive) smoke formation. First, and more specifically, there will likely be excessive smoke formation when large volumes of flare gas are suddenly vented to the flare stack due to plant upsets. Second, the composition of the flare gas or its heating value affects the amount of smoke formation. Third, the availability of sufficient control of steam/air flow affects the amount of smoke formation.

[0019] There are three typical flows to the flare system. First, there are emergency flows. Examples of an emergency flow include pressure relief flows and emergency depressurization. Second, there are episodic flows. Examples of episodic flows include venting that is required for maintenance, and venting that is required for regeneration and shutdown/startup operations. Third, there are continuous flows. Examples of continuous flow are a sweep gas that is put through the flare system piping, and pressure relief valve leakages. In any of these typical flows to the flare system, the amount of flare gas that is vented depends on the extent of valve failures, compressor failures, and/or process upsets. For example, if during normal conditions the flare gas flows at 4-6 million cubic feet per minute (mmcfm), and the compressor trips, the flare gas flow can increase to 150 mmcfm. This increase can cause excessive flaring and result in smoke and noise formation.

[0020] Compressor tripping can happen because of various individual component failures. When a compressor does trip, a standby compressor is started. Thereafter, it can take 30-60 minutes to reach steady state operating conditions. During this 30-60 minute period, the flaring can become very large.

[0021] When the flare gas is comprised of individual gases with high molecular weight, the smoke becomes thicker and black. However, when the flare gas is comprised of gases of lower molecular weight, the smoke becomes white and thinner. For example, ethylene (molecular weight-**18** 28) produces lighter smoke compared to butadiene (molecular weight~54). Also, the gas composition changes the heating value of the gas, thereby affecting the combustion efficiency, resulting in higher levels of smoke creation. The steam quality with dryness factor and temperature can also affect the quality of the smoke.

[0022] The quantity and/or quality of steam or air plays an important role in the formation of the smoke. The failure of an air compressor or nozzle can cause excessive smoke formation.

[0023] An embodiment addresses the various factors that cause smoke and noise formation by integrating monitoring and control. In the monitoring part of the system, there are several parameters of interest. First, there is the reliability of the compressors. Compressor reliability is monitored by analyzing a compressor's vibration, noise, motor current, speed, performance parameters, etc. Second, there is the composition of the flare gas. There exist a few online techniques for detecting gas composition that are known to those of skill in the art. One technique uses an infrared (IR) sensor with appropriate filters for detecting spectral responses of various gases. In another embodiment, catalytic type combustible sensors are used. Laser gas detection systems are another option for gas sensing. Finally, solid state sensors can be used. Thus, there are a wide variety of options for online gas (composition) sensing in refineries and other industrial plants. Third, the monitoring involves monitoring steam quantity, steam quality, and air flow. Fourth, the monitoring involves flare and smoke monitoring. For smoke and/or flare detection, the two standard approaches include using an IR sensor and a normal charge-coupled device (CCD) sensor.

[0024] FIG. **2** illustrates a monitoring system **202**A, **202**B and controlling parameters **204** for a flaring operation system **200**. The monitoring system **202**A, **202**B includes flare monitoring **232**, compressor monitoring **234**, and gas composition monitoring **236**. Data that are input into the monitoring system **202**A, **202**B, and in particular the flare monitoring **232**, include flare images **210**, temperature at a liquid propane gas (LPG) discharge **211**, an LPG flowrate **212**, an air/steam injection rate **213**, a steam quality **214**, and a steam temperature **215**. Data that are input into the compressor monitoring **234** include vibration, noise, motor current, speed, and radar signal **216**, flow **217**, discharge pressure **218**, ambient pressure **219**, ambient air flow **219**A, discharge temperature **220**, and ambient temperature **221**. Gas data **222** are input into gas composition monitoring **236**.

[0025] Based upon the data input into the monitoring system (**210**-**222**), and in particular, the amount of smoke or flaring (**210**), the various controlling parameters (**251**-**258**) are activated so as to control the smoke or flare. For example, if the pilot flame is visible (a blue color when LPG is used) during zero or low flaring, then the LPG flow rate (**251**) could be adjusted based on the requirement. Otherwise, the temperature of the pilot flame (**211**) (measured via thermocouples) can also be used for controlling the LPG flow rate. Similarly, if there is a large amount of smoke, then the steam/air quality (**253**, **254**) and quantity (**252**) can be varied. The

quality of air (**253**) can be controlled by providing an appropriate amount of oxygen or any other gas. The composition of the gas can also be varied using similar methods (**258**). The compressor control systems can be surge controlling, where the flow has to be varied using bleeding (**256**) or varying inlet guide vane (IGV) angle (**255**) or changing speed (**257**). Therefore, an embodiment using the integrated controls of FIG. **2** is effective for tackling various types of and reasons for smoke.

[0026] As further illustrated in FIG. **2**, a computer processor **250** executes the monitoring and control functions. The processor **250** receives input data from the monitoring system **202**A via a sensor **260**, and outputs control signals that affect the controlling parameters **204**. The input data from the monitoring systems **202**A can be stored in a database **270** for future consideration and analysis, and the computer processor **250** can also output data, alarms, reports, and other information to output device **280**.

[0027] In summary, in the control system, the monitored variables described above (**210-222**) form the inputs to the control system. The control system executes the control of some compressor failure modes like surge, the control of the flare smoke and noise (using the air/steam control system (**252**, **253**, **254**)), and the control of steam/air quality (**253**, **254**). FIG. **2** is a centralized control structure. In another embodiment, the monitoring and control system is a distributed structure, wherein for example the compressor control is local to the compressor location.

[0028] FIG. **3** is a flowchart of an example process **300** for monitoring and controlling a flaring operation. FIG. **3** includes a number of process and feature blocks **305-360**. Though arranged serially in the example of FIG. **3**, other examples may reorder the blocks, omit one or more blocks, and/or execute two or more blocks in parallel using multiple processors or a single processor organized as two or more virtual machines or sub-processors. Moreover, still other examples can implement the blocks as one or more specific interconnected hardware or integrated circuit modules with related control and data signals communicated between and through the modules. Thus, any process flow is applicable to software, firmware, hardware, and hybrid implementations.

[0029] Referring to FIG. **3**, at **305**, a computer processor monitors parameters affecting an amount of smoke generated during a flaring operation. At **310**, data relating to the parameters are received into the computer processor. At **315**, the computer processor analyzes the data relating to the parameters. At **320**, the computer processor uses the data analysis to predict an impending increase in the amount of smoke generated during the flaring operation. At **325**, the computer processor varies a value of one or more parameters to prevent or decrease the impending increase in the amount of smoke generated during the flaring operation.

[0030] At **330**, the computer processor suggests preventative actions to eradicate or decrease the impending increase in the amount of smoke generated during the flaring operation. The computer processor may report to output device **280** that a liquid propane gas flow rate (**212**) is either too low or two high, which may decrease the efficiency of the plant, which in turn may increase the smoke generated during flaring.

[0031] At **335**, the prediction of an impending increase in the amount of smoke generated during the flaring operation is based on an identification of a valve failure or a compressor problem. As indicated at **336**, the identification of the compressor problem can include a shaft failure, a bearing failure, a blade failure, a surge failure, a motor failure, and/or a gear failure. Additionally, as indicated at **337**, the compressor problem can include a time lag between the compressor problem and starting a standby compressor. In an embodiment, this lag time issue can be addressed by configuring a computer processor to cause a standby compressor to start immediately or substantially immediately after the identification of the compressor problem.

[0032] As indicated at **340**, the flare monitoring and control system can monitor and control an industrial plant, and as indicated at **341**, the industrial plant can be an oil or gas refinery or an oil or gas separation plant.

[0033] Block **345** indicates that the monitoring of the parameters includes monitoring a composition of a flare gas, and that a computer processor causes an injection of one or more gases into the flare gas to modify the composition of the flare gas.

[0034] Block **350** indicates that the monitoring of the parameters includes monitoring steam/air injection quantity and quality, and that a computer processor causes a modifying of the steam/air injection quantity.

[0035] Block **355** indicates that the monitoring of the parameters includes a monitoring of a flare image, a temperature at a liquid propane gas (LPG) discharge, a LPG flow rate, an air/steam injection rate, an air/steam quality, and/or a steam temperature, and that the computer processor causes a modifying of one or more of the LPG flow rate, the air/steam injection rate, and the air/steam quality as a function of the monitoring.

[0036] Block **360** indicates that the monitoring of the parameters includes a monitoring of a compressor. Specifically, the monitoring of the compressor includes the monitoring of one or more of vibration, noise, current, speed, radar signal, flow, discharge pressure, ambient pressure, discharge temperature, and ambient temperature. The computer processor causes the modifying of one or more of a compressor inlet guide vane (IGV) angle, a compressor bleeding, and a compressor motor speed or frequency as a function of the monitoring.

[0037] It should be understood that there exist implementations of other variations and modifications of the invention and its various aspects, as may be readily apparent, for example, to those of ordinary skill in the art, and that the invention is not limited by specific embodiments described herein. Features and embodiments described above may be combined with each other in different combinations. It is therefore contemplated to cover any and all modifications, variations, combinations or equivalents that fall within the scope of the present invention.

[0038] The Abstract is provided to comply with 37 C.F.R. §1.72(b) and will allow the reader to quickly ascertain the nature and gist of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims.

[0039] In the foregoing description of the embodiments, various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting that the claimed embodiments have more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby

incorporated into the Description of the Embodiments, with each claim standing on its own as a separate example embodiment.

1. A flare monitoring and control system comprising:

a computer processor operable to:

monitor a plurality of parameters, the parameters affecting an amount of smoke generated during a flaring operation;

receive data relating to the plurality of parameters;

analyze the data relating to the plurality of parameters;

predict an impending increase in the amount of smoke generated during the flaring operation; and

vary a value of one or more parameters to prevent the impending increase in the amount of smoke generated during the flaring operation.

2. The flare monitoring and control system of claim **1**, wherein the computer processor is operable to suggest preventative actions to eradicate or decrease the impending increase in the amount of smoke generated during the flaring operation.

3. The flare monitoring and control system of claim **1**, wherein the prediction of the impending increase in the amount of smoke generated during the flaring operation is based on an identification of a valve failure, a compressor problem, or a suboptimal gas composition with respect to combustibility.

4. The flare monitoring and control system of claim **3**, wherein the identification of the compressor problem comprises one or more of a shaft failure, a bearing failure, a blade failure, a surge failure, a motor failure, and a gear failure.

5. The flare monitoring and control system of claim **4**, wherein the compressor problem comprises a time lag between the compressor problem and starting a standby compressor, and wherein the computer processor is configured to cause the standby compressor to start immediately after the identification of the compressor problem.

6. The flare monitoring and control system of claim **1**, wherein the system monitors and controls an industrial plant.

7. The flare monitoring and control system of claim **6**, wherein the industrial plant comprises an oil or gas refinery or an oil or gas separation plant.

8. The flare monitoring and control system of claim **1**, wherein the monitoring of the plurality of parameters comprises monitoring a composition of a flare gas, and wherein the computer processor is configured to inject one or more gases into the flare gas to modify the composition of the flare gas.

9. The flare monitoring and control system of claim **1**, wherein the monitoring of the plurality of parameters comprises monitoring steam/air injection quantity and quality, and wherein the computer processor is configured to modify the steam/air injection quantity.

10. The flare monitoring and control system of claim **1**, wherein the monitoring of the plurality of parameters comprises a first monitoring of a flare image, a temperature at a liquid propane gas (LPG) discharge, a LPG flow rate, an air/steam injection rate, an air/steam quality, and a steam temperature; and wherein the computer processor is configured to modify one or more of the LPG flow rate, the air/steam injection rate, and the air/steam quality as a function of the first monitoring.

11. The flare monitoring and control system of claim **1**, wherein the monitoring of the plurality of parameters comprises a second monitoring of a compressor; and wherein the second monitoring of the compressor involves one or more of vibration, noise, current, speed, radar signal, flow, discharge pressure, ambient pressure, discharge temperature, and ambient temperature; and wherein the computer processor is configured to modify one or more of a compressor inlet guide vane (IGV) angle, a compressor bleeding, and a compressor motor speed or frequency as a function of the second monitoring.

12. A flare monitoring and control process comprising:

monitoring a plurality of parameters, the parameters affecting an amount of smoke generated during a flaring operation;

receiving data relating to the plurality of parameters;

analyzing the data relating to the plurality of parameters;

predicting an impending increase in the amount of smoke generated during the flaring operation; and

varying a value of one or more parameters to prevent the impending increase in the amount of smoke generated during the flaring operation.

13. The flare monitoring and control process of claim **12**, comprising suggesting preventative actions to eradicate or decrease the impending increase in the amount of smoke generated during the flaring operation.

14. The flare monitoring and control process of claim **12**, wherein the predicting the impending increase in the amount of smoke generated during the flaring operation is based on an identification of a valve failure, a compressor problem, or a suboptimal gas composition with respect to combustibility; wherein the identification of the compressor problem comprises one or more of a shaft failure, a bearing failure, a blade failure, a surge failure, a motor failure, and a gear failure; and wherein the compressor problem comprises a time lag between the compressor problem and starting a standby compressor, and wherein the computer processor is configured to cause the standby compressor to start immediately after the identification of the compressor problem.

15. The flare monitoring and control process of claim **12**, comprising monitoring and controlling an industrial plant; wherein the industrial plant comprises an oil or gas refinery or an oil or gas separation plant.

16. The flare monitoring and control process of claim **12**, wherein the monitoring of the plurality of parameters comprises monitoring a composition of a flare gas, and comprising injecting one or more gases into the flare gas to modify the composition of the flare gas.

17. A computer readable medium comprising instructions to execute a flare monitoring and control process comprising:

monitoring a plurality of parameters, the parameters affecting an amount of smoke generated during a flaring operation;

receiving data relating to the plurality of parameters;

analyzing the data relating to the plurality of parameters;

predicting an impending increase in the amount of smoke generated during the flaring operation; and

varying a value of one or more parameters to prevent the impending increase in the amount of smoke generated during the flaring operation.

18. The computer readable medium of claim **17**, comprising monitoring steam/air injection quantity and quality; and modifying the steam/air injection quantity.

19. The computer readable medium of claim **17**, wherein the monitoring of the plurality of parameters comprises a first monitoring of a flare image, a temperature at a liquid propane gas (LPG) discharge, a LPG flow rate, an air/steam injection

rate, an air/steam quality, and a steam temperature; and modifying one or more of the LPG flow rate, the air/steam injection rate, and the air/steam quality as a function of the first monitoring.

20. The computer readable medium of claim **17**, wherein the monitoring of the plurality of parameters comprises a second monitoring of a compressor; and wherein the second monitoring of the compressor involves one or more of vibration, noise, current, speed, radar signal, flow, discharge pressure, ambient pressure, discharge temperature, and ambient temperature; and modifying one or more of a compressor inlet guide vane (IGV) angle, a compressor bleeding, and a compressor motor speed or frequency as a function of the second monitoring.

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