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## Jig, method for assembling robot using jig, and robot


### Abstract

A jig includes: a first gear part that can be meshed with an input gear disposed in a casing by being inserted into the casing from the outside of the casing; a torque application part that is fixed to the first gear part, is disposed outside the casing in a state in which the first gear part is meshed with the input gear, and is capable of applying a torque about a first axis, which corresponds to an axis of the first gear part, to the first gear part; and a phase indicator provided on the torque application part to indicate the phase of the first gear part about the first axis.



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## Background/Summary

(1) The present disclosure relates to a jig, a method for assembling a robot using the jig, and a robot.

BACKGROUND

(2) A known gear mechanism includes a plurality of gears that transmit the rotation of the rotary axis of a motor to a driven member (for example, see Japanese Unexamined Patent Application, Publication No. 2013-44351).

(3) In this gear mechanism, holes are provided in an input gear to be meshed with a motor pinion provided on the rotary axis of the motor and in an output gear that is coupled to the driven member. By inserting positioning pins through the respective holes to position the gears, the phases of the gears are matched.

SUMMARY

(4) An aspect of the present disclosure is a jig including: a first gear part that can be meshed with an input gear disposed in a casing by being inserted into the casing from an outside of the casing; a torque application part that is fixed to the first gear part, is disposed outside the casing in a state in which the first gear part is meshed with the input gear, and is capable of applying a torque about a first axis, which corresponds to an axis of the first gear part, to the first gear part; and a phase indicator provided on the torque application part to indicate a phase of the first gear part about the first axis.

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## Description

BRIEF DESCRIPTION OF DRAWINGS

(1) FIG. **1** shows the overall configuration of a jig according to an embodiment of the present disclosure.

(2) FIG. **2** is a partial vertical sectional view showing a part of a robot using the jig in FIG. **1**.

(3) FIG. **3** is a partial vertical sectional view showing a part of the robot to which the jig in FIG. **1** is attached.

(4) FIG. **4** is a side view showing a motor to which the jig in FIG. **1** is attached.

(5) FIG. **5** is a perspective view showing a first modification of the jig in FIG. **1**.

(6) FIG. **6** is a perspective view showing a second modification of the jig in FIG. **1**.

(7) FIG. **7** is a perspective view showing a third modification of the jig in FIG. **1**.

(8) FIG. **8** is a side view showing an exploded state of a part of the robot according to the embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

(9) A jig **1** according to an embodiment of the present disclosure and a method for assembling a robot **100** using the jig **1** will be described below with reference to the drawings.

(10) As shown in FIG. **2**, the robot **100** assembled using the jig **1** according to this embodiment includes a casing **10** having an opening **11** and accommodating an input gear **30** therein, and a motor **20** removably attached to the opening **11** in the casing **10**. A drive gear **22** that is meshed with the input gear **30** in a state in which the motor **20** is attached to the casing **10** is attached to a shaft **21** of the motor **20**. A bearing **23** that is fitted to the inner surface of the opening **11** and supports the rotation of the drive gear **22** is disposed at the proximal end of the drive gear **22**.

(11) The opening **11** penetrates through the casing **10** in the axial direction of the input gear **30**.

(12) The drive gear **22** and the input gear **30** are gears, such as spur gears or helical gears, that can be meshed with each other by moving the drive gear **22** parallel to the axis of the input gear **30**, relative to the input gear **30**.

(13) The bearing **23** is disposed at a position away from the distal end toward the proximal end of the drive gear **22** so as to start to fit into the opening **11** in the casing **10** before the drive gear **22** starts to be meshed with the input gear **30**. Reference sign **12** in the drawing denotes a spacer for applying a preload to the bearing **23**.

(14) As shown in FIG. **1**, the jig **1** includes a cylindrical barrel part (torque application part) **2** having a central axis corresponding to a predetermined axis (first axis) L, an external gear part (first gear part) **3** provided at one end of the barrel part **2** in the axis L direction, and an internal gear part (second gear part) **4** provided at the other end of the barrel part **2** in the axis L direction.

(15) The external gear part **3** and the internal gear part **4** are disposed coaxially with the axis L. The external gear part **3** is provided on the outer surface of a shaft protruding from one end face of the barrel part **2** in the axis L direction, and the internal gear part **4** is formed in the inner surface of a hole recessed from the other end face of the barrel part **2** in the axis L direction.

(16) The external gear part **3** has a plurality of external teeth that can be meshed with the input gear **30**. More specifically, the external gear part **3** has the same shape as the drive gear **22**.

(17) The lengths of the external gear part **3** and the barrel part **2** in the axis L direction are set to such dimensions that at least the other end of the barrel part **2** is exposed to the outside of the casing **10** in a state in which the external gear part **3** is meshed with the input gear **30**.

(18) The internal gear part **4** has a plurality of internal teeth that can be meshed with the drive gear **22** fixed to the shaft **21** of the motor **20**. The internal gear part **4** has, for example, a cross-sectional shape complementary to the cross-sectional shape of the drive gear **22**, so that the drive gear **22** can be fitted tightly into the internal gear part **4**.

(19) The phase of the internal gear part **4** about the axis L with respect to the external gear part **3** is

set to such a phase relationship that the drive gear **22**, when arranged in the same phase as the external gear part **3**, can be meshed with the internal gear part **4** simply by moving the drive gear **22** in the axis L direction.

(20) The outer diameter of the barrel part **2** is set to such a dimension that an operator can grip the outer circumferential surface of the barrel part **2** and apply a torque greater than the brake torque of the motor **20** about the axis L in a state in which the internal gear part **4** is meshed with the drive gear **22** fixed to the shaft **21** of the motor **20**. Specifically, the barrel part **2** has such a shape that the point of application of a force to be applied in the tangential direction about the axis L can be set at the position of the outer circumferential surface of the barrel part **2**, which is away from the axis L in the radially outward direction.

(21) A mark (phase indicator) **5** is provided on the outer circumferential surface of the barrel part **2**.

(22) For example, as shown in FIG. **1**, the mark **5** is a triangular engraving formed in the outer circumferential surface of the barrel part **2** and is formed in the vicinity of the other end of the barrel part **2** exposed to the outside of the casing **10** in a state in which the external gear part **3** is meshed with the input gear **30**. The mark **5** indicates a phase in which the central vertex in the circumferential direction coincides with, for example, the center of one external tooth of the external gear part **3** in the tooth thickness direction and the center of one tooth groove of the internal gear part **4** in the width direction. Hence, even in a state in which the external gear part **3** is meshed with the input gear **30** in the casing **10**, it is possible to know the phase, about the axis L, of the external gear part **3** meshed with the input gear **30** by checking the mark **5** exposed to the outside of the casing **10**. Similarly, even in a state in which the internal gear part **4** is meshed with the drive gear **22**, and thus the drive gear **22** cannot be seen, it is possible to know the phase of the drive gear **22** about the axis L by checking the mark **5**.

(23) A bearing (guide part) **2***a* is attached to the outer circumferential surface at one end of the barrel part **2**. The bearing **2***a* has the same outer diameter as the bearing **23** and is disposed in the same positional relationship with respect to the tip of the external gear **3** as the positional relationship of the bearing **23** with respect to the tip of the drive gear **22**.

(24) A method of assembling the robot **100** using the thus-configured jig **1** according to this embodiment will be described below.

(25) In the assembling method according to this embodiment, in a state before the motor **20** is mounted into the casing **10**, first, as shown in FIG. **3**, the external gear part **3** of the jig **1** is inserted from the outside of the casing **10** into the casing **10** through the opening **11**.

(26) Before the external gear part **3** starts to be meshed with the input gear **30** inside the casing **10**, the bearing **2***a* provided at one end of the barrel part **2** starts to fit into the inner surface of the opening **11**. By rotating an inner ring with respect to an outer ring of the bearing **2***a*, rotation of the external gear part **3** about the axis L is guided. Furthermore, by advancing fitting of the outer ring of the bearing **2***a* into the opening **11**, movement of the external gear part **3** in the direction of the axis L is guided. By moving the external gear part **3** in the direction of the axis L while rotating, with the torque applied to the barrel part **2**, the external gear part **3** about the axis L to search for a phase in which the external gear part **3** is meshed with the input gear **30**, the external gear part **3** can be smoothly meshed with the input gear **30**.

(27) Then, in a state in which the external gear part **3** is meshed with the input gear **30**, the operator checks the position of the mark **5** indicated on the barrel part **2**. When the mark **5** is not positioned at a desired position, the operator applies a torque about the axis L to the barrel part **2** to rotate the barrel part **2** and the external gear part **3** about the axis L, so that the mark **5** is positioned at the desired position. In this way, it is possible to arrange the external gear part **3** in a desired phase and to arrange the input gear **30** in a phase in which the input gear **30** is meshed with the external gear part **3** arranged in the desired phase. The desired phase is, for example, a phase in which the central vertex of the mark **5** is positioned vertically upward. Herein, the positional arrangement of the mark **5** does not necessarily need to be strictly performed.

(28) Then, by removing the jig **1** from the casing **10** so as not to rotate the input gear **30** from this state, the task of adjusting the phase of the input gear **30** is completed.
(29) Next, as shown in FIG. **4**, the internal gear part **4** of the jig **1** is meshed with the drive gear **22** of the motor **20** arranged in a posture ready to be attached to the casing **10**. Then, in a state in which the internal gear part **4** is meshed with the drive gear **22**, the operator checks the position of the mark **5** indicated on the barrel part **2**. When the mark **5** is not positioned at the desired position, the operator grips the barrel part **2** with his/her hand and applies, to the barrel part **2**, a torque about the axis L greater than or equal to the brake torque of the motor **20**. By doing so, it is possible to rotate the drive gear **22** about the axis L while braking the motor **20** and to position the mark **5** at a desired position where, for example, the central vertex of the mark **5** is located vertically upward. This way, the phase of the drive gear **22** is adjusted to a phase in which the drive gear **22** is meshed with the input gear **30** in the casing **10** simply by moving the motor **20** maintained in the posture ready to be attached in the axial direction of the shaft **21**.
(30) Then, by removing the jig **1** from the drive gear **22** so as not to rotate the drive gear **22** from this state, the task of adjusting the phase of the drive gear **22** is completed.
(31) Next, the motor **20** with the drive gear **22** whose phase has been adjusted is lifted and inserted into the casing **10** through the opening **11** while being maintained in the posture ready to be attached. Because the phases of the drive gear **22** and the input gear **30** have been adjusted to such phases in which the drive gear **22** and the input gear **30** mesh with each other, the drive gear **22** can be easily meshed with the input gear **30** without rotating the motor **20** by a large amount about the axis of the shaft **21**, and the motor **20** can be fixed to the casing **10**.
(32) As described above, the jig **1** and the assembly method according to this embodiment have an advantage in that it is possible to easily adjust the phase of the input gear **30**, which is disposed at a position difficult for an operator to reach or directly see.
(33) Furthermore, by rotating the shaft **21** of the motor **20** with the brake applied, it is possible to adjust the phase of the drive gear **22** without preparing a power supply and a brake releasing device. Furthermore, because the drive gear **22** can be meshed with the input gear **30** without rotating the motor **20**, the motor **20** can be easily mounted into the casing **10** even if the installation space for the motor **20** is small, which is advantageous.
(34) Furthermore, because the jig **1** has both the external gear part **3** and the internal gear part **4**, the phases of the drive gear **22** and the input gear **30** can be adjusted with one jig **1**. This leads to an advantage in that there is no need to prepare different jigs.
(35) Because the external gear part **3** and the internal gear part **4** are arranged coaxially, the phases of both the external gear part **3** and the internal gear part **4** can be indicated with a single mark **5**.
(36) In this embodiment, the barrel part **2** has a cylindrical shape having a central axis corresponding to the axis L, and torque is applied by gripping the barrel part **2**. Instead, a non-cylindrical columnar barrel part **2** may be employed. Alternatively, as shown in FIG. **5**, the barrel part **2** may include a cylindrical main body (application part main body) **2***b* having a central axis corresponding to the axis L, and a long lever **2***c* extending radially outward from the outer circumferential surface of the main body **2***b*.
(37) This allows an operator to apply a larger torque about the axis L by applying a force in the tangential direction about the axis L to the end of the lever **2***c*. Thus, the phase of the drive gear **22** or the input gear **30** can be adjusted even more easily.
(38) Because the lever **2***c* has a predetermined phase relationship about the axis L with respect to the external gear part **3** and the internal gear part **4**, the lever **2***c* may be used as a phase indicator. That is, the phase of the drive gear **22** or the input gear **30** may be confirmed by the phase of the lever **2***c* about the axis L, instead of the mark **5**.
(39) In this embodiment, as shown in FIG. **6**, the barrel part **2** may include a cylindrical main body (application part main body) **2***d* extending in the axis L direction, and a tool attachment part **2***e* provided in the outer circumferential surface of the main body **2***d* to be engaged with a tool for

rotating the main body **2***d* about the axis L.
(40) The tool attachment part **2***e* includes, for example, two parallel flat portions formed in the outer circumferential surface of the main body **2***d*, on both sides of the central axis, such that a tool, such as a spanner, can be engaged therewith.
(41) Also in this case, a larger torque can be applied by applying a force to the tool engaged with the tool attachment part **2***e*. The phases of the external gear part **3** and the internal gear part **4** may be confirmed by the position of the tool attachment part **2***e*.
(42) There is another advantage in that the size of the jig **1** can be reduced, because the tool is attached only when the jig **1** is used.
(43) Although a triangular engraving has been shown as an example phase indicator in this embodiment, the mark may have any shape, and, instead of engraving, any method, such as scribing, a sticker, or painting, may be employed.
(44) Although the bearing **2***a* is provided at one end of the barrel part **2** in this embodiment, the one end of the barrel part **2** may be directly fitted into the opening **11** without providing the bearing **2***a*.
(45) The jig **1** having both the external gear part **3** and the internal gear part **4** has been described as an example. Instead, as shown in FIG. **7**, a jig set **1**′ including a first jig **1**A having the external gear part **3** and a second jig **1**B having the internal gear part **4** may be employed.
(46) In the example shown in FIG. **7**, the first jig **1**A includes a cylindrical first barrel part **2**A having a central axis corresponding to a predetermined axis L, and the external gear part **3** fixed to one end of the first barrel part **2**A in the axis L direction. The first barrel part **2**A includes a first lever (torque application part, phase indicator) **5**A, which extends radially outward from the outer circumferential surface of the first barrel part **2**A and allows a force in the tangential direction about the axis L to be applied to the first barrel part **2**A.
(47) The second jig **1**B includes a cylindrical second barrel part **2**B having a central axis corresponding to a predetermined axis (second axis) M, and the internal gear part **4** formed at one end of the second barrel part **2**B in the axis M direction. The second barrel part **2**B includes a second lever (second torque application part, second phase indicator) **5**B, which extends radially outward from the outer circumferential surface of the second barrel part **2**B and allows a force in the tangential direction about the axis M to be applied to the second barrel part **2**B.
(48) The first lever **5**A and the second lever **5**B have predetermined phase relationships with respect to the external gear part **3** and the internal gear part **4**, respectively.
(49) A robot **200** according to an embodiment of the present disclosure will be described below with reference to the drawings.
(50) As shown in FIG. **8**, the robot **200** according to this embodiment includes a casing **210** having an opening **211** and accommodating an input gear **230** therein, and a motor **220** removably attached to the opening **211** in the casing **210**. A drive gear **222** that is meshed with the input gear **230** in a state in which the motor **220** is attached to the casing **210** is attached to a shaft **221** of the motor **220**.
(51) A mark (phase indicator) **205** having a predetermined phase relationship with respect to the drive gear **222** is provided on the outer circumferential surface of the drive gear **222** at the proximal end.
(52) This allows an operator to adjust the phase of the drive gear **222** to a desired phase without using the jig **1**, by checking the phase of the mark **205** before attaching the motor **220** to the casing **210**. Hence, by adjusting only the phase of the input gear **230** using the jig **1**, the drive gear **222** and the input gear **230** can be arranged in such phases that they can be meshed with each other. Thus, the motor **220** can be easily mounted into the casing **210**.

## Claims

1. A jig, comprising: a first gear part configured to be meshed with an input gear disposed in a casing by insertion into the casing from an outside of the casing; a torque application part that is fixed to the first gear part, is disposed outside the casing in a state in which the first gear part is meshed with the input gear, and is capable of configured for applying a torque about a first axis, which corresponds to an axis of the first gear part, to the first gear part; a phase indicator provided on the torque application part to indicate a phase of the first gear part about the first axis; and a second gear part configured to be meshed with a drive gear attached to a shaft of a motor, wherein the second gear part is provided coaxially with the first gear part, on an opposite side from the first gear part with the torque application part therebetween in a direction of the first axis, and the torque application part is configured to apply a torque greater than a brake torque of the motor to the shaft in a state in which the second gear part is meshed with the drive gear.
2. The jig according to claim 1, further comprising a guide part provided on the torque application part and in contact with the casing to guide relative movement between the first gear part and the input gear in a direction of the first axis and in a rotation direction about the first axis.
3. The jig according to claim 1, wherein the phase indicator is a mark provided on the torque application part.
4. The jig according to claim 1, wherein the torque application part has such a shape that a point of application of a force to be applied in a tangential direction about the first axis can be set at a position away from the first axis in a radially outward direction.
5. The jig according to claim 4, wherein the torque application part includes an application part main body fixed to the first gear part, and a lever extending outward from the application part main body in a radial direction about the first axis.
6. The jig according to claim 5, wherein the phase indicator comprises the lever.
7. The jig according to claim 4, wherein the torque application part includes an application part main body fixed to the first gear part, and a tool attachment part provided on the application part main body, and the tool attachment part allowing is configured to allow a tool to be engaged with the application part main body about the first axis, in a state in which a handle of the tool extends outward in a radial direction about the first axis.
8. The jig according to claim 7, wherein the phase indicator comprises the tool attachment part.
9. A jig set, comprising: a first jig; and a second jig, wherein the first jig includes a first gear part configured to be meshed with an input gear disposed in a casing by insertion into the casing from an outside of the casing, a torque application part that is fixed to the first gear part, is disposed outside the casing in a state in which the first gear part is meshed with the input gear, and is configured for applying a torque about a first axis, which corresponds to an axis of the first gear part, to the first gear part, and a phase indicator provided on the torque application part to indicate a phase of the first gear part about the first axis, the second jig includes a second gear part that can configured to be meshed with a drive gear attached to a shaft of a motor, a second torque application part fixed to the second gear part and capable of applying a torque about a second axis corresponding to an axis of the second gear part, and a second phase indicator that indicates a phase about the second axis, and the second torque application part can is configured to apply a torque greater than a brake torque of the motor to the shaft in a state in which the second gear part is meshed with the drive gear.
10. A method for assembling a robot, the method comprising: in a state in which the first gear part of the jig according to claim 1 is inserted into the casing and meshed with the input gear, applying a torque about the first axis to the first gear part with the torque application part disposed outside the casing to rotate the input gear; adjusting a phase of the input gear to a phase in which the input gear can be meshed with a drive gear fixed to a shaft of a motor, on the basis of the phase of the first gear part indicated by the phase indicator; removing the jig from the casing; in a state in which the second gear part of the jig is meshed with the drive gear, applying a torque greater than a brake

torque of the motor about the first axis to the shaft with the torque application part to rotate the drive gear; adjusting a phase of the drive gear to a phase in which the drive gear can be meshed with the input gear, on the basis of the phase of the second gear part indicated by the phase indicator; removing the jig from the drive gear; and attaching the motor to the casing while causing the drive gear to be meshed with the input gear.