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(71) Applicant: **KOREA INSTITUTE OF MACHINERY & MATERIALS** [KR/KR]; 156, Gajeongbuk-ro, Yuseong-gu, Daejeon 305-343 (KR).

(72) Inventors: **KIM, Jin Bong**; 351, Changwon-daero, Seongsan-gu, Changwon-si, Gyeongsangnam-do 641-831 (KR). **MOON, Jin Bum**; 351, Changwon-daero, Seongsan-gu, Changwon-si, Gyeongsangnam-do 641-831 (KR). **PARK, Jisang**; 351, Changwon-daero, Seongsan-gu, Changwon-si, Gyeongsangnam-do 641-831 (KR). **LEE, Hak Gu**; 351, Changwon-daero,Seongsan-gu, Changwon-si, Gyeongsangnam-do 641-831 (KR). **YOON, Soon-Ho**; 351, Changwon-daero, Seongsan-gu, Changwon-si, Gyeongsangnam-do 641-831 (KR). **HWANG, Byung Sun**; 351, Changwon-daero, Seongsan-gu, Changwon-si, Gyeongsangnam-do 641-831 (KR). **KIM, Jihoon**; 351,

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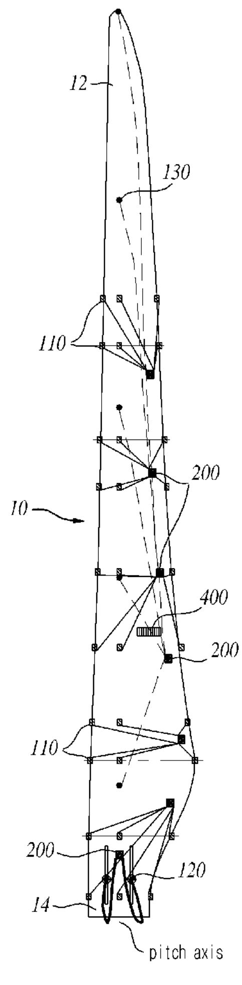
(54) Title: DATA ACQUISITION SYSTEM AND DATA ACQUISITION METHOD FOR TESTING OF WIND TURBINE BLADE



(57) Abstract: The present invention relates to a distributed data acquisition system, in which signal lines of sensors attached to a large-sized blade are shortened to prevent noise from being included in acquired data, and in which data is given time-synchronization, and to a data acquisition method capable of safely acquiring and storing data. The distributed data acquisition system according to the present invention includes: at least two distributed data acquisition devices(200) distributedly arranged on the wind turbine blade(10); and at least two sensors distributedly arranged on a surface or inside of the blade and connected to the adjacent distributed acquisition devices with a signal wire.

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Changwon-daero, Seongsan-gu, Changwon-si, Gyeongsangnam-do 641-831 (KR).

(74) **Agent**: **LEE, Won Hee**; 8th Fl., Sung-ji Heights II 147 Teheran-ro, Gangnam-gu, Seoul 135-910 (KR).

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Description

Title of Invention: DATA ACQUISITION SYSTEM AND DATA ACQUISITION METHOD FOR TESTING OF WIND TURBINE BLADE

Technical Field

[1] The present disclosure relates to a test for performance evaluation of a wind turbine blade, and more particularly, to a distributed data acquisition system, in which signal lines (cables) of sensors attached to a large-sized blade are shortened to prevent a noise from being included in acquired data and detected data are time-synchronized, and to a data acquisition method capable of safely acquiring and storing data.

[2]

Background Art

[3] In a wind turbine system, a rotor blade is the most important part that converts wind energy to mechanical energy, and is getting larger and larger up to a several-MW scale to improve power generation efficiency with expansion of offshore wind power.

[4] Fig. 1 is a diagram illustrating a general cross-sectional structure of a wind turbine blade. A blade 10 constituting a rotor blade has an air-foil shape having a leading edge 10a and a trailing edge 10b, and has a box-beam-type support structure composed of girders 2 and shear webs 4 in a skin 6 to withstand high bending load and centrifugal force.

[5] The blade has to be designed considering various load conditions applied while being operated, and it is also necessary to ensure that actual performance satisfies required standards. Particularly, it has to be proved that the blade can withstand both of ultimate load and fatigue load during the designed service life of 20 years or more, and, to this end, the blade has to pass tests executed by the international certification authority.

[6] Fig. 2 is a schematic diagram illustrating an example of a static test, and Fig. 3 is a schematic diagram illustrating an example of a fatigue test. Tests of the blade may be classified into the static test and the fatigue test.

[7] The static test is to prove that the strength and stiffness of the blade can sufficiently withstand the designed load. In the static test, as illustrated in Fig. 2, a root portion 14 of a blade 10 is fixed to a fixing base 20, and at least one saddle 30 is mounted on the blade 10. Static load measured by at least one load cell 40 is applied to the blade 10 to get the maximum displacement and the ultimate load. In this case, strain and stress states of the blade 10 are measured using lots of strain gauges (not shown) attached in a main load path of the blade 10, thereby verifying a structure design and an analysis result of the blade.

[8] The fatigue test is to prove that the blade can maintain the strength and stiffness under the repeated load during the designed service life. In the fatigue test, as illustrated in Fig. 3, at least one structure equipped with at least one hydraulic actuator 50 to move a mass 52 up and down may be provided so as to apply continuous operation load to the blade 10. Also in the fatigue test, the strain and stress states of the blade 10 are measured using data acquired from the plurality of strain gauges (not shown) attached on the surface of the blade 10.

[9] Fig. 4 is a schematic diagram for describing a problem of a data acquisition system for testing a wind turbine blade according to the related art. In the existing data acquisition system, as illustrated in Fig. 4, lots of strain gauges 110 are attached on the surface of the blade 10 to measure the strain and the stress acting on the blade 10. Cables C that are signal lines of the strain gauges 100 are drawn out in one direction of the blade 10 and are connected to a data acquisition device (DAQ) 200 having a number of channels. Fixing the cables C to the blade surface using tape or the like prevents the test from being interfered with due to the cables C shaking depending on the amplitude of the blade.

[10] As illustrated in Fig. 4, the data acquisition system according to the related art has a structure in which data measured by lots of strain gauges 110 are intensively collected in a single data acquisition device 200. That is, in the existing testing system, the cable C, a signal line of the strain gauge 110, becomes longer. Particularly, the length of the cable is increased more as the length of the blade is increased to about 60 m or more. In this case, the cable of the strain gauge disposed in the vicinity of a tip portion of the blade 10 becomes longer than the length of the blade 10. That is, the data acquisition system according to the related art has a structure in which the lengths of the cables of the sensors are increased by about 10 to 100 m or more.

[11] Meanwhile, a signal output from the strain gauge 110 is a minute analog signal in mV units. When the length of the cable connecting the strain gauges is increased, there is the problem that noise is easily included in the analog signal. That is, the data acquired by the data acquisition device 200 has a low signal-to-noise ratio, leading to a significant decrease in the reliability of the test. In severe cases, it may be difficult to identify whether a data value output through a display is a signal or noise.

[12] Moreover, about 100 or more strain gauges 110 are installed on the large-sized blade, which brings about a problem with the signal-to-noise ratio being further lowered as signal interference occurs due to a number of cables C that are complexly disposed on the surface of the blade 10.

[13] [Prior Art Literature]

[14] [Patent Literature]

[15] (Patent Literature 1) Korean Patent Laid-Open Publication No. 2011-0078999

[16] (Patent Literature 2) Korean Patent Laid-Open Publication No. 2013-0087920

[17]

Disclosure of Invention

Technical Problem

[18] The present invention has been made to solve the problems of the related art as described above, and an object of the present invention is to provide a data acquisition system and a data acquisition method for testing a wind turbine blade, which can improve the reliability of a test result by preventing noise from being included in data acquired from sensors.

[19] Another object of the present invention is to provide a data acquisition system and a data acquisition method, which can solve the problem of data not being comparable because the time information of detected data has become discordant due to the distributed arrangement of data acquisition devices.

[20] Still another object of the present invention is to provide a data acquisition system and a data acquisition method, which can prevent stored detected data from disappearing when the blade is damaged during testing.

[21]

Solution to Problem

[22] In order to achieve the objects of the present invention as described above, at least two distributed data acquisition devices(200) distributedly arranged on the wind turbine blade(10); and at least two sensors distributedly arranged on a surface or inside of the blade and connected to the adjacent distributed acquisition devices with a signal wire.

[23] Also, it is preferable that the data acquisition system further comprises a data storage device(300) storing detected data acquired by the distributed data acquisition devices(200).

[24] Also, it is preferable that the data acquisition system further comprises a data hub(400) acquiring the data acquired from the distributed data acquisition devices(200).

[25] Also, it is preferable that the data hub(400) is connected in parallel to the distributed data acquisition devices(200).

[26] Also, it is preferable that the data hub(400) is connected in series to the distributed data acquisition devices(200).

[27] Also, it is preferable that the data acquisition system further comprises a data storage device(300) storing the data acquired from the data hub(400).

[28] Also, it is preferable that the distributed data acquisition devices(200) are connected in series each other by each high-speed serial interface.

[29] Also, it is preferable that the data storage device(200) and the data hub(400) are communicated through a wired or wireless communication network.

[30] Also, the distributed data acquisition devices each comprise an A/D converter, an amplifier and a noise filter.

[31] Also, it is preferable that the data hub(400) is applied digital data from the distributed data acquisition devices(200).

[32] Also, the data hub may be fixedly attached to one face of the blade or disposed outside the blade.

[33]

[34] The objects of the present invention described above may be achieved by a data acquisition method for testing a wind turbine blade, the method including: distributedly arranging a number of sensors on a surface or inside of the blade , and distributedly arranging at least two distributed data acquisition devices (DAQ) on the blade, and connecting the sensors to the adjacent distributed acquisition devices with a signal wire; processing a test for the blade; and acquiring, by the distributed data acquisition devices, data detected by the sensors.

[35] Also, the data acquisition method of the present invention may further include, after the arranging of the distributed data acquisition devices connecting a data hub to the distributed data acquisition devices., wherein the distributed data acquisition devices and the data hub are connected in parallel or series or in a combination of parallel and serial connections.

[36] Also, the data acquisition method may further include, after the connecting of the data hub to the distributed data acquisition devices, setting the distributed data acquisition devices such that the data detected by the sensors are time-synchronized and acquired.

[37] Also, it is preferable that the acquiring of the data by the distributed data acquisition devices includes converting, by the distributed data acquisition device, the detected data into a digital signal.

[38]

Advantageous Effects of Invention

[39] In a data acquisition system according to a preferred embodiment of the present invention, distributed data acquisition devices are connected to sensors disposed in predetermined areas of a blade and distributedly acquire detected data. That is, since a number of distributed data acquisition devices are distributedly arranged on the surface of the blade, signal lines (cables) of the sensors can be shortened, and it is thus possible to prevent noise from being included in analog signals output from the sensors. Accordingly, the data acquired by the distributed data acquisition devices have a high

signal-to-noise ratio, thus drastically improving the reliability of test results. In addition, in the testing system of the present invention, it is possible to further reduce the occurrence of noise caused by signal interference by simplifying the configuration of the cables.

[40] Furthermore, the data acquisition system according to the present invention enables the detected data acquired by the distributed data acquisition devices to be time-synchronized and transmitted to an external data storage device. This makes it possible to solve the problem of time information discordance of the detected data, which is typically caused by the distributed arrangement of the data acquisition devices. The data acquisition system according to the present invention includes a data hub that is connected in parallel or series to a number of distributed data acquisition devices, and it is thus possible to achieve efficient data transmission.

[41] Moreover, in the data acquisition system according to the present invention, a data storage device is disposed outside and spaced apart from the blade, and it is thus possible to prevent data disappearance or loss caused by damage to the blade during testing.

[42] Other objects, specific advantages, and novel features of the present invention will be more clearly understood from the accompanying drawings, the following detailed description, and the preferred embodiments.

[43]

Brief Description of Drawings

[44] Fig. 1 is a diagram illustrating a general cross-sectional structure of a wind turbine blade.

[45] Fig. 2 is a schematic diagram illustrating an example of a static test.

[46] Fig. 3 is a schematic diagram illustrating an example of a fatigue test.

[47] Fig. 4 is a schematic diagram for describing a problem of a data acquisition system for testing a wind turbine blade according to the related art.

[48] Fig. 5 is a configuration diagram illustrating an example of a data acquisition system according to the present invention.

[49] Fig. 6 is a cross-sectional view of a blade for describing the arrangement of sensors.

[50] Fig. 7 is a configuration diagram schematically illustrating a data acquisition system according to a first embodiment of the present invention.

[51] Fig. 8 is a block diagram illustrating a connection state of data acquisition devices and a data hub for time synchronization of detected data in a testing system according to the first embodiment.

[52] Fig. 9 is a configuration diagram schematically illustrating a data acquisition system according to a second embodiment of the present invention.

[53] Fig. 10 is a block diagram illustrating an example of a configuration for time synchronization of detected data in a testing system according to the second embodiment.

[54] Fig. 11 is a block diagram illustrating a configuration for time synchronization of detected data according to a modified example of the second embodiment.

[55] Fig. 12 is a flowchart illustrating a data acquisition method for testing a wind turbine blade according to the present invention.

[56] Fig. 13 is a graph showing detected data obtained through a centralized data acquisition device according to the related art.

[57] Fig. 14 is a graph showing detected data obtained through a distributed data acquisition device according to the present invention.

[58]

Best Mode for Carrying out the Invention

[59] Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[60] It should be understood that detailed descriptions of well-known functions or structures related to the present invention will not be provided so as not to unnecessarily obscure the gist of the present invention. In addition, in assigning reference numerals and signs, the same reference numerals and signs will be used for the same constituent elements even when they are illustrated in the other drawings.

[61]

[62] **(Data Acquisition System for Testing Wind Turbine Blade)**

[63] First, a data acquisition system according to the present invention will be described with reference to Figs. 5 to 12.

[64] Fig. 5 is a configuration diagram illustrating an example of a data acquisition system according to the present invention, and Fig. 6 is a cross-sectional view of a blade for describing the arrangement of sensors. The data acquisition system according to the present invention is provided for the purpose of the static test and the fatigue test which are carried out for the performance evaluation of a wind turbine blade. The data acquisition system may be usefully applied to a test for a several-MW-scale large-sized blade, but it should be noted that the data acquisition system is also applicable to a test for a mid- or small-sized blade on a scale of 1 MW or less.

[65] As illustrated in Fig. 5, a data acquisition system according to an embodiment of the present invention includes a blade 10, sensors 110, 120, and 130, distributed data acquisition devices 200, and a data hub 400.

[66] A root portion 14 of the blade 10 is fixed to a fixing base (not shown) for a test.

[67] The sensors 110, 120, and 130 are distributedly arranged on a surface or inside of the blade 10, and play a role in converting, into electric signals, physical parameters such

as strain, acceleration, and displacement generated when a test load is applied to the blade 10, and then outputting the electric signals. The embodiment in Fig. 5 illustrates a case where strain gauges 110 and 120 and an accelerometer 130 are provided, and various sensors such as a displacement gauge (not shown) may also be provided.

[68] The strain gauges 110 may be arranged in many rows on the surface of the blade 10 from an end of the root portion 14 of the blade 10 toward a tip portion 12. According to this embodiment, the strain gauges 110 are arranged in ten rows in total. In this case, the strain gauges 110 arranged in each row are disposed in parallel to a cord direction of the blade 10, and have a predetermined distance from the end of the root portion 14.

[69] As illustrated in Fig. 6, four strain gauges 110 arranged in each row may be attached to a leading edge 10a, a trailing edge 10b, an upper face, and a lower face of the blade 10, respectively. Accordingly, this embodiment illustrates a case where a total of 80 strain gauges 110 are attached to the surface of the blade 10. It is obvious that the number and attached positions of the strain gauges 110 may be varied, for example, according to the size and structure of the blade 10.

[70] The strain gauges 110 described above are single-axis strain gauges, and are arranged in a longitudinal direction of the blade 10. The single-axis strain gauge 110 detects a minute tensile or compressive strain generated on the surface of the blade, and then outputs an analog electric signal. A stress state of the surface of the blade 10 may be measured by analyzing the detected data.

[71] According to this embodiment, a shear web of the root portion 14 of the blade 10 is equipped with two multi-axis strain gauges 120. That is, if the static test or fatigue test is required, a biaxial shear gauge or a triaxial rosette gauge may be provided at a specific position on the blade 10, and it is thus possible to measure a stress state that is complexly applied on the blade 10.

[72] As illustrated in Fig. 5, the accelerometers 130 may be arranged in a line along a pitch axis of the blade 10. According to this embodiment, a total of five accelerometers 130 may be attached to the surface or inside of the blade 10. Accordingly, acceleration data based on the longitudinal position of the blade 10 may be detected when a test load is applied.

[73] At least two distributed data acquisition devices (DAQ) 200 are distributedly arranged on the blade 10, and play roles in acquiring the detected data from the sensors 110, 120, and 130 disposed adjacent thereto. It is preferable that the distributed data acquisition device 200 is provided with an AD converter to convert the acquired analog signal into a digital signal. The distributed data acquisition device 200 may be provided with an amplifier (Amp) for amplifying a weak analog signal, and a filter for allowing only a signal having a predetermined band to pass therethrough.

[74] According to this embodiment, the distributed data acquisition device 200 is a box-

type module, and a total of seven data acquisition devices 200 are fixedly attached to one face of the blade 10, as illustrated in Fig. 5. Here, the data acquisition devices 200 are tightly fixed using double-sided tape, an adhesive, Velcro tape, or the like, so as to prevent the data acquisition devices 200 from being detached due to the amplitude of the blade 10 during testing. When the test is completed, the data acquisition devices 200 are detached and collected from the blade 10.

[75] In this embodiment, each of five distributed data acquisition devices 200 has eight channels, which are connected to the single-axis strain gauges 110 arranged in two rows on the surface of the blade 10. One distributed data acquisition device 200 has two channels, which are connected to the multi-axis strain gauges 120 disposed on the root portion 14. The other distributed data acquisition device 200 has five channels, which are connected to the accelerometers 130 arranged along the pitch axis of the blade 10.

[76] The distributed data acquisition device 200 distributedly acquires the detected data from a number of sensors 110, 120, and 130 disposed on the blade 10. In this case, since the data acquisition device 200 is provided adjacent to the sensors disposed in predetermined areas of the blade 10, the lengths of the cables that are the signal lines of the sensors 110, 120, and 130 may be shortened. For example, when a large-sized blade has a length of 60 m or more, the cable may have a length of about 1 to 10 m.

[77] Meanwhile, each of the distributed data acquisition devices 200 may have 2 to 20 channels depending on the size of the blade 10 and the number of attached sensors, and the number of the data acquisition devices 200 to be installed may be in the range of 2 to 100.

[78] Fig. 7 is a configuration diagram schematically illustrating a data acquisition system according to a first embodiment of the present invention. The data acquisition system according to the present invention may further include a data storage device 300 and a data hub 400 as illustrated in Fig. 7.

[79] The data storage device 300 has a function of receiving and storing the detected data from the distributed data acquisition device 200. It is preferable that the data storage device 300 is disposed apart from the blade 10 by a certain distance. This is because if the data storage device 300 is disposed on the surface of the blade 10, the stored data may disappear or be lost due to an impact when the blade 10 is damaged and dropped during testing.

[80] The data hub 400 is wired or wirelessly connected to the distributed acquisition devices 200 to relay data transmission to the data storage device 300. According to this embodiment, the data hub 400 is attached to a position on the surface of the blade 10 as illustrated in Fig. 7, and is connected in parallel to the distributed data acquisition device 200 to thereby receive the detected data from each of the data acquisition

devices 200.

[81] In this embodiment, the data storage device 300 is connected to the data hub 400 through a LAN cable to perform Ethernet communication. However, other wired or wireless communication methods may be applied.

[82] Although the data hub 400 is disposed at the central portion of the blade 10 and connected to the distributed data acquisition devices 200, the data hub 400 may be disposed outside the blade 10. This is because the data output from the distributed acquisition device 200 is a digital signal so that noise cannot be included in the detected data even when the length of the cable for connecting the distributed data acquisition device 200 to the data hub 400 is increased.

[83] Fig. 8 is a block diagram illustrating a connection state of the data acquisition devices and the data hub for time synchronization of the detected data in the testing system according to the first embodiment described above. Referring to Fig. 8, a number of data acquisition devices 200 are connected in parallel to the data hub 400. Since the detected data transmitted from the data acquisition devices 200 are different in terms of time information from each other, it is necessary to time-synchronize the detected data to analyze the detected data.

[84] To this end, in the first embodiment of the present invention, a high-speed serial interface such as a firewire for separately connecting the distributed data acquisition devices 200 may be provided as illustrated in Fig. 8. That is, after the distributed data acquisition devices 200 are installed on the blade, the data acquisition devices 200 connected by the high-speed serial interface are set such that the detected data are time-synchronized and acquired. The data detected by the sensors 110, 120, and 130 through the high-speed serial interface are time-synchronized and acquired by the data acquisition devices 200, and are collected at the data hub 400.

[85] As another embodiment, a configuration may be provided such that the distributed data acquisition devices 200 are not separately connected, but the time synchronization is achieved with the data transmission through a parallel connection line (PL). For example, LAN or CAN (controller area network) communication may be performed through the parallel connection line (PL), or a high-speed serial interface may be provided.

[86] Fig. 9 is a configuration diagram schematically illustrating a data acquisition system according to a second embodiment of the present invention. In the data acquisition system according to the present invention, the distributed data acquisition devices 200 may be connected in series as illustrated in Fig. 8.

[87] According to this embodiment, as the distributed data acquisition devices 200 are connected in series, the detected data acquired by each of the data acquisition devices 200 are transmitted in one direction and are then stored in the data storage device 300

via the data hub 400.

[88] In this case, the data hub 400 may be disposed at an edge of the blade 10 as illustrated in Fig. 9. Alternatively, data hub 400 may be disposed outside the blade.

[89] Fig. 10 is a block diagram illustrating a connection state of the data acquisition devices and the data hub for time synchronization of the detected data in a testing system according to the second embodiment described above. According to this embodiment, the data hub 400 is connected in series to a number of data acquisition devices 200.

[90] A serial connection line (SL) may be configured to perform CAN communication, or may be provided with a high-speed serial interface such as a firewire. That is, data transmission and time synchronization may be performed through a single serial connection line.

[91] Fig. 11 is a block diagram illustrating a connection state of data acquisition devices and a data hub for time synchronization of detected data in a testing system according to a third embodiment of the present invention. According to this embodiment, the data hub 400 has a structure in which it is connected in parallel to sets 200a, 200b, and 200c which are each formed through a serial connection of the data acquisition devices (DAQ). That is, it is a combined structure in which a number of serial connection lines SL1, SL2, and SL3 are connected in parallel.

[92] Each of the serial connection lines SL1, SL2, and SL3 may be configured to perform CAN communication or may be provided with a high-speed serial interface. Resultantly, the data detected by the sensors (not shown) may be time-synchronized and acquired by the distributed data acquisition devices (DAQ).

[93]

[94] **(Data Acquisition Method for Testing Wind Turbine Blade)**

[95] Hereinafter, a data acquisition method for testing a wind turbine blade according to an embodiment of the present invention will be described with reference to Fig. 12. Here, a description will be given by also referring to Figs. 5 to 11.

[96] Fig. 12 is a flowchart illustrating a data acquisition method for testing a wind turbine blade according to the present invention. The data acquisition method according to the present invention begins with distributedly arranging a number of sensors 110, 120, and 130 on a main load path acting on the blade 10 according to a static test or fatigue test (S100). In this case, the sensors may be strain gauges 110 and 120, an accelerometer 130, and a displacement gauge, and the like, and are attached and installed on the surface or inside of the blade 10.

[97] Thereafter, two or more distributed data acquisition devices 200 are arranged on the surface of the blade 10, and signal lines (cables) of the sensors 110, 120, and 130 in the arrangement area are connected to the data acquisition devices 200 (S200). In this case,

the number of sensors 110, 120, and 130 arranged in each area may be 2 to 20, and 2 to 100 data acquisition devices 200 may be arranged.

[98] Also, it is preferable that the distributed data acquisition devices 200 are fixedly attached to one face of the blade 10 so as to be adjacent to the sensors in the area. Thus, according to the present invention, the lengths of the signal lines (cables) may be decreased to 10 m or less.

[99] Next, the data hub 400 is disposed on one face or the outside of the blade 10, and is connected to the distributed data acquisition devices 200 through a wired or wireless communication network (S300). The connection method may be a parallel or serial connection method, and a combination of parallel and serial connections is also possible.

[100] Also, a data storage device 300 communicating with the data hub 400 in a wired or wireless manner may be disposed outside the blade 10.

[101] Afterwards, the distributed data acquisition devices 200 are set such that the data detected by the sensors 110, 120, and 130 are time-synchronized and acquired (S400). Lines (PL and SL) connecting the data acquisition devices 200 are configured to perform CAN communication, or may be provided with a high-speed serial interface such as a firewire so that data transmission and time synchronization may be simultaneously achieved.

[102] Subsequently, a test load prescribed according to a static test or a fatigue test is applied to the blade 10 (S500). The test load is measured by a separately provided load cell (not shown).

[103] Lastly, the sensors 110, 120, and 130 disposed on the blade 10 convert physical parameters such as strain, acceleration, and displacement into electric signals, and output the electric signals, and the output data are then acquired by the distributed data acquisition device 200 (S600). The data acquired by the data acquisition device 200 are time-synchronized, and converted into digital signals by a built-in AD converter. The acquired data are stored in the data storage device 300 via the data hub 400.

[104] The performance evaluation of the blade 10 is performed using the time-synchronized detected data stored in the data storage device 300. For example, the detected data is transmitted to a personal computer (PC) with a predetermined test program incorporated therein to analyze the detected data, and thus the performance evaluation of the blade according to the static test or the fatigue test may be performed.

[105]

[106] **(Comparative Example)**

[107] Fig. 13 is a graph showing detected data obtained through a centralized data acquisition device according to the related art, and Fig. 14 is a graph showing detected data obtained through the distributed data acquisition device according to the present

invention.

[108] Fig. 13(a) shows an output of the detected data acquired by the centralized data acquisition device described in the background art, and shows a change in strain (㎛/m) over time (s). The detected data are measured by the strain gauge (pressure) attached to the upper face of the blade and the strain gauge (suction) attached to the lower face thereof, which are 21 m apart from the end of the root portion of the blade.

[109] Fig. 14(a) shows an output of the detected data acquired by the distributed data acquisition device according to the present invention. The detected data are measured by the strain gauges (SS and PS) which are 22.8 m apart from the end of the root portion.

[110] As can be seen from Fig. 13(b), in the centralized data acquisition device, a strain error of the detected data is high, i.e., 10 ㎛/m or more. This is because the length of the cable connecting the strain gauge and the data acquisition device is long, and therefore noise is included in the detected analog signal.

[111] As can be seen from Fig. 14(b), however, in the distributed data acquisition device, a strain error of the detected data is small, i.e., even less than 1 ㎛/m. This is because a number of data acquisition devices are distributedly arranged on the blade, and thus the cables connected to the sensors are shortened to thereby prevent noise from being included in the signal. That is, the data acquired by the distributed data acquisition devices of the present invention have a high signal-to-noise ratio, thereby significantly improving the reliability of the test results.

[112] As described above, although the present invention has been described by the limited embodiments and drawings, it would be obvious that the present invention is not limited thereto and may thus be variously changed and modified within the technical idea of the present invention and the equivalent scope of the claims set forth below by a person skilled in the art to which the present invention pertains.

[113]

Claims

[Claim 1] A data acquisition system for testing a wind turbine blade, comprising:
at least two distributed data acquisition devices(200) distributedly arranged on the wind turbine blade(10); and
at least two sensors distributedly arranged on a surface or inside of the blade and connected to the adjacent distributed acquisition devices with a signal wire.

[Claim 2] The data acquisition system as set forth in claim 1, further comprising a data storage device(300) storing detected data acquired by the distributed data acquisition devices(200).

[Claim 3] The data acquisition system as set forth in claim 1, further comprising a data hub(400) acquiring the data acquired from the distributed data acquisition devices(200).

[Claim 4] The data acquisition system as set forth in claim 3, wherein the data hub(400) is connected in parallel to the distributed data acquisition devices(200).

[Claim 5] The data acquisition system as set forth in claim 3, wherein the data hub(400) is connected in series to the distributed data acquisition devices(200).

[Claim 6] The data acquisition system as set forth in claim 3, further comprising a data storage device(300) storing the data acquired from the data hub(400).

[Claim 7] The data acquisition system as set forth in claim 1, wherein the distributed data acquisition devices(200) are connected in series each other by each high-speed serial interface.

[Claim 8] The data acquisition system as set forth in claim 6, wherein the data storage device(300) is disposed outside the blade, the data storage device(200) and the data hub(400) are communicated through a wired or wireless communication network.

[Claim 9] The data acquisition system as set forth in claim 1, wherein the distributed data acquisition devices(200) each comprise an A/D converter, an amplifier and a noise filter.

[Claim 10] The data acquisition system as set forth in claim 3, wherein the data hub(400) is applied digital data from the distributed data acquisition devices(200).

[Claim 11] The data acquisition system as set forth in claim 3, wherein the data hub is fixedly attached to one face of the blade or is disposed outside the blade.

[Claim 12] A data acquisition method for testing a wind turbine blade, comprising: distributedly arranging a number of sensors on a surface or inside of a blade, and distributedly arranging at least two distributed data acquisition devices (DAQ) on the blade, and connecting the sensors to the adjacent distributed acquisition devices with a signal wire;
processing a test for the blade; and
acquiring, by the distributed data acquisition devices, data detected by the sensors.

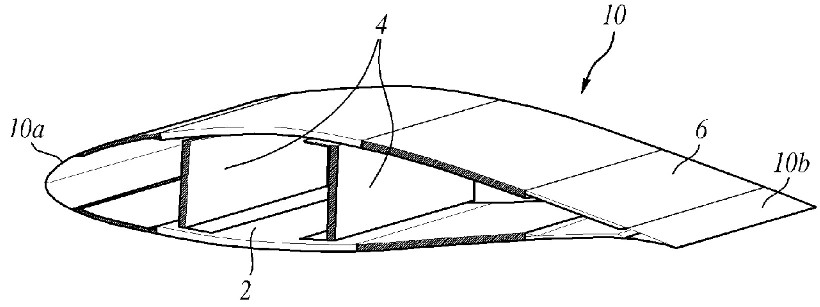
[Claim 13] The data acquisition method as set forth in claim 12, further comprising, after the arranging of the distributed data acquisition devices connecting a data hub to the distributed data acquisition devices.

[Claim 14] The data acquisition method as set forth in claim 13, wherein the distributed data acquisition devices and the data hub are connected in parallel or series or in a combination of parallel and serial connections.

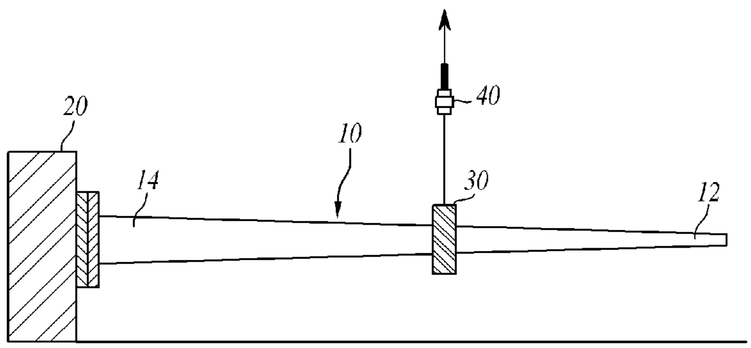
[Claim 15] The data acquisition method as set forth in claim 13, further comprising, after the connecting of the data hub to the distributed data acquisition devices, setting the distributed data acquisition devices such that the data detected by the sensors are time-synchronized and acquired.

[Claim 16] The data acquisition method as set forth in claim 12, wherein the acquiring of the data by the distributed data acquisition devices includes converting, by the distributed data acquisition device, the detected data into a digital signal.

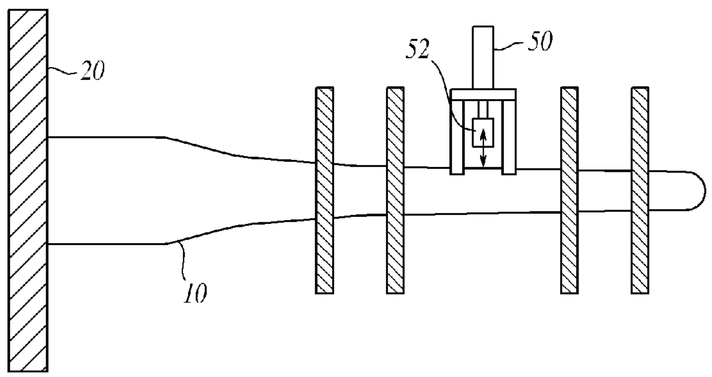
[Fig. 1]



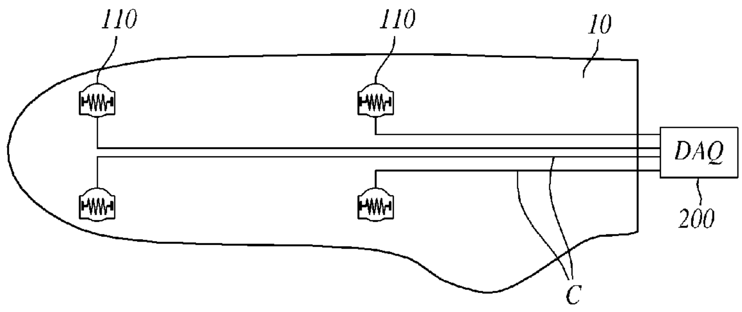
[Fig. 2]



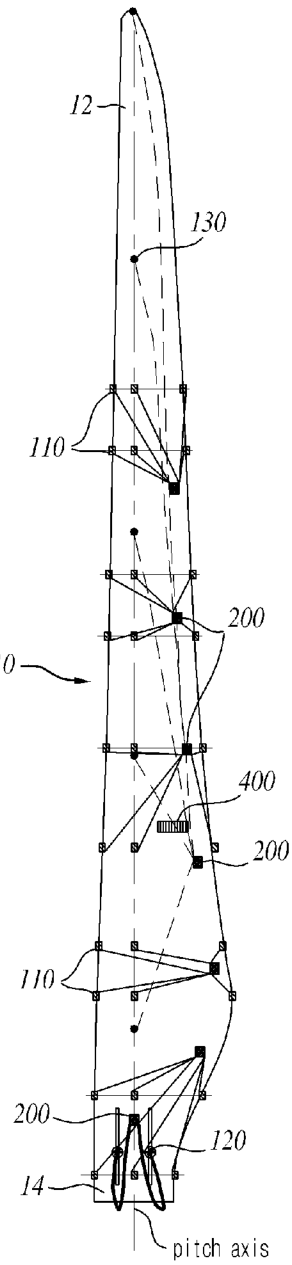
[Fig. 3]



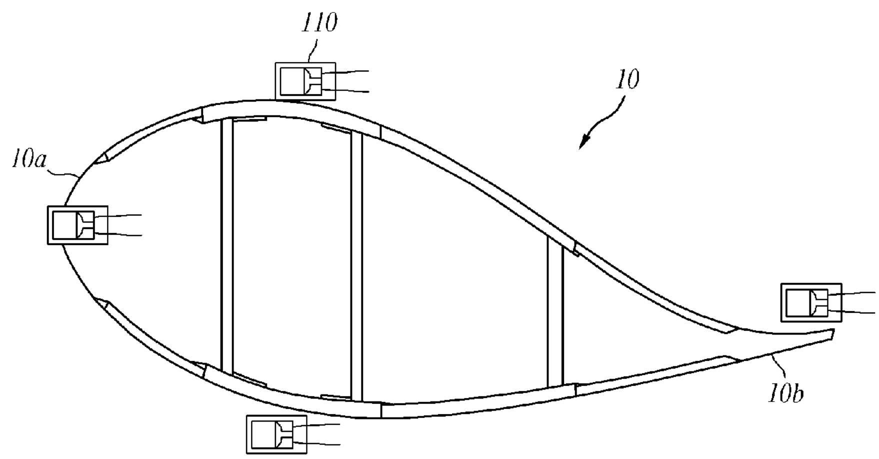
[Fig. 4]



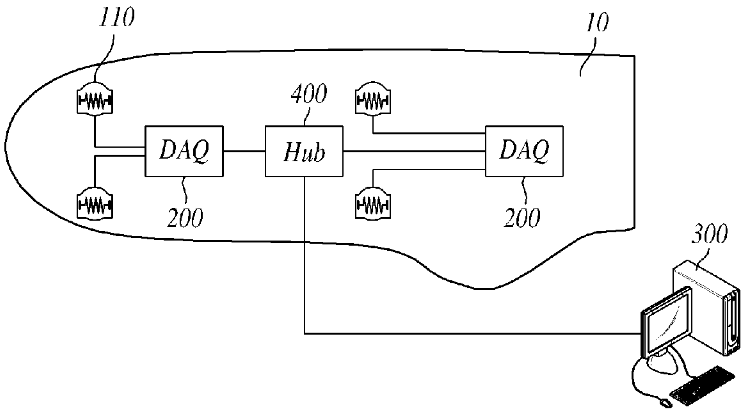
[Fig. 5]


12
130
110
200
10
400
200
110
200
120
14
pitch axis

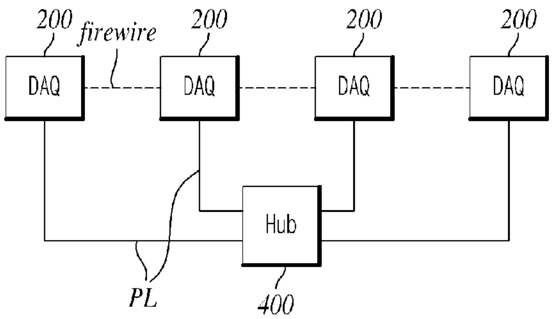
[Fig. 6]


110
10
10a
10b

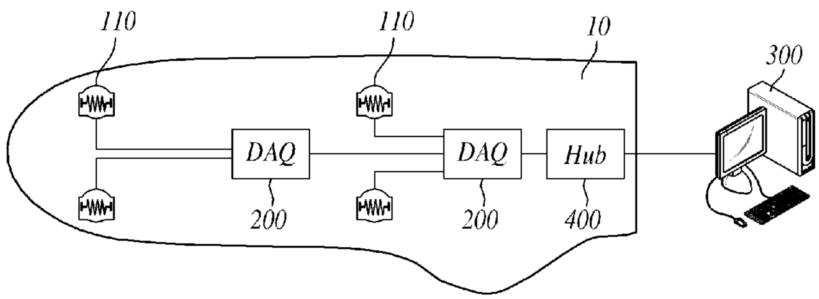
[Fig. 7]



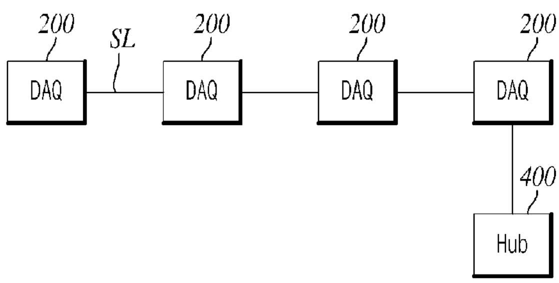
[Fig. 8]



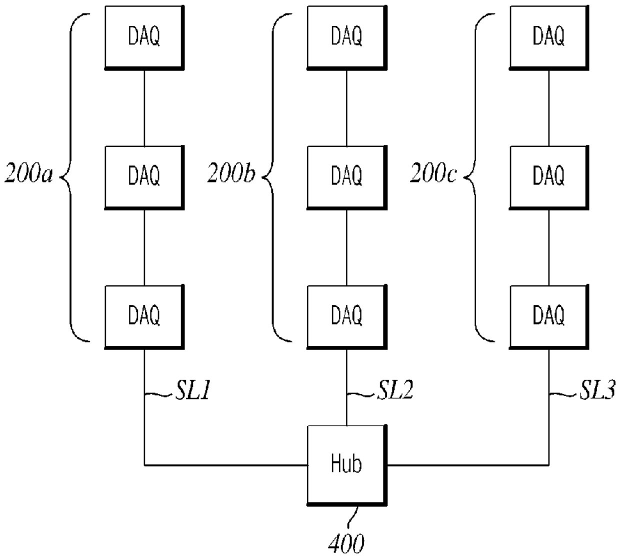
[Fig. 9]



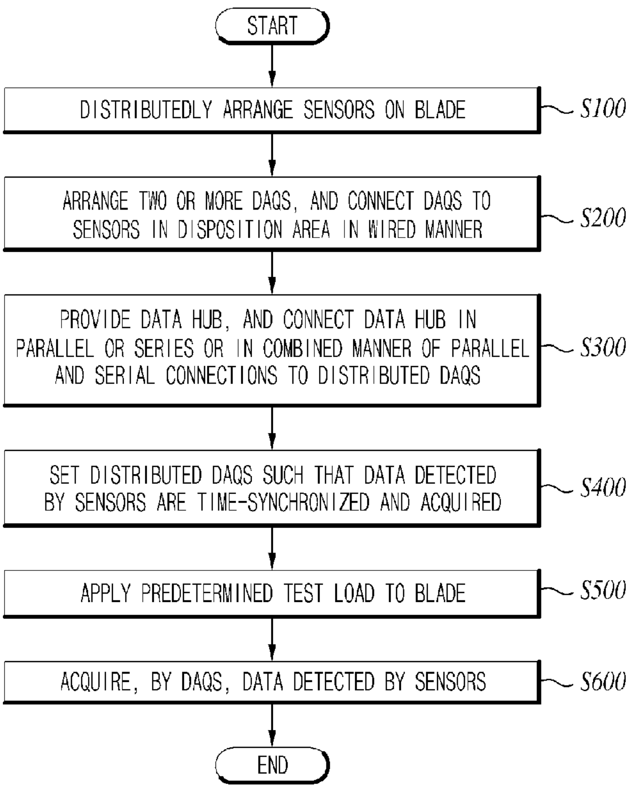
[Fig. 10]



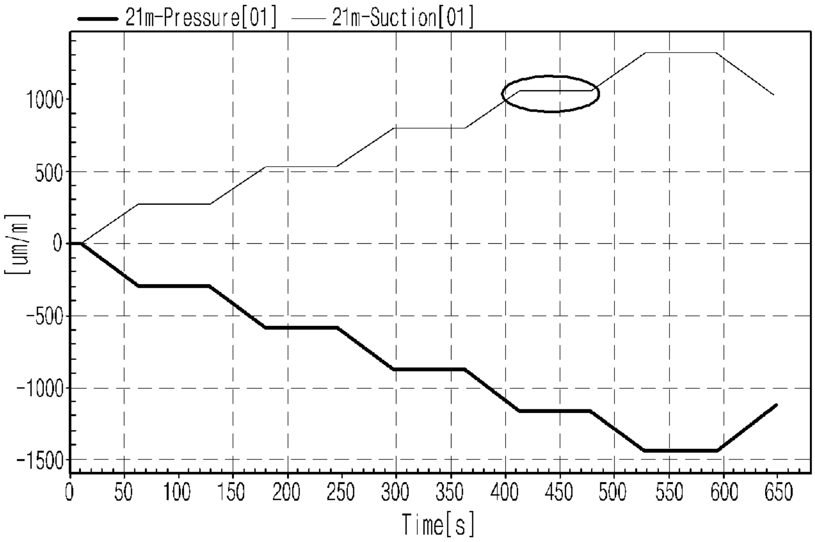
[Fig. 11]


DAQ
DAQ
DAQ
DAQ
DAQ
DAQ
DAQ
DAQ
DAQ
200a
200b
200c
SL1
SL2
SL3
Hub
400

[Fig. 12]


START
DISTRIBUTEDLY ARRANGE SENSORS ON BLADE
S100
ARRANGE TWO OR MORE DAQS, AND CONNECT DAQS TO SENSORS IN DISPOSITION AREA IN WIRED MANNER
S200
PROVIDE DATA HUB, AND CONNECT DATA HUB IN PARALLEL OR SERIES OR IN COMBINED MANNER OF PARALLEL AND SERIAL CONNECTIONS TO DISTRIBUTED DAQS
S300
SET DISTRIBUTED DAQS SUCH THAT DATA DETECTED BY SENSORS ARE TIME-SYNCHRONIZED AND ACQUIRED
S400
APPLY PREDETERMINED TEST LOAD TO BLADE
S500
ACQUIRE, BY DAQS, DATA DETECTED BY SENSORS
S600
END

[Fig. 13]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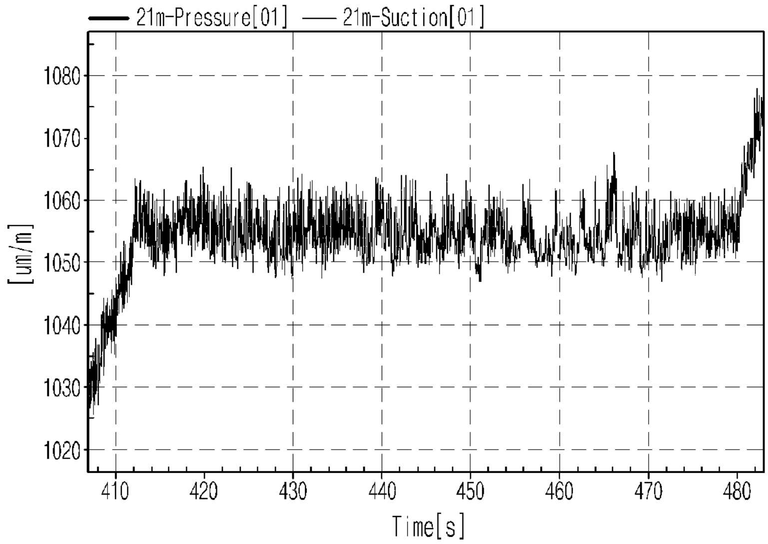
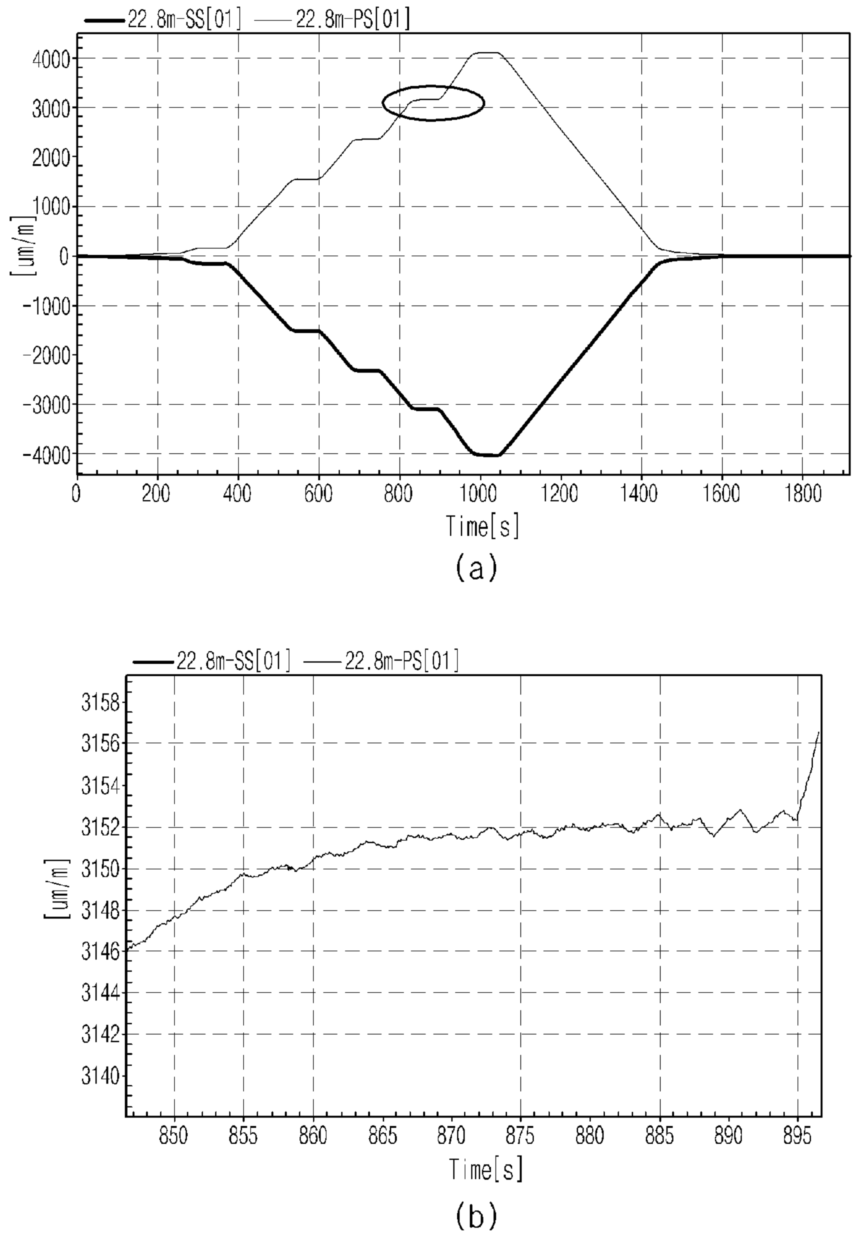
21m-Suction[01]
1000
500
0
-500
-1000
-1500
[um/m]
0 50 100 150 200 250 300 350 400 450 500 550 600 650
Time[s]

(a)


21m-Pressure[01]
21m-Suction[01]
1080
1070
1060
1050
1040
1030
1020
[um/m]
410 420 430 440 450 460 470 480
Time[s]

(b)

[Fig. 14]


22.8m-SS[01]
22.8m-PS[01]
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
[um/m]
0
200
400
600
800
1000
1200
1400
1600
1800
Time[s]
(a)
22.8m-SS[01]
22.8m-PS[01]
3158
3156
3154
3152
3150
3148
3146
3144
3142
3140
[um/m]
850
855
860
865
870
875
880
885
890
895
Time[s]
(b)