

NON-DESTRUCTIVE PIPE INSPECTION APPARATUS

【Technical Field】

[0001] The present disclosure relates to a non-destructive pipe inspection apparatus, and more particularly, to a non-destructive pipe inspection apparatus which generates
5 radiation from a radiation source toward a radiation film installed at an outer circumference of a pipe while traveling inside a pipe.

【Background Art】

[0002] A non-destructive inspection is performed to determine welding quality after pipe welding. As one example of the non-destructive inspection, a radiation film is disposed
10 along a circumference of a welded surface of a pipe, a radiation source is inserted inside the pipe, and a welding state is determined according to whether radiation is detected by the radiation film. Since a detected radiation amount is reduced inversely proportional to a squared distance of the radiation source, it is necessary to dispose the radiation source on a central axis of the pipe in order to accurately determine a defective weld. When
15 the pipe is a bent pipe, there is a problem in that it is difficult to accurately dispose the radiation source on the central axis of the pipe, which may reduce the measurement accuracy of a non-destructive inspection.

【Disclosure】

【Technical Problem】

[0003] A problem to be solved by the present disclosure is to provide a non-destructive
20 pipe inspection apparatus capable of increasing the measurement accuracy of a non-destructive inspection by disposing a radiation source on a central axis of a bent pipe.

[0004] The problems to be solved by the present disclosure are not limited to the above-described problem, and other problems not mentioned can be clearly understood by those skilled in the art from the following description.

【Technical Solution】

5 **[0005]** It is one aspect of the present disclosure to provide a non-destructive pipe inspection apparatus including a body part; a traveling unit deployed to the outside of the body part, and configured to bring a wheel provided at a deployed distal end into close contact with an inner wall of a pipe to generate a driving force; a monitoring unit configured to monitor an interior of the pipe; a traveling control apparatus configured to
10 control the traveling unit to rotate the body part along a circumference of the pipe according to the monitoring result; a guide tube installed at the body part, and configured to guide a feeding tube which has a radiation source for a non-destructive inspection of the pipe at a distal end side; and a first tube driver configured to move the guide tube in a first direction relative to the body part.

15 **[0006]** Here, the traveling unit may be provided at both opposite sides of the body part, and two or more traveling units in parallel with a traveling direction may be provided at one side of the body part.

[0007] Also, the traveling control apparatus may control a rotational speed of a wheel provided in each of a plurality of traveling units to correspond to a shape of the pipe.

20 **[0008]** Also, each of a plurality of traveling units may include a first leg configured to support a wheel provided at the first leg; and a second leg configured to partially overlap the first leg, wherein, as an overlapping distance between the first leg and the second leg

is adjusted, a distance of the wheel provided at the first leg with respect to the body part may be adjusted.

[0009] Also, distances between the body part and the wheels provided at each of the plurality of traveling units may be independently adjusted.

5 **[0010]** Also, when an obstacle in front in a traveling direction or a recessed portion in the inner wall of the pipe is present according to the monitoring result, the traveling control apparatus may control the traveling unit to rotate the body part along a circumference of the pipe.

[0011] Also, the traveling unit may be provided at both opposite sides of the body part,
10 and the non-destructive pipe inspection apparatus may further include a width adjusting unit configured to adjust a width between the wheels of the traveling unit provided at both of the opposite sides of the body part.

[0012] Also, the width adjusting unit may adjust the width between the wheels of the traveling unit provided at both of the opposite sides of the body part to allow forces of
15 the wheels of the traveling unit pushing against the inner wall of the pipe to be maintained constant.

[0013] Also, the non-destructive pipe inspection apparatus may further include a position displacement sensor configured to determine a position of the non-destructive pipe inspection apparatus inside the pipe, wherein the traveling control apparatus may
20 control the traveling unit by referring to the determined position of the non-destructive pipe inspection apparatus inside the pipe to allow a center of the body part to coincide with a central axis of the pipe.

[0014] Also, the non-destructive pipe inspection apparatus may further include an inspection controller configured to calculate a pivot angle of the guide tube, which allows the radiation source exposed at the distal end side of the guide tube to be located on a central axis of the pipe, and control the first tube driver according to the calculated pivot angle.

[0015] Also, the non-destructive pipe inspection apparatus may further include a position recognizing unit configured to recognize a position of the body part inside the pipe, wherein the inspection controller may calculate the pivot angle of the guide tube on the basis of the position of the body part and design information of the pipe.

[0016] Also, when at least a portion of the non-destructive pipe inspection apparatus is located within a bent section of the pipe, the inspection controller may calculate the pivot angle of the guide tube on the basis of the position of the body part, an inner diameter of the pipe, a curvature of the bent section.

[0017] Also, the non-destructive pipe inspection apparatus may further include a radiation film installed along an outer circumference of a welded portion side of the pipe, wherein the inspection controller may control the first tube driver to locate the radiation source at a central portion of the radiation film.

[0018] Also, the non-destructive pipe inspection apparatus may further include a feeding apparatus configured to feed the radiation source of the feeding tube to the distal end side of the guide tube by insertion of the feeding tube into the guide tube.

[0019] Also, the feeding apparatus may include a feeding gear member engaged with a gear formed on an outer circumferential surface of the feeding tube; and a drive member configured to drive the feeding gear member.

[0020] Also, the non-destructive pipe inspection apparatus may further include a second tube driver configured to move the guide tube in a second direction perpendicular to the first direction relative to the body part.

[0021] Also, the non-destructive pipe inspection apparatus may further include a roll angle measuring unit configured to measure a roll angle of the body part; and an inspection controller configured to calculate a first pivot angle of the guide tube in the first direction and a second pivot angle thereof in the second direction, which allow the radiation source to be located on the central axis of the pipe, on the basis of the position of the body part, the roll angle of the body part, and design information of the pipe, control the first tube driver according to the first pivot angle, and control the second tube driver according to the second pivot angle.

[0022] The details of other embodiments are included in the detailed description and the drawings.

【Brief Description of Drawings】

[0023] FIG. 1 is a side view of a non-destructive pipe inspection apparatus 100 according to one embodiment of the present disclosure.

[0024] FIG. 2 is a plan view of the non-destructive pipe inspection apparatus 100 according to one embodiment of the present disclosure.

[0025] FIG. 3 is a front view of the non-destructive pipe inspection apparatus 100 according to one embodiment of the present disclosure.

[0026] FIG. 4 is an enlarged perspective view of a portion B of FIG. 1.

[0027] FIG. 5 is an enlarged perspective view of a portion C of FIG. 1.

[0028] FIG. 6 is a diagram for describing the operation and an effect of the non-destructive pipe inspection apparatus according to one embodiment of the present disclosure.

[0029] FIG. 7 is a diagram for describing a non-destructive pipe inspection apparatus according to another embodiment of the present disclosure, and is a perspective view illustrating a portion corresponding to the portion C of FIG. 1.

[0030] FIGS. 8 and 9 are plan views for describing the operation and an effect of the non-destructive pipe inspection apparatus according to another embodiment of FIG. 7.

[0031] FIG. 10 is a cross-sectional view taken along lines D-D' and E-E' of FIG. 9.

[0032] FIG. 11 is a perspective view of a non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure.

[0033] FIG. 12 is a left side view of the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure.

[0034] FIG. 13 is a right side view of the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure.

[0035] FIG. 14 is a diagram illustrating a width adjustment between wheels according to an embodiment of the present disclosure.

[0036] FIG. 15 is a diagram illustrating a length adjustment of a wheel according to an embodiment of the present disclosure.

[0037] FIG. 16 is a block diagram illustrating a control apparatus according to still another embodiment of the present disclosure.

[0038] FIG. 17 is a diagram illustrating the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure traveling inside a pipe.

[0039] FIGS. 18 and 19 are diagrams illustrating the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure traveling inside a pipe of which a diameter varies.

[0040] FIG. 20 is a diagram illustrating the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure traveling inside a pipe which includes a bent section.

[0041] FIG. 21 is a diagram illustrating the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure rotating along a circumference of a pipe.

[0042] FIGS. 22 to 24 are diagrams illustrating the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure which travels after rotating inside a pipe.

[0043] FIG. 25 is a diagram illustrating the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure determining a central position inside a pipe.

[0044] FIG. 26 is a diagram illustrating the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure correcting a central position inside a pipe.

【Modes of the Invention】

[0045] Hereinafter, preferred embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. The advantages and features of the present disclosure and the manner of achieving the advantages and features will become apparent with reference to embodiments described in detail below together with the

accompanying drawings. The present disclosure may, however, be implemented in many different forms and should not be construed as being limited to the embodiments set forth herein, and these embodiments are provided such that this disclosure will be thorough and complete and will fully convey the scope of the present disclosure to those skilled in the art, and the present disclosure is defined by only the scope of the appended claims. Like reference numerals refer to like components throughout the disclosure.

[0046] Unless defined otherwise, all terms (including technical and scientific terms) used herein may be used in a sense commonly understood by those skilled in the art to which this present disclosure pertains. Further, terms which are defined in a commonly used dictionary are not ideally or excessively interpreted unless explicitly defined otherwise.

[0047] FIG. 1 is a side view of a non-destructive pipe inspection apparatus 100 according to one embodiment of the present disclosure, FIG. 2 is a plan view of the non-destructive pipe inspection apparatus 100 according to one embodiment of the present disclosure, and FIG. 3 is a front view of the non-destructive pipe inspection apparatus 100 according to one embodiment of the present disclosure.

[0048] Referring to FIGS. 1 to 3, the non-destructive pipe inspection apparatus 100 generates radiation from a radiation source toward a radiation film 20 installed along an outer circumference of a welded portion 12 of a pipe 10 while traveling inside the pipe 10. When radiation is not detected by the radiation film 20, the welded portion 12 of the pipe 10 is determined to have no defect. When radiation is detected by the radiation film 20, the welded portion 12 of the pipe 10 is determined to be defective, and an operator

determines a position of a defective weld on the basis of a position of the radiation film 20 where the radiation is detected, and then additionally performs welding.

[0049] The non-destructive pipe inspection apparatus 100 may include a body part 110, a wheel 120, a driver 130, a guide tube 140, a first tube driver 150, a position recognizing unit 160, a feeding device 170, and an inspection controller (not shown).

[0050] The body part 110 is located on a central axis of the pipe 10 and travels inside the pipe 10. The wheel 120, the driver 130, the guide tube 140, the first tube driver 150, the position recognizing unit 160, and the feeding device 170 are installed at the body part 110.

[0051] The wheel 120 supports the body part 110 on an inner surface of the pipe 10. As one example, the wheel 120 may include a traveling wheel 121 and an adjuster 122. In the illustrated example, two of four traveling wheels 121 are installed at upper and lower portions of the body part 110, respectively, but the installation number of the traveling wheels 121 and the installation positions thereof may be variously changed.

[0052] The adjuster 122 adjusts a distance between each of the traveling wheels 121 and the body part 110. The adjuster 122 may adjust the distance between each of the traveling wheels 121 and the body part 110 according to an inner diameter of the pipe 10. The adjuster 122 may adjust the position of each of the traveling wheels 121 by a hydraulic cylinder, a motor, or the like.

[0053] The adjuster 122 may adjust the position of each of the traveling wheels 121 in a radial direction of the pipe 10 to allow the traveling wheels 121 to be disposed at the same distance from the central axis of the pipe 10. Consequently, the body part 110 is located on the central axis of the pipe 10 by the wheel 120.

[0054] The wheel 120 may have a shock-absorbing device such as a spring which pressurizes the traveling wheel 121 toward the inner surface of the pipe 10. The driver 130 drives the traveling wheel 120 to move the body part 110 along the pipe 10. The driver 130 may be provided as a drive motor for rotationally driving the traveling wheel 121.

[0055] A radiation source S for a non-destructive inspection of the pipe 10 is provided at a distal end side of a feeding tube T. The radiation source S may generate radiation such as X-rays, γ -rays, β -rays, and the like.

[0056] The guide tube 140 is installed at a front side of the body part 110 to guide the feeding tube T. The radiation source S is supplied to a distal end side of the guide tube 140 by the feeding device 170.

[0057] FIG. 4 is an enlarged perspective view of a portion B of FIG. 1. Referring to FIG. 4, the feeding device 170, by insertion of the feeding tube T into the guide tube 140, may transfer the radiation source S of the feeding tube T to the distal end side of the guide tube 140. The feeding device 170 includes a support plate 171 provided at a rear side of the body part 110, a motor housing 172 installed at the support plate 171, a drive motor (i.e., a drive member) 173 installed at the motor housing 172, a feeding gear member 174 configured to be rotated by being connected to a drive shaft of the drive motor 173, and a coupler 176 formed at one side of the motor housing 172 and configured to allow the feeding tube T to be inserted therein.

[0058] An insertion tube 175 into which the feeding tube T is inserted is formed in the motor housing 172.

[0059] An opening is formed at the insertion tube 175, and the feeding gear member 174 is gear-engaged with a gear formed on an outer surface of the feeding tube T through the opening. When the drive motor 173 is driven, the feeding tube T is moved to the front side of the body part 110 through a guide tube of the body part 110, and is inserted into the guide tube 140. Accordingly, the radiation source S provided at the distal end side of the feeding tube T is exposed through a front end side of the guide tube 140.

[0060] Referring back to FIGS. 1 to 3, the position recognizing unit 160 is provided to recognize a position of the body part 110 inside the pipe 10. In the illustrated example, the position recognizing unit 160 is installed at a bottom surface of the distal end side of the guide tube 140, but an installation position of the position recognizing unit 160 is not limited thereto. As one example, the position recognizing unit 160 may be provided as a camera and an image processing unit. For example, the image processing unit may recognize a welded surface from an interior image of the pipe 10 captured by the camera, thereby recognizing a position of the body part 110 inside the pipe 10. As another example, the position recognizing unit 160 may measure a traveled distance of the body part 110 through a means such as an encoder or the like which is provided at the wheel 120, or may recognize the position of the body part 110 in other ways.

[0061] The first tube driver 150 rotates the guide tube 140 in a first direction with respect to the body part 110. As one example, the first direction may be a horizontal direction of the body part 110. FIG. 5 is an enlarged perspective view of a portion C of FIG. 1. Referring to FIGS. 1 to 3 and 5, the first tube driver 150 includes a support plate 151 provided at the front side of the body part 110; a drive housing 152 fixed to the support plate 151; a drive motor 153 installed at the drive housing 152; a drive pulley 154 coupled

to a drive shaft of the drive motor 153; a driven pulley 156 coupled to the drive pulley 154 through a belt 155; a rotating arm 157 configured to be rotated by being coupled to the driven pulley 156, and coupled to one side of the guide tube 140; a connection member 158 configured to connect the rotating arm 157 to the tube 140; and a fixing member 159
5 configured to fix the connection member 158 to the guide tube 140.

[0062] Referring back to FIGS. 1 to 3, the inspection controller (not shown) calculates a pivot angle of the guide tube 140, which allows the radiation source S exposed at the distal end side of the guide tube 140 to be located on the central axis of the pipe 10, and controls the first tube driver 150 according to the calculated pivot angle. Accordingly,
10 the drive motor 153 is driven, the driven pulley 156 is rotated by the drive pulley 154, and the rotating arm 157 is rotated such that the guide tube 140 is moved in a left-right direction around a central axis of the driven pulley 156.

[0063] The inspection controller may calculate the pivot angle of the guide tube 140 on the basis of a position of the body part 110 and design information of the pipe 10. FIG.
15 6 is a diagram for describing the operation and an effect of the non-destructive pipe inspection apparatus according to one embodiment of the present disclosure. Referring to FIG. 6, the body part 110 moves along the central axis of the pipe 10, but since the radiation source S cannot be located at the center of gravity of the body part 110 due to the nature of the non-destructive inspection, and should be exposed to the outside from
20 the body part 110, when at least a portion of the non-destructive pipe inspection apparatus 100 is located in a bent pipe, as indicated by a dotted line in FIG. 6, the radiation source S deviates from the central axis of the pipe 10 in a state in which the guide tube 140 is not pivoted by the first tube driver 150. In this case, since detected radiation amount is

reduced inversely proportional to a squared distance from the radiation source S, strong radiation is detected by a radiation film close to the radiation source S, and weak radiation is detected by a radiation film more distant from the radiation source S such that a defective weld may not be accurately measured.

5 **[0064]** According to the present embodiment, the first tube driver 150 is driven according to the position of the body part 110 and the design information of the pipe 10 (e.g., the inner diameter of the pipe, a curvature of a bent pipe, and the like), so that the guide tube 140 is pivoted as indicated by the dotted line and an arrow in FIG. 6 and thus the radiation source S is located on the central axis of the pipe 10 (i.e., a central portion
10 of the radiation film) such that the measurement accuracy of the non-destructive inspection can be improved. The feeding tube T may be made of a flexible material to allow the feeding tube T to be bent like the guide tube 140.

[0065] In the illustrated example, the first tube driver 150 is configured to pivot the guide tube 140, but the first tube driver 150 may also be provided as a mechanical device which
15 linearly moves the guide tube 140 in the first direction (i.e., the horizontal direction of the body part), and any device capable of moving the guide tube 140 to allow the radiation source S to be located on the central axis of the pipe 10 may be employed as the first tube driver 150 without limitation.

[0066] FIG. 7 is a diagram for describing a non-destructive pipe inspection apparatus
20 according to another embodiment of the present disclosure, and is a perspective view illustrating a portion corresponding to the portion C of FIG. 1. In describing an example of FIG. 7, overlapping descriptions for the same or corresponding elements as those of the above-described embodiment will be omitted. The non-destructive pipe inspection

apparatus 100 may further include a roll angle measuring unit (not shown) and a second tube driver 180.

[0067] The roll angle measuring unit is installed at the body part 110 to measure a roll angle thereof. The roll angle may be an angle at which the body part 110 is rotated
5 around the central axis of the pipe 10. As one example, the roll angle measuring unit may be provided as a means such as an angular velocity sensor, a geomagnetic sensor, or an inertial measuring unit (IMU).

[0068] The second tube driver 180 may pivot the guide tube 140 in a second direction (i.e., a longitudinal direction of the body part) perpendicular to the first direction (i.e., the
10 horizontal direction of the body part) with respect to the body part 110. As one example, the second tube driver 180 may be provided as a drive motor which is installed at the support plate 151 to pivot the drive housing 152 in the longitudinal direction of the body part 110, and a mechanical structure of the second tube driver 180 is not particularly limited as long as the mechanical structure is able to move the guide tube 140 in the
15 longitudinal direction of the body part 110. The guide tube 140 is pivoted in the longitudinal direction of the body part by driving of the second tube driver 180.

[0069] The inspection controller may calculate a first pivot angle in the first direction of the guide tube 140 and a second pivot angle in the second direction thereof, which allow the radiation source S to be located on the central axis of the pipe 10, on the basis of the
20 position of the body part 110, the roll angle thereof, and the design information thereof. The inspection controller may control the first tube driver 150 according to the first pivot angle and the second tube driver 180 according to the second pivot angle.

[0070] FIGS. 8 and 9 are plan views for describing the operation and an effect of the non-destructive pipe inspection apparatus according to another embodiment of FIG. 7, and FIG. 10 is a cross-sectional view taken along lines D-D' and E-E' of FIG. 9. Referring first to FIG. 8, the body part 110 is traveling inside the pipe 10 in a state in which the body part 110 is tilted by 90° when compared to the case shown in FIG. 2. In the embodiment of FIG. 8, the inspection controller drives the second tube driver 180 instead of the first tube driver 150 to pivot the guide tube 140 in the longitudinal direction of the body part 110, and accordingly, the radiation source S is located at a central portion of a radiation film 30, thus improving the measurement accuracy of the non-destructive inspection.

[0071] Referring to FIGS. 9 and 10, the body part 110 is traveling inside the pipe 10 in a state in which the body part 110 is tilted at an angle that is less than 90° when compared to the case shown in FIG. 2. In FIG. 10, a reference numeral 10a denotes a cross-section of the pipe taken along a line D-D' of FIG. 9, and a reference numeral 10b denotes a cross-section of the pipe taken along a line E-E' of FIG. 9. In a state in which the guide tube 140 is not pivoted, the center of the body part 110 is located at a central point C1 of the pipe 10 whereas the radiation source S is spaced apart from a central point C2 of a radiation film 40 by a distance L.

[0072] In order to allow the radiation source S to be located at the central point C2 of the radiation film 40, the inspection controller drives the first tube driver 150 to pivot the guide tube 140 in the first direction by the first pivot angle and move the radiation source S in the horizontal direction of the body part 110 by a distance L1, and the inspection controller drives the second tube driver 180 in the second direction to pivot the guide tube

140 by the second pivot angle and move the radiation source S in the longitudinal direction of the body part 110 by a distance L2. Consequently, since the radiation source S is located at the central portion of the radiation film 40, the measurement accuracy of the non-destructive inspection is improved.

5 [0073] In the illustrated example, the second tube driver 180 is configured to pivot the guide tube 140, but the second tube driver 180 may also be provided as a mechanical device which linearly moves the guide tube 140 in the second direction (i.e., the longitudinal direction of the body part), and any device capable of moving the guide tube 140 to allow the radiation source S to be located on the central axis of the pipe 10 may be
10 employed as the second tube driver 180 without limitation.

[0074] When the body part 110 can travel inside the pipe 10 without being tilted, the second tube driver 180 may be omitted. For example, when an omnidirectional wheel (e.g., an omni-wheel or a Mecanum wheel) is provided as the wheel of the body part 110 and thus the roll angle of the body part 110 can be adjusted, a horizontal state of the body
15 part 110 may be controlled and, in this case, the radiation source S exposed at the distal end side of the guide tube 140 may be located on the central axis of the pipe 10 by only the first tube driver 150.

[0075] Hereinafter, a non-destructive pipe inspection apparatus equipped with an omnidirectional wheel, specifically, a Mecanum wheel will be described in detail.

20 [0076] FIG. 11 is a perspective view of a non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure, FIG. 12 is a left side view of the non-destructive pipe inspection apparatus according to still another embodiment of

the present disclosure, and FIG. 13 is a right side view of the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure.

[0077] Referring to FIGS. 11 to 13, a non-destructive pipe inspection apparatus 101 is configured to include a body part 111, traveling units 310, 320, 330, and 340, width
5 adjusting units 210 and 220, monitoring units 410, 420, and 430, position displacement sensors 510 and 520, and a traveling control apparatus 600.

[0078] Although not shown in the drawings, the non-destructive pipe inspection apparatus 101 may include the guide tube 140, the first tube driver 150, the position recognizing unit 160, the feeding device 170, the second tube driver 180, and the
10 inspection controller which are described above. That is, the non-destructive pipe inspection apparatus 101 may determine whether a welded portion 120 formed in the pipe 10 is defective using a radiation source. Further, the non-destructive pipe inspection apparatus 101 may be provided with the above-described roll angle measuring unit to measure a roll angle of the body part 111. Meanwhile, since the guide tube 140, the first
15 tube driver 150, the position recognizing unit 160, the feeding device 170, the inspection controller, and the roll angle measuring unit have been described above, detailed descriptions thereof will be omitted.

[0079] The body part 111 serves to support the traveling units 310, 320, 330, and 340, the width adjusting units 210 and 220, and the monitoring units 410, 420, and 430. The
20 body part 111 may be configured such that one or more frames are connected to one another.

[0080] The traveling units 310, 320, 330, and 340 are deployed at the outside of the body part 111, and serve to bring wheels provided at the deployed ends into close contact with an inner wall of the pipe 10 to generate a driving force.

[0081] The non-destructive pipe inspection apparatus 101 according to the embodiment of the present disclosure is an apparatus which travels inside the pipe 10. Therefore, in order to allow the non-destructive pipe inspection apparatus 101 to maintain a posture thereof inside the pipe 10, the traveling units 310, 320, 330, and 340 are preferably provided at both opposite sides of the body part 111. The traveling units 310, 320, 330, and 340 may be deployed at both sides of the body part 111, and the wheel provided at a distal end of each of the traveling units 310, 320, 330, and 340 may be brought into close contact with the inner wall of the pipe 10.

[0082] Further, two or more traveling units 310, 320, 330, and 340 in parallel with a traveling direction, that is, a major axis of the pipe 10 may be provided at one side of the body part 111 having the traveling units 310, 320, 330, and 340.

[0083] FIGS. 12 and 13 illustrate that two of the traveling units 310, 320, 330, and 340 are provided at upper and lower sides of the body part 111, respectively. Hereinafter, both sides of the body part 111 refer to the upper side and the lower side of the body part 111. Further, a left side of FIG. 12 and a right side of FIG. 13 denote a front surface of the body part 111, and a right side of FIG. 12 and a left side of FIG. 13 denote a rear surface of the body part 111.

[0084] As the four wheels provided at the distal ends of the four traveling units 310, 320, 330, and 340 are in close contact with the inner wall of the pipe 10, the non-destructive pipe inspection apparatus 101 may maintain the posture thereof inside the pipe 10.

[0085] The plurality of traveling units 310, 320, 330, and 340 may include width adjusting gears 311, 321, 331, and 341, first legs 313, 323, 333, and 343, second legs 312, 322, 332, and 342, wheels 314, 324, 334, and 344, and drivers 315, 325, 335, and 345, respectively.

5 [0086] The width adjusting gears 311, 321, 331, and 341 may be coupled to the body part 111 and may be rotated around the coupled portions, respectively. The second legs 312, 322, 332, and 342 may be connected to the width adjusting gears 311, 321, 331, and 341, respectively. Further, the width adjusting gears 311, 321, 331, and 341 are each gear-engaged with horizontal gears provided at the width adjusting units 210 and 220 to
10 play a role in rotating the second legs 312, 322, 332, and 342.

[0087] As the second legs 312, 322, 332, and 342 of the traveling units 310, 320, 330, and 340 provided at both sides of the body part 111 are rotated, a width between the wheels 314, 324, 334, and 344 may be adjusted. A detailed description of a width adjustment between the wheels 314, 324, 334, and 344 will be described below with
15 reference to FIG. 14.

[0088] The first legs 313, 323, 333, and 343 serve to support the wheels 314, 324, 334, and 344. The first legs 313, 323, 333, and 343 and the second legs 312, 322, 332, and 342 may partially overlap with each other, and overlapping distances between the first legs 313, 323, 333, and 343 and the second legs 312, 322, 332, and 342 may be adjusted
20 such that a distance of each of the wheels 314, 324, 334, and 344 relative to the body part 111 may be adjusted. A detailed description of a distance adjustment of each of the wheels 314, 324, 334, and 344 relative to the body part 111 will be described below with reference to FIG. 15.

[0089] The wheels 314, 324, 334, and 344 are in close contact with the inner wall of the pipe 10 to play a role in generating a driving force. The non-destructive pipe inspection apparatus 101 moves due to friction between the wheels 314, 324, 334, and 344 and the inner wall of the pipe 10.

5 **[0090]** The wheels 314, 324, 334, and 344 according to the embodiment of the present disclosure include a Mecanum wheel. Accordingly, rotational directions of the wheels 314, 324, 334, and 344 provided in the traveling units 310, 320, 330, and 340, respectively, are controlled so that the non-destructive pipe inspection apparatus 101 may move forward or backward, and may rotate along the circumference of the pipe 10.

10 **[0091]** The drivers 315, 325, 335, and 345 serve to generate a driving force to rotate the wheels 314, 324, 334, and 344, respectively. The drivers 315, 325, 335, and 345 may adjust the rotational directions and rotational speeds of the wheels 314, 324, 334, and 344, respectively, according to a control signal of the traveling control apparatus 600.

[0092] The width adjusting units 210 and 220 serve to adjust widths between the wheels
15 314, 324, 334, and 344 of the traveling units 310, 320, 330, and 340 provided at both opposite sides of the body part 111, respectively. As shown in FIGS. 12 and 13, two of the traveling units 310, 320, 330, and 340 may be provided at the upper and lower sides of the body part 111, respectively, and the width adjusting units 210 and 220 may adjust widths between the wheels 314, 324, 334, and 344 provided at both sides of each of the
20 front and rear surfaces of the body part 111.

[0093] The width adjusting units 210 and 220 may be provided at the left and right sides of the body part 111, respectively. As shown in FIG. 12, the width adjusting unit 210 provided at the left side of the body part 111 may adjust the width between the wheels

314, 324, 334, and 344 provided at both sides of the rear surface of the body part 111. Similarly, as shown in FIG. 13, the width adjusting unit 220 provided at the right side of the body part 111 may adjust the width between the wheels 314, 324, 334, and 344 provided at both sides of the front surface of the body part 111.

5 [0094] The width adjusting units 210 and 220 are configured to include cylinders 211 and 221, pistons 212 and 222, and gears 213 and 223, respectively. The cylinders 211 and 221 may generate a pressure thereinside to push or pull the pistons 212 and 222, respectively. As the cylinders 211 and 221 generate a pushing force, lengths of the pistons 212 and 222 externally exposed may become longer, and as the cylinders 211 and
10 221 generate a pulling force, the lengths of the pistons 212 and 222 externally exposed may become shorter.

[0095] The gears 213 and 223 are connected to ends of the pistons 212 and 222, respectively. The gears 213 and 223 may be horizontally moved in a direction connecting the front surface to the rear surface of the body part 111 according to the
15 movement of the pistons 212 and 222. A horizontal gear is provided at upper and lower sides of each of the gears 213 and 223. The horizontal gear may be gear-engaged with each of the width adjusting gears 311, 321, 331, and 341 of the traveling units 310, 320, 330, and 340. As the horizontal gear is horizontally moved, the width adjusting gears 311, 321, 331, and 341 are rotated around the body part 111. As the width adjusting
20 gears 311, 321, 331, and 341 are rotated, the second legs 312, 322, 332, and 342 connected to the width adjusting gears 311, 321, 331, and 341 are also rotated around the body part 111 such that distances between the wheels 314, 324, 334, and 344 are adjusted on the basis of the body part 111.

[0096] The monitoring units 410, 420, and 430 serve to monitor an interior of the pipe 10. Specifically, the monitoring units may monitor front and rear sides of the traveling direction. To this end, the monitoring units 410 and 420 configured to monitor the front and rear sides, respectively, may be provided at the body part 111.

5 [0097] Further, the monitoring unit 430 configured to monitor a side surface of the front side may be provided for detailed monitoring of an obstacle present at the front side, a recessed portion in the inner wall of the pipe, or a point of interest.

[0098] An image capturing device such as a camera may serve as the monitoring units 410, 420, and 430. Further, a light source configured to emit light for securing forward
10 visibility may also be included in the monitoring units 410, 420, and 430.

[0099] The position displacement sensors 510 and 520 serve to sense a position of the non-destructive pipe inspection apparatus 101 inside the pipe. For example, the position displacement sensors 510 and 520 may sense a position of the body part 111 inside the pipe.

15 [0100] The center of the non-destructive pipe inspection apparatus 101 according to the embodiment of the present disclosure preferably travels along the central axis of the pipe 10. When the center of the non-destructive pipe inspection apparatus 101 deviates from the central axis of the pipe 10, a load may be unnecessarily applied to the traveling units 310, 320, 330, and 340 or the width adjusting units 210 and 220.

20 [0101] Meanwhile, due to gravity or various other factors, the center of the non-destructive pipe inspection apparatus 101 may deviate from the central axis of the pipe 10.

[0102] The position displacement sensors 510 and 520 may determine a distance to the inner wall of the pipe. For example, the position displacement sensors 510 and 520 may emit a laser to the inner wall of the pipe and then determine a distance to the inner wall of the pipe using the reflected laser. The two position displacement sensors 510 and 520
5 may emit the laser in opposite directions, and may determine whether the center of the non-destructive pipe inspection apparatus 101 coincides with the center axis of the pipe 10 by referring to the distances sensed by the respective position displacement sensors 510 and 520.

[0103] The traveling control apparatus 600 may perform to determine whether the center
10 of the non-destructive pipe inspection apparatus 101 and the central axis of the pipe 10 coincide with each other using the sensed distances.

[0104] Further, the traveling control apparatus 600 serves to control the traveling units 310, 320, 330, and 340 so that the body part 111 is rotated along the circumference of the pipe 10 according to the monitoring results of the monitoring units 410, 420, and 430.

15 As described above, the wheels 314, 324, 334, and 344 of the present disclosure may be Mecanum wheels, and the body part 111 may be moved forward and backward and may be rotated according to rotational directions of the wheels 314, 324, 334, and 344. The traveling control apparatus 600 may control the traveling units 310, 320, 330, and 340 to determine the rotational directions of the wheels 314, 324, 334, and 344, respectively, so
20 that the body part 111 is rotated along the circumference of the pipe 10.

[0105] Further, the traveling control apparatus 600 may perform overall control over the traveling units 310, 320, 330, and 340, the width adjusting units 210 and 220, and the monitoring units 410, 420, and 430.

[0106] FIG. 14 is a diagram illustrating a width adjustment between wheels according to an embodiment of the present disclosure.

[0107] Referring to FIG. 14, the gear 213 may be horizontally moved such that a width between the wheels 314 and 324 provided at both sides of the body part 111 may be adjusted.

[0108] The piston 212 and the gear 213 connected thereto are horizontally moved due to a pressure by the cylinder 211. The horizontal gears are provided at the upper and lower sides of the gear 213 and are gear-engaged with the width adjusting gears 311 and 321 of the traveling units 310 and 320, respectively. Thus, as the horizontal gears are horizontally moved, the width adjusting gears 311 and 321 are rotated around the connection portions with the body part 111.

[0109] Further, the width adjusting gears 311 and 321 are connected to the second legs 312 and 322 of the traveling units 310 and 320, respectively, and, as the width adjusting gears 311 and 321 are rotated, the second legs 312 and 322 are also rotated around the body part 111. The second legs 312 and 322 are connected to first legs 313 and 323, respectively, and the wheels 314 and 324 are provided at distal ends of the first legs 313 and 323, respectively. Consequently, due to the rotation of the width adjusting gears 311 and 321, both traveling units 310 and 320 are rotated around the connection portions with the body part 111.

[0110] As shown in the drawings, the traveling units 310 and 320 provided at the upper and lower sides are diagonally deployed from the connection portions with the body part 111 and are symmetrically disposed around the body part 111.

[0111] Accordingly, a distance between the body part 111 and the wheels 314 and 324 is varied by the rotation of the traveling units 310 and 320 such that the width between the wheels 314 and 324 is adjusted.

[0112] The width adjusting units 210 and 220 may adjust the width between the wheels 314 and 324 of the traveling units 310 and 320, which are provided at both opposite sides of the body part 111, to constantly maintain forces of the wheels 314 and 324 of the traveling units 310 and 320, which push the inner wall of the pipe 10. In other words, the width adjusting units 210 and 220 may adjust the width between the wheels 314 and 324 of the traveling units 310 and 320, which are provided at both of the opposite sides of the body part 111, to correspond to the inner diameter of the pipe 10.

[0113] When the forces of the wheels 314 and 324 pushing against the inner wall of pipe 10 are strong, the width adjusting units 210 and 220 may decrease the width between the wheels 314 and 324, and, when the forces of the wheels 314 and 324 pushing against the inner wall of pipe 10 are weak, the width adjusting units 210 and 220 may increase the width between the wheels 314 and 324.

[0114] Alternatively, the width adjusting units 210 and 220 may adjust the width between the wheels 314 and 324 by referring to the monitoring results of the monitoring units 410, 420, and 430. That is, an inner diameter of the pipe 10 is determined according to the monitoring results of the monitoring units 410, 420, and 430, and the width adjusting units 210 and 220 adjust the width between the two wheels 314 and 324 in advance to correspond to the determined inner diameter of the pipe 10. The traveling control apparatus 600 may perform the determination of the inner diameter of the pipe 10 by referring to the monitoring results of the monitoring units 410, 420, and 430.

[0115] As the width between the wheels 314 and 324 is adjusted by the width adjusting units 210 and 220, the forces of the wheels 314 and 324 pushing against the inner wall of the pipe 10 may be uniformly maintained.

[0116] Although FIG. 14 illustrates that the width between the wheels 314 and 324 provided at both sides of the rear surface is adjusted by the width adjusting unit 210 provided at the left side of the body part 111, like the width between the wheels 314 and 324, a width between the wheels 334 and 344 provided at both sides of the front surface may be adjusted by the width adjusting unit 220 provided at the right side of the body part 111.

[0117] FIG. 15 is a diagram illustrating a length adjustment of a wheel according to an embodiment of the present disclosure.

[0118] Referring to FIG. 15, a distance between the body part 111 and the wheel 314 may be varied according to a degree of overlap between the first leg 313 and the second leg 312.

[0119] The wheel 314 is provided at the distal end of the first leg 313, and the second leg 312 is rotatably connected to the body part 111. Further, the first leg 313 and the second leg 312 partially overlap, and the distance between the body part 111 and the wheel 314 is varied according to the degree of overlap between the first leg 313 and the second leg 312. That is, when an overlapping distance between the first leg 313 and the second leg 312 becomes longer, the distance between the body part 111 and the wheel 314 becomes shorter, and, when the overlapping distance between the first leg 313 and the second leg 312 becomes shorter, the distance between the body part 111 and the wheel 314 becomes longer.

[0120] The degrees of overlap between the first legs 313, 323, 333, and 343 and the second legs 312, 322, 332, and 342 may be actively or passively performed.

[0121] For example, a user may directly adjust lengths of the first legs 313, 323, 333, and 343 with respect to the second legs 312, 322, 332, and 342, respectively. To
5 minutely adjust a posture of the non-destructive pipe inspection apparatus 101 disposed inside the pipe 10, the user may adjust the lengths of the first legs 313, 323, 333, and 343 with respect to the second legs 312, 322, 332, and 342, respectively.

[0122] A separate driver (not shown) configured to minutely adjust the posture of the non-destructive pipe inspection apparatus 101 may be provided to adjust the lengths of
10 the first legs 313, 323, 333, and 343 with respect to the second legs 312, 322, 332, and 342, respectively.

[0123] On the other hand, the lengths of the first legs 313, 323, 333, and 343 with respect to the second legs 312, 322, 332, and 342 may be adjusted according to pressures applied to the wheels 314, 324, 334, and 344 in the traveling units 310, 320, 330, and 340,
15 respectively. For example, when an obstacle present on the inner wall of the pipe 10 applies a pressure to a specific wheel, the overlapping lengths between the first legs 313, 323, 333, and 343 and the second legs 312, 322, 332, and 342 become longer due to the applied pressure.

[0124] At this point, when the applied pressure due to the obstacle is removed, the
20 overlapping lengths between the first legs 313, 323, 333, and 343 and the second legs 312, 322, 332, and 342 may be returned to their original states. To this end, an elastic means (not shown) may be provided to maintain the overlapping lengths between the first legs 313, 323, 333, and 343 and the second legs 312, 322, 332, and 342. The elastic means

may be understood as serving to relieve an impact or pressure applied by the obstacle and transmit the impact or pressure to the body part 111.

[0125] Although FIG. 15 illustrates the length adjustment of the traveling unit 310 provided at the upper side of the rear surface of the body part 111, like the traveling unit 310, the remaining traveling units 320, 330, and 340 may each perform a length adjustment operation. At this point, the distances between the body part 111 and the wheels 314, 324, 334, and 344 provided at the plurality of traveling units 310, 320, 330, and 340 may be independently adjusted. Consequently, impacts generated at the wheels 314, 324, 334, and 344 may be alleviated by the first legs 313, 323, 333, and 343 and the second legs 312, 322, 332, and 342.

[0126] FIG. 16 is a block diagram illustrating a traveling control apparatus according to still another embodiment of the present disclosure.

[0127] Referring to FIG. 16, the traveling control apparatus 600 is configured to include an input unit 610, a storage unit 620, a controller 630, and an output unit 640.

[0128] The input unit 610 serves to receive the monitoring results of the monitoring units 410, 420, and 430. Further, various sensors configured to sense the direction of gravity or the forces of the 314, 324, 334, and 344 pushing against the inner wall of the pipe may be provided in the non-destructive pipe inspection apparatus 101 according to the embodiment of the present disclosure in addition to the monitoring units 410, 420, and 430. Accordingly, the input unit 610 may serve to receive the sensed results of the various sensors provided in the non-destructive pipe inspection apparatus 101.

[0129] Further, the non-destructive pipe inspection apparatus 101 according to the embodiment of the present disclosure may be manually operated by the user. Thus, the input unit 610 may receive a user command.

[0130] The input unit 610 may receive input information such as sensed information or commands from the monitoring units 410, 420, and 430, the various sensors, or the user in a wired or wireless communication manner.

[0131] The controller 630 performs overall control of the non-destructive pipe inspection apparatus 101 by referring to the input information transmitted from the input unit 610.

[0132] For example, the controller 630 may control the traveling units 310, 320, 330, and 340 so that the center of the body part 111 coincides with the central axis of the pipe 10 using distance information transmitted from the position displacement sensors 510 and 520. Since the wheels 314, 324, 334, and 344 provided in the traveling units 310, 320, 330, and 340 are Mecanum wheels, the non-destructive pipe inspection apparatus 101 moves in a direction perpendicular to the central axis of the pipe 10 to align the center of the non-destructive pipe inspection apparatus 101 with the central axis of the pipe 10.

[0133] Further, the controller 630 may control the traveling units 310, 320, 330, and 340 to rotate the body part 111 along the circumference of the pipe 10 by referring to the monitoring results of the monitoring units 410, 420, and 430. When an obstacle is present in front in a movement direction according to the monitoring results of the monitoring units 410, 420, and 430, or a recessed portion of the inner wall of the pipe is present, the controller 630 controls the traveling units 310, 320, 330, and 340 to rotate the body part 111 along the circumference of the pipe 10.

[0134] The controller 630 may determine a rotational angle of the body part 111 to be rotated along the circumference of the pipe 10 in consideration of a size and a position of the obstacle or the recessed portion. The controller 630 may rotate the body part 111 so that the non-destructive pipe inspection apparatus 101 can travel by avoiding the obstacle
5 or the recessed portion. However, when the size of the obstacle or the recessed portion is sufficiently small, the controller 630 may allow the body part 111 to travel without rotating.

[0135] Further, the controller 630 may control the width adjusting units 210 and 220 to vary the widths between the wheels 314, 324, 334, and 344 by referring to the forces of
10 the wheels 314, 324, 334, and 344 pushing against the inner wall of the pipe 10. When the forces of the wheels 314, 324, 334, and 344 pushing against the inner wall of the pipe 10 are strong, the controller 630 may control the width adjusting units 210 and 220 to reduce the widths between the wheels 314, 324, 334, and 344. Similarly, when the
15 forces of the wheels 314, 324, 334, and 344 pushing against the inner wall of the pipe 10 are weak, the controller 630 may control the width adjusting units 210 and 220 to increase the widths between the wheels 314, 324, 334, and 344.

[0136] The controller 630 may control rotational speeds of the wheels 314, 324, 334, and 344 provided in the plurality of traveling units 310, 320, 330, and 340 to correspond to a shape of the pipe 10. When the rotational speeds of the wheels 314, 324, 334, and
20 344 are the same in a state in which there is curvature in the pipe 10 in front in the traveling direction, some of the wheels 314, 324, 334, and 344 may slip. Thus, the controller 630 may control the rotational speeds of the wheels 314, 324, 334, and 344 to

correspond to the shape of the pipe 10 by referring to input information which is input from the monitoring units 410, 420, and 430 or other sensors.

[0137] Further, the controller 630 may control the monitoring units 410, 420, and 430 and other sensors (not shown). For example, the controller 630 may control whether to
5 operate the monitoring units 410, 420, and 430 and the other sensors.

[0138] The controller 630 may generate a control command for controlling the traveling units 310, 320, 330, and 340, the width adjusting units 210 and 220, the monitoring units 410, 420, and 430, and the other sensors (not shown), and the generated control command may be output by the output unit 640. As the control command output by the output unit
10 640 is transmitted to each module, the corresponding module performs a corresponding operation.

[0139] The storage unit 620 serves to temporarily or permanently store the input information which is input through the input unit 610 and the control command which is output through the output unit 640. The input information which is input through the
15 input unit 610 may be used for control performed by the controller 630 and also used for observation purposes. For example, information sensed while traveling in the pipe 10 is transmitted to the user at a later time, and the user may determine an inner state of the pipe 10 through the sensed information. Alternatively, the information sensed while traveling in the pipe 10 may be transmitted to the user in real time through the output unit
20 640.

[0140] Further, the storage unit 620 may store a preset user command. The controller 630 may control each module to automatically perform a corresponding operation by referring to the user command stored in the storage unit 620.

[0141] Hereinafter, a traveling behavior of the non-destructive pipe inspection apparatus moving inside the pipe will be described with reference to FIGS. 17 to 26. For convenience of description, the reference numerals of the detailed components of the non-destructive pipe inspection apparatus will be omitted in FIGS. 17 to 26. Components
5 corresponding to the omitted reference numerals are the same as those shown in FIGS. 12, 13, and 16.

[0142] FIG. 17 is a diagram illustrating the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure traveling inside a pipe.

[0143] Referring to FIG. 17, the non-destructive pipe inspection apparatus 101 may
10 travel inside the pipe 10. While traveling inside the pipe 10, the non-destructive pipe inspection apparatus 101 may collect status information inside the pipe 10 using the monitoring units 410, 420, and 430 and sensors installed in the non-destructive pipe inspection apparatus 101. Further, the non-destructive pipe inspection apparatus 101 may determine whether the welded portion 120 formed in the pipe 10 is defective using
15 a radiation source.

[0144] FIG. 17 illustrates the pipe 10 having a constant diameter, and a force of each wheel pushing against the inner wall of the pipe 10 may be uniformly maintained. The width adjusting units 210 and 220 may adjust a width between wheels at both sides to allow each wheel to push against the inner wall of the pipe with a uniform force. As
20 each wheel travels while pushing against the inner wall of the pipe with a uniform force, the non-destructive pipe inspection apparatus 101 may travel in a more stable posture.

[0145] FIGS. 18 and 19 are diagrams illustrating the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure traveling inside a pipe of which a diameter varies.

[0146] Referring to FIG. 18, the non-destructive pipe inspection apparatus 101 may travel in the pipe 10 having a diameter that gradually increases. The non-destructive pipe inspection apparatus 101 according to the embodiment of the present disclosure includes two width adjusting units 210 and 220. One of the two width adjusting units 210 and 220 controls a width between two wheels provided at both sides of a front surface and the other controls a width between two wheels provided at both sides of a rear surface.

[0147] As the two width adjusting units 210 and 220 independently adjust the widths between the wheels at the front and rear surfaces, even when the non-destructive pipe inspection apparatus 101 travels inside the pipe 10 having the diameter that gradually changes, the force of each wheel pushing against the inner wall of the pipe may be uniformly formed.

[0148] Accordingly, even in an interior of the pipe 10 having the diameter that is gradually varied, the non-destructive pipe inspection apparatus 101 may travel in a stable posture.

[0149] Meanwhile, even when the width is adjusted by the width adjusting units 210 and 220, corresponding wheels may not be able to push against the inner wall of the pipe with a sufficient force since the diameter of the pipe 10 is excessively large. In this case, a length of the first leg with respect to the second leg of each of the corresponding wheels may be adjusted such that the force of each of the corresponding wheels pushing against the inner wall of the pipe may be supplemented.

[0150] Referring to FIG. 19, the non-destructive pipe inspection apparatus 101 may travel inside the pipe 10 including sections 10a, 10b, and 10c which have different diameters.

[0151] As described above, as the two width adjusting units 210 and 220 independently
5 adjust the widths between the wheels at the front and rear surfaces, even when the non-destructive pipe inspection apparatus 101 travels inside the pipe 10 including the sections 10a, 10b, and 10c which have different diameters, a force of each wheel pushing against the inner wall of the pipe may be uniformly formed.

[0152] Alternatively, according to another embodiment of the present disclosure, the
10 controller 630 may control the width adjusting units 210 and 220 by referring to a state of the front in a traveling path.

[0153] The controller 630 of the non-destructive pipe inspection apparatus 101 traveling in the section 10a may recognize that a diameter of the section 10b in front of the non-destructive pipe inspection apparatus 101 is varied by referring to the monitoring results
15 of the monitoring units 410 and 430. Thus, as soon as the non-destructive pipe inspection apparatus 101 enters the section 10b, the controller 630 may control the width adjusting units 210 and 220 to adjust the width to increase between the two wheels provided at both sides of the front surface. At this point, after the width between the two wheels provided at both sides of the front surface increases, the controller 630 may
20 control the width adjusting units 210 and 220 to adjust a width to increase between two wheels provided at both sides of the rear surface.

[0154] Similarly, the controller 630 of the non-destructive pipe inspection apparatus 101 traveling in the section 10b may recognize that a diameter of the section 10c in front of

the non-destructive pipe inspection apparatus 101 is varied by referring to the monitoring results of the monitoring units 410 and 430. Thus, as soon as the non-destructive pipe inspection apparatus 101 enters the section 10c, the controller 630 may control the width adjusting units 210 and 220 to adjust the width to decrease between the two wheels. At this point, after the width between the two wheels provided at both sides of the front surface decreases, the controller 630 may control the width adjusting units 210 and 220 to adjust a width to decrease between two wheels provided at both sides of the rear surface.

[0155] FIG. 20 is a diagram illustrating the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure traveling inside a pipe which includes a bent section.

[0156] Referring to FIG. 20, the non-destructive pipe inspection apparatus 101 may travel in a bent section of the pipe 10. Meanwhile, as shown in the drawing, when the non-destructive pipe inspection apparatus 101 travels, the number of revolutions of wheels in contact with the inner wall of the pipe inside the bent section differs from that of the wheel in contact with the inner wall of the pipe outside the bent section.

[0157] Therefore, when rotational speeds of all the wheels are the same in the bent section, slipping may occur and thus the posture of the non-destructive pipe inspection apparatus 101 may become unstable.

[0158] Accordingly, even in the bent section, the controller 630 may control the rotation speed of each wheel to allow stable traveling. For example, the controller 630 may control the traveling units 310, 320, 330, and 340 to reduce the rotational speeds of the wheels in contact with the inner wall of the pipe inside the bent section, and to increase

the rotational speeds of the wheels in contact with the inner wall of the pipe outside the bent section.

[0159] The rotation speed of each wheel is adjusted to correspond to a movement distance such that the non-destructive pipe inspection apparatus 101 may travel in a more stable posture.

[0160] FIG. 21 is a diagram illustrating the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure rotating along a circumference of a pipe.

[0161] Referring to FIG. 21, the non-destructive pipe inspection apparatus 101 may rotate along an inner circumference inside the pipe 10. The wheels according to still another embodiment of the present disclosure may be Mecanum wheels, and the controller 630 may control rotational directions of the wheels provided in the traveling units 310, 320, 330, and 340, respectively, thereby allowing the non-destructive pipe inspection apparatus 101 to rotate along the inner circumference of the pipe 10.

[0162] The controller 630 may control a rotational direction, a rotational angle, and a rotational speed of the non-destructive pipe inspection apparatus 101.

[0163] FIGS. 22 to 24 are diagrams illustrating the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure which travels after rotating inside the pipe.

[0164] Referring to FIG. 22, the non-destructive pipe inspection apparatus 101 may travel in the bent section of the pipe 10. When the rotation speed of each wheel is controllable, traveling as shown in FIG. 20 may be possible. However, when traveling is performed as shown in FIG. 20 in a state in which the rotational speed of each wheel is

not controllable, the posture of the non-destructive pipe inspection apparatus 101 may become unstable.

[0165] Accordingly, the non-destructive pipe inspection apparatus 101 according to still another embodiment of the present disclosure may travel in the bent section after rotating
5 along a circumference of the inner wall of the pipe 10.

[0166] In the case that traveling is performed as shown in FIG. 22, distances that wheels provided at both sides should travel in the bent section are the same. Thus, even though the wheels rotate at the same rotational speed, stable traveling is possible without slipping.

[0167] Referring to FIG. 23, in the case that a recessed portion in the inner wall of the
10 pipe is present in front of the non-destructive pipe inspection apparatus 101, the non-destructive pipe inspection apparatus 101 may rotate along the circumference of the inner wall of the pipe and then continue to travel.

[0168] In FIG. 23, when traveling is performed while maintaining an initial posture, the wheels provided at one side may fall into the recessed portion. In order to prevent the
15 falling of the wheels, when the controller 630 determines that the recessed portion is present in front of the non-destructive pipe inspection apparatus 101 on the basis of the monitoring results of the monitoring units 410 and 430, the controller 630 may control the traveling units 310, 320, 330, and 340 to allow the non-destructive pipe inspection apparatus 101 to rotate along the circumference of the inner wall of the pipe.

[0169] Referring to FIG. 24, in the case that an obstacle OB is present in front of the
20 non-destructive pipe inspection apparatus 101, the non-destructive pipe inspection apparatus 101 may rotate along the circumference of the inner wall of the pipe and then continue to travel.

[0170] In FIG. 24, when traveling is performed while maintaining an initial posture, the wheels provided at one side may be caught on the obstacle OB. In order to prevent the catching of the wheels, when the controller 630 determines that the obstacle OB is present in front of the non-destructive pipe inspection apparatus 101 on the basis of the monitoring results of the monitoring units 410 and 430, the controller 630 may control the traveling units 310, 320, 330, and 340 to allow the non-destructive pipe inspection apparatus 101 to rotate along the circumference of the inner wall of the pipe.

[0171] FIG. 25 is a diagram illustrating the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure determining a central position inside the pipe, and FIG. 26 is a diagram illustrating the non-destructive pipe inspection apparatus according to still another embodiment of the present disclosure correcting a central position inside the pipe.

[0172] Referring to FIG. 25, the position displacement sensors 510 and 520 may determine a position of the non-destructive pipe inspection apparatus inside the pipe.

[0173] Two position displacement sensors 510 and 520 may be provided in the non-destructive pipe inspection apparatus 101, and each of the two position displacement sensors 510 and 520 may emit a laser to the inner wall of the pipe and determine a distance to the pipe using the reflected laser.

[0174] Distance information sensed by the position displacement sensors 510 and 520 may be transmitted to the traveling control apparatus, and the traveling control apparatus may determine the position of the non-destructive pipe inspection apparatus 101 relative to a central axis PC of the pipe by referring to the transmitted distance information.

[0175] Consequently, the traveling control apparatus may control the traveling units 310, 320, 330, and 340 to allow a center RC of the non-destructive pipe inspection apparatus 101 to coincide with the central axis PC of the pipe. Since the wheels of traveling units 310, 320, 330, and 340 are Mecanum wheels, the non-destructive pipe inspection apparatus may move in a direction perpendicular to the central axis PC of the pipe. Accordingly, the center RC of the non-destructive pipe inspection apparatus 101 and the central axis PC of the pipe may coincide with each other.

[0176] While the embodiments of the present disclosure have been described with reference to the accompanying drawings, those skilled in the art can understand that the present disclosure can be implemented in other specific forms without departing from the technical spirit or the necessary features of the present disclosure. Therefore, it should be understood that the above-described embodiments are not restrictive but illustrative in all aspects.

What is claimed is:

1. A non-destructive pipe inspection apparatus comprising:

a body part;

5 a traveling unit deployed to the outside of the body part, and configured to bring
a wheel provided at a deployed distal end into close contact with an inner wall of a pipe
to generate a driving force;

a monitoring unit configured to monitor an interior of the pipe;

a traveling control apparatus configured to control the traveling unit to rotate the
body part along a circumference of the pipe according to the monitoring result;

10 a guide tube formed to be elongated in one direction parallel to a traveling
direction of the body part, configured to have a first distal end side pivotally coupled to
the body part, and configured to guide a feeding tube which has a radiation source for a
non-destructive inspection of the pipe at a second distal end side; and

a first tube driver configured to rotate the guide tube in a first direction relative to
15 the body part in order to form a certain angle between long axis of the guide tube and the
traveling direction of the body part.

2. The apparatus of claim 1, wherein:

the traveling unit is provided at both opposite sides of the body part, and

20 two or more traveling units in parallel with a traveling direction are provided at
one side of the body part.

3. The apparatus of claim 2, wherein the traveling control apparatus
controls a rotational speed of a wheel provided in each of a plurality of traveling units to
correspond to a shape of the pipe.

4. The apparatus of claim 1, wherein each of a plurality of traveling units includes:

a first leg configured to support a wheel provided at the first leg; and

a second leg configured to partially overlap the first leg,

5 wherein, as an overlapping distance between the first leg and the second leg is adjusted, a distance of the wheel provided at the first leg with respect to the body part is adjusted.

5. The apparatus of claim 4, wherein distances between the body part and the wheel provided at each of the plurality of traveling units are independently adjusted.

10 6. The apparatus of claim 1, wherein, when an obstacle in front in a traveling direction or a recessed portion in the inner wall of the pipe is present according to the monitoring result, the traveling control apparatus controls the traveling unit to rotate the body part along a circumference of the pipe.

7. The apparatus of claim 1, wherein:

15 the traveling unit is provided at both opposite sides of the body part, and the non-destructive pipe inspection apparatus further includes a width adjusting unit configured to adjust a width between the wheels of the traveling unit provided at both of the opposite sides of the body part.

8. The apparatus of claim 7, wherein the width adjusting unit adjusts the
20 width between the wheels of the traveling unit provided at both of the opposite sides of the body part to allow forces of the wheels of the traveling unit pushing against the inner wall of the pipe to be maintained constant.

9. The apparatus of claim 1, further comprising a position displacement

sensor configured to determine a position of the non-destructive pipe inspection apparatus inside the pipe,

wherein the traveling control apparatus controls the traveling unit by referring to the determined position of the non-destructive pipe inspection apparatus inside the pipe
5 to allow a center of the body part to coincide with a central axis of the pipe.

10. The apparatus of claim 1, further comprising an inspection controller configured to calculate a pivot angle of the guide tube, which allows the radiation source exposed at the second distal end side of the guide tube to be located on a central axis of the pipe, and control the first tube driver according to the calculated pivot angle.

10 11. The apparatus of claim 10, further comprising a position recognizing unit configured to recognize a position of the body part inside the pipe,

wherein the inspection controller calculates the pivot angle of the guide tube on the basis of the position of the body part and design information of the pipe.

12. The apparatus of claim 10, wherein, when at least a portion of the non-
15 destructive pipe inspection apparatus is located within a bent section of the pipe, the inspection controller calculates the pivot angle of the guide tube on the basis of the position of the body part, an inner diameter of the pipe, a curvature of the bent section.

13. The apparatus of claim 10, further comprising a radiation film installed along an outer circumference of a welded portion side of the pipe,

20 wherein the inspection controller controls the first tube driver to locate the radiation source at a central portion of the radiation film.

14. The apparatus of claim 1, further comprising a feeding device configured to feed the radiation source of the feeding tube to the second distal end side of the guide

tube by insertion of the feeding tube into the guide tube.

15. The apparatus of claim 14, wherein the feeding device includes:

a feeding gear member engaged with a gear formed on an outer circumferential surface of the feeding tube; and

5 a drive member configured to drive the feeding gear member.

16. The apparatus of claim 1, further comprising a second tube driver configured to rotate the guide tube in a second direction perpendicular to the first direction relative to the body part in order to form a certain angle between the long axis of the guide tube and the traveling direction of the body part.

10 17. The apparatus of claim 16, further comprising:

a roll angle measuring unit configured to measure a roll angle of the body part; and

an inspection controller configured to calculate a first pivot angle of the guide tube in the first direction and a second pivot angle thereof in the second direction, which
15 allow the radiation source to be located on the central axis of the pipe, on the basis of the position of the body part, the roll angle of the body part, and design information of the pipe, control the first tube driver according to the first pivot angle, and control the second tube driver according to the second pivot angle.