

FLEXIBLE TUBE SUPPORTING DEVICE

BACKGROUND OF THE INVENTION

Field of the Invention

5 [0001]

The present invention relates to a flexible tube supporting device.

Description of Related Art

[0002]

10 For example, boilers for garbage incineration require periodic measurement of boiler tube wall thickness to detect defects. As a general method for measuring a wall thickness of a boiler tube, a water immersion UT method and so on are known.

[0003]

For example, Patent Document 1 describes a technique of measuring a wall
15 thickness of a boiler tube without cutting the boiler tube. In the technique described in Patent Document 1, a guide tube which guides an ultrasonic probe (sensor) for measuring a wall thickness is used. The guide tube is introduced into a tube header from an inspection hole formed in the tube header, and a distal end thereof is introduced into the boiler tube.

20 [0004]

After that, the ultrasonic probe connected to a sensor cable (flexible tube) is introduced into the guide tube from the inspection hole side, and the ultrasonic probe is moved forward. Therefore, the ultrasonic probe advances along the inside of the guide tube and is introduced into the boiler tube by being guided by the guide tube.

25 [0005]

Further, Patent Document 2 describes a technique of installing a multipoint supporting roller (supporting device) on a sensor cable to reduce friction between a sensor cable and a boiler tube. This multipoint supporting roller includes a plurality of hollow universal joints through which the sensor cable is inserted, and a plurality of rollers installed on an outer circumference of each of the universal joints. Each of the rollers come into contact with an inner surface of the tube and rolls in an axis of the tube.

[Citation List]

[Patent Documents]

[0006]

10 [Patent Document 1] Japanese Patent No. 4056679

[Patent Document 2] Japanese Unexamined Patent Application, First
Publication No. H2-32252

SUMMARY OF THE INVENTION

15 [0007]

However, in the multipoint supporting roller described in Patent Document 2, the sensor cable passing through the inside of a universal joint is not able to bend in a range of the length of the universal joint. Therefore, the bendability of the sensor cable may deteriorate (a bending radius may increase), and thus when the bending radius of the boiler tube to be inspected is small, the sensor may not be able to be inserted due to becoming caught midway.

[0008]

It is an object of the present invention to provide a flexible tube supporting device which is a supporting device for supporting a flexible tube (sensor cable) inserted into a rigid tube (boiler tube) such that it is able to extend in an axial direction of the tube

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and is capable of reducing a bending radius of the flexible tube.

[0009]

According to a first aspect of the present invention, there is provided a flexible tube supporting device including a supporting tool main body installed on an outer

5 circumference of a flexible tube inserted into a rigid tube in an axial direction of the tube, and a plurality of rollers provided between the supporting tool main body and the tube at intervals in a circumferential direction of the tube, rotatably installed on the supporting tool main body and configured to be in contact with an inner circumferential surface of the tube, wherein the supporting tool main body includes a first main body portion in
10 which a through-hole having a diameter larger than an outer diameter of the flexible tube is formed, and a second main body portion including a wedge portion inserted into a radial gap between the through-hole and the flexible tube.

[0010]

According to such a configuration, since the wedge portion is inserted into the
15 gap and is pressed against the outer circumferential surface of the flexible tube, the supporting tool main body can be fixed to the flexible tube. Further, due to such a structure, it is possible to reduce the length of the supporting tool main body, to which the roller is installed, in the axial direction and to reduce a bending radius of the flexible tube.

20 [0011]

In the flexible tube supporting device, an axial length of the supporting tool main body may be smaller than an outer diameter of the roller.

[0012]

According to such a configuration, it is possible to prevent the supporting tool
25 main body from coming into contact with the flexible tube and causing frictional

resistance. Further, in the flexible tube, it is possible to reduce a length restrained by the supporting tool main body.

[0013]

In the flexible tube supporting device, the through-hole may have a tapered shape in which a diameter gradually increases toward one side in the axial direction, and the wedge portion may have a tapered outer circumferential surface in which a diameter gradually increases toward one side in the axial direction and an inner circumferential surface having an inner diameter slightly larger than the outer diameter of the flexible tube.

10 [0014]

According to such a configuration, the wedge portion can be inserted more easily into the gap between the through-hole and the flexible tube.

[0015]

In the flexible tube supporting device, the first main body portion may have a bearing portion disposed between adjacent rollers in the circumferential direction and having a groove into which an end of the rotating shaft of the roller is inserted from the axial direction, and the second main body portion may have a holding portion configured to hold the rotating shaft inserted into the bearing portion from the axial direction.

[0016]

20 According to such a configuration, it is possible to hold the roller with a simpler structure.

[0017]

According to the present invention, since the wedge portion is inserted into the gap and is pressed against the outer circumferential surface of the flexible tube, the supporting tool main body can be fixed to the flexible tube. Further, due to such a

25

structure, it is possible to reduce the radius of the supporting tool main body to which the roller is installed and thus to reduce the bending radius of the flexible tube.

BRIEF DESCRIPTION OF THE DRAWINGS

5 [0018]

FIG. 1 is an overall schematic view of a tube wall thickness measuring apparatus and a boiler according to an embodiment of the present invention.

FIG. 2 is a side view of a sensor probe and a flexible tube supporting device of the tube wall thickness measuring apparatus according to the embodiment of the present
10 invention.

FIG. 3 is a view of a flexible tube supporting device according to an embodiment of the present invention when seen from an axial direction.

FIG. 4 is a view of the flexible tube supporting device according to the embodiment of the present invention when seen from an axial direction of a boiler tube.

15 FIG. 5 is a cross-sectional view taken along line V-V of FIG. 4.

FIG. 6 is a view of the flexible tube supporting device according to the embodiment of the present invention when seen from the axial direction of the boiler tube.

FIG. 7 is a cross-sectional view taken along line VII-VII of FIG. 6.

20 FIG. 8 is an exploded view of the flexible tube supporting device according to the embodiment of the present invention.

FIG. 9 is a view illustrating a method for assembling the flexible tube supporting device according to the embodiment of the present invention.

FIG. 10 is a view illustrating an operation of the flexible tube supporting device
25 according to the embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0019]

Hereinafter, an embodiment of a tube wall thickness measuring apparatus 1
5 including a flexible tube supporting device 5 of the present invention will be described in
detail with reference to the drawings.

As illustrated in FIG. 1, the tube wall thickness measuring apparatus 1 according
to the present embodiment is used for measuring a wall thickness of a boiler tube 52 in a
boiler 50. For example, the tube wall thickness measuring apparatus 1 may measure the
10 wall thickness of the boiler tube 52 using a sensor such as an ultrasonic probe.

[0020]

The boiler 50 includes a tube header 51 and a plurality of boiler tubes 52. The
boiler tubes 52 are a plurality of rigid tubes serving as flow paths for water vapor and
arranged in an extension direction of the tube header 51, and one ends thereof are
15 connected to the tube header 51. Each of the boiler tubes 52 communicates with the
tube header 51 and extends to be orthogonal to the tube header 51.

[0021]

A plurality of inspection holes 53 which are holes for inspection are formed in
the tube header 51 by being spaced apart from each other in the extension direction of the
20 tube header 51. The inspection holes 53 and the boiler tube 52 are disposed such that
they have a relative positional relationship of being twisted with respect to each other.

The boiler tube 52 has linearly extending portions and a bent portion 52a
connecting the linearly extending portions. An inner diameter of the boiler tube 52 is,
for example, 68 mm.

25 A sensor probe 2 is introduced into the boiler tube 52 via the inspection holes 53

and the tube header 51.

[0022]

Next, a tube wall thickness measuring apparatus 1 for measuring a wall thickness of the boiler tube 52 to be inspected will be described.

5 The tube wall thickness measuring apparatus 1 includes a data collection device 31, a data analysis device 32 which analyzes data collected by the data collection device 31, a cable winding device 33 connected to the data collection device 31, a cable 30 which is a flexible tube discharged from the cable winding device 33, a sensor probe 2 which is a sensor installed on a distal end of the cable 30, a supporting device 5 installed
10 on an outer circumference of the cable 30, and a guide tube 34 which is a guide device for the sensor probe 2.

[0023]

 The data collection device 31 is a device in which thickness data of the boiler tube 52 measured by the sensor probe 2 is input via the cable 30. That is, the data
15 collection device 31 serves to collect the thickness data of the boiler tube 52.

 The data analysis device 32 is a computer used for analyzing the thickness data of the boiler tube 52 collected by the data collection device 31.

[0024]

 The cable 30 is inserted into the rigid boiler tube 52 in an axial direction Da of
20 the boiler tube 52. The cable 30 is, for example, an elongated flexible tube formed of a metal, vinyl or the like and is able to bend over an entire length thereof. An outer diameter of the cable 30 is, for example, 12 mm. The cable 30 includes a data signal wiring which connects the sensor probe 2 with the data collection device 31 and a water supply hose which rotates a sensor main body portion 3 at the time of measuring the wall
25 thickness by water pressure.

The sensor probe 2 is provided at the distal end portion of the cable 30 and measures thickness data of the boiler tube 52 by emitting ultrasonic waves. The sensor probe 2 has a cylindrical sensor main body portion 3 and a centering mechanism 4 which holds the sensor main body portion 3 at a center position inside the boiler tube 52.

5 Further, the centering mechanism may be expandable and contractible.

[0025]

The cable winding device 33 is connected to a rear end of the cable 30 and is used for winding the cable 30 inserted into the boiler tube 52.

[0026]

10 The guide tube 34 is a tube which guides the cable 30 and the sensor probe 2 to be introduced into the boiler tube 52 and is disposed in the tube header 51 prior to measurement of the wall thickness of the boiler tube 52. The guide tube 34 is disposed such that it connects the inspection hole 53 and the boiler tube 52 which are in a twisted relationship with respect to each other.

15 [0027]

The guide tube 34 is formed of a bellows-shaped flexible hose. Therefore, the guide tube 34 is formed to be telescopic and bendable. The guide tube 34 may maintain a bent state as long as an external force is not applied while the guide tube 34 is bent.

The guide tube 34 is inserted from the inside of the inspection hole 53 into the tube header 51 and extends while bending in the tube header 51, and a distal end thereof is
20 connected to the boiler tube 52.

[0028]

The supporting device 5 is a device which supports the cable 30 to reduce friction between the cable 30 and the boiler tube 52. As illustrated in FIG. 2, the
25 supporting device 5 supports the cable 30 so that the cable 30 is located at a center

position of the boiler tube 52 in a radial direction.

A plurality of supporting devices 5 are installed in the vicinity of an end of the cable 30 on the sensor probe 2 side at predetermined intervals (for example, 50 mm).

[0029]

5 As illustrated in FIGS. 2 and 3, the supporting device 5 of the embodiment includes a supporting tool main body 6 installed at the outer circumference of the cable 30, and a plurality of rollers 7 installed at the supporting tool main body 6. The supporting tool main body 6 is fixed to the cable 30 to be immovable in the extension direction of the cable 30.

10 The plurality of rollers 7 are provided at intervals in a circumferential direction of the boiler tube 52 between the supporting tool main body 6 and the boiler tube 52. The roller 7 is a cylindrical member which is rotatably installed at the supporting tool main body 6. A rotating shaft 9 of the roller 7 extends in a direction orthogonal to an axis A of the cable 30, and the roller 7 rolls in the axial direction Da.

15 [0030]

The roller 7 includes a cylindrical roller main body 8 and a rotating shaft 9 which is coaxial with an axis of the roller main body 8.

An outer circumferential surface 8a of the roller main body 8 has an arcuate cross-sectional shape including an axis of the roller main body 8 so that a diameter thereof gradually decreases toward an end thereof (end in an extension direction of the rotating shaft 9). The cross-sectional shape of an outer circumferential surface 8a of the roller main body 8 is formed to be along an inner circumferential surface of the boiler tube 52 or to have a radius of curvature smaller than a radius of the inner circumferential surface of the boiler tube 52.

25 At least part of each roller main body 8 is in contact with the inner

circumferential surface of the boiler tube 52.

[0031]

The supporting tool main body 6 includes a first main body portion 11 in which a through-hole 14 (refer to FIGS. 4 and 5) having a diameter larger than an outer diameter of the cable 30 is formed, and a second main body portion 12 having a wedge portion 21 (refer to FIG. 7) which is inserted into a radial gap (refer to FIG. 9) between the through-hole 14 and the cable 30. The supporting tool main body 6 may be assembled by inserting the wedge portion 21 of the second main body portion 12 into the through-hole 14 of the first main body portion 11 and then fastening the second main body portion 12 to the first main body portion 11 with a screw.

[0032]

As illustrated in FIGS. 4 and 5, the first main body portion 11 includes a cylindrical portion 13 in which the through-hole 14 is formed and a plurality of bearing portions 15 protruding radially outward from the cylindrical portion 13 around an axis A. A groove 16 which supports the rotating shaft 9 (refer to FIG. 3) of the roller 7 from the other side Da2 in the axial direction and restricts movement of the rotating shaft 9 in the radial direction and the circumferential direction is formed in each of the bearing portions 15.

[0033]

The bearing portion 15 has a first flat surface 15a which is a flat surface facing one side Da1 in the axial direction. The groove 16 is formed in the first flat surface 15a and is concave toward the other side Da2 in the axial direction. A pair of grooves 16 formed in the bearing portions 15 adjacent to each other in the circumferential direction cooperate to support the rotating shaft 9. Therefore, the roller 7 is disposed between adjacent bearing portions 15 in the circumferential direction.

[0034]

A plurality of screw holes 17 are formed in a surface of the first main body portion 11 facing the one side Da1 in the axial direction of the cylindrical portion 13. The screw hole 17 is formed from the surface facing the one side Da1 in the axial direction toward the other side Da2 in the axial direction.

[0035]

An inner circumferential surface of the through-hole 14 has a tapered shape in which a diameter gradually increases toward the one side Da1 in the axial direction. In other words, an inner diameter of the through-hole 14 gradually expands toward the one side Da1 in the axial direction. A taper angle of the inner circumferential surface of the through-hole 14 is, for example, 1/10 to 1/20. A free space portion 18 which is chamfered is formed at an end of the through-hole 14 on the other side Da2 in the axial direction. A shape of the free space portion 18 may be formed by C-chamfering or R-chamfering.

[0036]

As illustrated in FIGS. 6 and 7, the second main body portion 12 includes an annular ring portion 20, a cylindrical wedge portion 21 protruding from an inner circumference side end of the ring portion 20 to the other side Da2 in the axial direction, and a plurality of holding portions 22 protruding radially outward from the ring portion 20 around the axis A.

The holding portion 22 has a second flat surface 22a which is a flat surface in surface contact with the first flat surface 15a of the bearing portion 15 of the first main body portion 11. The second flat surface 22a is a surface which faces the other side Da2 in the axial direction.

A plurality of holes 23 corresponding to the screw holes 17 of the cylindrical

portion 13 of the first main body portion 11 are formed in the ring portion 20. The hole 23 has a shape corresponding to the screw 25 to be used. In the embodiment, since countersunk screws are used for the screws 25 (refer to FIG. 8), the holes 23 are subjected to a spot facing process.

5 [0037]

The wedge portion 21 has an outer circumferential surface 21a having a tapered shape in which a diameter gradually increases toward the one side Da1 in the axial direction, and an inner circumferential surface 21b having an inner diameter slightly larger than the outer diameter of the cable 30 (refer to FIG. 2). In other words, an outer

10 diameter of the outer circumferential surface 21a of the wedge portion 21 gradually expands toward the one side Da1 in the axial direction. A taper angle of the outer circumferential surface is the same as a taper angle of the inner circumferential surface of the through-hole 14 of the cylindrical portion 13 of the first main body portion 11.

[0038]

15 As illustrated in FIG. 9, at an intersection between the outer circumferential surface 21a of the wedge portion 21 and the second flat surface 22a of the holding portion 22, a slit 24 is formed over an entire circumference thereof in the circumferential direction. The slit 24 is a groove which is formed to be inclined to the one side Da1 in the axial direction going radially inward from the intersection between the outer

20 circumferential surface 21a and the second flat surface 22a.

[0039]

As illustrated in FIG. 2, the supporting tool main body 6 (first main body portion 11 and second main body portion 12) is formed so that a length L thereof in an axial direction Da is smaller than a diameter D of the roller 7. For example, a diameter of the

25 roller 7 is 14 mm, and a thickness of a supporting tool main body in the axial direction

Da is $L=13$ mm.

[0040]

Next, a method of assembling the supporting device 5 will be described.

FIG. 8 is an exploded view of the supporting device 5.

5 An assembling method of the supporting device 5 includes a cable inserting process of inserting the cable 30 into the through-hole 14 of the first main body portion 11, a roller rotating shaft inserting process of inserting the rotating shaft 9 of the roller 7 into the groove 16 of the first main body portion 11, a wedge portion driving process of driving the wedge portion 21 of the second main body portion 12 between the
10 through-hole 14 of the first main body portion 11 and the outer circumferential surface 30a of the cable 30, and a screw fastening process of fixing the first main body portion 11 and the second main body portion 12 using the screws 25.

[0041]

As illustrated in FIG. 9, in the wedge portion driving process, the wedge portion
15 21 is inserted into a gap G between the inner circumferential surface of the through-hole 14 and the outer circumferential surface 30a of the cable 30. Therefore, the inner circumferential surface 21b of the wedge portion 21 and the outer circumferential surface 30a of the cable 30 are brought into surface contact with each other, and the wedge portion 21 is pressed against the outer circumferential surface of the cable 30.

20 In the screw fastening process, the second flat surface 22a of the second main body portion 12 and the first flat surface 15a of the first main body portion 11 are brought close to each other such that they come into surface contact with each other. Therefore, the wedge portion 21 is inserted further into the gap G between the through-hole 14 and the cable 30. When the wedge portion 21 is inserted into the gap G,
25 the supporting device 5 (supporting tool main body 6) cannot move in the axial direction

Da.

Further, the second flat surface 22a of the second main body portion 12 covers the first flat surface 15a in which the groove 16 of the first main body portion 11 is formed, and thus the roller 7 is rotatably installed.

5 [0042]

According to the above-described embodiment, since the wedge portion 21 is inserted into the gap G between the through-hole 14 and the cable 30 and is pressed against the outer circumferential surface 30a of the cable 30, the supporting tool main body 6 can be fixed to the cable 30. Further, due to such a structure, it is possible to
10 reduce the length L (refer to FIG. 2) of the supporting tool main body 6, to which the roller 7 is installed, in the axial direction Da and to reduce a bending radius of the cable 30.

[0043]

Further, by making the length of the supporting tool main body 6 in the axial
15 direction Da smaller than the outer diameter of the roller 7, it is possible to prevent the supporting tool main body 6 from coming in contact with the boiler tube 52 and causing frictional resistance.

Further, in the cable 30, a length restrained by the supporting tool main body 6 can be shortened. Therefore, as illustrated in FIG. 10, it is possible to reduce the
20 bending radius of the cable 30. In the example illustrated in FIG. 10, the supporting device 5 is installed at the cable 30 having a diameter of 12 mm so that a distance S therebetween is 50 mm. For reference, a minimum radius of curvature R of the cable 30 is 38.4mm.

[0044]

25 Further, since the wedge portion 21 having a shape corresponding to the shape

of the through-hole 14 is driven into the tapered through-hole 14, the wedge portion 21 can be more easily inserted into the gap G between the through-hole 14 and the cable 30.

Further, since the rotating shaft 9 of the roller 7 is inserted into the groove 16 of the bearing portion 15 of the first main body portion 11 and the rotating shaft 9 is held by the holding portion 22 of the second main body portion 12, it is possible to hold the roller 7 with a simpler structure.

[0045]

Further, since the free space portion 18 is formed on the first main body portion 11 of the supporting tool main body 6, the length of the cable 30 restricted by the supporting tool main body 6 is further shortened, and the cable 30 can be more easily bent.

Further, since the slit 24 is formed between the wedge portion 21 and the holding portion 22 of the second main body portion 12, the wedge portion 21 is easily bent. Accordingly, the wedge portion 21 can be easily inserted into the gap G.

[0046]

Although the embodiments of the present invention have been described in detail with reference to the drawings, a specific configuration is not limited to this embodiment, and design changes and the like within a scope not deviating from the gist of the present invention are included.

Further, in the above-described embodiment, the number of rollers 7 installed at each supporting device 5 is set to 6, but the present invention is not limited thereto. The number of rollers 7 may be three or more.

Further, in the above-described embodiment, the wedge portion 21 has a continuous shape in the circumferential direction. However, the present invention is not limited thereto, and a plurality of wedge portions 21 may be provided at intervals in the

circumferential direction.

EXPLANATION OF REFERENCES

[0047]

- | | |
|----|---|
| 5 | 1 Tube wall thickness measuring apparatus |
| | 2 Sensor probe |
| | 3 Sensor main body portion |
| | 4 Centering mechanism |
| | 5 Supporting device |
| 10 | 6 Supporting tool main body |
| | 7 Roller |
| | 8 Roller main body |
| | 9 Rotating shaft |
| | 11 First main body portion |
| 15 | 12 Second main body portion |
| | 13 Cylindrical portion |
| | 14 Through-hole |
| | 15 Bearing portion |
| | 15a First flat surface |
| 20 | 16 Groove |
| | 17 Screw hole |
| | 18 Free space portion |
| | 20 Ring portion |
| | 21 Wedge portion |
| 25 | 22 Holding portion |

	22a Second flat surface
	23 Hole
	24 Slit
	25 Screw
5	30 Cable
	31 Data collection device
	32 Data analysis device
	33 Cable winding device
	34 Guide tube
10	50 Boiler
	51 Tube header
	52 Boiler tube
	52a Bent portion
	53 Inspection hole
15	A Axis
	Da Axial direction
	Da1 One side in axial direction
	Da2 Other side in axial direction

What is claimed is:

1. A flexible tube supporting device, comprising:

5 a supporting tool main body installed on an outer circumference of a flexible tube inserted into a rigid tube in an axial direction of the tube, and
a plurality of rollers provided between the supporting tool main body and the tube at intervals in a circumferential direction of the tube, rotatably installed on the supporting tool main body and configured to be in contact with an inner circumferential surface of the tube,

10 wherein the supporting tool main body comprises a first main body portion in which a through-hole having a diameter larger than an outer diameter of the flexible tube is formed, and a second main body portion including a wedge portion inserted into a radial gap between the through-hole and the flexible tube.

15 2. The flexible tube supporting device according to claim 1, wherein an axial length of the supporting tool main body is smaller than an outer diameter of the roller.

3. The flexible tube supporting device according to claim 1 or 2, wherein the through-hole has a tapered shape in which a diameter gradually increases toward one side
20 in the axial direction, and

the wedge portion has a tapered outer circumferential surface in which a diameter gradually increases toward one side in the axial direction and an inner circumferential surface having an inner diameter slightly larger than the outer diameter of the flexible tube.

4. The flexible tube supporting device according to any of claims 1 to 3, wherein the first main body portion has a bearing portion disposed between the adjacent rollers in the circumferential direction and having a groove into which an end of the rotating shaft of the roller is inserted from the axial direction, and
- 5 the second main body portion has a holding portion configured to hold the rotating shaft inserted into the bearing portion from the axial direction.