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

(11) EP 3 561 271 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
12.01.2022 Bulletin 2022/02

(21) Application number: **19170457.6**

(22) Date of filing: **23.04.2019**

(51) Int Cl.:
F02D 35/02 *(2006.01)* ***F02D 39/04*** *(2006.01)*
F02D 41/00 *(2006.01)* ***F02D 41/14*** *(2006.01)*
G01L 23/30 *(2006.01)*

(54) **SYSTEM FOR MEASURING OUTPUT OF LARGE-SIZED LOW-SPEED TWO-STROKE ENGINE AND METHOD FOR MEASURING OUTPUT OF LARGE-SIZED LOW-SPEED TWO-STROKE ENGINE**

SYSTEM ZUM MESSEN DER LEISTUNG EINES GROSSFORMATIGEN ZWEITAKTMOTORS MIT NIEDRIGER DREHZAHL UND VERFAHREN ZUM MESSEN DER LEISTUNG EINES GROSSFORMATIGEN ZWEITAKTMOTORS MIT NIEDRIGER DREHZAHL

SYSTÈME ET PROCÉDÉ DE MESURE DE LA PUISSANCE D'UN MOTEUR DEUX TEMPS À FAIBLE VITESSE ET DE GRANDE TAILLE

(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

(30) Priority: **23.04.2018 KR 20180046997**

(43) Date of publication of application:
30.10.2019 Bulletin 2019/44

(73) Proprietors:
- **Jung, Kyun Sik**
  Geumjeong-gu, Busan 46270 (KR)
- **Lee, Su Kyoung**
  Geumjeong-gu, Busan 46270 (KR)

(72) Inventors:
- **Jung, Kyun Sik**
  Geumjeong-gu, Busan 46270 (KR)
- **Lee, Su Kyoung**
  Geumjeong-gu, Busan 46270 (KR)

(74) Representative: **FARAGO Patentanwälte**
Thierschstraße 11
80538 München (DE)

(56) References cited:
WO-A1-2004/048762 **DE-A1-102011 083 471**
KR-B1- 101 061 290 **US-A1- 2016 146 132**

Printed by Jouve, 75001 PARIS (FR)

Description

BACKGROUND

Field

[0001] The present disclosure relates to a system for measuring output of a large-sized low-speed two-stroke engine and a method for measuring output of a large-sized low-speed two-stroke engine, more particularly, to a system and method for measuring output of a large-sized low-speed two-stroke engine, the system and method being able to more accurately measure output of an engine by removing a torsion error and an explosion angle error of a crankshaft.

Description of the Related Art

[0002] In general, a ship engine monitoring device is rising as necessary equipment for maintenance of ship engines. In particular, ship engine monitoring devices necessarily require a technology that minimizes measurement errors to perform precise and accurate measurement on engines, and to this end, various measuring technologies have been developed.

[0003] An indicator for measuring the output of ship engines is representative of the measurement technology of ship engine monitoring devices and is classified into a mechanical type and an electronic type.

[0004] A mechanical indicator has been generally used for ships in the related art, and is mounted on a test cock of an engine and performs measurement by drawing the pressure of a combustion chamber on paper and then calculating the area using a measurer called a planimeter. However, the mechanical indicator has a problem that there is an error of around about 10% between the actual state of an engine and the measurement result due to the proficiency of the person who performs measurement and an error of the measurer.

[0005] Accordingly, recently, electronic indicators compensating for the defects of mechanical indicators are generally used.

[0006] An electronic indicator measures the output of a ship engine, unlikely the mechanical indicator, by drawing a volume diagram through sampling on pressure for one cycle of the engine using digital equipment and by automatically calculating the area.

[0007] The electronic indicator samples pressure for one cycle of an engine through a time-based method or an angle-based method.

[0008] Sampling based on the time-based method is a method of collecting pressure values in accordance with a set time unit for one cycle of an engine and sampling based on the angle-based method means a method of collecting pressure values in accordance with a set angle unit for one cycle of an engine.

[0009] However, sampling based on the time-based method has a problem of causing a large top dead center (TDC) error because it ignores an instantaneous speed change of an engine.

[0010] Accordingly, sampling based on an angle-based method that collects pressure values using an angle sensor (encoder) that is installed at an end of a crankshaft is usually applied in the related art.

[0011] That is, ship engine monitoring devices of the related art measure the output of an engine using an electronic pressure measurement technology employing the sampling technology based on the angle-based method for accurate and precise measurement.

[0012] Meanwhile, in measurement of the output of an engine, a TDC error of 1 degree causes an about 10% error in the output of the engine, so it is very important to measure a TDC when measuring the output of an engine and previous researches recommend a TDC error within at least 0.1 degrees.

[0013] However, ship engine monitoring devices of the related art do not consider errors in torsion of a crankshaft and in explosion angle of cylinders when measuring the output of a large-sized low-speed two-stroke engine. That is, ship engine monitoring devices of the related art match a Z-pulse (a signal generating a pulse one time for one revolution) of an angle sensor mounted at the end of a crankshaft opposite to a flywheel with the actual TDC of a first cylinder, so accurate measurement is possible for the first cylinder. However, a torsion error and an explosion angle error of the crankshaft are not considered for the other cylinders, so the error between the actual output of the engine and the measured output exceeds a reference error range. That is, since the flywheel of an engine is disposed opposite the first cylinder where an angle sensor is set, ship engine monitoring devices of the related art determine that rotation occurs relatively early due to torsion by rotation, so they recognize the position of a TDC to be placed before the actual position. Accordingly, the calculated output value is larger than the actual output value of the engine.

[0014] For example, as for a 6-cylinder large-sized low-speed two-stroke engine, since the explosion angles of the cylinders are designed with intervals of 60 degrees, ship engine monitoring devices of the related art perform calculation under the assumption that the TDC of the second cylinder shows up after 60 degrees in accordance with the explosion order, when measuring the output of the engine. However, in actual large-sized low-speed two-stroke engines, the explosion angles according to the explosion order do not progress accurately with the intervals of 60 degrees and torsion of the crankshaft due to rotation is generated, so an error of over 15% is generated between the actual output of the engine and the measured output. For reference, the larger the size and the lower the speed, the larger the torsion of a crankshaft.

[0015] WO 2004 048762 A1 discloses the determination of the actual top dead center (TDC) of a predetermined reference cylinder and corrected using a known loss angle.

[0016] DE 10 201 1 083471 A1 discloses a deviation of the expected TDC based on the measured TDC of the reference cylinder that is caused by torsion of the crankshaft. This torsion is detected using at least two cylinder pressure sensors in the first and last cylinders.

[0017] US 2016 146132 A1 discloses angle deviation of cylinders caused by torsion of the crankshaft and that the cylinder pressure detection becomes more accurate if the exact position of the piston in the respective cylinder is known. KR 101 061 290 B1 discloses a crank angle sensor and an evaluation of the piston TDC after compression using in-cylinder pressure sensors and a loss angle known from measurements and stored in a table in the ECU.

SUMMARY

[0018] The present disclosure has been made in an effort to solve the problems described above and an object of the present disclosure is to provide an output measurement system and method of a large-sized low-speed two-stroke engine, the system and method being able to measure the accurate output of an engine by removing output errors of cylinders due to a torsion error and an explosion angle error of a crankshaft, by determining the differences between the position of the compression TDC of a reference cylinder and the positions of the compression TDCs of the other cylinders except for the reference cylinder, using a plurality of graphs, and then correcting the differences between the cylinders by adjusting the points in time of detection of an angle sensor unit.

[0019] An output measurement system of a large-sized low-speed two-stroke engine according to the invention for achieving the objects is an output measurement system of a large-sized low-speed two-stroke engine that measures output of an engine for one cycle. The system includes: a pressure sensor unit that detects individual combustion pressure of cylinders; an angle sensor unit that detects rotation angles of a crankshaft with a Z-pulse thereof matched with an actual TDC of a predetermined reference cylinder; and an output measurer that collects combustion pressure of cylinders at the rotation angles of the crankshaft from the pressure sensor unit and the angle sensor unit, shows a plurality of graphs about combustion pressure of the cylinders at the rotation angles of the crankshaft, combustion pressure of the cylinders at combustion chamber volumes, and pressure change rates of the cylinders at the rotation angles of the crankshaft, finds out the position of a compression TDC and a loss of angle of the reference cylinder from the graph about the pressure change rates of the cylinders at the rotation angles of the crankshaft, adjusts points in time when the angle sensor unit detects the rotation angle of the crankshaft for the other cylinders except for the reference cylinder, and then measures output of the cylinders.

[0020] According to the invention, the output measurer matches the positions of compression TDCs of the other cylinders except for the reference cylinder with the position of the compression TDC of the reference cylinder in the graph about pressure change rates of the cylinders at the rotation angles of the crankshaft by adjusting the points in time when the angle sensor unit detects the rotation angle of the crankshaft for the other cylinders except for the reference cylinder.

[0021] When determining the position of the compression TDC and the loss of angle of the reference cylinder from the graph about pressure change rates of the cylinders at the rotation angles of the crankshaft, the output measurer may further create a graph showing a trend line about the positions of the compression TDCs of the cylinders and the degree of torsion and a table showing the positions of the compression TDCs of the cylinders.

[0022] When determining the position of the compression TDC and the loss of angle of the reference cylinder from the graph about pressure change rates of the cylinders at the rotation angles of the crankshaft, the output measurer may further create a table showing position correction values for the other cylinders except for the reference cylinder by calculating the differences between the position of the compression TDC of the reference cylinder and the positions of the compression TDCs of the other cylinders except for the reference cylinder.

[0023] An output measurement method of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure is an output measurement method of a large-sized low-speed two-stroke engine that measures output of an engine for one cycle. The method includes: matching a Z-pulse of an angle sensor unit mounted on a predetermined reference cylinder with an actual TDC of the reference cylinder; creating a Pθ graph showing combustion pressure of cylinders at rotation angles of a crankshaft and a dP graph showing pressure change rates of the cylinders at the rotation angle of the crankshaft by collecting the combustion pressure of the cylinders at the rotation angles of the crankshaft; determining the position of a compression TDC and a loss of angle of the reference cylinder from the dP graph; matching positions of compression TDCs of the other cylinders except for the reference cylinder with the position of the compression TDC of the reference cylinder in the dP graph by adjusting points in time when the angle sensor unit detects the rotation angle of the crankshaft for the other cylinders except for the reference cylinder; and measuring output of the cylinders by creating a PV graph showing combustion pressure of the cylinders at combustion chamber volumes.

[0024] The determining of the position of a compression TDC and a loss of angle of the reference cylinder from the dP graph may include: creating a graph showing a trend line about the positions of the compression TDCs of the cylinders and the degree of torsion and a table showing the positions of the compression TDCs of the cylinders; determining the position of the compression TDC and the loss of angle of the reference cylinder on the basis of the dP graph, the graph showing a trend line about the positions of the compression TDCs of the cylinders and the degree of torsion, and the table showing the positions of the compression TDCs of the cylinders; and creating a table showing position correction values for the other cylinders except for the reference cylinder by calculating the differences between the position of the compression TDC of the reference cylinder and the positions of the compression TDCs of the other cylinders except for the reference cylinder.

[0025] According to embodiments of the present disclosure, it is possible to measure the accurate output of an engine by removing output errors of cylinders due to a torsion error and an explosion angle error of a crankshaft, by determining the differences between the position of the compression TDC of a reference cylinder and the positions of the compression TDCs of the other cylinders except for the reference cylinder, using a plurality of graphs, and then correcting differences between the cylinders by adjusting the points in time of detection of the angle sensor unit.

[0026] Further, since it is possible to quickly and accurately measure the output of an engine, as compared with output measurement equipment of the related art, the reliability of equipment can be improved.

[0027] Further, it is possible to accurately find out the position of Pmax and measure output by collecting accurate engine data for cylinders in response to angle signals. Furthermore, it is possible to accurately find out the points in time of fuel ignition and fuel injection in cylinders, the fuel injection amount of the cylinders, knocking, the matching relationship between post-combustion and a turbocharger, etc. by performing fuel analysis using the collected data. In addition, it is possible to not only optimize combustion, but improve the lifespan and fuel consumption efficiency of an engine by selectively adjusting the point in time of fuel injection, the fuel injection amount, turbocharger matching, etc., as needed, by providing a solution for optimum combustion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] The above and other aspects, features and other advantages of the present disclosure will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a diagram schematically showing the configuration of a system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure;
FIG. 2 is a Pθ graph showing combustion pressure of cylinders at rotation angles of a crankshaft measured by the system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure;
FIG. 3 is a PV graph showing combustion pressure at combustion chamber volumes of cylinders measured by the system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure;
FIG. 4 is a dP graph showing pressure change rates of cylinders at rotation angles of a crankshaft measured by the system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure;
FIG. 5 is a dP graph enlarging the portion "A" of FIG. 4;
FIG. 6A is a graph showing a trend line of the position of a compression TDC and the degree of torsion for cylinders measured by the system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure and FIG. 6B is a table showing the positions of the compression TDCs of cylinders;
FIG. 7 is a table showing position correction values of the compression TDCs of cylinders calculated by the system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure;
FIG. 8 is a dP graph showing pressure change rates of cylinders at rotation angles of a crankshaft corrected by the system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure;
FIG. 9 is a diagram showing an output measurement result created by the system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure; and
FIGS. 10 and 11 are flowcharts showing a method for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENT

[0029] FIG. 1 is a diagram schematically showing the configuration of a system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure.

[0030] Referring to FIG. 1, a system for measuring output of a large-sized low-speed two-stroke engine 100 (hereafter, referred to as an output measurement system 100') according to an embodiment of the present disclosure, which is an output measurement system that measures the output for one cycle of a large-sized low-speed two-stroke engine that is applied to ships etc., includes a plurality of sensor units.

[0031] The plurality of sensor units includes a pressure sensor unit 10 that detects signals about individual combustion pressure of cylinders (not shown) and an angle sensor unit 20 that detects a signal about a rotation angle of a crankshaft (not shown).

[0032] The pressure sensor unit 10 is installed at the test cock (not shown) of an engine (E/G) and detects individual combustion pressure of a plurality of cylinders of the engine. The pressure sensor unit 10 is electrically connected with an output measurer 30 to be described below and transmits signals about the detected individual combustion pressure of the cylinders to the output measurer 30.

[0033] The angle sensor unit 20 is installed at the end, which is positioned opposite a flywheel (not shown), of a crankshaft and detects the rotation angle of the crankshaft, and is electrically connected with the output measurer 30 and transmits a signal about the detected rotation angle of the crankshaft to the output measurer 30. A Z-pulse (a signal generating a pulse one time for one revolution) of the angle sensor unit 20 is matched with the actual TDC of a predetermined reference cylinder. The reference cylinder means a first cylinder that is connected with a crankshaft and generates explosion first when an engine is driven. The actual TDC means the center point between the moment when a piston reaches the position of a TDC and a dial gauge stops moving and the moment when the dial gauge starts to move again, when the position of a piston is measured by a dial gauge. For reference, the actual TDC is marked on the flywheel of an engine. For example, the angle sensor unit 20 may be an encoder having a predetermined resolution.

[0034] Though not shown in the drawings, an AD converter (not shown) that converts analog signals transmitted from the sensors into digital signals may be further provided between the plurality of sensors (the pressure sensor unit 10 and the angle sensor unit 20) and the output measurer 30.

[0035] The output measurement system 100 includes the output measurer 30.

[0036] The output measurer 30 is electrically connected with a plurality of sensors, receives signals about individual combustion pressure of cylinders detected by the sensors and a signal about the rotation angle of a crankshaft, and collects combustion pressure of the cylinders at rotation angles of the crankshaft for one cycle of an engine from the received signals.

[0037] The output measurer 30 analyzes combustion chamber volumes and pressure change rates of the cylinders by introducing the collected data into a predetermined expression and shows the analysis result in a plurality of graphs about combustion pressure of the cylinders at rotation angles of the crankshaft, about combustion pressure for combustion chamber volumes of the cylinders, and about pressure change rates of the cylinders at rotation angles of the crankshaft.

[0038] Analysis items analyzed by the output measurer 30, and graphs are described in detail hereafter.

[0039] FIG. 2 is a Pθ graph showing combustion pressure of cylinders at rotation angles of a crankshaft measured by the system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure, FIG. 3 is a PV graph showing combustion pressure at combustion chamber volumes of cylinders measured by the system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure, FIG. 4 is a dP graph showing pressure change rates of cylinders at rotation angles of a crankshaft measured by the system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure, and FIG. 5 is a dP graph enlarging the portion "A" of FIG. 4. FIG. 6A is a graph showing a trend line of the position of a compression TDC and the degree of torsion for cylinders measured by the system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure, FIG. 6B is a table showing the positions of the compression TDCs of cylinders, and FIG. 7 is a table showing position correction values of the compression TDCs of cylinders calculated by the system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure. FIG. 8 is a dP graph showing pressure change rates of cylinders at rotation angles of a crankshaft corrected by the system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure, and FIG. 9 is a diagram showing an output measurement result created by the system for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure.

[0040] Referring to FIG. 2, the output measurer 30 collects combustion pressure of cylinders at rotation angles of a crankshaft for one cycle of an engine, by taking a signal from the angle sensor unit 20 measuring the rotation angle of the crankshaft as a trigger, and then shows the result in a Pθ graph showing the rotation angle of the crankshaft for the cylinders on X-axis and the combustion pressure at the rotation angle on Y-axis. For reference, the crankshaft is set to rotate 360 degrees per cycle of an engine.

[0041] Referring to FIG. 3, the output measurer 30 calculates combustion chamber volumes of the cylinders at the rotation angles of the crankshaft from the following Expressions 1 and 2 and shows the combustion chamber volumes in a PV graph showing combustion pressure at the combustion chamber volumes of the cylinders. For reference, a combustion chamber volume, that is, an area in a PV graph may mean the output (indicated horsepower) of a cylinder. Accordingly, the sum of the output of cylinders may mean the output of an engine.

[Expression 1]

$$V(i) = vc + s \times X(i)$$

where V(i) is a combustion chamber volume at a rotation angle, vc is a gap volume, s is the cross-sectional area of a cylinder, X(i) is piston displacement for rotation of a crankshaft, and vc = vh(stroke volume) / (Comratio(compression ratio) - 1.0), vh = s × stroke(height from top dead center to bottom dead center), and s = 3.14 × bore^2/4 may be defined. For example, 'i' indicating a crank angle may be set as 1°, 0.5°, 0.2°, etc., depending on sampling.

[Expression 2]

$$X(i) = rr \times [(1.0 - \cos(de)) + \frac{1.0 \times (1.0 - \cos(2de))}{4.0 \times ramda}]$$

where rr is a crank radius, de is a crank angle, and ramda = ℓ (length of connecting rod) / rr.

[0042] Referring to FIG. 4, the output measurer 30 calculates pressure change rates of the cylinders at the rotation angles of the crankshaft and then shows the pressure change rates in a dP graph showing the pressure change rates of the cylinder at the rotation angles of the crankshaft.

[0043] That is, the output measurer 30, in order to find out fine changes in pressure that are difficult to find out from the Pθ graph, differentiates the combustion pressure values of the cylinders at the rotation angles of the crankshaft, using the following Expression 3, and shows the result in the dP graph.

[Expression 3]

$$dP = \frac{P(i-2) - P(i+2) + 8.0 \times [P(i+1) - P(i-1)]}{12}$$

where dP is a pressure change rate at a rotation angle, P is sampling pressure, and i is a rotation angle of a crankshaft. The term 'P' that indicates sampling pressure is absolute pressure. For example, when sampling pressure is P0, P = P0 + Patm (atmospheric pressure) may be defined.

[0044] The output measurer 30 finds out the position of a compression TDC and a loss of angle of a reference cylinder from the graph about the pressure change rates of the cylinders at rotation angles of the crankshaft, that is, the dP graph.

[0045] In detail, the output measurer 30 finds out the position of the compression TDC of the reference cylinder from a position where dp/dθ = 0 when the crankshaft is positioned close to 180 degrees from the dP graph shown in FIG. 4. That is, the position of a compression TDC shows a Pcomp position that is the point where the internal pressure of a cylinder reaches the maximum by compressing the air in the cylinder before fuel is injected, so it is possible to find out the positions of the compression TDCs of not only the reference cylinder, but other cylinders from the Pcom position, that is, the first point (close to 180 degrees) where dp/dθ = 0 in the dP graph. For reference, the point where dp/dθ = 0 when the crankshaft is positioned close to 195 degrees in FIG. 4 is the Pmax position where maximum combustion pressure is reached by combustion of fuel. Referring to FIG. 5, the output measurer 30 finds out the positions of the compression TDCs of the cylinders, and then finds out errors in the compression TDCs of the cylinders and calculates a loss of angle of the reference cylinder. That is, since the Z-pulse of the angle sensor unit 20 has been matched with the actual TDC of the reference cylinder, the output measurer 30 calculates the loss of angle of the reference cylinder by calculating the difference between 180 degrees that is a peak reference and the angle of the crankshaft corresponding to the position of the compression TDC of the reference cylinder.

[0046] In order to find out the position of the compression TDC and the loss of angle of the reference cylinder from the dP graph, the output measurer 30 may further create a graph showing a trend line of the positions of the compressions TDCs of cylinders and the degree of torsion, as shown in FIG. 6A, and a table showing the positions of the compression TDCs of cylinders, as shown in FIG. 6B. For reference, in FIG. 6A, the compression TDC of the reference cylinder (first cylinder) is set as the position of 0 under the assumption that it is the accurate TDC because it has been set with the Z-pulse of the encoder matched, and the compression TDCs of the other cylinders except for the reference cylinder are shown at positions spaced by the differences from the compression TDC of the reference cylinder. Accordingly, the output measurer 30 can easily find out whether there is torsion of the crankshaft, the degree of torsion of the crankshaft, whether there is an explosion angle error of the crankshaft, etc. by comparing the positions of the compression TDCs of the cylinders with the trend line and determining the degree of deviation of the positions of the compression TDCs of the cylinders from the trend line on the basis of the graph shown in FIG. 6A. The output measurer 30, as shown in FIG. 7, can calculate and show position correction values for the other cylinders except for the reference cylinder in a table by calculating the differences between the position of the compression TDC of the reference cylinder and the positions of the compression TDCs of the other cylinders except for the reference cylinder.

[0047] The output measurer 30 finds out the position of the compression TDC and a loss of angle of the reference cylinder from the dP graph and then adjusts the points in time when the angle sensor unit 20 detects the rotation angle of the crankshaft for the other cylinders except for the reference cylinder by applying the calculated correction values to the angle sensor unit 20.

[0048] That is, by adjusting the points in time when the angle sensor unit 20 detects the rotation angle of the crankshaft for the other cylinders except for the reference cylinder, the output measurer 30 can match the positions of the compression TDCs of the other cylinders except for the reference cylinder with the position of the compression TDC of the reference cylinder in the graph (dP graph) about compression change rates of cylinders at rotation angles of a crankshaft, as shown in FIG. 8.

[0049] The output measurer 30 measures output of the cylinders by creating a PV graph showing combustion pressure at combustion chamber volumes of cylinders after matching the positions of the compression TDCs of the other cylinders except for the reference cylinder with the position of the compression TDC of the reference cylinder by adjusting the points in time when the angle sensor unit 20 detects the rotation angle of the crankshaft.

[0050] The output measurer 30 can further analyze heat generation rates and combustion gas temperature of the cylinders by introducing the data collected from the sensor units into a predetermined expression and can show the analysis result in a plurality of graphs about heat generation rates of the cylinders at rotation angles of the crankshaft and about combustion gas temperature of the cylinders at rotation angles of the crankshaft.

[0051] Referring to FIG. 9, the output measurer 30 can calculate heat generation rates of the cylinders at rotation angles of the crankshaft on the basis of the following Expressions 4, 5, and 6 and can show the heat generation rates in a heat generation rate graph showing the heat generation rates of the cylinders at the rotation angles of the crankshaft.

[Expression 4]

$$ROHR = \frac{A}{\kappa - 1}\left(V\frac{dP}{d\theta} + \kappa P\frac{dV}{d\theta}\right)$$

where ROHR (Rate Of Heat Release) is a heat generation rate at a rotation angle, A = 1.0 / 42700.0, κ is a specific heat ratio.

[Expression 5]

$$\kappa = C_0 + C_1 T + C_2 T^2 + \frac{C_3}{air}$$

where C_0 = 1.4373, C_1 = -1.318 × 10^{-4}, C_2 = 3.12 × 10^{-8}, C_3 = -4.8 × 10^{-2}, ***air*** is an excess air ratio, and T is combustion gas temperature at a rotation angle. For reference, the combustion gas temperature T can be calculated from the ideal gas equation of state and a theoretical air amount of 14.5 kgf that is the theoretical air amount of diesel oil can be applied.

[Expression 6]

$$dV(i) = dr \times \left(\frac{360}{\text{Encoder Resolution}} \right) \times s \times rr \times \left(\sin(de) + \left(\frac{1.0}{(2.0 \times ramda)} \times \sin(2.0 \times de)\right)\right)$$

where dV is a differentiated combustion chamber volume, dr = pai(3.141593) / 180, s = 3.14 × bore^2/4, rr is a crank radius, de is a rotation angle of a crankshaft, and ramda = ℓ(length of connecting rod) / rr. For reference, the encoder resolution is the intrinsic pulse value of an encoder and all encoders having any resolution can be applied to Expression

6 by the term '360/encoder resolution'.

[0052] The output measurer 30 can calculate combustion gas temperature of the cylinders at rotation angles of the crankshaft on the basis of the following Expression 7, and can show the combustion gas temperature in a combustion gas temperature graph showing combustion gas temperature of the cylinders at the rotation angles of the crankshaft.

[0053] That is, since combustion occurs for a very short time in a combustion chamber, there is a limit in measuring combustion gas temperature in a combustion chamber using existing thermometers. Accordingly, the output measurer 30 can calculate the combustion gas temperature at the rotation angles of the crankshaft using the ideal gas equation of state.

[Expression 7]

$$T(i) = \frac{P(i)\,V(i)}{GR}$$

where T(i) is combustion gas temperature at a rotation angle, G is gas weight, R is a gas constant, P(i) is combustion chamber pressure at a rotation angle, and V(i) is a combustion chamber volume at a rotation angle.

[0054] The gas weight G in Expression 7 can be calculated by the following Expression 8.

[Expression 8]

$$G = \frac{PV}{TR} \times ve$$

where P is initial pressure (or scavenging pressure), V is a combustion chamber volume, T is initial temperature (or scavenging temperature), and ve is charging efficiency of intake air of an engine. For example, it is preferable to apply charging efficiency of intake air of an engine of 0.8 for four strokes and 0.75 for two strokes, but it is not limited thereto and can be adjusted, according to the charging efficiency. That is, the strokes of a 4-stroke engine are clear in comparison to the strokes of a 2-stroke engine, so charging efficiency of intake air of an engine higher than that of the 2-stroke engine can be applied.

[0055] The output measurer 30 can further show an instantaneous speed change graph by analyzing instantaneous speeds of an engine at rotation angles of a crankshaft.

[0056] Referring to FIG. 9, the output measurer 30 can calculate instantaneous speeds of an engine at rotation angles of a crankshaft for one cycle of the engine from the following Expression 9 and can show the result in an instantaneous speed change graph showing instantaneous speed changes of an engine at rotation angles of a crankshaft for one cycle of the engine.

[0057] For reference, the instantaneous speed of an engine is changed by compression and explosion in cylinders, so the engine does not rotate at a constant speed for one revolution. Accordingly, since a large-sized low-speed engine rotates at a low speed, the instantaneous speed changes by the number of cylinders for one revolution.

[0058] The instantaneous speed of an engine can be defined by the following Expression 9.

[Expression 9]

$$Instantaneous\ speed[rpm] = \frac{60}{encoder\ resolution \times (count\ clocktime) \times (count\ number)}$$

where 'Instantaneous speed' is the instantaneous speed of an engine, 'encoder resolution' is the number of pulses (revolution) of an encoder, 'count clock time' is the speed of inter-pulse internal count signal, and 'count number' is the number of internal count signals calculated from the speed of inter-pulse internal count signals.

[0059] The output measurer 30 can determine the combustion state of an engine by analyzing at least two or more of a plurality of created graphs.

[0060] In detail, the output measurer 30 can determine a fuel-air ratio state of fuel of cylinders, a fuel injection state of fuel of cylinders, a fuel consumption state of cylinders, a fuel amount state of cylinders, a knocking state of an engine, a post-combustion state of cylinders, and a combustion state of an engine related to at least one of whether the items of maximum combustion pressure of cylinders are matched by analyzing at least two or more of a plurality of graphs.

[0061] The output measurer 30 can further show a table including at least one analysis datum together with a plurality of graphs.

[0062] Referring to FIG. 9, the output measurer 30 can measure the output of an engine and then show the measurement result in a table including at least one datum of the number of revolutions (rpm) of the engine , maximum compression pressure (Pcomp), maximum combustion pressure (Pmax), a crank angle position at maximum combustion pressure, IMEP (Indicated Mean Effective Pressure), IHP (Indicated Horse Power), BHP (Brake Horse Power), ROHR (Rate Of Heat Release), and SFC (Specific Fuel Consumption) for cylinders.

[0063] A method for measuring output of a large-sized low-speed two-stroke engine (hereafter, referred to as an 'output measurement method for an engine') according to an embodiment of the present disclosure is described hereafter.

[0064] For reference, components for describing the output measurement method for an engine are given the same reference numerals used for describing the output measurement system for the convenience of description, and the same or repeated description is not provided.

[0065] FIGS. 10 and 11 are flowcharts showing a method for measuring output of a large-sized low-speed two-stroke engine according to an embodiment of the present disclosure.

[0066] The output measurement method for an engine, which is an output measurement method of measuring the output for one cycle of a large-sized low-speed two-stroke engine, is performed by the output measurement system 100.

[0067] Referring to FIG. 10, the output measurement system 100 matches the Z-pulse of an angle sensor unit 20 mounted on a predetermined reference cylinder with the actual TDC of the reference cylinder (S100).

[0068] Next, the output measurement system 100 collects combustion pressure of cylinders at rotation angles of a crankshaft and then creates a Pθ graph showing the combustion pressure of the cylinder at the rotation angle of the crankshaft and a dP graph showing pressure change rates of the cylinders at the rotation angles of the crankshaft (S200).

[0069] That is, the output measurement system 100 creates a Pθ graph, as shown in FIG. 2, by collecting combustion pressure of the cylinders at the rotation angles of the crankshaft after matching the Z-pulse of the angle sensor unit 20 with the actual TDC of the reference cylinder, and creates a dP graph, as shown in FIG. 4, by applying the collected data to a predetermined expression.

[0070] Next, the output measurement system 100 finds out the position of the compression TDC and a loss of angle of the reference cylinder from the dP graph, as shown in FIG. 10 (S300).

[0071] In detail, referring to FIG. 11, the output measurement system 100 can create a graph showing a trend line about the positions of the compression TDCs of the cylinders and the degree of torsion and a table showing the positions of the compression TDCs of the cylinders (S310), can find out the position of the compression TDC and a loss of angle of the reference cylinder on the basis of the dP graph, the graph showing a trend line about the positions of the compression TDCs of the cylinders and the degree of torsion, and the table showing the positions of the compression TDCs of the cylinders (S320), and then can create a table showing position correction values for the other cylinders except for the reference cylinder by calculating the differences between the position of the compression TDC of the reference cylinder and the positions of the compression TDCs of the other cylinders except for the reference cylinder (S330) on the basis of the result of S320.

[0072] That is, the output measurement system 100 can show position correction values for the other cylinders except for the reference cylinder in a table, as shown in FIG. 7, by determining the positions of the compression TDCs of the cylinders (the point where $dp/d\theta = 0$ when the crankshaft is positioned close to 180 degrees), the loss of angle of the reference cylinder, the errors in the compression TDCs of the cylinders, whether there is torsion of the crankshaft, an explosion angle error of the crankshaft, etc. from the dP graphs shown in FIGS. 4 and 5, the graph showing a trend line about the positions of the compression TDCs of the cylinders and the degree of torsion shown in FIG. 6A, and the table showing the positions of the compression TDCs of the cylinders shown in FIG. 6B, and then by calculating the differences between the position of the compression TDC of the reference cylinder and the positions of the compression TDCs of the other cylinders except for the reference cylinder. For example, referring to FIGS. 5 and 6B, it can be seen that the position of the compression TDC of a reference cylinder (first cylinder) is 179.85, the loss of angle of the reference cylinder is 0.15 degrees, and the maximum error in compression TDC of the cylinders is about 1 degree. Referring to FIG. 6A, the positions of the compression TDCs of the cylinders are out of the trend line in accordance with the explosion order, so it can be seen that there are explosion angle errors. Accordingly, correction values can be calculated for the other cylinders as shown in FIG. 7.

[0073] Next, the output measurement system 100, as shown in FIG. 10, matches the position of the compression TDC of the reference cylinder with the positions of the compression TDCs of the other cylinders except for the reference cylinder in the dP graph by adjusting the points in time when the angle sensor unit 20 detects the rotation angle of the crankshaft for the other cylinders except for the reference cylinder on the basis of the calculated position correction values (S400).

[0074] That is, by adjusting the points in time when the angle sensor unit 20 detects the rotation angle of the crankshaft for the other cylinders except for the reference cylinder, the output measurement system 100 can match the positions of the compression TDCs of the other cylinders except for the reference cylinder with the position of the compression TDC of the reference cylinder in the graph (dP graph) about compression change rates of cylinders at rotation angles of a crankshaft, as shown in FIG. 8.

[0075] Next, the output measurement system 100 measures the output of the cylinders by creating a PV graph showing the combustion pressure at combustion chamber volumes of the cylinders (S500).

[0076] That is, the output measurement system 100 can measure the output (indicated horsepower (IHP)) of the cylinders by creating a PV graph showing the combustion pressure at combustion chamber volumes of the cylinders, as shown in FIG. 3, and then by calculating the area of the graph using a predetermined expression, after matching the position of the compression TDC of the reference cylinder with the positions of the compression TDCs of the other cylinders except for the reference cylinder by adjusting the points in time when the angle sensor unit 20 detects the rotation angle of the crankshaft.

[0077] The output measurement system 100 can further determine the combustion state of the engine from the plurality of graphs shown in FIG. 9.

[0078] Meanwhile, the output measurement method for an engine may be implemented in a form of program commands that may be executed through various computer means and may be recorded in computer-readable recording media. The recording media may include program commands, data files, data structures, etc. The program commands that are recorded on the recording media may be those specifically designed and configured for the present disclosure or may be those available and known to those engaged in computer software in the art. For example, the recording media may include magnetic media such as hard disks, floppy disks, and magnetic tape, optical media such as CD-ROMs and DVDs, magneto-optical media such as floptical disks, and hardware devices specifically configured to store and execute program commands, such as ROM, RAM, and flash memory. The program commands may include not only machine language codes compiled by a compiler, but also high-level language codes that can be executed by a computer using an interpreter. Further, a hardware device may be configured to operate as one or more software modules to perform the operation of the present disclosure.

[0079] Further, the output measurement method for an engine may be implemented as a computer program or an application that is stored on recording media and executed by a computer.

[0080] As described above, according to embodiments of the present disclosure, it is possible to measure the accurate output of an engine by removing output errors of cylinders due to a torsion error and an explosion angle error of a crankshaft, by determining the differences between the position of the compression TDC of a reference cylinder and the positions of the compression TDCs of the other cylinders except for the reference cylinder, using a plurality of graphs, and then correcting the differences between the cylinders by adjusting the points in time of detection of the angle sensor unit 20.

[0081] Further, since it is possible to quickly and accurately measure the output of an engine, as compared with output measurement equipment of the related art, the reliability of equipment can be improved.

[0082] Further, it is possible to accurately find out the position of Pmax and measure output by collecting accurate engine data for cylinders in response to angle signals. Furthermore, it is possible to accurately find out the points in time of fuel ignition and fuel injection in cylinders, the fuel injection amount of the cylinders, knocking, the matching relationship between post-combustion and a turbocharger, etc. by performing fuel analysis using the collected data. In addition, it is possible to not only optimize combustion, but improve the lifespan and fuel consumption efficiency of an engine by selectively adjusting the point in time of fuel injection, the fuel injection amount, turbocharger matching, etc., as needed, by providing a solution for optimum combustion.

Claims

1. An output measurement system (100) of a large-sized low-speed two-stroke engine that measures output of an engine for one cycle, the system comprising:

   a pressure sensor unit (10) that detects individual combustion pressure of cylinders;
   an angle sensor unit (20) that detects rotation angles of a crankshaft with a Z-pulse thereof matched with an actual TDC of a predetermined reference cylinder; and
   an output measurer (30) that collects combustion pressure of the cylinders at the rotation angles of the crankshaft from the pressure sensor unit and the angle sensor unit, shows a plurality of graphs about combustion pressure of the cylinders at the rotation angles of the crankshaft, combustion pressure of the cylinders at combustion chamber volumes, and pressure change rates of the cylinders at the rotation angles of the crankshaft, finds out the position of a compression TDC and a loss of angle of the reference cylinder from the graph about the pressure change rates of the cylinders at the rotation angles of the crankshaft, adjusts points in time when the angle sensor unit detects the rotation angle of the crankshaft for the other cylinders except for the reference cylinder, and then measures output of the cylinders,
   characterized in that
   the output measurer matches the positions of compression TDCs of the other cylinders except for the reference

cylinder with the position of the compression TDC of the reference cylinder in the graph about the pressure change rates of the cylinders at the rotation angles of the crankshaft by adjusting the points in time when the angle sensor unit detects the rotation angle of the crankshaft for the other cylinders except for the reference cylinder.

2. The output measurement system (100) of claim 1, wherein when determining the position of the compression TDC and the loss of angle of the reference cylinder from the graph about the pressure change rates of the cylinders at the rotation angles of the crankshaft, the output measurer (30) further creates a graph showing a trend line about the positions of the compression TDCs of the cylinders and the degree of torsion and a table showing the positions of the compression TDCs of the cylinders.

3. The output measurement system (100) of claim 1, wherein when determining the position of the compression TDC and the loss of angle of the reference cylinder from the graph about the pressure change rates of the cylinders at the rotation angles of the crankshaft, the output measurer (30) further creates a table showing position correction values for the other cylinders except for the reference cylinder by calculating the differences between the position of the compression TDC of the reference cylinder and the positions of the compression TDCs of the other cylinders except for the reference cylinder.

4. An output measurement method of a large-sized low-speed two-stroke engine that measures output of an engine for one cycle, the method comprising:

detecting individual combustion pressure of cylinders using a pressure sensor unit (10) matching a Z-pulse of an angle sensor unit (20) mounted on a predetermined reference cylinder with an actual TDC of the reference cylinder (S100);
creating a Pθ graph showing combustion pressure of cylinders at rotation angles of a crankshaft and a dP graph showing pressure change rates of the cylinders at the rotation angle of the crankshaft by collecting the combustion pressure of the cylinders at the rotation angles of the crankshaft (S200);
determining the position of a compression TDC and a loss of angle of the reference cylinder from the dP graph (S300);
matching positions of compression TDCs of the other cylinders except for the reference cylinder with the position of the compression TDC of the reference cylinder in the dP graph by adjusting points in time when the angle sensor unit detects the rotation angle of the crankshaft for the other cylinders except for the reference cylinder (S400); and
measuring output of the cylinders by creating a PV graph showing the combustion pressure of the cylinders at combustion chamber volumes (S500).

5. The method of claim 4, wherein the determining of the position of a compression TDC and a loss of angle of the reference cylinder from the dP graph includes:

creating a graph showing a trend line about the positions of the compression TDCs of the cylinders and the degree of torsion and a table showing the positions of the compression TDCs of the cylinders (S310);
determining the position of the compression TDC and the loss of angle of the reference cylinder on the basis of the dP graph, the graph showing the trend line about the positions of the compression TDCs of the cylinders and the degree of torsion, and the table showing the positions of the compression TDCs of the cylinders (S320); and
creating a table showing position correction values for the other cylinders except for the reference cylinder by calculating the differences between the position of the compression TDC of the reference cylinder and the positions of the compression TDCs of the other cylinders except for the reference cylinder (S330).

6. A computer-readable recording medium on which a program for executing the method of claim 4 or 5 in a computer is recorded, that when executed on a computer, causes the computer to carry out the method of claim 4 or 5.

Patentansprüche

1. Ein Leistungsmesssystem (100) eines großformatigen Zweitaktmotors mit niedriger Drehzahl, das die Leistung eines Motors über einen Zyklus misst, wobei das System Folgendes umfasst:

eine Drucksensoreinheit (10), die den individuellen Verbrennungsdruck von Zylindern erfasst;
eine Winkelsensoreinheit (20), die Rotationswinkel einer Kurbelwelle erfasst, wobei ein Z-Impuls davon mit einem tatsächlichen OTP eines vordefinierten Referenzzylinders abgeglichen ist; und
eine Leistungsmessvorrichtung (30), die Verbrennungsdruck der Zylinder an den Rotationswinkeln der Kurbelwelle von der Drucksensoreinheit und der Winkelsensoreinheit erfasst, eine Vielzahl von Graphen zum Verbrennungsdruck der Zylinder an den Rotationswinkeln der Kurbelwelle, zum Verbrennungsdruck der Zylinder an den Verbrennungskammervolumina und zu den Druckänderungsraten der Zylinder an den Rotationswinkeln der Kurbelwelle anzeigt, die Position eines Kompressions-OTPs und einen Winkelverlust des Referenzzylinders anhand des Graphen über die Druckänderungsraten der Zylinder an den Rotationswinkeln der Kurbelwelle feststellt, die Zeitpunkte anpasst, zu denen die Winkelsensoreinheit den Rotationswinkel der Kurbelwelle für die anderen Zylinder, mit Ausnahme des Referenzzylinders, erfasst, und anschließend die Leistung der Zylinder misst;
dadurch gekennzeichnet, dass
die Leistungsmessvorrichtung die Positionen von Kompressions-OTPs der anderen Zylinder, mit Ausnahme des Referenzzylinders, mit der Position des Kompressions-OPTs des Referenzzylinder im Graphen über die Druckänderungsraten der Zylinder an den Rotationswinkeln der Kurbelwelle durch Anpassung der Zeitpunkte abgleicht, wenn die Winkelsensoreinheit den Rotationswinkel der Kurbelwelle für die anderen Zylinder, mit Ausnahme des Referenzzylinders, erfasst.

2. Das Leistungsmesssystem (100) gemäß Anspruch 1, wobei bei der Ermittlung der Position des Kompressions-OTPs und des Winkelverlusts des Referenzzylinders aus dem Graph über die Druckänderungsraten der Zylinder an den Rotationswinkeln der Kurbelwelle die Leistungsmessvorrichtung (30) weiter einen Graphen erstellt, der eine Trendkurve zu den Positionen der Kompressions-OTPs der Zylinder und dem Grad der Torsion anzeigt, und eine Tabelle, welche die Positionen der Kompressions-OTPs der Zylinder anzeigt.

3. Das Leistungsmesssystem (100) gemäß Anspruch 1, wobei bei der Ermittlung der Position des Kompressions-OTPs und des Winkelverlusts des Referenzzylinders aus dem Graph über die Druckänderungsraten der Zylinder an den Rotationswinkeln der Kurbelwelle die Leistungsmessvorrichtung (30) weiter eine Tabelle erstellt, die Positionskorrekturwerte für die anderen Zylinder, mit Ausnahme des Referenzzylinders, durch Berechnung der Unterschiede zwischen der Position des Kompressions-OTPs des Referenzzylinders und den Positionen der Kompressions-OTPs der anderen Zylinder, mit Ausnahme des Referenzzylinders, anzeigt.

4. Ein Leistungsmessverfahren eines großformatigen Zweitaktmotors mit niedriger Drehzahl, das die Leistung eines Motors über einen Zyklus misst, wobei das Verfahren Folgendes umfasst:

das Erfassen des individuellen Verbrennungsdrucks der Zylinder mit Hilfe einer Drucksensoreinheit (10), wobei ein Z-Impuls einer Winkelsensoreinheit (20), die an einem vordefinierten Referenzzylinder montiert ist, mit einem tatsächlichen OTP des Referenzzylinders (S100) abgeglichen wird;
das Erstellen eines Pθ-Graphs, der den Verbrennungsdruck der Zylinder an Rotationswinkeln einer Kurbelwelle zeigt; und eines dP-Graphs, der Druckänderungsraten der Zylinder am Rotationswinkel der Kurbelwelle zeigt, durch Erfassen des Verbrennungsdrucks der Zylinder an den Rotationswinkeln der Kurbelwelle (S200);
das Bestimmen der Position eines Kompressions-OTPs und eines Winkelverlusts des Referenzzylinders aus dem dP-Graph (S300);
das Abgleichen der Positionen der Kompressions-OTPs der anderen Zylinder, mit Ausnahme des Referenzzylinders, mit der Position des Kompressions-OTPs des Referenzzylinders im dP-Graph durch das Anpassen der Zeitpunkte, wenn die Winkelsensoreinheit den Rotationswinkel der Kurbelwelle für die anderen Zylinder, mit Ausnahme des Referenzzylinders, erfasst (S400); und
das Messen der Leistung der Zylinder durch Erstellen eines PV-Graphen, der den Verbrennungsdruck der Zylinder an den Verbrennungskammervolumina zeigt (S500).

5. Das Verfahren gemäß Anspruch 4, wobei das Bestimmen der Position eines Kompressions-OTPs und eines Winkelverlusts des Referenzzylinders aus dem dP-Graph Folgendes einschließt:

das Erstellen eines Graphen, der eine Trendkurve über die Positionen der Kompressions-OTPs der Zylinder und den Torsionsgrad zeigt, und einer Tabelle, die die Positionen der Kompressions-OTPs der Zylinder zeigt (S310);
das Bestimmen der Position des Kompressions-OTPs und des Winkelverlusts des Referenzzylinders auf der Grundlage des dP-Graphs, wobei der Graph die Trendkurve über die Positionen der Kompressions-OTPs der

Zylinder und den Torsionsgrad zeigt und die Tabelle die Positionen der Kompressions-OTPs der Zylinder zeigt (S320); und

das Erstellen einer Tabelle, die Positionskorrekturwerte für die anderen Zylinder, mit Ausnahme des Referenzzylinders, durch Berechnen der Unterschiede zwischen der Position des Kompressions-OPTs des Referenzzylinders und den Positionen der Kompressions-OTPs der anderen Zylinder, mit Ausnahme des Referenzzylinders, zeigt (S330).

6. Ein maschinenlesbares Aufnahmemedium, auf dem ein Programm zur Ausführung des Verfahrens gemäß Anspruch 4 oder 5 auf einem Computer gespeichert ist, welches, wenn es auf einem Computer ausgeführt wird, den Computer veranlasst, das Verfahren gemäß Anspruch 4 oder 5 durchzuführen.

Revendications

1. Système de mesure de puissance (100) d'un moteur deux temps à faible vitesse et de grande taille qui mesure la puissance d'un moteur pour un cycle, ce système comprenant:

une unité de détection de pression (10) qui détecte la pression de combustion individuelle des cylindres;

une unité de détection d'angle (20) qui détecte les angles de rotation d'un vilebrequin avec son impulsion Z harmonisée avec un TDC réel d'un cylindre de référence prédéterminé; et

un mesureur de puissance (30) qui collecte la pression de combustion des cylindres aux angles de rotation du vilebrequin depuis l'unité de détection de pression et l'unité de détection d'angle, présente une pluralité de graphiques sur la pression de combustion des cylindres aux angles de rotation du vilebrequin, la pression de combustion des cylindres au niveau des volumes de chambre de combustion, et les taux de changement de pression des cylindres aux angles de rotation du vilebrequin, trouve la position d'un TDC de compression et une perte d'angle du cylindre de référence à partir du graphique sur les taux de changement de pression des cylindres aux angles de rotation du vilebrequin, règle les points dans le temps où l'unité de détection d'angle détecte l'angle de rotation du vilebrequin pour les autres cylindres à l'exception du cylindre de référence, puis mesure la puissance des cylindres,

caractérisé en ce que

le mesureur de puissance harmonise les positions des TDC de compression des autres cylindres à l'exception du cylindre de référence avec la position du TDC de compression du cylindre de référence dans le graphique concernant les taux de changement de pression des cylindres aux angles de rotation du vilebrequin en réglant les points dans le temps où l'unité de détection détecte l'angle de rotation du vilebrequin pour les autres cylindres à l'exception du cylindre de référence.

2. Système de mesure de puissance (100) selon la revendication 1, dans lequel, lors de la détermination de la position du TDC de compression et de la perte d'angle du cylindre de référence, à partir du graphique concernant les taux de changement de pression des cylindres aux angles de rotation du vilebrequin, le mesureur de puissance (30) crée en outre un graphique présentant une ligne de tendance concernant les positions des TDC de compression des cylindres et le degré de torsion et un tableau représentant les positions des TDC de compression des cylindres.

3. Système de mesure de puissance (100) selon la revendication 1, dans lequel, lors de la détermination de la position du TDC de compression et de la perte d'angle du cylindre de référence, à partir du graphique concernant les taux de changement de pression des cylindres aux angles de rotation du vilebrequin, le mesureur de puissance (30) crée en outre un tableau présentant des valeurs de correction de position pour les autres cylindres à l'exception du cylindre de compression en calculant les différences entre la position du TDC de compression du cylindre de référence et les positions des TDC de compression des autres cylindres à l'exception du cylindre de référence.

4. Procédé de mesure de puissance d'un moteur deux temps à faible vitesse et de grande taille qui mesure la puissance d'un moteur pour un cycle, ce procédé comprenant:

la détection de la pression de combustion individuelle des cylindres en utilisant une unité de détection de pression (10) harmonisant une impulsion Z d'une unité de détection d'angle (20) montée sur un cylindre de référence prédéterminé avec un TDC réel du cylindre de référence (S100);

la création d'un graphique Pθ présentant la pression de combustion de cylindres aux angles de rotation du vilebrequin et d'un graphique dP présentant les taux de changement de pression des cylindres aux angles de rotation du vilebrequin en collectant la pression de combustion des cylindres aux angles de rotation du vilebrequin

(S200);
la détermination de la position d'un TDC de compression et d'une perte d'angle du cylindre de référence à partir du graphique dP (S300);
l'harmonisation des positions des TDC de compression des autres cylindres à l'exception du cylindre de référence avec la position du TDC de compression du cylindre de référence dans le graphique dP en réglant les points dans le temps où l'unité de détection détecte l'angle de rotation du vilebrequin pour les autres cylindres à l'exception du cylindre de référence (S400); et
la mesure de la puissance des cylindres en créant un graphique PV présentant la pression de combustion des cylindres au niveau des volumes de chambre de combustion (S500).

5. Procédé selon la revendication 4, dans lequel la détermination de la position d'un TDC de compression et d'une perte d'angle du cylindre de référence à partir du graphique dP inclut:

la création d'un graphique montrant une ligne de tendance concernant les positions des TDC de compression des cylindres et le degré de torsion et un tableau présentant les positions des TDC de compression des cylindres (S310);
la détermination de la position du TDC de compression et de la perte d'angle du cylindre de référence sur la base du graphique dP, le graphique présentant la ligne de tendance concernant les positions des TDC de compression des cylindres et le degré de torsion, et le tableau présentant les positions des TDC de compression des cylindres (S320); et
la création d'un tableau présentant des valeurs de correction de position pour les autres cylindres à l'exception du cylindre de référence en calculant les différences entre la position du TDC de compression du cylindre de référence et les positions des TDC de compression des autres cylindres à l'exception du cylindre de référence (S330).

6. Support d'enregistrement lisible par ordinateur sur lequel est enregistré un programme pour l'exécution du procédé selon la revendication 4 ou 5 sur un ordinateur lequel programme, une fois exécuté sur un ordinateur, amène l'ordinateur à réaliser le procédé selon la revendication 4 ou 5.

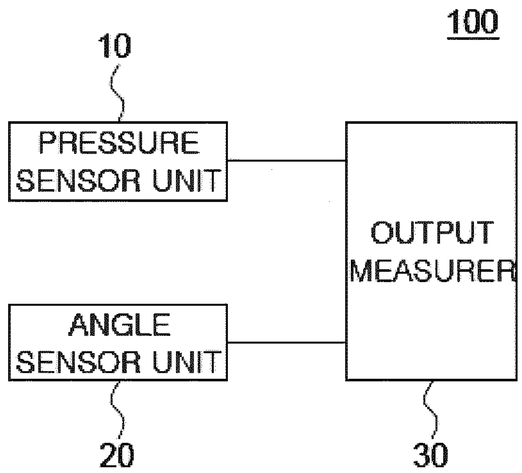

100
10
PRESSURE SENSOR UNIT
ANGLE SENSOR UNIT
OUTPUT MEASURER
20
30

FIG. 1

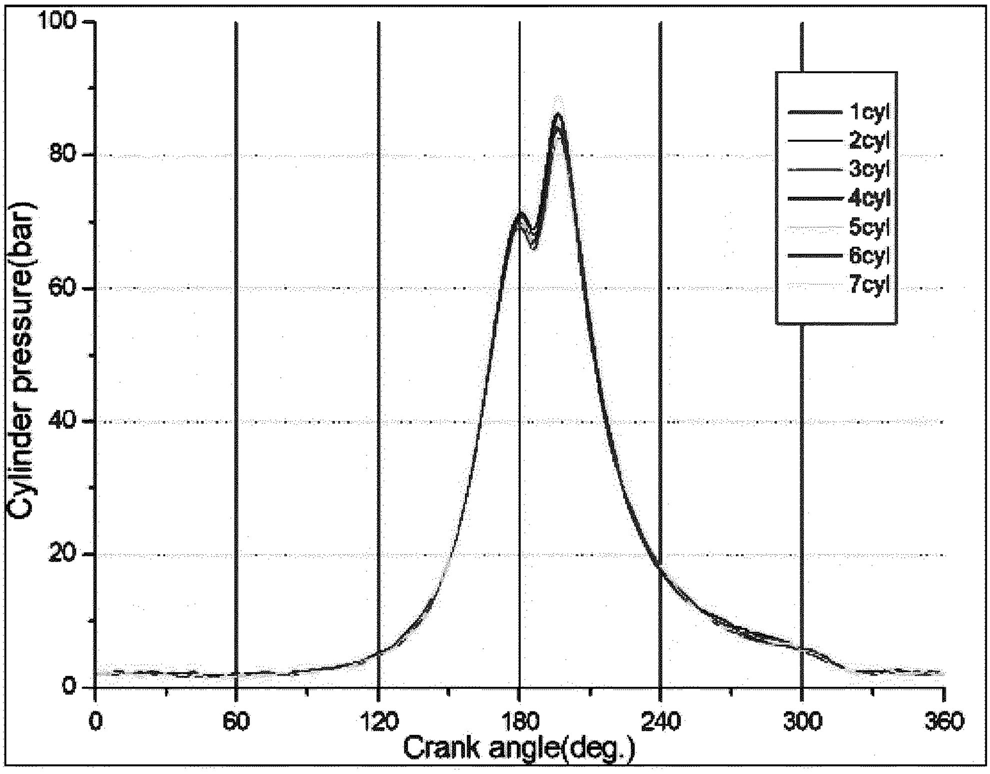

100
80
60
40
20
0
Cylinder pressure(bar)
0
60
120
180
240
300
360
Crank angle(deg.)
1cyl
2cyl
3cyl
4cyl
5cyl
6cyl
7cyl

FIG. 2

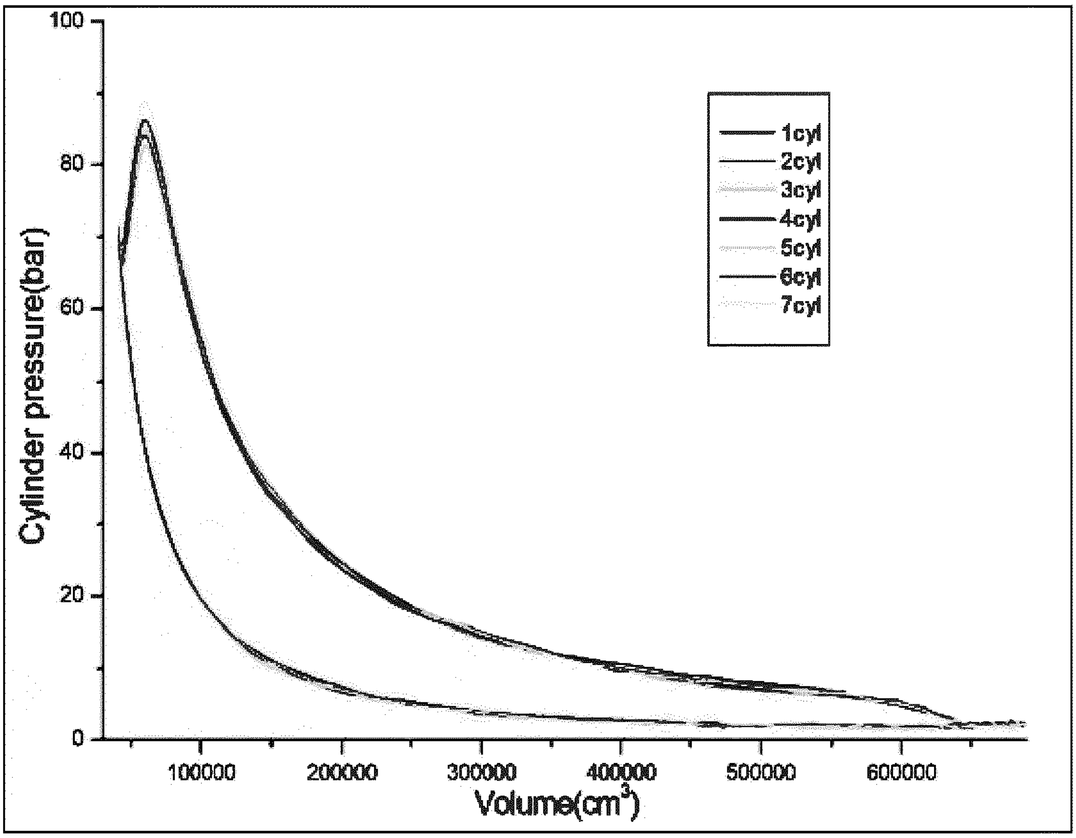

Cylinder pressure(bar)
Volume(cm^3)
0
20
40
60
80
100
100000
200000
300000
400000
500000
600000
1cyl
2cyl
3cyl
4cyl
5cyl
6cyl
7cyl

FIG. 3

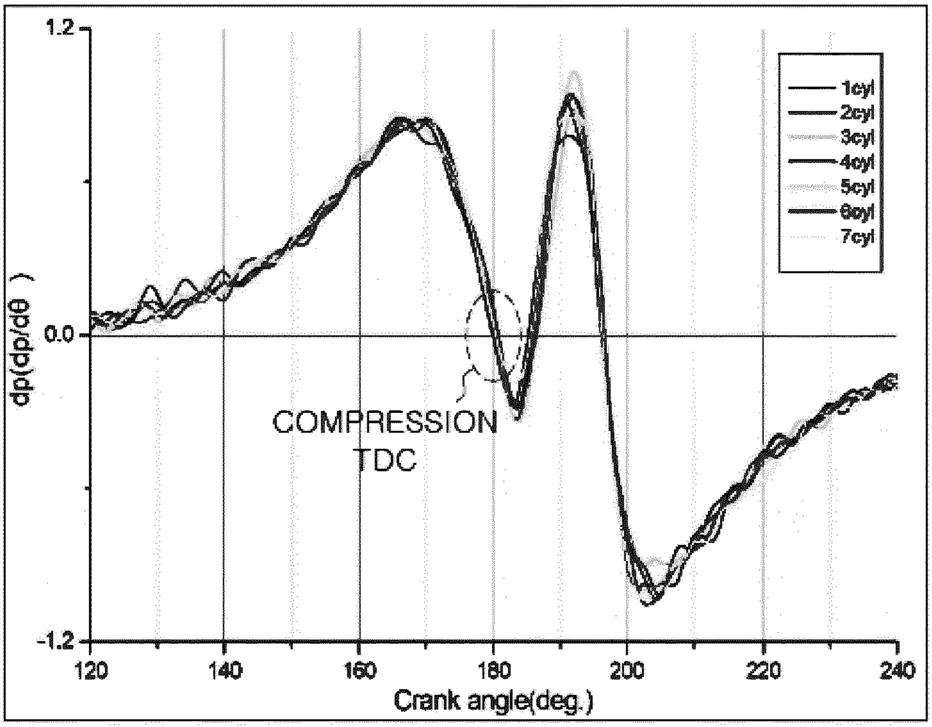

1.2
0.0
-1.2
dp(dp/dθ)
120
140
160
180
200
220
240
Crank angle(deg.)
1cyl
2cyl
3cyl
4cyl
5cyl
6cyl
7cyl
COMPRESSION
TDC

FIG. 4

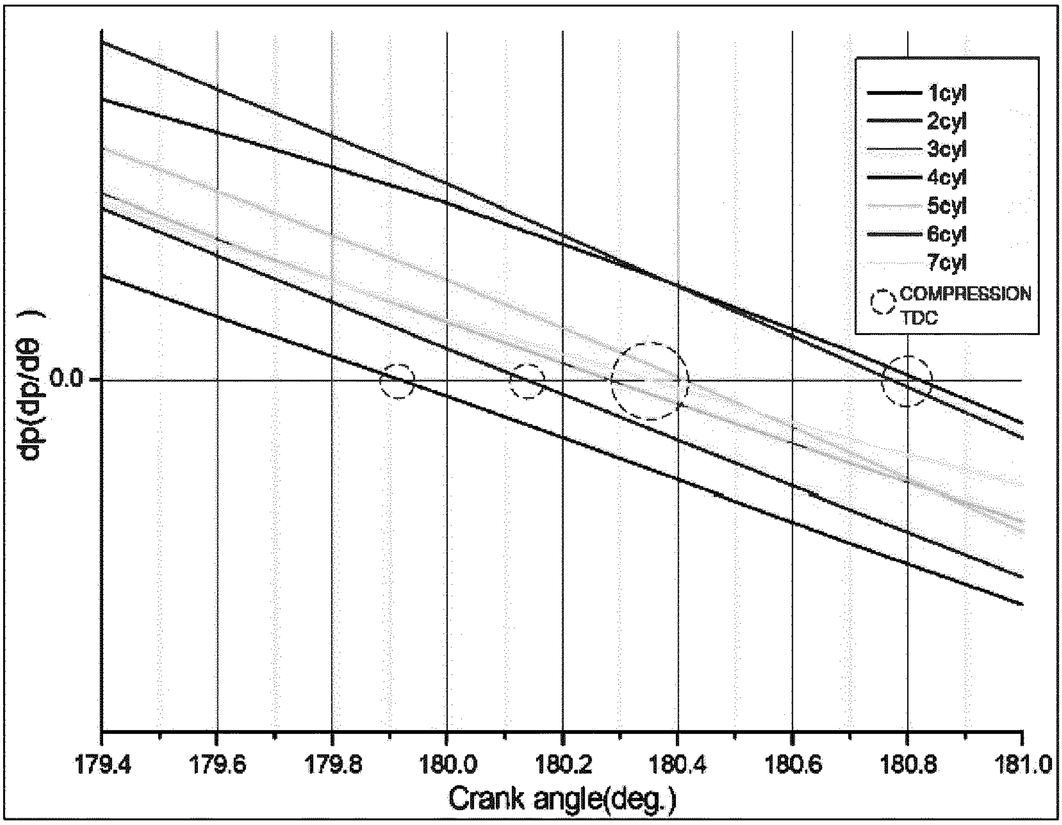
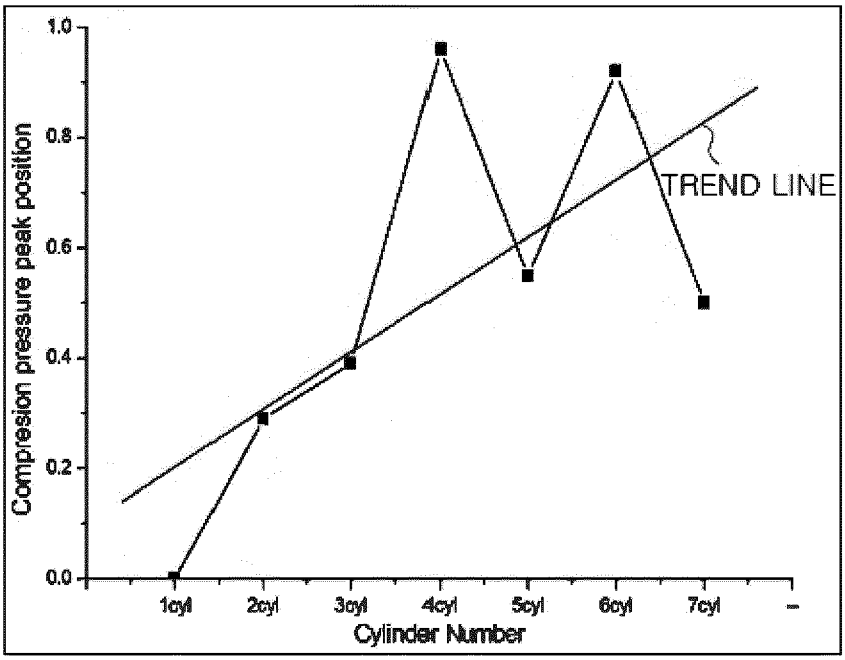

dp(dp/dθ)
0.0
179.4
179.6
179.8
180.0
180.2
180.4
180.6
180.8
181.0
Crank angle(deg.)
1cyl
2cyl
3cyl
4cyl
5cyl
6cyl
7cyl
COMPRESSION
TDC

FIG. 5

(a)



(b)

CYLINDER	1cyl	2cyl	3cyl	4cyl	5cyl	6cyl	7cyl
POSITION OF COMPRESSION TDC	179.85	180.14	180.24	180.81	180.4	180.77	180.35

FIG. 6

CYLINDER	1cyl	2cyl	3cyl	4cyl	5cyl	6cyl	7cyl
CORRECTION ANGLE	0	0.29	0.39	0.96	0.55	0.92	0.5

FIG. 7

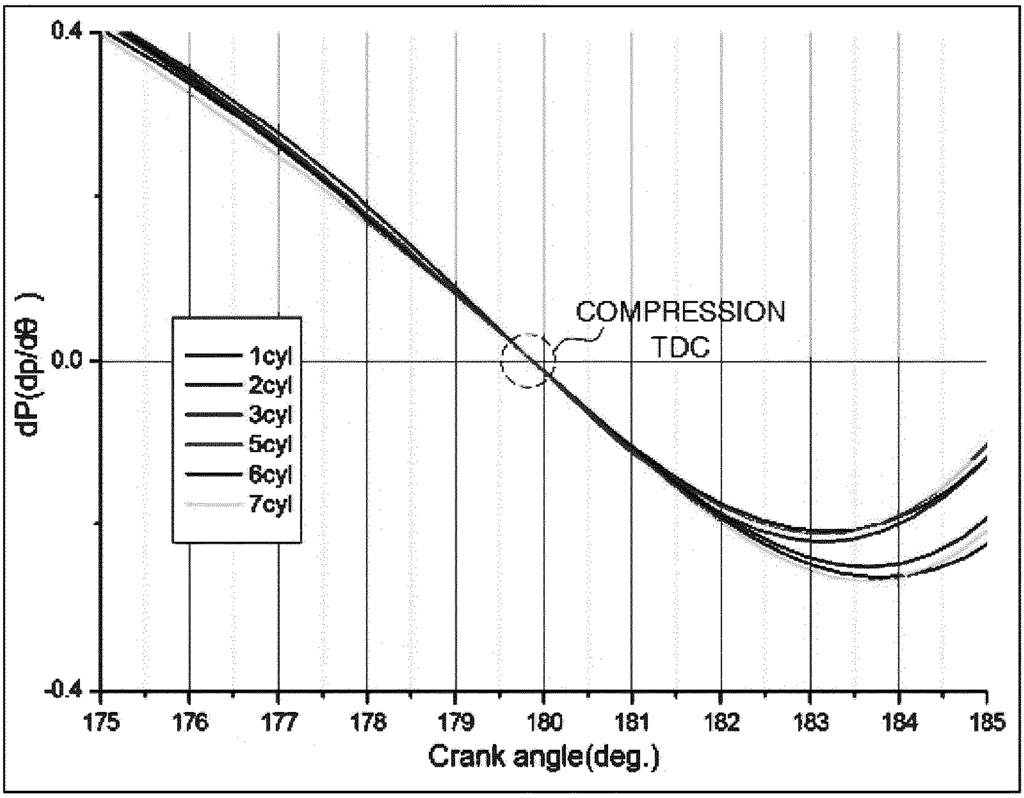

0.4
0.0
-0.4
dP(dp/dθ)
1cyl
2cyl
3cyl
5cyl
6cyl
7cyl
COMPRESSION
TDC
175
176
177
178
179
180
181
182
183
184
185
Crank angle(deg.)

FIG. 8

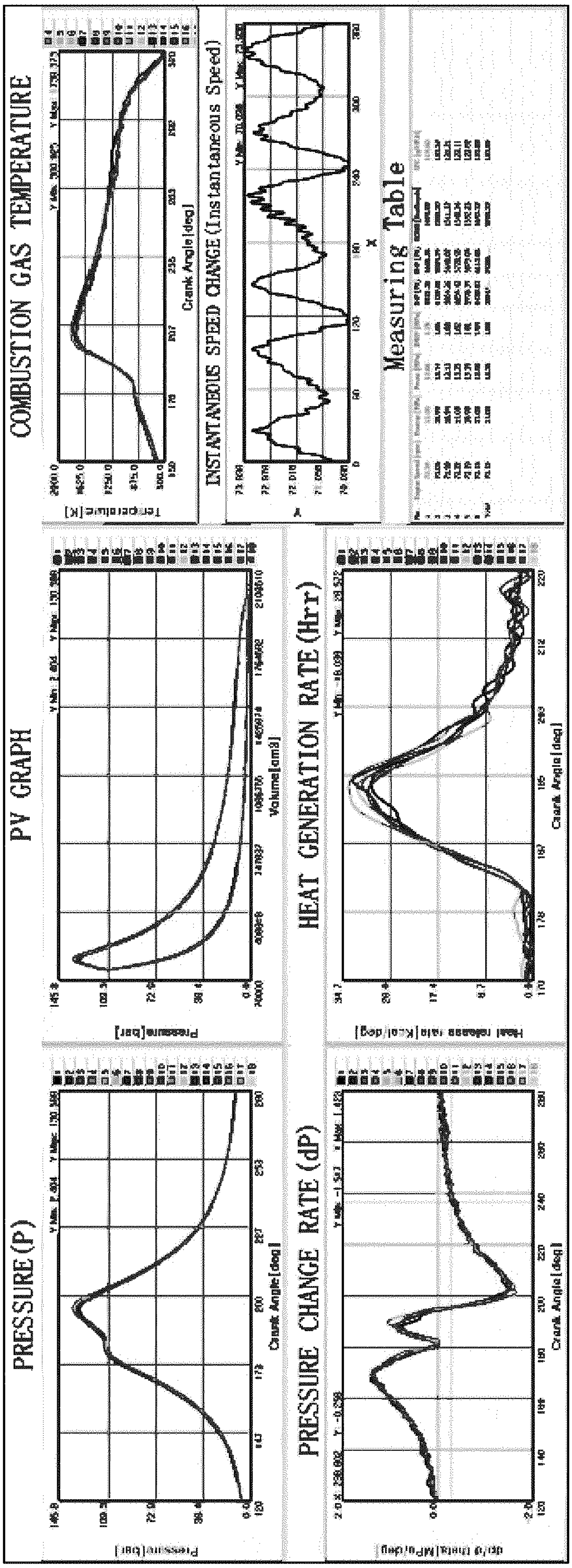

PRESSURE (P)
PV GRAPH
COMBUSTION GAS TEMPERATURE
INSTANTANEOUS SPEED CHANGE (Instantaneous Speed)
Measuring Table
PRESSURE CHANGE RATE (dP)
HEAT GENERATION RATE (Hrr)

FIG. 9

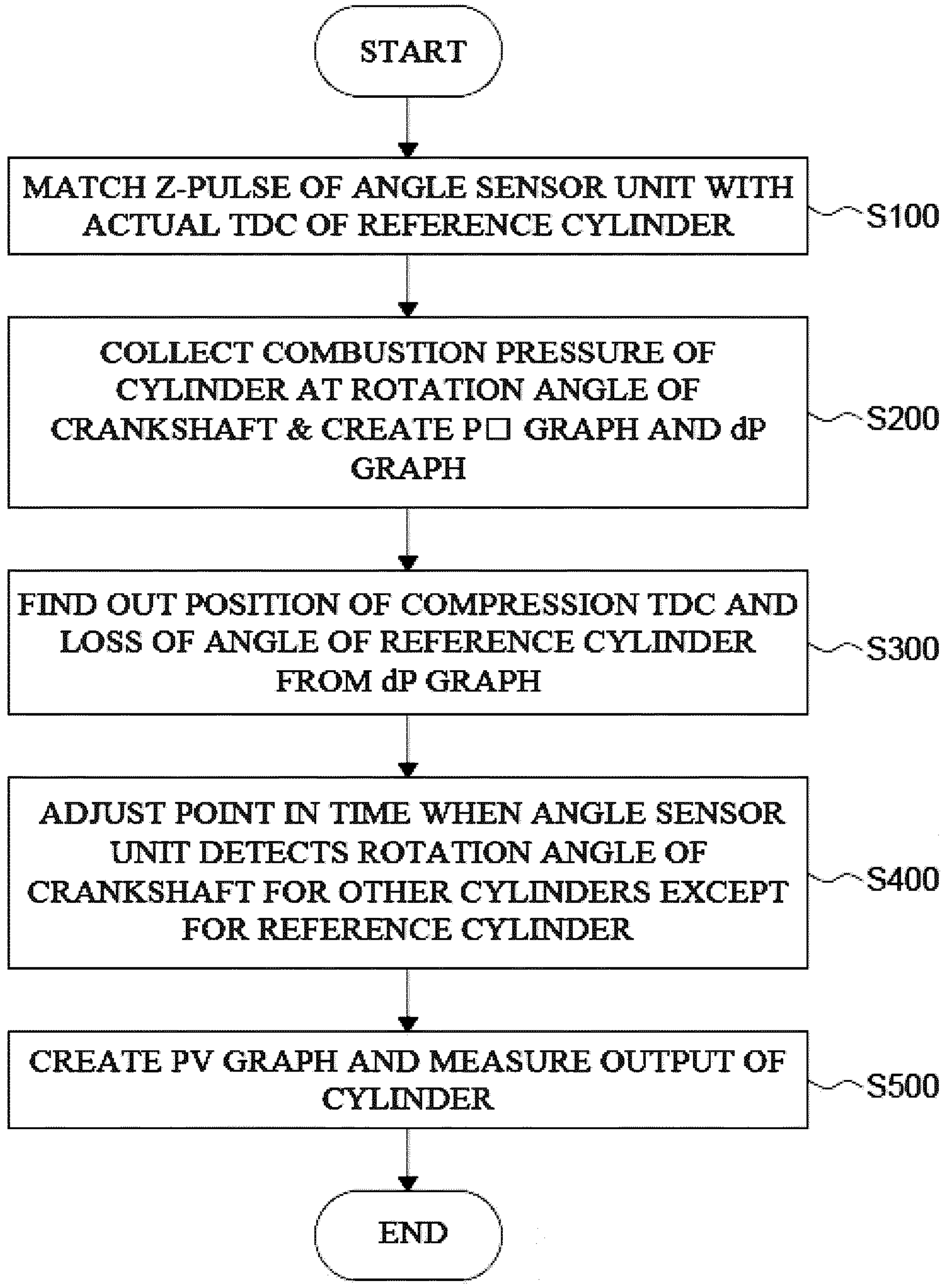

START
MATCH Z-PULSE OF ANGLE SENSOR UNIT WITH ACTUAL TDC OF REFERENCE CYLINDER
S100
COLLECT COMBUSTION PRESSURE OF CYLINDER AT ROTATION ANGLE OF CRANKSHAFT & CREATE P□ GRAPH AND dP GRAPH
S200
FIND OUT POSITION OF COMPRESSION TDC AND LOSS OF ANGLE OF REFERENCE CYLINDER FROM dP GRAPH
S300
ADJUST POINT IN TIME WHEN ANGLE SENSOR UNIT DETECTS ROTATION ANGLE OF CRANKSHAFT FOR OTHER CYLINDERS EXCEPT FOR REFERENCE CYLINDER
S400
CREATE PV GRAPH AND MEASURE OUTPUT OF CYLINDER
S500
END

FIG. 10

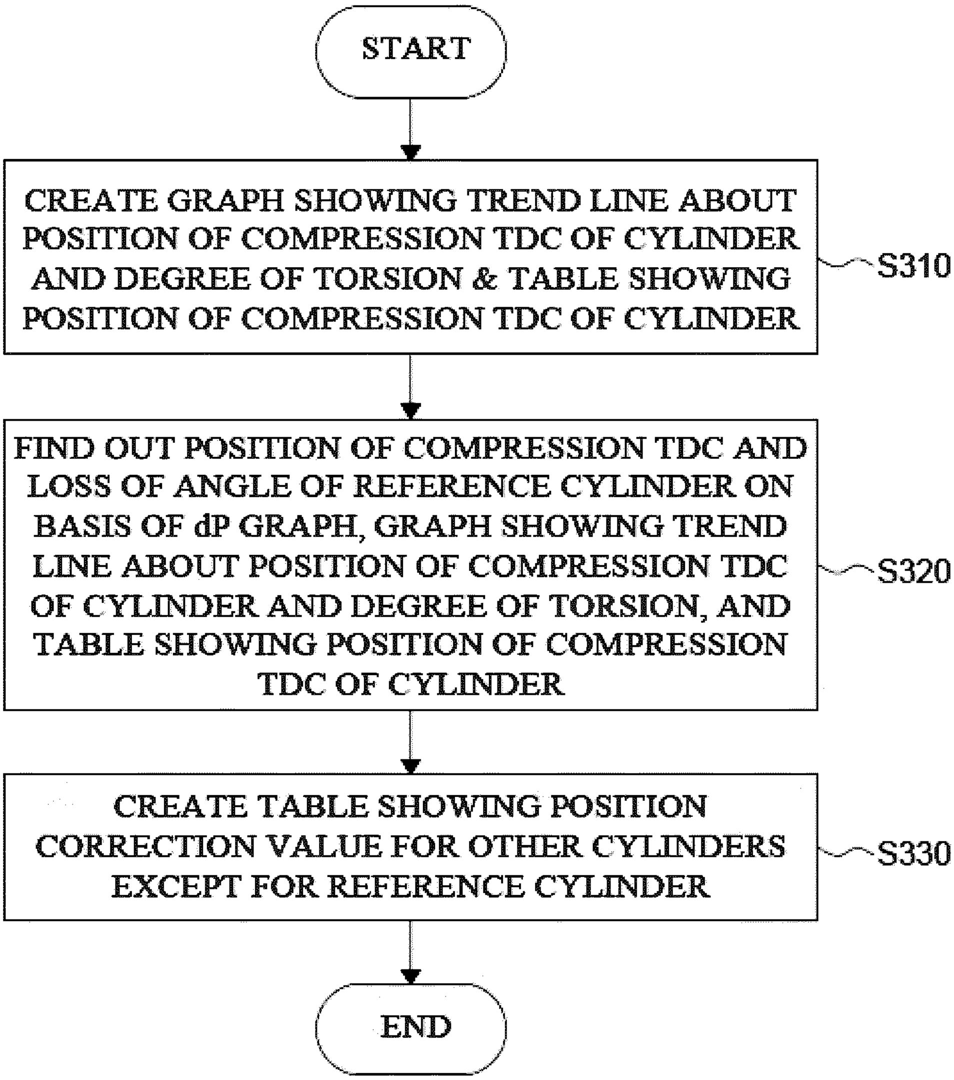

START
CREATE GRAPH SHOWING TREND LINE ABOUT POSITION OF COMPRESSION TDC OF CYLINDER AND DEGREE OF TORSION & TABLE SHOWING POSITION OF COMPRESSION TDC OF CYLINDER
S310
FIND OUT POSITION OF COMPRESSION TDC AND LOSS OF ANGLE OF REFERENCE CYLINDER ON BASIS OF dP GRAPH, GRAPH SHOWING TREND LINE ABOUT POSITION OF COMPRESSION TDC OF CYLINDER AND DEGREE OF TORSION, AND TABLE SHOWING POSITION OF COMPRESSION TDC OF CYLINDER
S320
CREATE TABLE SHOWING POSITION CORRECTION VALUE FOR OTHER CYLINDERS EXCEPT FOR REFERENCE CYLINDER
S330
END

FIG. 11

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2004048762 A1 **[0015]**
- DE 102011083471 A1 **[0016]**
- US 2016146132 A1 **[0017]**
- KR 101061290 B1 **[0017]**