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(71) Applicant: **Alstom Technology Ltd**
5400 Baden (CH)

(72) Inventors:
- **Koller, Martin**
  CH-5400, Baden (CH)
- **Scheuermann, Hubert**
  D-67150, Niederkirchen (DE)
- **Mäckle, Frank**
  CH-5210, Windisch (CH)

(54) **Steam turbine overspeed protection**

(57) A steam turbine (10) comprises an overspeed control system (16) for responding to the deloading of the steam turbine (10). The steam turbine (10) has a control system (16) with: a control system fault alert (FA) for identifying a fault in the control system (16); a trigger event (TE) defining the point of deloading of the steam turbine (10); a control feature (12) configured to achieve a control state (CS) in response to the deloading; and a predetermined control time (CT) providing an expected time interval between the trigger event (TE) and the point in time at which the control feature (12) achieves the control state (CS). The control system fault alert (FA) is configured to initiate if, in response to the deloading of the steam turbine (10), the control state (CS) is not achieved within the control time (CT). In this way, an active alert is provided that may be used as a fault warning and/or steam turbine (10) trip.

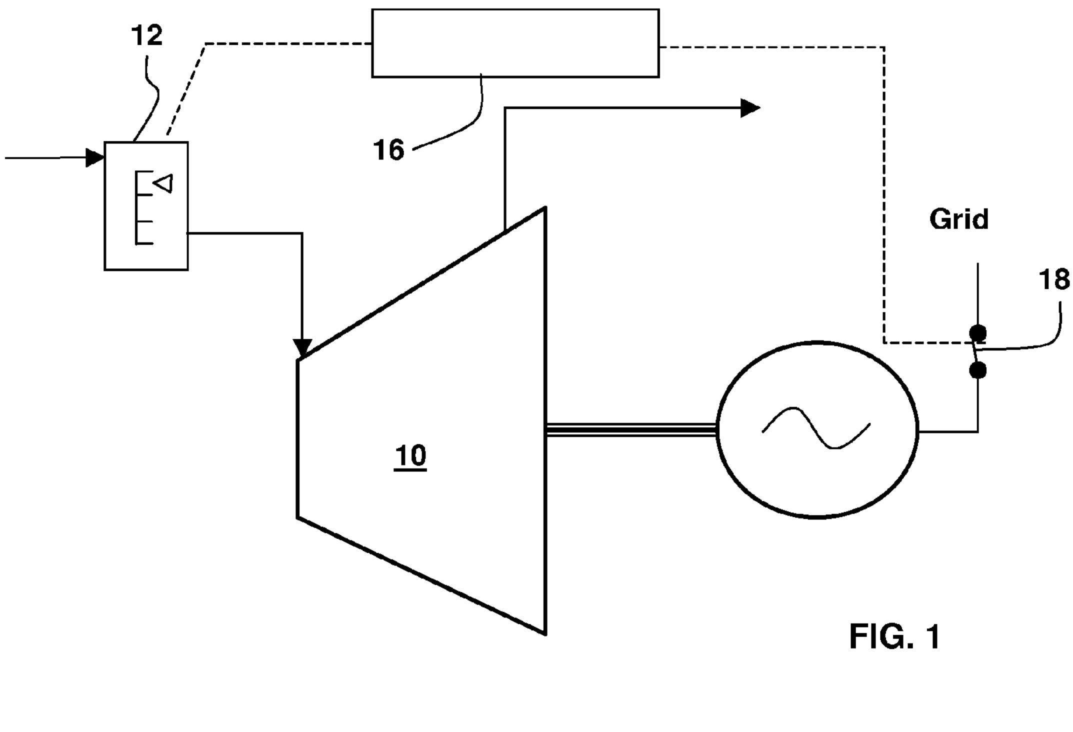

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates generally to steam turbine overspeed protection and more specifically to the control of overspeed in the case of a steam turbine unloading event.

BACKGROUND INFORMATION

[0002] Typically, steam turbines are equipped with trip systems to ensure that the steam turbine speed does not exceed a defined overspeed value. Overspeed may occur following steam turbine unloading events and result in a transient rotational speed spike caused by the delay in system dynamics and control system lag as the turbine's control system assumes new control positions. The event may be an undetectable load shedding event, such as a sudden drop in power demand, or else a detectable event, such as the opening of a power breaker.

[0003] Power grid codes typically pre-define operating bands that limit operation above nominal speeds. The overspeed trip setpoint is thus determined by adding the expected overspeed resulting from a load shedding event to the peak overspeed within an operating band.

[0004] Following an unloading event, it is generally preferable that the power plant is available to be brought on line as soon as possible. As it may take long to bring a plant on line after a trip is preferable to limit the number of trips.

[0005] Machine damage may also occur below the maximum rotor designed overspeed if, for example, resonance build-up occurs within the blading. While damaging resonance build-up in the blading typically occurs only if a particular system specific overspeed is sustained and so does not occur during transient overspeed events such as unloading events, it is nonetheless preferable to minimise the exposure of blades to overspeed in order to reduce potential blade stressing.

SUMMARY

[0006] An objective of the invention is to overcome the problem of steam turbine overspeed exposure during upset conditions..

[0007] The disclosure attempts to address this problem by means of the subject matters of the independent claims. Advantageous embodiments are given in the dependent claims.

[0008] The disclosure is based on the general idea of varying the trip setting based on the monitoring of an intermediate steam turbine control system parameters. If the intermediate control parameter has neither started nor completed its expected action within a predetermined time an alert is raised. The underlying presumption is that in such a case a control fault has occurred which means the control system will not be able to prevent the tripping of the steam turbine on overspeed. A further aspect therefore provides a steam turbine trip thus limiting the overspeed exposure of the steam turbine.

[0009] An aspect therefore provides a steam turbine compromising an overspeed control system for responding to the deloading of the steam turbine. The control system comprises: a control system fault alert for identifying a fault in the control system; a trigger event that defines the point of deloading of the steam turbine; a control feature configured to achieve a control states in respond to the deloading; and a predetermined control time defined as the expected time interval between the trigger event and the point at which the control feature has achieved the control state. In this arrangement the control system fault alert is configured to initiate if, in response to the deloading of the steam turbine, the control states is not achieved with the control time.

[0010] Another aspect provides a method of generating a steam turbine overspeed control system fault alert comprising providing a steam turbine with the overspeed control system wherein the control system has a trigger event that defines the point of deloading of the steam turbine. A control feature, configured to achieve a control state in response to the trigger event within a control time, is provided to the control system. The method further includes initiating a fault alert if the control state is not achieved within the control time.

[0011] Other aspects and advantages of the present disclosure will become apparent from the following description, taken in connection with the accompanying drawings, which by way of example illustrate exemplary embodiments of the present invention

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] By way of example, an embodiment of the present disclosure is described more fully hereinafter with reference to the accompanying drawings, in which:

Figure 1 is a schematic of an exemplary steam plant ;

Figure 2 is an exemplary correlation, for the steam plant of Fig. 1 of overspeed to control time; and

Figure 3 -5 are various embodiments of control logic of the steam plant of Fig. 1

DETAILED DESCRIPTION

[0013] Exemplary embodiments of the present disclosure are now described with references to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for purposes of explanation, numerous specific details are set forth to provide a thorough understanding of the disclosure. However, the present disclosure may be practiced without these specific details, and is not limited to the exemplary embodiments disclosed herein.

[0014] In an exemplary embodiment, applied to a steam turbine 10 shown in Fig. 1, an overspeed control system 16 for preventing or at least minimising overspeed OS of a steam turbine 10 in both normal and upset conditions is provided.

[0015] In an exemplary embodiment shown in Fig. 1, a steam turbine 10 compromises an overspeed control system 16 for responding to the deloading of the steam turbine 10. In order to control the overspeed OS and provide an alert of a potential control system 16 fault, the control system 16, as shown in Fig. 3, has: a control system fault alert FA for identifying a fault in the control system 16; a trigger event TE used to identify of the steam turbine 10 is deloading; a control feature 12 configured to achieve a control state CS in response to the deloading; and a control time CT defined as the estimated time it takes between first initiation of the trigger event TE and the point in time at which the control feature 12 achieves the control states CS. By evaluating if the control state CS has been achieved within the control time CT following a trigger event TE, it is possible to determine if a control system fault has occurred. In such as case a fault alert FA maybe provided. The fault alert FA maybe used simply as a fault indicator or alternatively as a means to initiate a steam turbine trip.

[0016] A trigger event TE may be any indication that identifies that a steam turbine 10 unloading event has occurred. For example, the trigger event TE may be a predefined overspeed OS or alternatively, when the steam turbine 10 is a component of a power plant, a signal that a breaker 18 of the power plant, as shown in Fig. 1, is open.

[0017] A control feature 12, as shown in Fig. 1, may be a steam control valve for controlling the amount of steam fed to the steam turbine 10 by means of changing the control states CS of the control valve. Alternatively, a control feature 12 may be an extraction control valve (not shown) for controlling steam extraction from the steam turbine 10. Examples of control states CS include predefined valve positions, such as partially open or closed, and valve position ranges, such as "less than 80% open".

[0018] Within the control system 16, it takes a finite time from initiation of the trigger event TE before the control state CS is reached. This time is defined in this disclosure at the control time CT. The consequence of this time is that the steam turbine 10 will continue to do work following a trigger event TE, resulting in overspeed OS. As system dynamics maybe estimated, it is possible, using known techniques, to estimate the turbine overspeed OS for a known control time CT. The result, as shown in Fig. 2, is that it is possible to correlate overspeed OS with control time CT such that overspeed OS maybe used as a pseudo control time CT. Using this principle, as shown in Fig. 4, an exemplary embodiment uses overspeed OS as a measure of control time CT in the overspeed control system 16 in order to provide a fault alert FA. As control time CT is also directly related to a trigger event TE as it forms the basis for the measurement, in a further exemplary embodiment shown in Fig. 5, overspeed OS is further used as an indication of the trigger event TE. In this way, a fault alert FA is configured to initiate if the steam turbine 10 achieves an overspeed OS if the control feature 12 has not achieved the control states CS.

[0019] Each of these exemplary embodiments may comprise control features 12 that each comprise several control actions resulting in either as final control states CS or intermediate control states CS. A final control state CS is a state of the control feature 12 that has the longest control time CT of all the control states CS of that control feature 12. An example of a final control state CY is the closed state a valve control feature 12 that is normally open. In this example, an intermediate control state CS is a partially open valve position or alternative a range of partially open valve position above a certain value.

[0020] In an exemplary embodiment, arranged as shown in FIG. 1, the control feature 12 is a steam control valve for controlling the amount of steam fed to a steam turbine 10 and the control state CS is the closing of the control valve below an estimated value that is estimated based on nominal full load steam turbine 10 operation.

[0021] In another exemplary embodiment arranged as shown in FIG. 1, the control feature 12 is also a steam control valve for controlling the steam flow to a steam turbine 10 but the control action is the full closure of the steam control valve.

[0022] In a further exemplary embodiment, which may be applied to any exemplary embodiment, the control feature 12 includes a control measurement device for determining the control states CS of the control feature 12. An example is a proximity switch located on an exemplary control valve.

[0023] In an exemplary embodiment, the control system 16 includes a plurality of control features 12 wherein the by means of a voting system, the status of the control system 16 is determined. For example, in an embodiment with two control features 12, a fault alert FA may be initiated if either one or both of the control features 12 does not achieve the expected control state CS. With further control features 12 other redundant voting systems maybe be used, for example, one out of three, two out of three, three out of three etc.

[0024] In a not shown exemplary embodiment, the control state CS is determined by means of a measurement device. In another not shown exemplary embodiment the control state CS is determined by means of the command to the control feature 12.

[0025] It will be appreciated by those skilled in the art that the present invention can be embodied in other specific forms. The presently disclosed embodiments are therefore considered in all respects to be illustrative and not restricted. The scope of the invention is indicated by the appended claims rather than the foregoing description and all changes that come within the meaning and range and equivalences thereof are intended to be embraced therein.

REFERENCE NUMBERS

[0026]

10	Steam turbine
12	Control feature
16	Control system
18	Breaker
FA	Fault alert
OS	Overspeed
CT	Control time
T	Time
TE	Trigger Event
CS	Control state

Claims

1. A steam turbine (10) compromising:

an overspeed control system (16) for responding to the deloading of the steam turbine (10), the control system (16) comprising:

a control system fault alert (FA) for identifying a fault in the control system (16);
a trigger event (TE) that defines the point of deloading of the steam turbine (10);
a control feature (12) configured to achieve a control state (CS) in response to the deloading; and
a predetermined control time (CT) providing an expected time interval between the trigger event (TE) and the point in time at which the control feature (12) achieves the control state (CS),
wherein the control system fault alert (FA) is configured to initiate if, in response to the deloading of the steam turbine (10), the control state (CS) is not achieved within the control time (CT).

2. The steam turbine (10) of claim 1 wherein the control time (CT) is the steam turbine (10) overspeed (OS) correlated to the control time (CT) such that the control system fault alert (FA) is configured to initiate if, in response to the deloading of the steam turbine (10) the control state (CS) is not achieved before a predefined overspeed (OS).

3. The steam turbine (10) of claim 2 wherein control (CT) and trigger event (TE) are correlated to the overspeed (OS) such that the fault alert (FA) is configured to initiate if the steam turbine (10) achieves an overspeed (OS) and the control feature (12) has not achieved the control state (CS).

4. The steam turbine (10) of claim 2 wherein the control feature (12) has a plurality of control of states (CS), each with a different calculated control time (CT), wherein
the control state (CS) with the longest control time (CT) defines a final control state (CS), and
the or each other control states (CS) define one or more intermediate control states (CS),
wherein the alert is configured to initiate based on an intermediate control state (CS).

5. The steam turbine (10) of any one of claims 1 to 4 comprising a plurality of control features (12) wherein the alert is configured to initiate based on a voting system of control features (12).

6. The steam turbine (10) of any one of claims 1 to 5 wherein the control feature (12) is a steam control valve for controlling the amount of steam fed to or from the steam turbine (10) and the control state (CS) is a valve position of the steam control valve.

7. The steam turbine (10) of any one of claims 1 to 6 wherein the control states (CS) is substituted by a control state (CS) command of the control feature (12).

8. The steam turbine (10) of any one of claims 1 to 7 wherein the steam turbine (10) is a component of a power plant and the trigger event (TE) is a signal that a breaker (18) of the power plant is open.

9. The steam turbine (10) of any one of claims 1 to 7 wherein the trigger event (TE) is a predefined overspeed (OS).

10. The steam turbine (10) of any one of claims 1 to 9 further comprising a trip system for tripping the steam turbine (10) based on the fault alert (FA).

11. A method of generating a steam turbine (10) overspeed control system fault alert (FA) comprising:

providing a steam turbine (10) with an overspeed control system (16)
providing the control system (16) with
a trigger event (TE) that defines the point of deloading of the steam turbine (10); and
a control feature (12) configured to achieve a control state (CS) in response to the trigger event (TE) within a control time (CT) as meas-

ured from the trigger event (TE);
initiating a fault alert (FA) if the control state (CS) is not achieved within the control time (CT).

12. The method of claim 11 further comprising correlating the control time (CT) with steam turbine (10) overspeed (OS) in the event of a trigger event (TE), wherein overspeed (OS) is used to approximate either the control time (CT) or the control time (CT) and trigger event (TE), by means of the correlation.

13. The method of claim 11 or 12 wherein the steam turbine (10) is component of a power plant and the trigger event (TE) is an indication that a breaker (18) of the power plant has opened.

14. The method of claim 11 or 12 wherein the trigger event (TE) is a predetermined overspeed (OS).

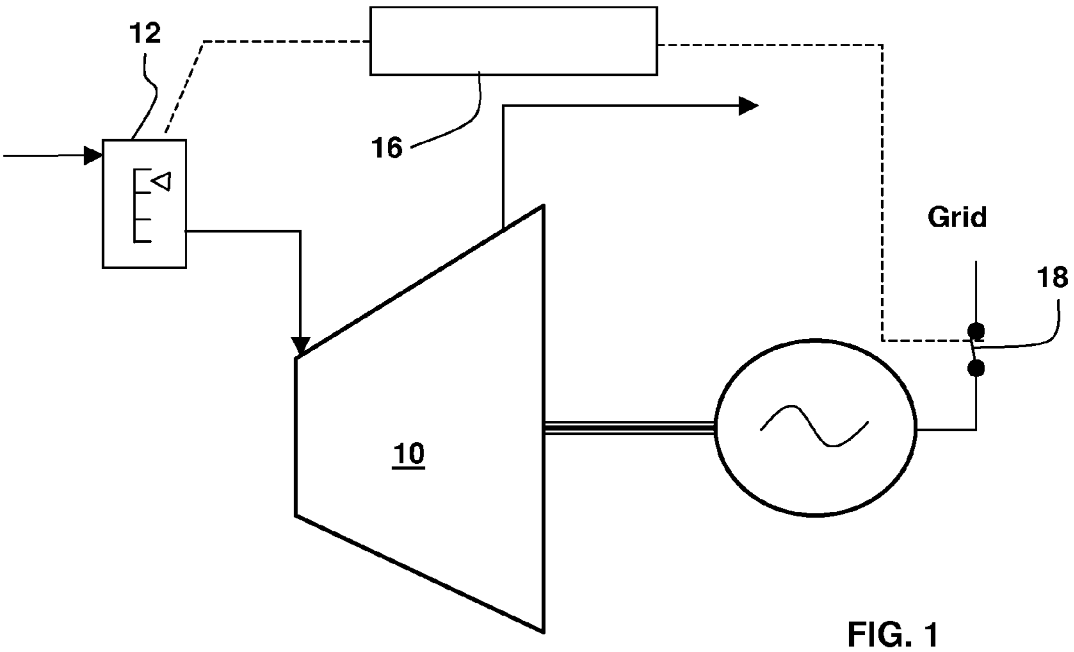

FIG. 1

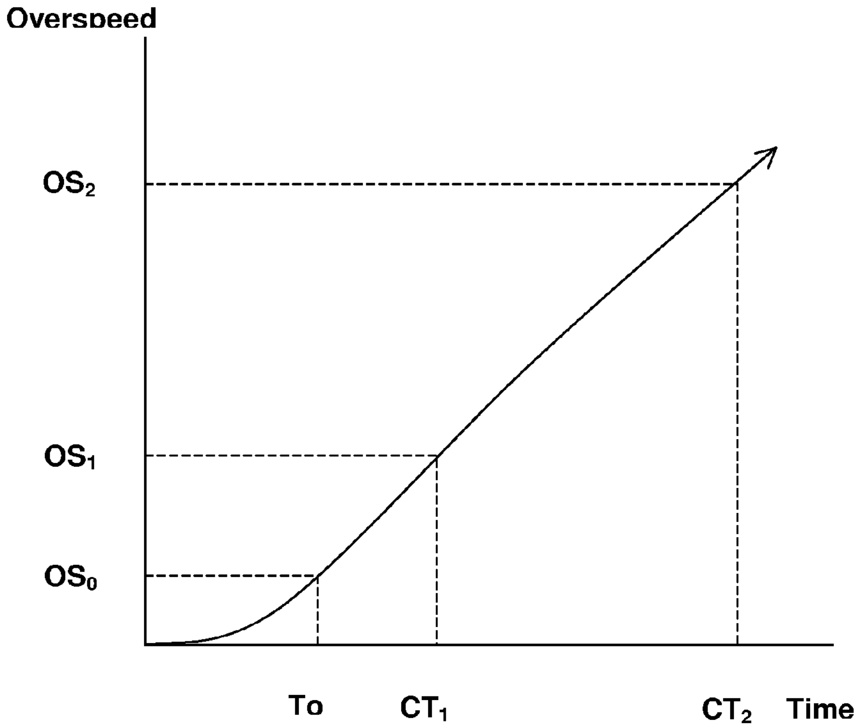

FIG. 2

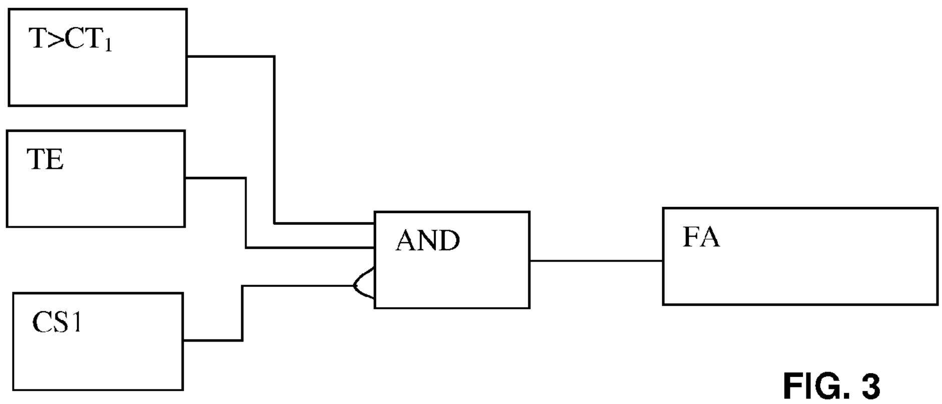

FIG. 3

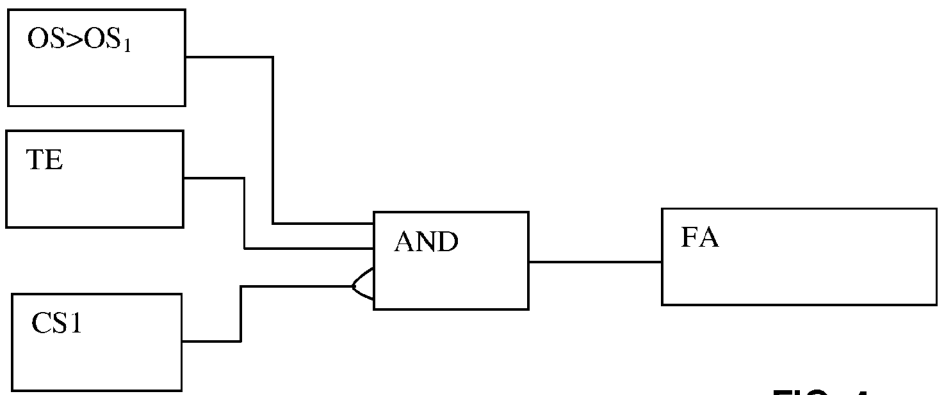

FIG. 4

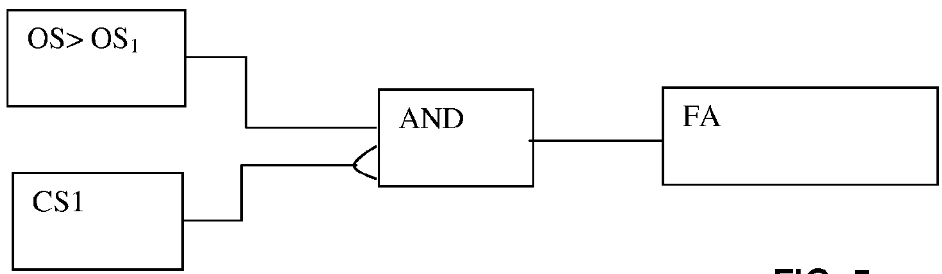

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 10 19 5773

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	FR 2 091 373 A5 (KRAFTWERK UNION AG) 14 January 1972 (1972-01-14) * page 1, line 1 - page 13, line 10; figures 1-3 *	1-14	INV. F01D21/02
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TECHNICAL FIELDS SEARCHED (IPC)
F01D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	26 May 2011	Robelin, Bruno

CATEGORY OF CITED DOCUMENTS

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