(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 657 461 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
30.10.2013 Bulletin 2013/44

(51) Int Cl.:
F01D 17/14 *(2006.01)*

(21) Application number: **13165099.6**

(22) Date of filing: **24.04.2013**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **25.04.2012 US 201213455781**

(71) Applicant: **General Electric Company**
Schenectady, New York 12345 (US)

(72) Inventors:
- **Rittenhouse, Brian Allen**
  Greenville, SC South Carolina 29615 (US)
- **Jarrett Jr., Harry McFarland**
  Greenville, SC South Carolina 29615 (US)
- **Waugh, Daniel Richard**
  Greenville, SC South Carolina 29615 (US)

(74) Representative: **Cleary, Fidelma**
GPO Europe
GE International Inc.
The Ark
201 Talgarth Road
Hammersmith
London W6 8BJ (GB)

(54) Compressor of a gas turbine system

(57) A compressor 12 of a gas turbine system 10 includes at least one inlet row having a plurality of inlet guide vanes. Also included is at least one stator row 14 having a plurality of stator vanes. Further included is a first actuation mechanism 32 operably connected to the at least one stator row 14 , wherein the first actuation mechanism is configured to positionally manipulate the at least one stator row 14. Yet further included is a second actuation mechanism 34 operably connected to the at least one stator row, wherein the second actuation mechanism is configured to positionally manipulate the at least one stator row.

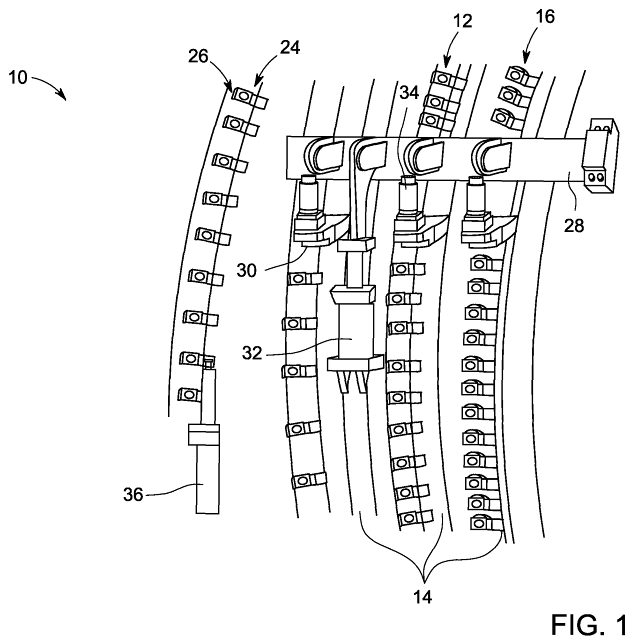

FIG. 1

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Description

[0001] The subject matter disclosed herein relates to compressors of gas turbine systems, and more particularly to positional control of inlet guide and/or stator vanes.

[0002] Gas turbine systems often include multiple rows or stages, where a rotor is turned at a high speed, such that air is drawn into the compressor and accelerated by rotating blades that transfer air downstream and onto or past an adjacent row of stator vanes. The pressure of the air flowing through the compressor is increased through each row or stage of the compressor, thereby forming a compressed gas.

[0003] In an effort to increase the efficiency of gas turbine systems, and more specifically compressors of such systems, variable stator vanes may be employed to impart an effect on the air flowing through the compressor in such a manner as to control the effect of the angle of flow to the adjacent downstream row or stage. Although efficiency improvements may be seen at all operating conditions, variable stator vanes are particularly useful at relatively low rotational speeds and during turndown.

[0004] According to one aspect of the invention, a compressor of a gas turbine system includes at least one inlet row having a plurality of inlet guide vanes. Also included is at least one stator row having a plurality of stator vanes. Further included is a first actuation mechanism operably connected to the at least one stator row, wherein the first actuation mechanism is configured to positionally manipulate the at least one stator row. Yet further included is a second actuation mechanism operably connected to the at least one stator row, wherein the second actuation mechanism is configured to positionally manipulate the at least one stator row.

[0005] According to another aspect of the invention, a compressor of a gas turbine system includes a plurality of rows, each of the plurality of rows having a plurality of stator vanes. Also included is a first actuation mechanism operably connected to the plurality of rows, wherein the first actuation mechanism is configured to positionally manipulate the plurality of rows. Further included is a second actuation mechanism operably connected to at least one row of the plurality of rows, wherein the second actuation mechanism is configured to positionally manipulate the at least one row. According to yet another aspect of the invention, a compressor of a gas turbine system includes at least one inlet row having a plurality of inlet guide vanes. Also included is a plurality of stator rows, each of the plurality of stator rows having a plurality of stator vanes. Further included is an electric actuator operably connected to the plurality of stator rows, wherein the hydraulic actuator is configured to positionally manipulate the plurality of stator rows. Yet further included is an electrically driven screw actuator operably connected to at least one stator row of the plurality of stator rows, wherein the electrically driven screw actuator is configured to positionally manipulate the at least one stator row.

[0006] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

[0007] The subject matter, which is regarded as the invention, is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a side perspective view of a compressor section of a gas turbine system; and

FIG. 2 is a schematic view of a plurality of variable stator vanes of the compressor section.

[0008] The detailed description explains embodiments of the invention, together with advantages and features, by way of example with reference to the drawings.

[0009] Referring to FIGS. 1 and 2, a gas turbine system 10 includes an axial flow compressor 12 having a plurality of stages or stator rows 14. Each stator row 14 comprises at least one, but typically a plurality of, circumferentially spaced variable stator vanes 16 that are positioned upstream of a row of circumferentially spaced rotor blades (not shown) that are operably connected to, and extend radially away from, a rotor (not shown). The rotor is configured to rotate about a central axis. The rotor blades are constrained to rotate about the axis and within a compressor casing (not illustrated). Additionally, the compressor 12 includes at least one inlet guide row 24 that comprises at least one, but typically a plurality of, inlet guide vanes 26, which may be variable as well. The inlet guide row 24 is positioned at the entry to the compressor 12.

[0010] In operation, air flows into the compressor 12 and is compressed into a high pressure gas. The high pressure gas is supplied to a combustor assembly (not illustrated) and mixed with fuel, for example natural gas and/or liquid fuel.

[0011] A linkage 28 is operably coupled to at least one of the stator rows 14, and therefore the variable stator vanes 16. The linkage 28 is typically operably coupled to a plurality of the stator rows 14, as is the case in the illustrated embodiment, where the linkage 28 is coupled to three such stator rows 14. The linkage 28 includes a torque shaft 30 and a first actuator mechanism 32 that is configured to drive the linkage 28. The first actuator mechanism 32 is typically an electric actuator or a hydraulic actuator, but it is contemplated that several other actuator types may be employed to successfully drive the linkage 28 and therefore the stator rows 14. As described above, the first actuator mechanism 32 is operably coupled to a plurality of the stator rows 14 and thereby achieves relatively fast adjustment of the stator rows 14 and the variable stator vanes 16. Relatively fast adjustment is beneficial during transitioning of the gas turbine system 10, and specifically the compressor 12, between various operating conditions. The first actuator mechanism 32 may be disposed within the compressor 12 in a number of ways, including but not limited to direct or indirect attachment to the compressor casing or stable structures within the compressor casing. Such mounting may include the use of mechanical fasteners for establishing a secure relationship between the first actuator mechanism 32 and an associated structure within the compressor 12.

[0012] In order to establish more control precision over adjustment of the stator rows 14, and therefore the variable stator vanes 16, a second actuator mechanism 34 is associated with an individual stator row 14. The second actuator mechanism 34 is configured to enhance the precision of the adjustment for each stator row 14. Furthermore, the second actuator mechanism 34 functions to provide independent control over each stator row 14, such that the number of achievable positional combinations of the stator rows 14 is increased greatly. A number of actuator types may be employed as the second actuator mechanism 34, with one type being a screw type actuator electrically driven by a motor, such as a trimmer motor. Typically, the compressor 12 will house a plurality of second actuator mechanisms 34, with the precise number of second actuator mechanisms 34 being determined by how many stator rows 14 are desired to be controlled.

[0013] The inlet guide row 24 may also be positionally adjusted with an operable connection to an inlet row actuator 36. The inlet row actuator 36 may be of the hydraulic type, electrically driven, or any other suitable alternative.

[0014] In operation, the variable stator vanes 16 and/or the inlet guide vanes 26 correct the deflection given to air flowing through the compressor 12 by upstream rotor blades and presenting the air at a correct angle to the next row of rotor blades. In addition to this base load function, the variable stator vanes 16 and/or the inlet guide vanes 26 may be adjusted to enhance performance during transitions of the gas turbine system 10, such as turndown transitioning. The first actuator mechanism 32 provides the ability to respond quickly to adjustment requirements and the second actuator mechanism 34 maintains a slower, but more precise adjustment capability of each independent stator row 14 and/or inlet guide row 24.

[0015] Advantageously, the primary and secondary adjustment of the stator rows 14 by the first actuator mechanism 32 and the second actuator mechanism 34, respectively, improve base load performance through enhanced control of the relationship between the variable stator vanes 16 and/or the inlet guide vanes 26, as well as improved performance during turn down. The dual adjustment also allows for improved efficiency at a greater number of operating and flow conditions.

[0016] While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

[0017] Various aspects and embodiments of the present invention are defined by the following numbered clauses:

1. A compressor of a gas turbine system comprising:

    at least one inlet row having a plurality of inlet guide vanes;

    at least one stator row having a plurality of stator vanes;

    a first actuation mechanism operably connected to the at least one stator row, wherein the first actuation mechanism is configured to positionally manipulate the at least one stator row; and

    a second actuation mechanism operably connected to the at least one stator row, wherein the second actuation mechanism is configured to positionally manipulate the at least one stator row.

2. The compressor of clause 1, wherein the first actuation mechanism is hydraulically actuated.

3. The compressor of clause 1 or clause 2, wherein at least one of the first actuation mechanism and the second actuation mechanism is driven by an electric motor.

4. The compressor of any preceding clause, further comprising:

    a plurality of stator rows, each of the plurality of stator rows having the plurality of stator vanes;

    a linkage operably connecting the first actuation mechanism to the plurality of stator rows; and

    a plurality of second actuation mechanisms, each of the plurality of second actuation mechanisms operably connected to one of the plurality of stator rows.

5. The compressor of any preceding clause, wherein

each of the plurality of second actuation mechanisms is configured to independently positionally manipulate each of the plurality of stator rows.

6. The compressor of any preceding clause, wherein the plurality of stator rows are operably coupled together.

7. The compressor of any preceding clause, wherein the linkage operably couples the plurality of stator rows together.

8. The compressor of any preceding clause, wherein the second actuation mechanism positionally manipulates the at least one stator row with greater precision than the first actuation mechanism.

9. The compressor of any preceding clause, wherein the at least one stator row is positionally variable with respect to the at least one inlet row.

10. A compressor of a gas turbine system comprising:

a plurality of rows, each of the plurality of rows having a plurality of stator vanes;

a first actuation mechanism operably connected to the plurality of rows, wherein the first actuation mechanism is configured to positionally manipulate the plurality of rows; and

a second actuation mechanism operably connected to at least one row of the plurality of rows, wherein the second actuation mechanism is configured to positionally manipulate the at least one row.

11. The compressor of any preceding clause, wherein the first actuation mechanism is electrically actuated.

12. The compressor of any preceding clause, wherein the second actuation mechanism comprises a screw driven by an electric motor.

13. The compressor of any preceding clause, further comprising at least one inlet row having a plurality of inlet vanes.

14. The compressor of any preceding clause, wherein the plurality of rows is positionally variable with respect to at least one inlet row.

15. The compressor of any preceding clause, further comprising:

a linkage operably connecting the first actuation mechanism to the plurality of rows; and

a plurality of second actuation mechanisms, each of the plurality of second actuation mechanisms operably connected to one of the plurality of rows.

16. The compressor of any preceding clause, wherein each of the plurality of second actuation mechanisms is configured to independently positionally manipulate each of the plurality of rows.

17. The compressor of any preceding clause, wherein the linkage operably couples the plurality of rows together.

18. A compressor of a gas turbine system comprising:

at least one inlet row having a plurality of inlet guide vanes;

a plurality of stator rows, each of the plurality of stator rows having a plurality of stator vanes;

an electric actuator operably connected to the plurality of stator rows, wherein the hydraulic actuator is configured to positionally manipulate the plurality of stator rows; and

an electrically driven screw actuator operably connected to at least one stator row of the plurality of stator rows, wherein the electrically driven screw actuator is configured to positionally manipulate the at least one stator row.

19. The compressor of any preceding clause, wherein the plurality of stator rows is positionally variable with respect to the at least one inlet row.

20. The compressor of any preceding clause, further comprising a plurality of second actuation mechanisms, each of the plurality of second actuation mechanisms operably connected to one of the plurality of stator rows for independently positionally manipulating each of the plurality of stator rows.

Claims

1. A compressor (12) of a gas turbine system comprising:

at least one inlet row (24) having a plurality of inlet guide vanes (26);
at least one stator row (14) having a plurality of stator vanes;
a first actuation mechanism (32) operably con-

nected to the at least one stator row, wherein the first actuation mechanism is configured to positionally manipulate the at least one stator row; and
a second actuation mechanism (34) operably connected to the at least one stator row, wherein the second actuation mechanism is configured to positionally manipulate the at least one stator row.

2. The compressor of claim 1, wherein the first actuation mechanism (32) is hydraulically actuated.

3. The compressor of claim 1 or claim 2, wherein at least one of the first actuation mechanism and the second actuation mechanism is driven by an electric motor.

4. The compressor of any preceding claim, further comprising:

a plurality of stator rows, each of the plurality of stator rows having the plurality of stator vanes;
a linkage operably connecting the first actuation mechanism to the plurality of stator rows; and
a plurality of second actuation mechanisms, each of the plurality of second actuation mechanisms operably connected to one of the plurality of stator rows.

5. The compressor of any preceding claim, wherein each of the plurality of second actuation mechanisms is configured to independently positionally manipulate each of the plurality of stator rows.

6. The compressor of any preceding claim, wherein the plurality of stator rows are operably coupled together.

7. The compressor of any preceding claim, wherein the linkage operably couples the plurality of stator rows together.

8. The compressor of any preceding claim, wherein the second actuation mechanism positionally manipulates the at least one stator row with greater precision than the first actuation mechanism.

9. The compressor of any preceding claim, wherein the at least one stator row is positionally variable with respect to the at least one inlet row.

10. A compressor of a gas turbine system comprising:

a plurality of rows, each of the plurality of rows having a plurality of stator vanes;
a first actuation mechanism operably connected to the plurality of rows, wherein the first actuation mechanism is configured to positionally manipulate the plurality of rows; and
a second actuation mechanism operably connected to at least one row of the plurality of rows, wherein the second actuation mechanism is configured to positionally manipulate the at least one row.

11. The compressor of any preceding claim, wherein the first actuation mechanism is electrically actuated.

12. The compressor of any preceding claim, wherein the second actuation mechanism comprises a screw driven by an electric motor.

13. The compressor of any preceding claim, comprising:

a plurality of stator rows, each of the plurality of stator rows having a plurality of stator vanes; wherein
the first actuation mechanism includes an electric actuator operably connected to the plurality of stator rows, wherein the hydraulic actuator is configured to positionally manipulate the plurality of stator rows; and
the second actuation mechanism includes an electrically driven screw actuator operably connected to at least one stator row of the plurality of stator rows, wherein the electrically driven screw actuator is configured to positionally manipulate the at least one stator row.

14. The compressor of any preceding claim, wherein the plurality of stator rows is positionally variable with respect to the at least one inlet row.

15. The compressor of any preceding claim, further comprising a plurality of second actuation mechanisms, each of the plurality of second actuation mechanisms operably connected to one of the plurality of stator rows for independently positionally manipulating each of the plurality of stator rows.

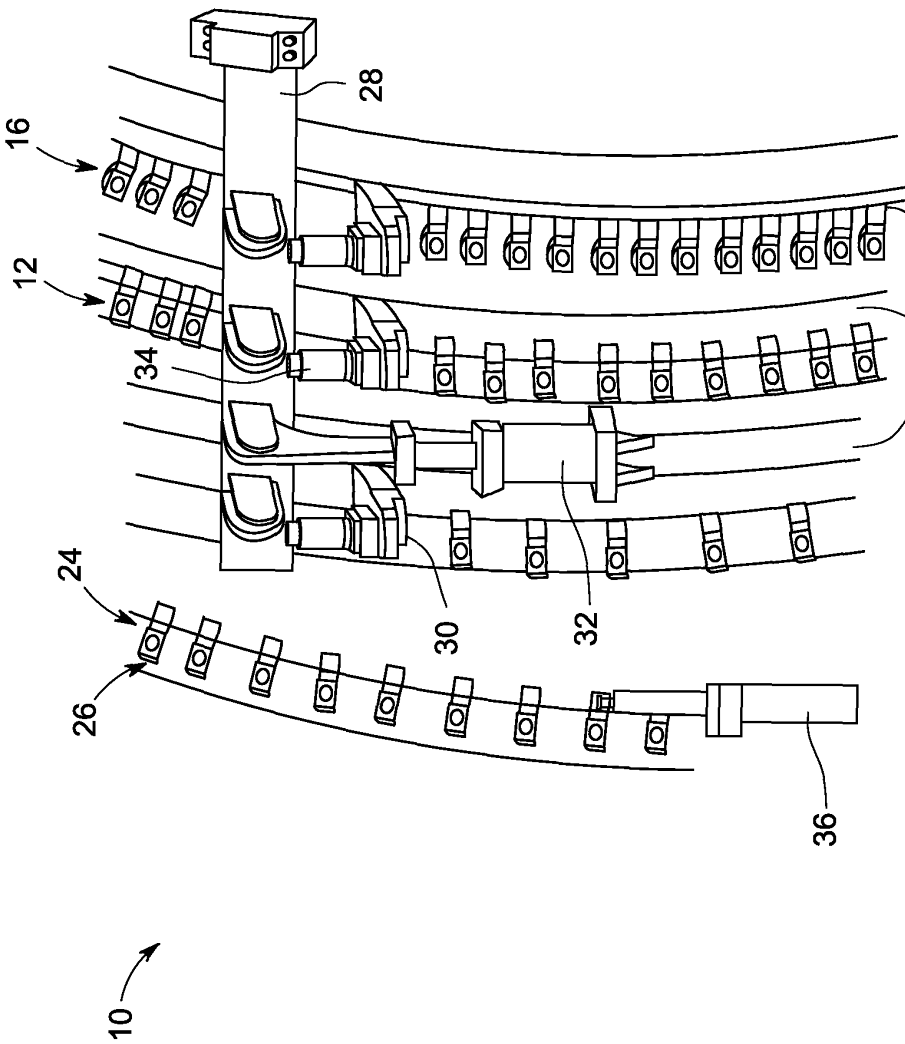

FIG. 1

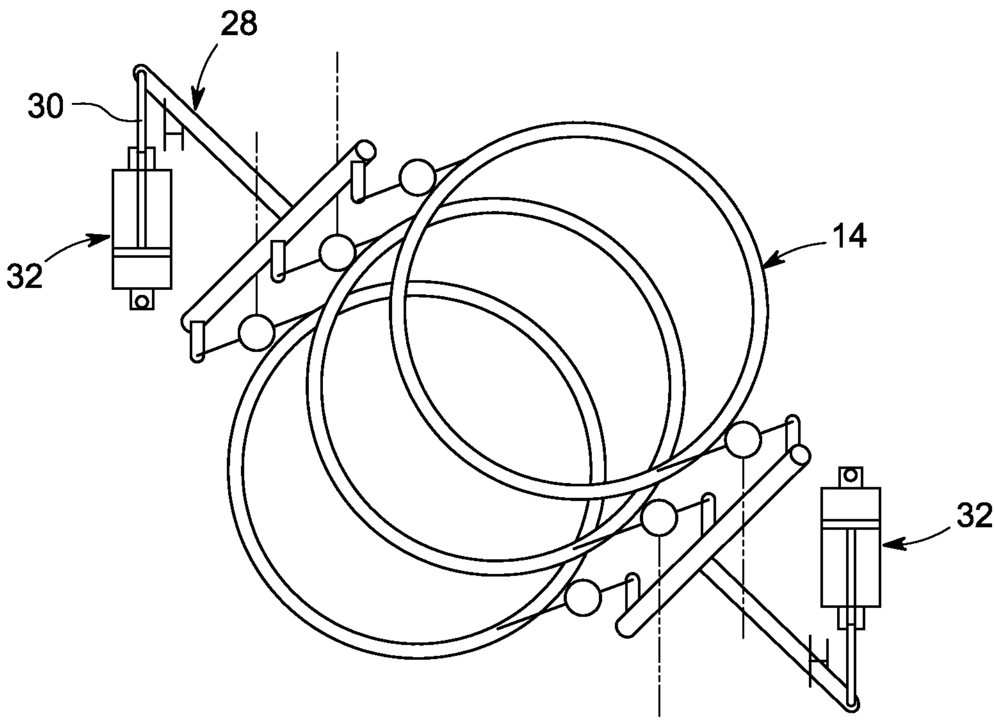

FIG. 2