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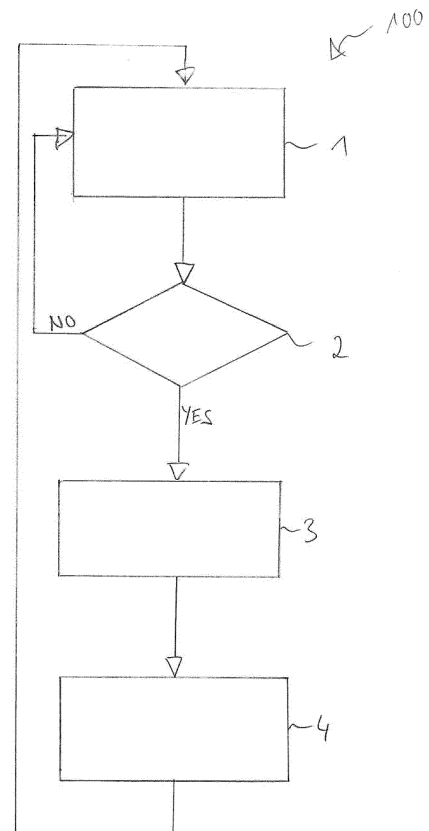
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(54) **DETECTION OF COMBUSTION CHAMBER DYNAMICS IN TURBINE SYSTEMS**

(57) Combustion chamber dynamics in a turbine system are detected by obtaining (1) pilot flow measurement values from at least one fuel pilot flow sensor and pressure band measurement values from at least one pressure sensor in at least two distinct pressure bands, checking (2) the pilot flow measurement values against a first criterion and the pressure band measurement values against a second criterion, and detecting (3) combustion chamber dynamics and outputting (4) a warning or an alert if both the pilot flow measurement values and the pressure band measurement values match their respective criteria. The method may rely on measurement data that are already provided by any turbine system (for use in corresponding control systems) and can thus be carried out without the need for any additional measurement hardware or other modifications of the turbine system itself. It provides a simple heuristic method which can automatically recognize and report the HPCCD failures. It is simple in formulation and can easily be understood by any engineer. It is also simple in computation, therefore it can be realized in any modern monitoring system. It enhances the current methods realized in the control systems and can report both early HPCCD warnings as well as critical HPCCD failures. Furthermore, it can be done uniformly for a whole turbine fleet.

**FIG 1**



**Description**

**[0001]** The present invention relates to the field of monitoring and failure detection in turbine systems, in particular detection of combustion chamber dynamics failures in gas turbine systems.

**[0002]** Any gas turbine is instrumented with a large number of sensors which register the most important physical control parameters, e.g., gas flow, pilot split flow and flame pressure frequency bands. The lean main flame is stabilized by a rich and hot pilot flame receiving the pilot split flow.

**[0003]** Using the turbine data, i.e., the parameter values and the events from the control system, a service engineer monitors the turbine performance. So, in handling a turbine trip (abnormal turbine shutdown), his primal task is to figure out the failure mode (e.g., combustion chamber dynamics), then eliminate the root-cause (e.g., gas/liquid properties, split flow settings or fuel/air ratios) and start the turbine again as soon as possible (e.g., minimizing the outage hours).

**[0004]** Combustion dynamics refers to the combustion process inside the combustion can and liner of the gas turbine. When fuel is burned, there is a pressure increase, and depending on the design of the combustor, the fuel nozzles, the liner, etc., the combustion process can be smooth or it can be subject to pressure oscillations or pulsations. These oscillations or pulsations, if not minimized, can lead to premature failure of combustion components as well as unstable flame.

**[0005]** The High Pressure Combustion Chamber Dynamics (HPCCD) is one of the most frequent failures. If there is a turbine trip (i.e., an abnormal turbine shutdown), the monitoring engineer always checks whether a HPCCD failure is detected. In many cases, turbines are equipped with a dedicated device which indirectly measures the pressure in the burning chamber, performs the Fast Fourier Transform (FFT) and reports the pressure values in either 3 or 4 bands (e.g., in psi units).

**[0006]** In order to determine a HPCCD failure, the engineer may proceed in two ways:

1. He can examine the graph of pressure bands to see whether there are some "sudden jumps".
2. He can check the sequence of events from the control system written right before the turbine trip to see whether there is an event indicating the "HPCCD failure".

**[0007]** However, the monitoring engineer is typically responsible for a number of turbines, such as 20 turbines or more. These turbines can be from different vendors, i.e., there may be different "event text" messages meaning the "HPCCD failure". Furthermore, the control system may either not report HPCCD failures in general or recognize HPCCD failures too late, e.g., when the turbine is already tripped due to significant vibrations.

**[0008]** Most control systems use two simple rules:

1. Issue a warning if any band value exceeds 1.0 psi;
2. Issue a critical alert if any band value exceeds 1.4 psi.

**[0009]** Typically, the engineer can decide to shutdown the turbine if too many warnings or some critical alerts are issued. In the latter case, some turbine control systems may decide to shutdown the turbine in an automatic way.

**[0010]** There is a need for improving the automatic recognition and reporting of HPCCD failures.

**[0011]** This need may be met by the subject matter according to the independent claims. Advantageous embodiments of the present invention are described by the dependent claims.

**[0012]** According to a first aspect of the invention there is provided a method of detecting combustion chamber dynamics in a turbine system. The method comprises (a) obtaining pilot flow measurement values from at least one fuel pilot flow sensor and pressure band measurement values from at least one pressure sensor in at least two distinct pressure bands, (b) checking the pilot flow measurement values against a first criterion and the pressure band measurement values against a second criterion, and (c) detecting combustion chamber dynamics and outputting a warning or an alert if both the pilot flow measurement values and the pressure band measurement values match their respective criteria.

**[0013]** The following explanations and advantages do not necessarily refer to the first aspect of the invention as claimed in claim 1. They may rather refer to specific embodiments of the invention and therefore do not limit the scope of claim 1.

**[0014]** The method may rely on measurement data that are already provided by any turbine system (for use in corresponding control systems) and can thus be carried out without the need for any additional measurement hardware or other modifications of the turbine system itself.

**[0015]** The steps (a), (b) and (c) of the method may be performed by one or more processors such as a microprocessors and/or microcontrollers or any other electric or electronic circuit or application-specific integrated circuit.

**[0016]** During operation of the turbine system, individual measurement values from the fuel pilot flow sensor and the pressure sensor can be obtained. That is, individual series of measurement values (e.g. with a predetermined sampling interval, such as 1s, 2s, 5s, 10s, 15s, 20s, 30s, or 60s) can be obtained for the fuel pilot flow sensor and for each pressure band of the pressure sensor.

**[0017]** The method provides a simple heuristic method which can automatically recognize and report the HPCCD failures. The method and device are simple in formu-

lation and can easily be understood by any engineer. The method is also simple in computation, therefore it can be realized in any modern monitoring system. It enhances the current methods realized in the control systems and can report both early HPCCD warnings as well as critical HPCCD failures. Furthermore, it can be done uniformly for a whole turbine fleet.

**[0018]** According to an embodiment of the invention, the method further comprises checking the pilot flow measurement values against the first criterion by calculating a standard deviation of the pilot flow measurement values in a first time interval, the first criterion being fulfilled if the standard deviation remains below a first threshold for a first time period; and checking the pressure band measurement values against the second criterion by calculating standard deviation values for each of the pressure band measurement values in a second time interval and a maximum value as the maximum of the standard deviation values, the second criterion being fulfilled if the maximum value exceeds a second threshold during the first time period.

**[0019]** This embodiment provides a simple heuristic method based on the standard deviation function. The first time interval, the second time interval and the first time period may in particular constitute so-called moving windows in the sense that the method is performed at regular intervals (for example every minute or every 5 minutes) and that the last x minutes of measurement values preceding the time of performing the method are used.

**[0020]** According to an embodiment of the invention, the method further comprises checking the pilot flow measurement values against the first criterion by verifying that the pilot flow measurement values are larger than zero for a first time period, and checking the pressure band measurement values against the second criterion by calculating a maximum value as the maximum of the pressure band measurement values at any given point in time, the second criterion being fulfilled if the maximum value constantly exceeds a second threshold during a second time period.

**[0021]** This embodiment provides a simple heuristic method based on the maximum function. The first time period and the second time period may in particular constitute so-called moving windows in the sense that the method is performed at regular intervals (for example every minute or every 5 minutes) and that the last x minutes of measurement values preceding the time of performing the method are used.

**[0022]** According to an embodiment of the invention, the method further comprises checking the pilot flow measurement values against the first criterion by verifying that the pilot flow measurement values are larger than zero for a first time period, and checking the pressure band measurement values against the second criterion by calculating a maximum value as the maximum of the pressure band measurement values at any given point in time, the second criterion being fulfilled if the maximum

value exceeds a second threshold at least once during the first time period.

**[0023]** This embodiment provides a simple heuristic method based on the maximum function.

**[0024]** According to an embodiment of the invention, the method further comprises detecting combustion chamber dynamics and outputting a warning if the pilot flow measurement values and the pressure band measurement values match the criteria according to claim 2, in particular with the first time interval being between 5 and 15 minutes, in particular 10 minutes, the first threshold being between 30 % and 70 %, in particular 50 %, the first time period being between 15 and 45 minutes, in particular 30 minutes, the second time interval being between 2 and 10 minutes, in particular 5 minutes, and the second threshold being between 0.1 and 0.5 psi, in particular 0.2 psi.

**[0025]** This embodiment provides a simple heuristic method based on empiric time intervals, i.e., 30 and 10 minutes, and empiric pressure and pilot values. The latter can also be tuned up for a particular turbine type.

**[0026]** According to an embodiment of the invention, the method further comprises detecting combustion chamber dynamics and outputting a warning if the pilot flow measurement values and the pressure band measurement values match the criteria according to claim 3, in particular with the first time period being between 15 and 60 minutes, in particular 30 minutes, the second threshold being between 0.5 and 0.9 psi, in particular 0.8 psi, and the second time period being between 5 and 15 minutes, in particular 10 minutes.

**[0027]** This embodiment provides a simple heuristic method based on empiric time intervals, i.e., 30 and 10 minutes, and empiric pressure values, i.e. 0.8 psi. The latter can also be tuned up for a particular turbine type.

**[0028]** According to an embodiment of the invention, the method further comprises detecting combustion chamber dynamics and outputting a warning if the pilot flow measurement values and the pressure band measurement values match the criteria according to claim 4, in particular with the first time period being between 15 and 60 minutes, in particular 30 minutes, and the second threshold being 1.0 psi.

**[0029]** This embodiment provides a simple heuristic method based on empiric time intervals, i.e., 30 minutes, and empiric pressure values, i.e. 1.0 psi. The latter can also be tuned up for a particular turbine type.

**[0030]** According to an embodiment of the invention, the method further comprises detecting combustion chamber dynamics and outputting an alert if the pilot flow measurement values and the pressure band measurement values match the criteria according to claim 4, in particular with the first time period being between 15 and 60 minutes, in particular 30 minutes, and the second threshold being 1.4 psi.

**[0031]** This embodiment provides a simple heuristic method based on empiric time intervals, i.e., 30 minutes, and empiric pressure values, i.e. 1.4 psi. The latter can

also be tuned up for a particular turbine type.

**[0032]** According to a second aspect of the invention, a device for detecting combustion chamber dynamics in a turbine system is provided. The device comprises (a) a unit for obtaining individual pilot flow measurement values from at least one fuel pilot flow sensor, (b) a unit for obtaining individual pressure band measurement values from at least one pressure sensor in at least two distinct pressure bands, (c) a unit for checking the pilot flow measurement values against a first criterion, (d) a unit for checking the pressure band measurement values against a second criterion, and (e) a unit for detecting combustion chamber dynamics and outputting a warning or an alert if both the pilot flow measurement values and the pressure band measurement values match their respective criteria.

**[0033]** The second aspect of the invention is based on the same idea as the first aspect described above and provides a device capable of performing the methods according to the first aspect and the above embodiments thereof. A single unit may represent several or all of the units (a) to (e). The units may be one or more processors such as a microprocessors and/or microcontrollers or any other electric or electronic circuit or application-specific integrated circuit.

**[0034]** According to a third aspect of the invention, there is provided a system for monitoring a plurality of turbine systems, each turbine system comprising at least one fuel pilot flow sensor and at least one pressure sensor, the monitoring system comprising (a) a communication unit for receiving measurement values from the fuel pilot flow sensor and pressure sensor of each turbine system, (b) a storage unit for storing the received measurement values, and (c) a processing unit for performing the method according to the first aspect of the invention on the stored data for each turbine system.

**[0035]** The third aspect of the invention is based on the idea that the simple method of detecting combustion chamber dynamics according to the first aspect may be used in a system for monitoring several turbine systems.

**[0036]** The measurement values from each of the turbine systems are received via a communication unit (e.g. a communication network) and stored in a storage unit for processing by a processing unit.

**[0037]** The processing unit may be one or more processors such as a microprocessors and/or microcontrollers or any other electric or electronic circuit or application-specific integrated circuit.

**[0038]** It is noted that the system according to the third aspect of the invention may be implemented at a plant with several turbine systems or at a remote location. In both cases, it may collect measurement data from several plants.

**[0039]** According to an embodiment of the invention, the system further comprises a notification unit transmitting a notification message to an operator of a turbine system if the processing unit has detected combustion chamber dynamics in the turbine system.

**[0040]** In this embodiment of the invention, the notification unit transmits a notification message to the operator of the relevant turbine system in case of combustion chamber dynamics, such that the operator can take the necessary action.

**[0041]** Preferably, the notification message may contain various information, such as a turbine ID, a pressure sensor ID, the time of detecting the error, etc.

**[0042]** According to a fourth aspect of the invention, there is provided a computer program comprising computer executable instructions, which, when executed by a processor, causes the processor to perform the steps of the method according to the first aspect or any of the above embodiments.

**[0043]** The computer program may be installed on a suitable computer system to enable performance of the methods described above.

**[0044]** According to a fifth aspect of the invention, there is provided a computer readable data carrier loaded with the computer program according to the fourth aspect.

**[0045]** It is noted that embodiments of the invention have been described with reference to different subject matters. In particular, some embodiments have been described with reference to method type claims whereas other embodiments have been described with reference to apparatus type claims. However, a person skilled in the art will gather from the above and the following description that, unless otherwise indicated, in addition to any combination of features belonging to one type of subject matter also any combination of features relating to different subject matters, in particular to combinations of features of the method type claims and features of the apparatus type claims, is part of the disclosure of this document.

**[0046]** The aspects defined above and further aspects of the present invention are apparent from the examples of embodiments to be described hereinafter and are explained with reference to the examples of embodiments. The invention will be described in more detail hereinafter with reference to examples of embodiments. However, it is explicitly noted that the invention is not limited to the described exemplary embodiments.

Figure 1 shows a flowchart of a method according to an embodiment of the invention.

Figure 2 shows a block diagram of a monitoring system according to an embodiment of the invention.

**[0047]** The illustration in the drawing is schematic. It is noted that in different figures, similar or identical elements are provided with the same reference numerals.

**[0048]** Figure 1 shows a flowchart of a method 100 of detecting combustion chamber dynamics in a turbine system according to an embodiment of the invention. More specifically, the turbine system, i.e. a gas turbine, comprises at least one fuel pilot flow sensor and at least one pressure sensor, the latter providing individual meas-

urement values in at least two distinct pressure bands.

**[0049]** The fuel pilot flow sensor may be a sensor measuring the opening of a valve for the fuel pilot flow in percent. It may also be a virtual sensor using the current control setpoint for that valve as its virtual measurement value. Furthermore, the valve may be splitting fuel between pilot and main. In that case, the fuel pilot flow sensor measures the percentage of fuel being delivered to the pilot.

**[0050]** The pressure sensor can give a signal based on a change in pressure on its surface using acoustic dynamics pressure tapping. The pressure tapping can be taken in the combustion cans and/or the centre casing. Usually, the pressure sensor measures dynamics in three to four pressure bands. The frequency ranges of the pressure bands depend on the specific turbine type. For example, a first pressure band may be in the range of 20-55 Hz, a second pressure band in the range of 140-200 Hz, and a third pressure band in the range of 280-405 Hz. The method may be using two, three, four or more pressure bands.

**[0051]** The method 100 begins at step 1 where individual pilot flow measurement values as well as individual pressure band measurement values in at least two distinct pressure bands are obtained from the respective sensors.

**[0052]** The measurement values from each sensor typically have the form of a series of measurement values (or samples) separated in time by a predetermined amount, such as 1 second or 1 minute.

**[0053]** At step 2, it is determined whether pilot flow measurement values match a first criterion and whether the pressure band measurement values match a second criterion.

**[0054]** If the pilot flow measurement values and the pressure band measurement values do not both match their respective criteria, the turbine is deemed to be working without combustion chamber dynamics and the method 100 returns to step 1.

**[0055]** On the other hand, if both the pilot flow measurement values and the pressure band measurement values match their respective criteria, combustion chamber dynamics are detected in step 3 and the method 100 proceeds to step 4, where measures are taken to notify the operator of the turbine system of the combustion chamber dynamics, e.g. by activating an alarm, sending a message, or in any other suitable manner. Thereafter, the method returns to step 1.

**[0056]** In the following, five specific embodiments for the method 100 are described in detail.

**[0057]** Let  $\#PILOT$  denote the pilot flow measurement values and  $\#BAND1$ ,  $\#BAND2$ ,  $\#BAND3$  the individual pressure band measurement values obtained in three distinct pressure bands.

**[0058]** Let  $sd(X, T_m)$  denote the standard deviation of sensor value "X" sampled in a T-minute time interval. Let  $\max(X_1, X_2, \dots, X_k)$  denote the maximum of  $X_1, X_2, \dots, X_k$ .

**[0059]** According to a first embodiment, a warning "Warning: unstable CCD" is issued

if  $sd(\#PILOT, 10m) < 50 \%$

holds true for a duration at least 30 minutes and

5  $\max(sd(\#BAND1, 5m), sd(\#BAND2, 5m), sd(\#BAND3, 5m)) > 0.2$

holds true at least once.

**[0060]** In other words, the first embodiment checks for a condition when the fuel pilot flow is stable for at least 10 minutes whilst the pressure in any of the bands gets unstable.

**[0061]** According to a second embodiment, a warning "Warning: HPCCD Level 0.8 psi for 10 min" is issued

10 if  $\#PILOT > 0$  holds true for a duration at least 30 minutes and

15  $\max(\#BAND1, \#BAND2, \#BAND3) > 0.8$  holds true for a duration at least 10 minutes.

**[0062]** In other words, the second embodiment checks for a condition when the turbine already runs for at least 30 minutes whilst the pressure in any band constantly exceeds 0.8 psi for at least of 10 minutes.

**[0063]** Notice that the first two embodiments enhance the standard HPCCD conditions with the two first "early" warnings which give indications that some critical HPCCD may happen in the near future. So, the monitoring engineer has enough time to make required corrections without shutting down the running turbine, i.e., adjust the pilot flow (split ratio), change the fuel type and so on.

**[0064]** According to a third embodiment, a warning "Warning: HPCCD Level 1.0 psi" is issued

30 if  $\#PILOT > 0$  holds true for a duration at least 30 minutes and

$\max(\#BAND1, \#BAND2, \#BAND3) > 1.0$  holds true at least once.

35 **[0065]** In other words, the third embodiment checks for a condition when the turbine already runs for at least 30 minutes whilst the pressure in any band suddenly exceeds 1.0 psi.

**[0066]** According to a fourth embodiment, an alert "Alert: HPCCD Level 1.4 psi" is issued

40 if  $\#PILOT > 0$  holds true for a duration at least 30 minutes and

$\max(\#BAND1, \#BAND2, \#BAND3) > 1.4$  holds true at least once.

45 **[0067]** In other words, the embodiment checks for a condition when the turbine already runs for at least 30 minutes whilst the pressure in any band suddenly exceeds 1.4 psi.

**[0068]** According to a fifth embodiment, the previous four embodiments are combined.

**[0069]** Figure 2 shows a block diagram of a monitoring system according to an embodiment of the invention. The shown system comprises a monitoring device (or monitoring station) 205, a first turbine plant 210, a second turbine plant 220, and a third turbine plant 230. The first turbine plant comprises a controller C1 and three turbine systems T11, T12 and T13. The controller C1 is in communication with the turbines T11, T12 and T13 and re-

ceives measurement values from sensors in each turbine T11, T12, T13 and transmits control signals to the turbines T11, T12 and T13. Similarly, the second turbine plant 220 comprises a controller C2 and three turbine systems T21, T22 and T23, and the third turbine plant 230 comprises a controller C3 and four turbine systems T31, T32, T33, and T34. As a general note, more turbine plants may be added and the number of turbine systems per plant may vary from what is shown in Figure 2.

[0070] The device 205 is in communication with each of the turbine plants 210, 220 and 230 via a communication unit, such as a network interface, and receives the measurement values collected by the respective controllers C1, C2 and C3, preferably in a continuous manner. The received measurement values are stored in a suitable storage unit and processed in accordance with the method described above in conjunction with Figure 1. If the processing reveals combustion chamber dynamics in one of the turbine systems T11, T12, T13, T21, T22, T23, T31, T32, T33, T34, a notification unit transmits a corresponding notification message to the operator of the relevant turbine plant 210, 220, 230, such that proper action can be taken, e.g. adjusting the pilot flow (split ratio).

[0071] Accordingly, the plant operator can rely on being notified in case of combustion chamber dynamics in one of the plant turbines. Thereby, the cumbersome labor associated with the study of printed curves or unreliable messages from the controllers C1, C2, C3 is no longer necessary.

[0072] The turbine data therefore can be stored on a central server in a remote diagnostic center. Using a client-server software application, a diagnostic engineer can browse the sensor data along with the events from the control system.

[0073] It is noted that the term "comprising" does not exclude other elements or steps and the use of the articles "a" or "an" does not exclude a plurality. Also elements described in association with different embodiments may be combined. It is further noted that reference signs in the claims are not to be construed as limiting the scope of the claims.

## Claims

1. A method of detecting combustion chamber dynamics in a turbine system, the method comprising

- obtaining (1) pilot flow measurement values from at least one fuel pilot flow sensor and pressure band measurement values from at least one pressure sensor in at least two distinct pressure bands,
- checking (2) the pilot flow measurement values against a first criterion and the pressure band measurement values against a second criterion, and

- detecting (3) combustion chamber dynamics and outputting (4) a warning or an alert if both the pilot flow measurement values and the pressure band measurement values match their respective criteria.

2. The method according to the preceding claim, further comprising

- checking the pilot flow measurement values against the first criterion by calculating a standard deviation of the pilot flow measurement values in a first time interval, the first criterion being fulfilled if the standard deviation remains below a first threshold for a first time period,
- checking the pressure band measurement values against the second criterion by calculating standard deviation values for each of the pressure band measurement values in a second time interval and a maximum value as the maximum of the standard deviation values, the second criterion being fulfilled if the maximum value exceeds a second threshold during the first time period.

3. The method according to any of the preceding claims, further comprising

- checking the pilot flow measurement values against the first criterion by verifying that the pilot flow measurement values are larger than zero for a first time period,
- checking the pressure band measurement values against the second criterion by calculating a maximum value as the maximum of the pressure band measurement values at any given point in time, the second criterion being fulfilled if the maximum value constantly exceeds a second threshold during a second time period.

4. The method according to any of the preceding claims, further comprising

- checking the pilot flow measurement values against the first criterion by verifying that the pilot flow measurement values are larger than zero for a first time period,
- checking the pressure band measurement values against the second criterion by calculating a maximum value as the maximum of the pressure band measurement values at any given point in time, the second criterion being fulfilled if the maximum value exceeds a second threshold at least once during the first time period.

5. The method according to claim 2, further comprising

- detecting combustion chamber dynamics and

- outputting a warning if the pilot flow measurement values and the pressure band measurement values match the criteria according to claim 2,  
 - in particular with
- the first time interval being between 5 and 15 minutes, in particular 10 minutes,
  - the first threshold being between 30 % and 70 %, in particular 50 %, 10
  - the first time period being between 15 and 45 minutes, in particular 30 minutes,
  - the second time interval being between 2 and 10 minutes, in particular 5 minutes, and 15
  - the second threshold being between 0.1 and 0.5 psi, in particular 0.2 psi.
6. The method according to claim 3, further comprising
- detecting combustion chamber dynamics and outputting a warning if the pilot flow measurement values and the pressure band measurement values match the criteria according to claim 3, 20
  - in particular with 25
  - the first time period being between 15 and 60 minutes, in particular 30 minutes,
  - the second threshold being between 0.5 and 0.9 psi, in particular 0.8 psi, and 30
  - the second time period being between 5 and 15 minutes, in particular 10 minutes.
7. The method according to claim 4, further comprising
- detecting combustion chamber dynamics and outputting a warning if the pilot flow measurement values and the pressure band measurement values match the criteria according to claim 4, 35
  - in particular with 40
  - the first time period being between 15 and 60 minutes, in particular 30 minutes, and 45
  - the second threshold being 1.0 psi.
8. The method according to claim 4, further comprising
- detecting combustion chamber dynamics and outputting an alert if the pilot flow measurement values and the pressure band measurement values match the criteria according to claim 4, in particular with 50
  - the first time period being between 15 and 60 minutes, in particular 30 minutes, and 55
  - the second threshold being 1.4 psi.
9. A device (205) for detecting combustion chamber dynamics in a turbine system, the device comprising
- a unit for obtaining individual pilot flow measurement values from at least one fuel pilot flow sensor,
  - a unit for obtaining individual pressure band measurement values from at least one pressure sensor in at least two distinct pressure bands,
  - a unit for checking the pilot flow measurement values against a first criterion,
  - a unit for checking the pressure band measurement values against a second criterion, and
  - a unit for detecting combustion chamber dynamics and outputting a warning or an alert if both the pilot flow measurement values and the pressure band measurement values match their respective criteria.
10. A system for monitoring a plurality of turbine systems, each turbine system comprising at least one fuel pilot flow sensor and at least one pressure sensor, the monitoring system comprising
- a communication unit for receiving measurement values from the fuel pilot flow sensor and pressure sensor of each turbine system,
  - a storage unit for storing the received measurement values, and
  - a processing unit for performing the method according to any of claims 1 to 8 on the stored data for each turbine system.
11. The system according to the preceding claim, further comprising
- a notification unit transmitting a notification message to an operator of a turbine system if the processing unit has detected combustion chamber dynamics in the turbine system.
12. A computer program, which, when executed by a processor, causes the processor to perform the steps of the method according to any of claims 1 to 8.
13. A computer readable data carrier loaded with the computer program which, when executed by a processor, causes the processor to perform the steps of the method according to any of claims 1 to 8.

FIG 1

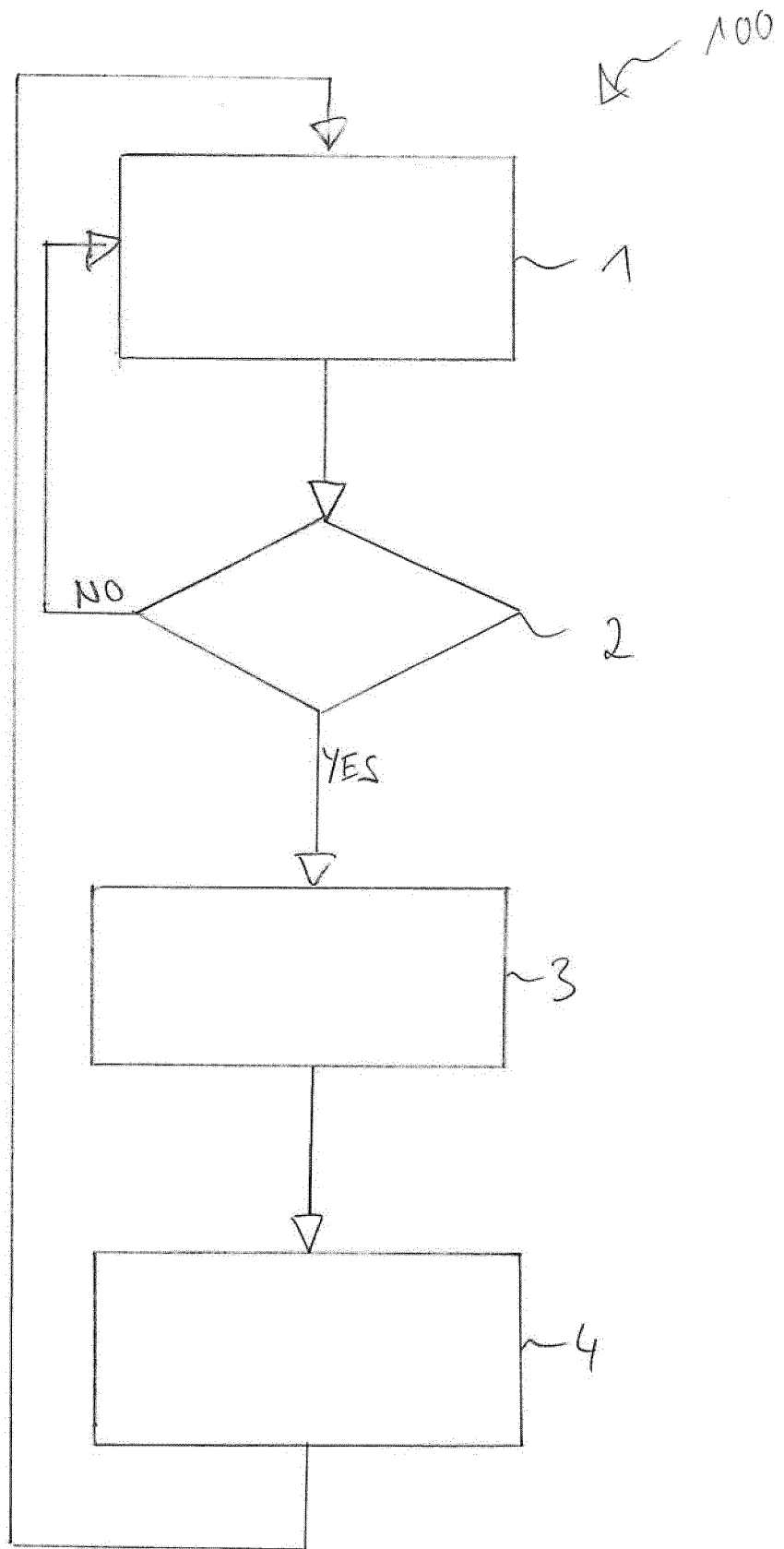
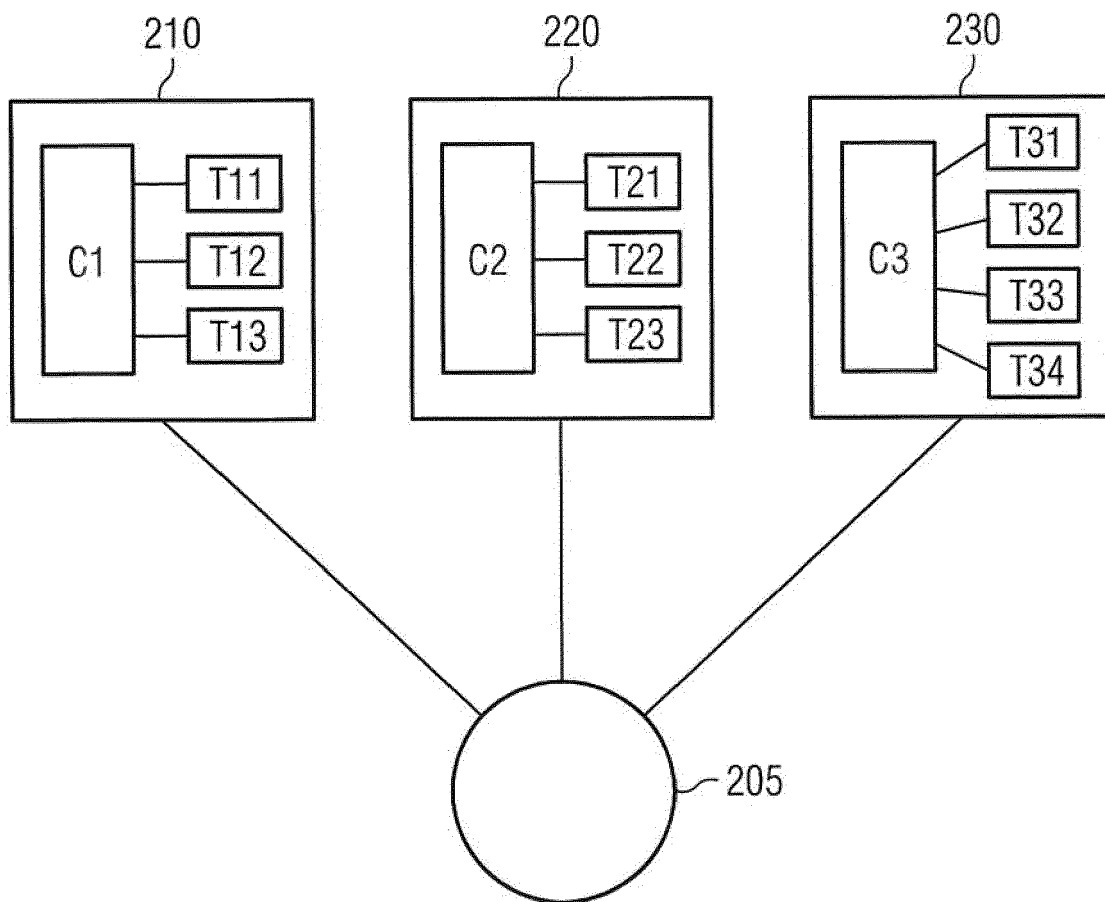


FIG 2





## EUROPEAN SEARCH REPORT

Application Number  
EP 16 17 0693

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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                           |                                                         |                                                                               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|-------------------------------------------------------------------------------|
| Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages                                                                             | Relevant to claim                                       | CLASSIFICATION OF THE APPLICATION (IPC)                                       |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | JP 2004 204780 A (MITSUBISHI HEAVY IND LTD) 22 July 2004 (2004-07-22)<br>* paragraphs [0028], [0029], [0031] - [0033], [0039] *<br>* figures 2, 4, 7, 9 * | 1-4,9-12                                                | INV.<br>F23M11/04<br>F23R3/00<br>F23N5/24<br>F23N5/20<br>F23N5/16<br>F23N5/18 |
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