

[0009] According to the present invention, different initial tensions may be easily set by setting the close-contact state between the wires of the inner coil spring and the outer coil spring in accordance with the spacing between the one-side receiving member and the other-side receiving member.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

FIG. 1 is a perspective view showing the main part of the manipulator to which the flexural structure according to Embodiment 1 of the present invention is applied.

FIG. 2 is a cross-sectional view of the manipulator of FIG. 1.

FIG. 3 is a schematic diagram showing the main part of FIG. 2.

FIG. 4(A) and (B) are conceptual diagrams of the manipulator of FIG. 1, in which FIG. 4(A) shows the state before the initial tension is applied, and FIG. 4(B) shows the state after the initial tension is applied.

FIG. 5(A) and (B) are conceptual diagrams of the manipulator of FIG. 1, in which FIG. 5(A) shows the extended state, and FIG. 5(B) shows the flexed state.

FIG. 6(A) and (B) are comparisons of the return characteristics of the flexural structure from the flexed state to the extended state with the comparative examples, in which FIG. 6(A) is a graph showing overall changes, and FIG. 6(B) is an enlarged graph of the vicinity of the origin of FIG. 6(A).

FIG. 7(A) and (B) are conceptual diagrams of the manipulator to which the flexural structure according to Embodiment 2 of the present invention is applied, in which FIG. 7(A) shows the extended state, and FIG. 7(B) shows the flexed state.

FIG. 8 is a conceptual diagram showing the manipulator to which the flexural

structure according to Embodiment 3 of the present invention is applied.

FIG. 9 is a conceptual diagram showing the manipulator to which the flexural structure according to Embodiment 4 of the present invention is applied.

DESCRIPTION OF EMBODIMENTS

[0011] The present invention achieves the object of easily setting different initial tensions by setting a close-contact state between wires of an inner coil spring and an outer coil spring in accordance with a spacing between a one-side receiving member and an other-side receiving member.

[0012] That is, the flexural structure 1 has a multi-structured flexible body 15 that is bendable from an extended state to a flexed state and includes an outer coil spring 23, an inner coil spring 25, a one-side receiving member 13, and an other-side receiving member 14.

[0013] The outer coil spring 23 and the inner coil spring 25 constitute the multi-structured flexible body 15. The inner coil spring 25 is provided inside the outer coil spring 23 and has a wire overlap a wire of the outer coil spring 23 in a coil radial direction. The one-side receiving member 13 receives one side of the multi-structured flexible body 15, while the other-side receiving member 14 receives an other side of the multi-structured flexible body 15. In the multi-structured flexible body 15, the close-contact state between the wires of the inner and outer coil springs 25 and 23 is set in accordance with a spacing between the one-side receiving member 13 and the other-side receiving member 14.

[0014] When setting the close-contact state, a friction between the wires may be set to zero or infinitesimally small with respect to a restoring force of the multi-structured flexible body 15 returning from the flexed state to the extended state.

[0015] The flexural structure 1 may include a close-contact setting part 21 that adjusts the spacing between the one-side receiving member 13 and the other-side receiving member 14 and

setting a close-contact state between the wires of the inner coil spring 25 and the outer coil spring 23.

[0016] The close-contact setting part 21 is only required to be able to set the close-contact state between the wires of the inner and outer coil springs 25 and 23, and the structure may be freely set and realized according to the application target, etc.

[0017] The flexural structure 1 may include a plurality of cord-like members 19, one side of which is fixed to the one-side receiving member 13 and an other side of which is routed through the other-side receiving member 14, for operating a displacement of the multi-structured flexible body 15 to the flexed state, and the close-contact setting part 21 may share the cord-like members 19 when setting the close-contact state.

[0018] Further, the flexural structure 1 may include an operation part 22 that is provided on the other side of the cord-like members 19 and that operates a displacement between the extended state and the flexed state of the multi-structured flexible body 15 by relative pulling and pulling back operations between the plurality of cord-like members 19, the close-contact setting part 21 may support the operation part 22 in a position adjustable manner toward a direction of the multi-structured flexible body 15 in the extended state, and the close-contact state may be set by adjusting a position of the operation part 22 in the extended state of the multi-structured flexible body 15.

[0019] The operation part 22 may include a pulley 29 that is supported by the other-side receiving member 14 and is rotatably operable and movable for wrapping the cord-like members 19 around the one-side receiving member 13, and the close-contact setting part 21 may include a tensioner 31 that adjusts a position of the pulley 29.

[0020] The close-contact setting part 21 may include receiving parts 33 provided on the other side of the cord-like members 19 and elastic bodies 35 interposed between the other-side receiving member 14 and the receiving parts 33 and applying tension to the plurality of cord-like members

may be simplified.

[0063] The pulley 29 is supported in a position adjustable manner toward the axial direction of the multi-structured flexible body in the extended state, and By adjusting the position of the pulley 29 of the operation part 22 in the extended state of the multi-structured flexible body 15, the close-
5 contact state between the wires of the inner and outer coil springs 25 and 23 is set.

[0064] When the position of the pulley 29 is adjusted, the relationship between the pulley 29 and the operating mechanism is also adjusted. In the structure in which the pulley 29 is supported by the operating mechanism, the position of the operating mechanism may be supported in a position adjustable manner. When the pulley 29 is omitted and each driving wire 19 is coupled
10 to the operating mechanism, the position of the operating mechanism may be adjustable.

[0065] The close-contact setting part 21 is provided with a tensioner 31 that adjusts the position of the pulley 29. The tensioner 31 adjusts the position of the pulley 29 to set the close-contact state between the wires of the inner and outer coil springs 25 and 23.

[0066]

15 [Setting of close-contact state]

FIG. 4(A) and (B) are conceptual diagrams of the manipulator of FIG. 1, in which FIG. 4(A) shows the state before the initial tension is applied, and FIG. 4(B) shows the state after the initial tension is applied.

[0067] As shown in FIG. 4(A) and FIG. 4(B), a half-finished product of the flexural structure 1
20 before application of initial tension is attached to the end part of the shaft 5, and an initial tension is applied to the double coil spring 16.

[0068] The half-finished product of the flexural structure 1 includes an outer coil spring 23, an inner coil spring 25, and a movable part 13, as shown in FIG. 4(A). In this half-finished product of the flexural structure 1, the inner coil spring 25 and the outer coil spring 23 of the double coil
25 spring 16 are sparse, and there is a gap between the wires in the axial direction.

WHAT IS CLAIMED IS:

[Claim 1]

A flexural structure, in which a multi-structured flexible body is bendable from an extended state to a flexed state, the flexural structure comprising:

- 5 an outer coil spring, constituting the multi-structured flexible body;
- an inner coil spring, provided inside the outer coil spring and having a wire overlap a wire of the outer coil spring in a coil radial direction to constitute the multi-structured flexible body;
- a one-side receiving member, receiving one side of the multi-structured flexible body; and
- an other-side receiving member, receiving an other side of the multi-structured flexible body;
- 10 wherein a close-contact state between wires of the inner coil spring and the outer coil spring is set in an extended state of the multi-structured flexible body in accordance with a spacing between the one-side receiving member and the other-side receiving member.

[Claim 2]

The flexural structure according to claim 1, wherein

- 15 when setting the close-contact state, a friction between the wires is made smaller with respect to a restoring force of the multi-structured flexible body returning from the flexed state to the extended state.

[Claim 3]

The flexural structure according to claim 1 or 2, comprising:

- 20 a close-contact setting part, adjusting the spacing between the one-side receiving member and the other-side receiving member and setting a close-contact state between the wires of the inner coil spring and the outer coil spring.

[Claim 4]

The flexural structure according to claim 3, wherein the close-contact setting part comprises

- 25 a plurality of cord-like members, one side of which is fixed to the one-side receiving member and

an other side of which is routed through the other-side receiving member, for operating a displacement of the multi-structured flexible body to a flexed state, and

the cord-like members are shared when setting the close-contact state.

[Claim 5]

5 The flexural structure according to claim 4, wherein

the close-contact setting part comprises an operation part that is provided on the other side of the cord-like members and that operates a displacement between an extended state and a flexed state of the multi-structured flexible body by relative pulling and pulling back operations between the plurality of cord-like members,

10 the operation part is supported in a position adjustable manner toward a direction of the multi-structured flexible body in the extended state, and

the close-contact state is set by adjusting a position of the operation part in an extended state of the multi-structured flexible body.

[Claim 6]

15 The flexural structure according to claim 5, wherein

the operation part comprises a pulley that is supported by the other-side receiving member and is rotatably operable and movable for wrapping the cord-like members around the one-side receiving member, and

the close-contact setting part comprises a tensioner that adjusts a position of the pulley.

20 [Claim 7]

The flexural structure according to claim 4, wherein

the close-contact setting part comprises: a receiving part, provided on the other side of the cord-like members; and an elastic body, interposed between the other-side receiving member and the receiving part and applying tension to the plurality of cord-like members with respect to the

25 one-side receiving member in an extended state of the multi-structured flexible body, and

the close-contact state is set by applying the tension by the elastic body.

[Claim 8]

The flexural structure according to any one of claims 1 to 7, comprising:

5 a flexible tube, having one end part coupled to the one-side receiving member, enclosing the inner coil spring and the outer coil spring, and constituting the multi-structured flexible body along with the inner coil spring and the outer coil spring; and

an attaching base part, coupled to an other end part of the flexible tube and penetrating the inner coil spring and the outer coil spring along with the flexible tube,

wherein the other-side receiving member is fixed in an end part of a hollow shaft, and

10 the close-contact setting part sets the close-contact state by coupling the attaching base part to the end part of the hollow shaft to move the attaching base part and having the other-side receiving member to receive other end parts of the inner coil spring and the outer coil spring.

[Claim 9]

15 A half-finished product of a flexural structure in which a multi-structured flexible body is bendable from an extended state to a flexed state, the half-finished product of the flexural structure comprising:

an outer coil spring, constituting the multi-structured flexible body;

20 an inner coil spring, provided inside the outer coil spring and having a wire overlap a wire of the outer coil spring in a non-close-contact state in a coil radial direction to constitute the multi-structured flexible body; and

a one-side receiving member, receiving one side of the multi-structured flexible body,

wherein when assembled to a device side, a close-contact state between wires of the inner coil spring and the outer coil spring is set in an extended state of the multi-structured flexible body in accordance with a spacing between the one-side receiving member and an other-side receiving member on the device side.

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