DESCRIPTION

CLEARANCE MEASUREMENT METHOD, CLEARANCE MEASUREMENT DEVICE, THREADED JOINT MEASUREMENT METHOD, THREADED JOINT MEASUREMENT SYSTEM, MEASUREMENT TERMINAL, THREADED JOINT MANUFACTURING METHOD, AND THREADED JOINT QUALITY MANAGEMENT METHOD

Field

[0001] The present invention relates to a clearance measurement method, a clearance measurement device, a threaded joint measurement method, a threaded joint measurement system, a measurement terminal, a threaded joint manufacturing method, and a threaded joint quality management method in a pipe joint structure for joining pipes.

Background

[0002] In the related art, a pipe-based structural body used for foundations of buildings or for suppressing landslides may require may have a required length of several tens of meters depending on construction conditions. In particular, a steel pipe made of a steel material has a remarkable tendency. In a case of transporting the pipe-based structural body to a construction site, long structural body cannot be transported due to traffic restrictions. Therefore, the long structural body is divided into transportable lengths of a few meters to be joined during the construction process (including placement) at the construction site.

[0003] A threaded joint is used as a method of joining the pipe-based structural body at the construction site, and a threaded joint as disclosed in Patent Literature 1 is used as an example. The threaded joint is attached to each

end portion of a pipe to be joined, and is rotated to join the pipe at the construction site, thereby assembling the pipe-based structural body.

[0004] Generally, threaded joints are attached to the pipes at a factory such that a male joint is attached to one pipe and a female joint is attached to another separate pipe, and then shipped to the site. There are several methods as manufacturing procedures, but the male joint and the female joint are often manufactured as a set. After manufacture, the set of joints may be attached to the distal end of a long pipe.

Citation List

Patent Literature

[0005] Patent Literature 1: JP-H10-311028A

Summary

Technical Problem

[0006] Since the feasibility of the joining of the threaded joints is determined by the matching thread shapes of the male joint and the female joint to be a set with the male joint, a joining check is usually performed before use. However, under the conditions of the threaded joints, in particular, in a case where the threaded joint has a large diameter of 700 mm or more, the length of the pipe to which the threaded joint is connected is 5 m or more and is long, or the material of the threaded joint or the connected pipe is a heavy object made of a metal material such as steel, it is difficult to perform the joining check. In this case, there are problems such as considerable time and effort for the joining check, damage to the joint itself, and concerns regarding safety assurance.

[0007] In particular, in the case of the threaded joint, there may be a point where a clearance (also referred to as

play or gap) between the thread of the male joint and the thread of the female joint is insufficient in a range from a joining start position where the male joint and the female joint are disengaged (including a state immediately before the male joint is threaded into the female joint) to a joining completion position where the joining between the male joint and the female joint is completed. In a case where the clearance between the thread of the male joint and the thread of the female joint is insufficient, a connection step of the joint may be interrupted. Therefore, there has been a demand for a technique of easily determining whether the threaded joints have joinable thread shapes, prior to use on-site regardless of the condition of the threaded joint or the connected pipes.

[0008] The present invention has been made in view of the above, and an object thereof is to provide a clearance measurement method, a clearance measurement device, a threaded joint measurement method, a threaded joint measurement system, a measurement terminal, a threaded joint manufacturing method, and a threaded joint quality management method capable of more easily performing a joining check in a threaded joint regardless of a state of the threaded joint or a connected pipe.

Solution to Problem

[0009] (1) To solve the above-described problem and achieve the object, a clearance measurement method according to one aspect of the present invention measures, for a set of threaded joints including a male joint and a female joint corresponding to the male joint, a clearance between a thread of the male joint and a thread of the female joint, and includes: an initial state setting step of setting an initial state of the male joint and the female joint based on data on a thread shape of each of the

male joint and the female joint; a clearance measurement step of measuring the clearance between the thread of the male joint and the thread of the female joint corresponding to the thread of the male joint in the initial state; and a rotation state setting step of setting a state rotated by a predetermined angle in a direction in which joining is performed in a case where the joining between the male joint and the female joint is not completed after the clearance measurement step, wherein processing from the clearance measurement step to the rotation state setting step is repeatedly executed until the joining is completed.

[0010] (2) The clearance measurement method according to the invention (1) of one aspect of the present invention, further includes at least one of: a step of determining pass or fail regarding the set of the threaded joints based on the clearance measured in the clearance measurement step and a predetermined criterion; and an interference information assignment step of assigning information on an interference point to a point that is determined to be the interference point based on the clearance measured in the clearance measurement step and the predetermined criterion.

[0011] (3) A threaded joint measurement method according to one aspect of the present invention includes: a shape measurement step of measuring, for a set of threaded joints including a male joint and a female joint corresponding to the male joint, each of a thread shape of the male joint and a thread shape of the female joint; and a clearance measurement step of measuring a clearance for each set of the threaded joints using the clearance measurement method according to the invention (1) or (2) based on data on the thread shape measured in the shape measurement step.

[0012] (4) A threaded joint manufacturing method according to one aspect of the present invention

manufactures a set of threaded joints including a male joint and a female joint corresponding to the male joint, and includes: a joint manufacturing step of manufacturing the threaded joint; and a joint measurement step of executing the threaded joint measurement method according to the invention (3) on the set of the threaded joints including the male joint and the female joint manufactured by the joint manufacturing step.

[0013] (5) A threaded joint quality management method according to one aspect of the present invention manages a quality of a set of threaded joints including a male joint and a female joint corresponding to the male joint, and includes: a joint manufacturing step of manufacturing the threaded joint; a joint measurement step of measuring, for the set of the threaded joints manufactured by the joint manufacturing step, a thread shape of the threaded joint using the threaded joint measurement method according to the invention (3) or (4); and a quality management step of managing the quality of the manufactured threaded joint using a result obtained from the joint measurement step.

[0014] (6) A clearance measurement device according to one aspect of the present invention measures, for a set of threaded joints including a male joint and a female joint corresponding to the male joint, a clearance between a thread of the male joint and a thread of the female joint, and includes: a control unit configured to repeatedly execute processing until joining is completed, the processing including joining completion state setting processing of setting a joining completion state in which the joining between the male joint and the female joint is completed based on data on a thread shape of each of the male joint and the female joint, and rotation state setting processing of measuring the clearance between the thread of

the male joint and the thread of the female joint corresponding to the thread of the male joint in the joining completion state and then setting a state rotated by a predetermined angle in a direction in which the joining is performed in a case where the joining between the male joint and the female joint is not completed.

[0015] (7) In the clearance measurement device according to the invention (6) of one aspect of the present invention, the control unit is configured to execute clearance measurement step of measuring the clearance between the thread of the male joint and the thread of the female joint corresponding to the thread of the male joint in the initial state before the rotation state setting processing.

[0016] (8) The clearance measurement device according to the invention (6) or (7) of one aspect of the present invention, further includes: a communication unit, wherein the communication unit is configured to execute, by the control unit, at least one of acquisition processing of data on the thread shape of each of the male joint and the female joint and output processing of information regarding the clearance obtained by the clearance measurement step.

[0017] (9) A threaded joint measurement system according to one aspect of the present invention includes: a measurement unit configured to measure, for a set of threaded joints including a male joint and a female joint corresponding to the male joint, each of a thread shape of the male joint and a thread shape of the female joint; and the clearance measurement device according to any one of the inventions (6) to (8) configured to measure a clearance for each set of the threaded joints based on data on the thread shape measured by the measurement unit.

[0018] (10) A measurement terminal according to one

aspect of the present invention is configured to measure, for a set of threaded joints including a male joint and a female joint corresponding to the male joint, a clearance between a thread of the male joint and a thread of the female joint and controlled by a control unit, and includes: a measurement unit configured to measure each of a thread shape of the male joint and a thread shape of the female joint by control of the control unit; a communication unit configured to execute, by control of the control unit, at least one of output processing of outputting the measured thread shape as data to the clearance measurement device according to any one of the inventions (6) to (8) and acquisition processing of acquiring information regarding the clearance for each set of the threaded joints from the clearance measurement device; and an output unit configured to output the acquired information in a predetermined format by control of the control unit.

[0019] (11) In the measurement terminal according to the invention (10) of one aspect of the present invention, the control unit is configured to execute at least one of: processing of determining pass or fail regarding the set of the threaded joints based on the acquired information regarding the clearance and a predetermined criterion; and interference information assignment processing of assigning information on an interference point to a point that is determined to be the interference point based on the acquired information regarding the clearance and the predetermined criterion.

[0020] (12) A threaded joint measurement system according to one aspect of the present invention includes: the measurement terminal according to the invention (10) or (11); and the clearance measurement device according to any

one of the inventions (6) to (8) configured to measure a clearance for each set of the threaded joints based on data on a thread shape measured by the measurement terminal.

[0021] (13) A threaded joint quality management method according to one aspect of the present invention manages a quality of a threaded joint for a set of threaded joints including a male joint and a female joint corresponding to the male joint, and includes: managing the quality of the set of the threaded joints using information regarding a clearance obtained from the clearance measurement step executed by the control unit of the clearance measurement device according to any one of the inventions (6) to (8).

Advantageous Effects of Invention

[0022] With the clearance measurement method, the clearance measurement device, the threaded joint measurement method, the threaded joint measurement system, the measurement terminal, the threaded joint manufacturing method, and the threaded joint quality management method according to the present invention, it is possible to more easily perform a joining check in a threaded joint regardless of a state of the threaded joint or a connected pipe.

Brief Description of Drawings

[0023]

[FIG. 1] FIG. 1 is a diagram illustrating a joining start state of a threaded joint to be measured in a threaded joint measurement system according to an embodiment of the present invention.

[FIG. 2A] FIG. 2A is a diagram illustrating a joining completion state of a threaded joint to be measured in the threaded joint measurement system according to the embodiment of the present invention.

[FIG. 2B] FIG. 2B is a diagram illustrating an initial

state of a threaded joint to be measured in the threaded joint measurement system according to the embodiment of the present invention.

[FIG. 3] FIG. 3 is a block diagram illustrating a threaded joint measurement system according to a first example of the embodiment of the present invention.

[FIG. 4] FIG. 4 is a block diagram illustrating a threaded joint measurement system according to a second example of the embodiment of the present invention.

[FIG. 5] FIG. 5 is a flowchart for describing a threaded joint measurement method according to a first embodiment of the present invention.

[FIG. 6A] FIG. 6A is a flowchart for describing a clearance measurement step according to the first embodiment of the present invention.

[FIG. 6B] FIG. 6B is a flowchart for describing an initial state setting step of the clearance measurement step according to the first embodiment of the present invention.

[FIG. 7A] FIG. 7A is a diagram for describing coordinates of a threaded joint in a clearance measurement method according to the embodiment of the present invention.

[FIG. 7B] FIG. 7B is a diagram for describing coordinates of a threaded joint in a clearance measurement method according to the embodiment of the present invention.

[FIG. 7C] FIG. 7C is a diagram for describing coordinates of a threaded joint in a clearance measurement method according to the embodiment of the present invention.

[FIG. 8] FIG. 8 is an enlarged cross-sectional view illustrating a joint portion of the threaded joint according to the embodiment of the present invention.

[FIG. 9] FIG. 9 is an enlarged cross-sectional view illustrating an interference portion in the joint portion of the threaded joint according to the embodiment of the

present invention.

[FIG. 10] FIG. 10 is a flowchart for describing a first modification example of the clearance measurement step in the clearance measurement method according to the first embodiment of the present invention.

[FIG. 11] FIG. 11 is a flowchart for describing a second modification example of the clearance measurement step in the clearance measurement method according to the first embodiment of the present invention.

[FIG. 12] FIG. 12 is a flowchart for describing a threaded joint measurement method according to a second embodiment of the present invention.

[FIG. 13] FIG. 13 is a flowchart for describing a threaded joint measurement method according to a third embodiment of the present invention.

Description of Embodiments

[0024] Hereinafter, embodiments of the present invention will be described with reference to the drawings. Note that in all the drawings of the following embodiments, the same or corresponding portions are denoted by the same reference numerals. In addition, the present invention is not limited by the embodiments described below.

[0025] First, a threaded joint to be measured by a threaded joint measurement system according to an embodiment of the present invention will be described. Figs. 1, 2A, and 2B are diagrams respectively illustrating a joining start state of a threaded joint, a joining completion state, and a joining start state of a threaded joint to be measured (measurement target) in a clearance measurement system according to the present embodiment.

[0026] (Male Joint and Female Joint To Be Measured)

As illustrated in FIG. 1, a threaded joint 10 according to the present embodiment includes a male joint

11 serving as an inner joint and a female joint 12 serving as an outer joint. A male thread 13 is formed on a distal end side which is a side where the male joint 11 is inserted and fitted. A female thread 14 is formed on a distal end side which is a side where insertion and fitting are performed in the female joint 12. The female thread 14 formed in the female joint 12 is formed in a thread shape corresponding to the male thread 13 formed in the male joint 11. As a result, the male joint 11 and the female joint 12 are configured to correspond to each other, allowing the male joint 11 to be inserted into the female joint 12 by the thread. Note that a known shape or an unknown shape can be used as the thread shape. The thread shape may be a single-start thread or multiple-start thread, and in the present embodiment, for example, multiple-start thread is used. In addition, the thread shape can be a tapered thread or a parallel thread, and is, for example, a parallel thread in the present embodiment. In addition, the material is not particularly limited. Examples include steel, metallic materials other than steel, concrete, resin, or a combination of a plurality of materials. A material of the threaded joint is selected according to the purpose of use or the condition of a pipe or the like to be described later. The present invention is particularly effective in the case of a threaded joint in which the joining check before shipment from the factory is challenging due to a large diameter or a heavy object (long).

[0027] Each of pipes 15 and 16 constitutes a structural body. The pipe 15 constitutes an upper structural body. The pipe 16 constitutes a lower structural body. As the structural body, various structural bodies can be employed, such as a structural body having a predetermined function

in a state of being embedded in the ground or the like, a structural body used as a part of a structural body on the ground, a structural body that transports a gas or a liquid by utilizing an internal space of the pipes 15 and 16, and the like. Examples of the structural body having a predetermined function in a state of being embedded in the ground include a pile, a retaining pile, a landslide prevention pile, a pipe sheet pile, a sheet pile wall, and a tunnel. Examples of the structural body used as a part of a structural body on the ground include columns and beams. Examples of structural body that transports a gas or a liquid by using an internal space of the pipes 15 and 16 include an oil well pipe, a water pipe, a gas pipe, and the like. In addition, examples of the pipes 15 and 16 include a steel pipe, a concrete pipe, a resin pipe, and a pipe obtained by combining a plurality of materials. In the present invention, since the pipes 15 and 16 are large in diameter, long in length, or heavy objects, it is particularly effective in the case of a steel pipe with a threaded joint in which a joining check before shipment from the factory is challenging.

[0028] In the present embodiment, the male joint 11 having the male thread 13 is fixed to the upper pipe 15. The female joint 12 having the female thread 14 is fixed to the lower pipe 16. In addition, contrary to the above, the male joint 11 may be fixed to the lower pipe 16, and the female joint 12 may be fixed to the upper pipe 15. In addition, the male joint 11 and the female joint 12 may be used as measurement targets without connecting the pipes 15 and 16.

[0029] (First Example of Embodiment)

Next, a threaded joint measurement system according to a first example of the embodiment of the present invention

will be described. FIG. 3 is a block diagram illustrating the threaded joint measurement system according to the first embodiment.

[0030] As illustrated in FIG. 3, a threaded joint measurement system 1 includes a clearance measurement device 20 and a measurement unit 35. Furthermore, the clearance measurement device 20 is connected to a thread processing device 40. The threaded joint measurement system 1 may employ a configuration including the clearance measurement device 20, the measurement unit 35, and the thread processing device 40. In addition, in the threaded joint measurement system 1 according to the first embodiment, it is assumed that the clearance measurement device 20 is fixed and used, but the measurement unit 35 and the clearance measurement device 20 may be in a close state or a long distance.

[0031] (Clearance Measurement Device)

The clearance measurement device 20 includes a control unit 21, a storage unit 22, and an input/output unit 23. Note that the input/output unit 23 may not be provided. As the clearance measurement device 20, a known computer, a server, a laptop, a mobile terminal, a tablet, a smartphone, or a virtual device on a network, such as cloud can be used.

[0032] Specifically, a control unit 31 as control means includes a processor such as a central processing unit (CPU), a digital signal processor (DSP), or a field-programmable gate array (FPGA) having hardware, and a main storage unit such as a random access memory (RAM) or a read only memory (ROM) (none of which is illustrated).

[0033] The storage unit 22 physically includes a storage medium selected from a volatile memory such as a RAM, a non-volatile memory such as a ROM, an erasable programmable

ROM (EPROM), a hard disk drive (HDD), a solid state drive (SSD), a removable medium, and the like. Note that the removable medium is, for example, a universal serial bus (USB) memory, or a disk recording medium such as a compact disc (CD), a digital versatile disc (DVD), or a Blu-ray (registered trademark) disc (BD). In addition, the storage unit 22 may be configured using a computer-readable recording medium such as a memory card that can be attached from the outside. The storage unit 22 can store an operating system (OS), various programs, various tables, various databases, and the like for executing the operation of the clearance measurement device 20. The various programs include a learning model and a neural network. These various programs can also be recorded on a computer-readable recording medium such as a hard disk, a flash memory, a CD-ROM, a DVD-ROM, or a flexible disk and widely distributed.

[0034] The storage unit 22 stores a clearance database 221 and a pipe type database 222. In the pipe type database 222, various kinds of information (pipe type information) regarding the male joint 11 and the female joint 12 constituting the threaded joint 10 are stored as basic information in a searchable manner. Note that the pipe type information includes information such as an identification ID of the threaded joint 10, dimensions (diameter, thread dimension, thread pitch, thread height, length, and the like) of the male joint 11 and the female joint 12, and specifications. The clearance database 221 stores, in a searchable manner, information regarding the clearance between the male thread 13 and the female thread 14 based on the pipe type information, and information (hereinafter, clearance information) of a measurement result regarding the clearance between the male thread 13

and the female thread 14 measured by the measurement unit 35 described later. Note that the clearance information includes, in addition to the information of the measurement result of the clearance, various kinds of information related to the clearance, such as information of a flag as interference point information defining an interference point, and pass/fail (pass or fail) information for the set of the threaded joints 10.

[0035] A clearance calculation unit 211 of the control unit 21 is configured to be able to store, as digital data, the thread shapes of the male thread 13 and the female thread 14 measured by the measurement unit 35 in the clearance database 221 of the storage unit 22. The storage unit 22 may be provided in a housing different from the control unit 21, and a virtual storage device such as an external storage device or a cloud on a network can be used.

[0036] In the present embodiment, the control unit 21 loads a program stored in the storage unit 22 into a work area of a main storage unit, executes the program, and controls each component and the like through the execution of the program, so that a function matching a predetermined purpose can be realized. Specifically, the control unit 21 can realize the functions of the clearance calculation unit 211 and a determination unit 212 by executing the program.

[0037] The input/output unit 23 includes, for example, a touch panel display, a speaker microphone, a button, a switch, a jog dial, and the like. The input/output unit 23 as an output unit is configured to notify the outside of predetermined information by displaying characters, figures, and the like on a screen of a display such as a liquid crystal display, an organic EL display, or a plasma display, or outputting sound from a speaker, under the

control of the control unit 21. The input/output unit 23 includes a printer that prints and outputs predetermined information on printing paper or the like. Various kinds of information stored in the storage unit 22 can be checked on, for example, a display of the input/output unit 23 installed in a predetermined office or the like.

[0038] The input/output unit 23 as an input unit is selected from, for example, a keyboard, a touch panel keyboard incorporated in the input/output unit 23 to detect a touch operation on a display panel, a voice input device that enables a call with the outside, a switch, a jog dial, and the like. The input/output unit 23 as input means can input a measurement value of the clearance from the input/output unit 23 in a case where the clearance of the thread cross section of the male thread 13 or the female thread 14 is visually measured using the input/output unit 23 as output means. In addition, as will be described in detail later, in the joining of the male thread 13 and the female thread 14, it is also possible to set a flag or tilt based on the presence or absence of interference from the input/output unit 23. Specifically, "0" may be input from the input/output unit 23 in a case where there is interference between the male thread 13 and the female thread 14, and "1" may be input from the input/output unit 23 in a case where there is no interference.

[0039] (Measurement Unit)

The measurement unit 35 includes at least one handheld 3D scanner, for example. As the 3D scanner, for example, a laser irradiation device, an infrared irradiation device, or the like can be adopted. Since the handheld 3D scanner needs to be operated while maintaining a focal length (for example, 20 cm to 40 cm) according to the model, it is desirable to secure a space of 50 cm or more around the

scan target.

[0040] From the viewpoint of determining the feasibility of the joining between the male joint 11 and the female joint 12, the measurement unit 35 preferably sets the measurement accuracy to about half or less of a desired clearance, specifically, for example, about (0.75/2=) 0.375 mm or less in a case where the clearance is 0.75 mm. Note that the measurement accuracy is variously set according to the size of the threaded joint 10, the thread shapes of the male thread 13 and the female thread 14, and the like, and is not limited to these numerical values. In particular, since the threaded joint 10 has a three-dimensional shape, a blind spot easily occurs due to the uneven portion, and thus, for example, a handheld 3D scanner, which is a handheld measuring instrument, is desirable from the viewpoint of operability. Note that, in general, in a high-accuracy type among the handheld 3D scanners, it is necessary to attach a marker for shape measurement to a target object every about 10 cm. On the other hand, in a case where the threaded joint 10 is large, it is desirable to use a markerless handheld 3D scanner which does not require attachment of a marker for shape measurement from the viewpoint of efficiency.

[0041] Specifically, a sensor constituting the measurement unit 35 can measure a distance from an installation position to a target object, for example, the thread surface of the male thread 13 or the female thread 14 by irradiation and reflection of predetermined light such as laser light. The measurement unit 35 can execute so-called sensing that measures the distance from the measurement position to the surface of the target object in association with two-dimensional position information. The sensing includes various measurements performed by the

measurement unit 35. As the two-dimensional position information, coordinates (x, y) on the xy plane, coordinates (r, θ) at the distance r and the rotation angle θ, and the like can be used. The thread shapes of the surfaces of the male thread 13 and the female thread 14 can be three-dimensionally measured based on the information on the distance corresponding to the two-dimensional position information.

[0042] In addition, when selecting the equipment of the measurement unit 35, it is more preferable that the resolution is high. In this case, the resolution may be any resolution as long as the shape of the thread that affects the clearance used to determine the feasibility of the joining between the male joint 11 and the female joint 12 can be accurately reproduced. In the present embodiment, since local unevenness may be less likely to occur in the shapes of the threads of the male thread 13 and the female thread 14, the resolution may be about 1 mm or less, but is not limited to this numerical value. In addition, since the determination regarding the feasibility of the joining is performed by combining the male joint 11 and the female joint 12 on the scanned data, in the case of the target object of which the direction is not fixed in one direction, it is desirable to ensure directionality by providing a marker or an indicator based on the shape that can be recognized by scanning.

[0043] The measurement unit 35 outputs a measurement value of the thread shape measured by sensing to the clearance measurement device 20. The clearance calculation unit 211 in the control unit 21 of the clearance measurement device 20 stores the acquired measurement value in the clearance database 221 of the storage unit 22.

[0044] (Thread Processing Device)

The thread processing device 40 is a device for an adjustment step for the male thread 13 and the female thread 14 of the threaded joint 10. The thread processing device 40 includes a control unit 41, a storage unit 42, an input/output unit 43, and a thread processing unit 45. The control unit 41, the storage unit 42, and the input/output unit 43 are functionally and physically configured similarly to the control unit 21, the storage unit 22, and the input/output unit 23, respectively. The thread processing device 40 is connected to the clearance measurement device 20.

[0045] The control unit 41 loads a program stored in the storage unit 42 into a work area of a main storage unit, executes the program, and controls each component and the like through the execution of the program, so that a function matching a predetermined purpose can be realized. Specifically, the control unit 41 can realize the function of a processing control unit 411 by executing a program. The processing control unit 411 is configured to be able to control the thread processing unit 45.

[0046] The clearance calculation unit 211 of the clearance measurement device 20 reads the clearance information from the clearance database 221 stored in the storage unit 22, and outputs the clearance information to the thread processing device 40. The thread processing device 40, which has acquired the clearance information, at least temporarily stores the acquired clearance information in the storage unit 42. In a case where an instruction to correct the interference point between the male thread 13 and the female thread 14 is input from an operator or the like through the input/output unit 43, the processing control unit 411 of the control unit 41 controls the thread processing unit 45 to execute machining processing of

correcting the interference point based on the acquired clearance information. Note that the thread processing device 40 may be integrated with the clearance measurement device 20. Furthermore, the threaded joint 10 can be manufactured by the thread processing device 40. As described above, the threaded joint measurement system 1 according to the first example of the embodiment is configured.

[0047] (Second Example of Embodiment)

Next, a threaded joint measurement system according to a second embodiment of the present invention will be described. FIG. 4 is a block diagram illustrating the threaded joint measurement system according to the second embodiment. As illustrated in FIG. 4, a threaded joint measurement system 1A includes a clearance measurement device 20A and a measurement terminal 30A that can communicate with each other via a network 2.

[0048] The network 2 is, for example, a public communication network such as the Internet, and includes, for example, one or a combination of a local area network (LAN), a wide area network (WAN), a telephone communication network such as a mobile phone, a public line, a virtual private network (VPN), a dedicated line, and the like. The network 2 appropriately combines wired communication and wireless communication.

[0049] The threaded joint measurement system 1A may be further connected to the thread processing device 40A capable of communicating with at least the clearance measurement device 20A via the network 2. Note that the threaded joint measurement system 1A may employ a configuration including the clearance measurement device 20, the measurement terminal 30A, and the thread processing device 40A.

[0050] (Clearance Measurement Device)

The clearance measurement device 20A includes the control unit 21, the storage unit 22, the input/output unit 23, and a communication unit 24. The communication unit 24 as communication means is, for example, a local area network (LAN) interface board, a wireless communication circuit for wireless communication, or the like. The LAN interface board and the wireless communication circuit are connected to the network 2. The communication unit 24 is connected to the network 2 and communicates with the measurement terminal 30A and the thread processing device 40A. Other configurations are similar to those of the clearance measurement device 20 in the first embodiment.

[0051] (Measurement Terminal)

The measurement terminal 30A includes a control unit 31, a storage unit 32, an input/output unit 33, a communication unit 34, and the measurement unit 35. The control unit 31, the storage unit 32, the input/output unit 33, and the communication unit 34 have physically and functionally similar configurations to those of the control unit 21, the storage unit 22, the input/output unit 23, and the communication unit 24 described above, respectively.

[0052] Furthermore, the measurement unit 35 in the measurement terminal 30A according to the second embodiment is configured similarly to the measurement unit 35 in the first embodiment. The control unit 31 loads a program stored in the storage unit 32 into the work area of the main storage unit and executes the program, so that a function matching a predetermined purpose can be realized. Specifically, the control unit 31 can realize the function of a measurement control unit 311 by executing a program. The measurement control unit 311 is configured to be able to control the measurement unit 35.

[0053] (Thread Processing Device)

The thread processing device 40A includes the control unit 41, the storage unit 42, the input/output unit 43, a communication unit 44, and the thread processing unit 45. The communication unit 44 as communication means is physically and functionally configured similarly to the communication unit 24 described above, and is connected to the network 2. The communication unit 44 is connected to the network 2 and communicates with at least the clearance measurement device 20A. Other configurations are similar to those of the thread processing device 40 in the first embodiment. As described above, the threaded joint measurement system 1A according to the second example of the embodiment is configured.

[0054] (First Embodiment)

(Threaded Joint Measurement Method)

Next, a measurement method of the threaded joint 10 using the threaded joint measurement system 1 according to the first example or the threaded joint measurement system 1A according to the second example of the embodiment configured as described above will be described. FIG. 5 is a flowchart illustrating a measurement method of the threaded joint 10 according to the first embodiment.

[0055] (Manufacturing Step of Threaded Joint)

As illustrated in FIG. 5, first, in step ST1, a joint manufacturing step is executed by the thread processing device 40. In step ST1, first, a forged ring is manufactured by heat treatment. Next, the forged ring is processed to a joint by rotating the forged ring through rotary cutting and bringing a cutting blade into contact with the forged ring to perform the cutting. Note that the movement of the cutting blade can be automatically controlled by the control of the processing control unit

411 according to a predetermined program. Here, as an example, in a case where the thread shape of the joint is a multi-start thread, the same location is gradually cut until one section, that is, one thread lead, is completed. In a case where one thread lead is completed, the cutting blade is moved to the next thread lead. After the thread in the joint is completed, test-joining is actually performed, and the arrival line is marked with an eye-mark in a joining completion state that satisfies structural performance. Thereafter, the joining is released and an arrow is marked on the starting line on the outer peripheral surface (however, select a point where there is no thread) of each joint, and an arrow is marked on the male joint 11 corresponding to the eye-mark of the female joint 12 at the time of release. Note that is not always necessary to use a forged ring, and a steel pipe or the like having a cuttable plate thickness may be used.

[0056] (Pipe Connection Step)

Next, the processing proceeds to step ST2, and a pipe connection step is executed. In step ST2, first, the joining of the threaded joint performed in step ST1 is released. Next, one joint of the male joint 11 and the female joint 12, here, for example, the female joint 12 is attached to the horizontal steel pipe. Next, the single body of the male joint 11 is test-joined to the steel pipe with the female joint in the horizontal placement state. After checking whether the test-joining reaches the arrival line, the joining is released. Subsequently, the other joint of the male joint 11 and the female joint 12, here, for example, the male joint 11 is attached to the horizontal steel pipe.

[0057] Here, in the case of a combination of a steel threaded joint and a steel pipe, it is checked whether the

joining can be performed up to the joining completion position by this test-joining while allowing the influence of thermal deformation due to welding. Note that in a case where a steel threaded joint and a steel pipe are combined with the steel pipe sheet pile, for example, after welding a steel coupling joint that connects the steel pipes horizontally, the threaded joint is welded to the steel pipe. Note that step ST2 may not be executed.

[0058] (Threaded Joint Measurement Method)

Here, a threaded joint measurement method according to the present embodiment will be described. The present embodiment includes a shape measurement step of measuring the shape of the threaded joint after processing, and a clearance measurement step for a set of threaded joints based on the measured shape of the threaded joint. These shape measurement step and clearance measurement step are executed before the threaded joint 10 is actually used.

[0059] (Shape Measurement Step)

That is, after step ST1 or step ST2 is executed, the processing proceeds to step ST3 to execute the shape measurement step. In the shape measurement step, first, for one set of threaded joints 10 manufactured in step ST1, the measurement unit 35 measures the thread shape of each of the male thread 13 of the male joint 11 and the female thread 14 of the female joint 12. The measurement unit 35 outputs or transmits (hereinafter, referred to as transmission) measurement data of the measured thread shape to the clearance measurement device 20. Here, in the shape measurement step of the threaded joint 10, the measurement of the thread shape using the measurement unit 35 is performed, for example, by measuring the distance from the measurement unit 35 to the surface of the threaded joint (male joint 11, female joint 12).

[0060] In addition, in the shape measurement step of the threaded joint 10, the thread shape can also be measured through photogrammetry by imaging the threaded joint (male joint 11, female joint 12) from a plurality of viewpoints to acquire a plurality of pieces of image data and then using the plurality of acquired images. Specifically, after point cloud data is acquired by the handheld 3D scanner constituting the measurement unit 35, the acquired point cloud data is polygonized (converted to STL or meshed), and the shape measurement and virtual arrangement of the threaded joint 10 as the target object are executed using CAD software that performs three-dimensional measurement. Here, in order to realize the virtual arrangement, for example, in a case where the shape is ascertained in detail, it is preferable to use the vertex of the thread as a data point. That is, in order to measure the shape of the thread, it is preferable that the vertex of the thread is included in the data point of the point cloud data, and in practice, it is preferable to set the resolution to be equal to or less than the radius of curvature of the vertex of the thread, for example, approximately 0.5 mm or less.

[0061] However, local unevenness may be less likely to occur as the shape of the thread, and the resolution may be about 1 mm in consideration of the fact that the contact that affects the joinability is a surface contact of the thread surface. In addition, as an example, as a guideline for the accuracy of data points, by setting the accuracy to half or less of the clearance, specifically, for example, 0.375 mm or less in a case where the clearance is 0.75 mm, it is possible to perform determination with practically sufficient accuracy.

[0062] Note that, since the male joint 11 and the female

joint 12 are regarded as rigid bodies and the joint determination is performed using CAD software that performs three-dimensional measurement, there is no problem in the pass determination in a case where there is a clearance, but even in a case where there is interference to some extent, there is a case where fitting can be performed by the deformability of the joint as an elastic body.

[0063] From the above, the accuracy of the assessment can be improved by setting determination criterion values (it is not always necessary to set zero as the criterion; for example, a clearance of -0.2 mm (a virtual interference amount of 0.2 mm) can be used as the criterion to determine the feasibility of the joining. In addition, depending on the measurement accuracy, interference may occur even in a case where the clearance has a positive value, and thus it is desirable to set appropriate determination criteria) in consideration of the measurement accuracy, the neglect of local contact, frictional resistance, the elastic deformation amount, and usage conditions (direction during the joining such as vertical, horizontal, inclined and ambient temperature). Note that the positive and negative of the clearance depends on the method of organizing, and thus the negative may be a state in which the clearance exists.

[0064] In addition, in the threaded joint 10, it is not always necessary to measure the entire threaded joint, and the measurement unit 35 may measure the outer surface side of the male joint 11 and the inner surface side of the female joint 12. In this case, it is possible to shorten the measurement time and reduce the capacity of the measurement data. In addition, when the acquired point cloud data is polygonized (converted to STL or meshed), points within a range of a predetermined surface error (for

example, 0.01 mm) can be omitted to reduce data capacity.

[0065] (Clearance Measurement Step)

Next, the processing proceeds to step ST4, and a clearance measurement step as the clearance measurement method will be described. FIG. 6A is a flowchart illustrating the clearance measurement step according to the first embodiment, and FIG. 6B is a flowchart illustrating a setting method of an initial state of the clearance measurement step according to the first embodiment. Note that the flowcharts illustrated in Figs. 6A and 6B are executed by the clearance measurement device 20.

[0066] (Acquisition Step)

As illustrated in FIG. 6A, in the clearance measurement method according to the first embodiment, first, in step ST41 as an acquisition step, the control unit 21 of the clearance measurement device 20 acquires measurement data from the measurement unit 35. The measurement data is measurement data regarding the thread shape of the male thread 13 of the male joint 11 and the thread shape of the female thread 14 of the female joint 12 which are measured by the measurement unit 35 in step ST3.

[0067] (Initial State Setting Step)

Next, the processing proceeds to step ST42 as an initial state setting step, and the clearance calculation unit 211 of the control unit 21 sets the initial states of the male joint 11 and the female joint 12 based on the acquired measurement data of the thread shapes of the male thread 13 and the female thread 14.

[0068] In the present invention, the "initial state" refers to a state, as illustrated in FIG. 2A, in which the entire length of the threaded portion of the male joint 11 in the axial direction of the pipe is almost fully housed

inside the female joint 12, and a predetermined initial state is set by performing vertical movement and rotation based on threading theory, using the joining completion state in which the joining is completed as the criterion. Here, in other words, the "joining completion state" means a state in which the male joint 11 is threaded into the female joint 12 and can be no longer rotated significantly in a direction in which the threads advance, and ideally a so-called shoulder-touch state, as illustrated in FIG. 2A, where the non-threaded portion of the male joint 11 comes into contact with the distal end portion of the female joint 12. Note that the vertical movement based on the threading theory is movement in the vertical direction by a thread pitch per 1/number of thread leads (rotation). In addition, the vertical movement amount from the joining completion state to the initial state is calculated by multiplication of the thread pitch and the number of threads (thread pitch × number of threads), and the rotation number is calculated by multiplication of the reciprocal of the multiplier and the number of threads (1/number of thread leads (rotation) × number of threads). Note that the order of the vertical movement and the rotation may be any order, and is not limited. In addition, in a case where the number of threads is set to the total number of threads, as illustrated in FIG. 2B, a state where the joints are separated immediately before the start of joining is obtained, but the determination from the semi-joining state can be started by setting the number of threads to an arbitrary number of threads.

[0069] Specifically, as illustrated in FIG. 6B, the control unit 21 acquires the data acquired in step ST41 (refer to FIG. 6A) as data for initial setting (step ST411). Next, for example, a state in which the male joint

11 and the female joint 12 are joined as illustrated in FIG. 2A is set (step ST412). Next, the processing proceeds to step ST413, and vertical movement based on the threading theory is executed. In addition, the processing proceeds to step ST414, and rotational movement based on the threading theory is executed. Steps ST413 and ST414 may be executed in the reverse order. Alternatively, in step ST415, a state in which the threads start to contact during joining is set. The processing in step ST415 sets a state illustrated in FIG. 2B, where the threads of the male joint 11 and the female joint 12 start to contact during joining, but this is determined at a single point, and thus the state can be set as a predetermined initial state.

[0070] Thereafter, the processing proceeds to step ST416, and a predetermined initial state is set based on the processing of steps ST413, ST414, and ST415. Note that processing of only one of steps ST413, ST414, and ST415 may be executed, processing of all of steps ST413, ST414, and ST415 may be executed, or processing of any of steps ST413 and ST414, and step ST415 may be executed. As described above, the control unit 21 performs the vertical movement and the rotational movement on the male joint 11 to a predetermined position in the female joint 12, and sets a so-called loosened state as a predetermined initial state.

[0071] The maximum feature of the present invention is to set, as a predetermined initial state, a state in which the male joint 11 is loosened by performing the vertical movement and the rotational movement to a predetermined position in the female joint 12, based on the threading theory described above with the joining completion state as a criterion, and then to start the measurement of the clearance from the predetermined initial state.

[0072] Normally, in the case of performing the joining

check using an actual object, the position where the male thread and the female thread are assembled (the start position of the thread with respect to the circumferential direction of the joint) is specified while being moved. Here, in the case of a single-start thread, there is only one start position of the thread with respect to the circumferential direction of the joint, and it is difficult to specify the initial position to be the initial state depending on the conditions of the threaded joint described above. In the case of a multi-start thread, there are a plurality of start positions of the thread with respect to the circumferential direction of the joint, but in a case where use at a specific start position is assumed, it is difficult to specify an initial position to be the initial state. In particular, in a case where virtual joining is simulated using a computer or the like, since a plurality of conditions are conceivable over the circumferential direction and the axial direction in setting the position where the male thread and the female thread are assembled, it is more difficult to start threading the male thread into the female thread.

[0073] However, the joining completion position where the joining between the male thread and the female thread is completed can be easily set in any environment including a virtual case and a hypothetical case. Therefore, in the present invention, by setting a predetermined initial state in which the male joint 11 is loosened by performing the vertical movement and the rotational movement to a predetermined position in the female joint 12, based on the threading theory described above with the joining completion position as a criterion, and measuring the clearance while joining the male thread to the female thread, the clearance measurement step is simplified, and

the clearance can be measured more easily regardless of the state of the threaded joint or the connected pipe.

[0074] (Clearance Measurement Step)

Next, in step ST43 as a clearance measurement step, the clearance between the male thread 13 and the female thread 14 is derived based on the measurement data. The derivation of the clearance is executed by the clearance calculation unit 211 of the control unit 21 from a predetermined initial state of the male thread 13 and the female thread 14 at a preset point. Note that in the present specification, the clearance is also referred to as a gap, play, or the like.

[0075] Here, Figs. 7A, 7B, and 7C illustrate a creation method of a coordinate system of a measurement position. That is, as illustrated in FIG. 7A, a plane for creating a cross section of the male thread 13 of the male joint 11 and a cross section of the female thread 14 of the female joint 12 along the radial direction is created, and a cross-sectional line L illustrated in FIG. 7B is created. Next, two straight lines l are created from the cross-sectional line to create an intersection point C. Next, as illustrated in FIG. 7C, a circle (hereinafter, fit circle) in which an error from a point (designated point) to which a curve is designated is minimized is created. A coordinate system is created by the center point of the fit circle and a plurality of intersection points C. Note that the creation method of the coordinate system described with reference to Figs. 7A to 7C is merely an example, and the creation and setting of the coordinate system can be performed by any method.

[0076] Returning to FIG. 6A, based on the coordinate system created in this manner, it is possible to select, as preset points, four points shifted by, for example, 90° on

a circumference with respect to the center of the circle in the cross section (a plane perpendicular to an up-down direction in Figs. 1, 2A, and 2B) of the male joint 11 and the female joint 12. Note that the preset points may be, for example, eight points shifted by 45° on the circumference with respect to the center of the circle, and are not necessarily limited to predetermined positions or the number.

[0077] In step ST43, as described above, the clearance calculation unit 211 generates a cross-sectional view of the thread from the data of the thread shape at the preset four or eight positions, and derives a clearance c between the threads of the male thread 13 and the female thread 14. As described above, by setting the method of obtaining the measurement point as illustrated in Figs. 7A to 7C, the clearance calculation unit 211 can automatically calculate the determined points by a predetermined method. Note that the input/output unit 23 of the clearance measurement device 20 may be caused to output the cross-sectional view of the thread generated by the clearance calculation unit 211, and the operator may visually determine the presence or absence of the clearance and input the presence or absence of the clearance from the input/output unit 23.

[0078] In addition, an example of a cross section of the threaded joint 10, which is generated by the clearance calculation unit 211 of the clearance measurement device 20 according to the first embodiment and converted into data is illustrated in Figs. 8 and 9. FIG. 8 is an enlarged cross-sectional view illustrating a part of a state in which the male thread 13 and the female thread 14 of the data-converted threaded joint 10 are joined without interfering with each other. FIG. 9 is an enlarged cross-sectional view illustrating a part of a state in which the

male thread 13 and the female thread 14 of the data-converted threaded joint 10 partially interfere with each other and are not appropriately joined.

[0079] As illustrated in FIG. 8, in a case where no interference occurs between thread crests 13a and 14a and thread roots 13b and 14b, respectively, the male joint 11 and the female joint 12 are joined. Here, for example, a height h of the thread crest 13a of the male thread 13 to be appropriately joined is, for example, 5.0 mm. Note that the center of each of the thread crests 13a and 14a is assumed to be the closest point at half the distance between the corner and the corner of the male thread 13. In addition, white points p are measurement points where sufficient resolution with respect to the male thread 13 of the male joint 11 and the female thread 14 of the female joint 12 can be ensured. As the number of white points p increases, the determination accuracy of the central positions of the male thread 13 and the female thread 14 can be improved.

[0080] The height h of each of the thread crests 13a and 14a is a distance between the center of each of the thread crests 13a and 14a and the bottom on the stabbing side. The clearance c in the radial direction between the thread crest 13a of the male thread 13 and the thread root 14b of the female thread 14 is, for example, 0.75 mm. Note that the clearance c is a radial component of the rotation axis of the male joint 11 in a line connecting the center of the thread crest 13a and the center of the thread root 14b. That is, the clearance c can be derived as $c = r2 - r1$, where a distance r1 is the distance from the center of the diameter of the male joint 11 to the surface of the thread crest 13a in the circumferential direction of the male joint 11 and a distance r2 is the distance from the center

of the diameter of the male joint 11 to the thread root 14b of the female joint 12.

[0081] The clearance c is not necessarily limited to the above definition, and various definitions depending on the feasibility of the joining of the threaded joint 10 can be set. For example, as another example of the definition of the clearance c, it is also possible to adopt a method of deciding a position in consideration of the vertices of the thread crests 13a and 14a. That is, in a case where the vertices to be measured are determined in advance and are obliquely connected, a distance corresponding to the radial direction or the axial direction between the connected vertices can be measured to obtain the clearance c. In addition, the distance may be measured in the normal direction for each point or line connecting points in the male joint 11, that is, for each mesh, and the distance when the male joint 11 is in contact with the female joint 12 in the joined state, that is, the shortest distance may be set as the clearance c. Conversely, the distance may be measured in a direction from the female joint 12 toward the male joint 11.

[0082] On the other hand, as illustrated in FIG. 9, from the positional relationship between the male joint 11 and the female joint 12, in a case where interference (interference portion E) occurs at least partially between the thread crests 13a and 14a and the thread roots 13b and 14b, a state in which the male joint 11 and the female joint 12 are not joined is reached. Here, for example, the height h of the thread crest 13a of the male thread 13 in a state of not being appropriately joined is, for example, 5.0 mm. The clearance c in the radial direction between the thread crest 13a of the male thread 13 and the thread root 14b of the female thread 14 will interfere, for

example, by -1 mm, that is, 1 mm in the radial direction.

[0083] Note that in the examples of Figs. 8 and 9 described above, the thread pitch P is, for example, 12.5 mm, but is not limited thereto. The thread pitch P is a distance in the axial direction from an end of the thread root 13b of the male thread 13 in one thread lead to a start position of the thread root 13b of the male thread 13 in the next thread lead. Alternatively, the thread pitch P is a distance in the axial direction from an end of the thread crest 14a of the female thread 14 in one thread lead to a start position of the thread crest 14a in the next thread lead. In the case of a single-start thread, the thread pitch P means the distance traveled by the thread when one rotation is made. On the other hand, in the case of a multi-start thread, it is difficult to define the thread pitch P as a constant distance because the distance traveled when one rotation is made varies depending on the number of thread leads. Therefore, the thread pitch P is defined as described above in the present specification, but is not necessarily limited to the definition described above.

[0084] The clearance calculation unit 211 stores a result of the clearance c derived at a plurality of positions, for example, four or eight positions set in advance, as the clearance information in the clearance database 221. Note that in the male joint 11 and the female joint 12, the clearance c is derived for all the thread crests 13a and 14a and the thread roots 13b and 14b of the joined portions at a plurality of preset points. Then, a minimum clearance c along the radial direction with respect to the rotation axis is derived. Specifically, the clearance calculation unit 211 extracts, by predetermined measurement software, a value at which the clearance c

between the male thread 13 of the male joint 11 and the female thread 14 of the female joint 12 in each longitudinal section (refer to FIG. 7B) is minimum in the radial direction of the rotation axis. In addition, information on the derived clearance c may be stored in the storage unit 22 in association with the threaded joint identification ID of the pipe type information stored in the pipe type database 222.

[0085] (Clearance Determination Step)

Next, the processing proceeds to step ST44 as a clearance determination step, and the determination unit 212 of the control unit 21 reads the clearance information from the clearance database 221 of the storage unit 22, and determines the feasibility of the joining according to a predetermined criterion. That is, the determination unit 212 performs determination based on whether the clearance c between the male thread 13 of the male joint 11 and the female thread 14 of the female joint 12 is equal to or less than a predetermined value as a predetermined criterion, for example. Note that the predetermined value can be set to any value, and in the present embodiment, the predetermined value is set to zero, for example.

[0086] In step ST44, in a case where the determination unit 212 determines that the clearance c between the male thread 13 of the male joint 11 and the female thread 14 of the female joint 12 is equal to or less than the predetermined value, specifically, for example, equal to or less than zero ($c \leq 0$) (step ST44: Yes), the processing proceeds to step ST48. In step ST48, the determination unit 212 outputs information indicating that the threaded joint 10 to be measured has failed, and stores the fail information as the clearance information in the clearance database 221. Thus, the clearance measurement step ends.

[0087] In step ST44, in a case where the determination unit 212 determines that the clearance c between the male thread 13 of the male joint 11 and the female thread 14 of the female joint 12 is larger than the predetermined value, specifically, for example, larger than zero (c > 0) (step ST44: No), the processing proceeds to step ST45. That is, in a case where the clearance c in the joined portion at a plurality of preset points is larger than a predetermined value, it is determined that the male joint 11 and the female joint 12 can be joined without causing interference. Here, in a case where the predetermined value is set to zero, as long as the clearance c is always in a positive state (c = r2 - r1 >0), the determination unit 212 can determine that the male joint 11 and the female joint 12 can be joined without causing interference. Note that the interference portion E may be determined in the same manner because the interference portion E may occur not only in the radial direction of the thread portion but also in the pipe axial direction of the thread portion and a point other than the thread portion. However, in the threaded joint 10, since the deformation of the thread portion in the radial direction is most likely to occur, the determination unit 212 can determine that the joining is possible in a case where the clearance of the thread portion in the radial direction satisfies the above-described condition (c > predetermined value). Note that, in this case, as a static examination, a method of considering that the entire shape of the joint is rigid without being deformed using measurement software or CAD is adopted. However, as a dynamic examination, a method of considering factors such as the shape of the joint being elastically deformed due to partial minute interference, and the frictional resistance can also be adopted. As the

dynamic examination, dynamic analysis is performed by FEM, mechanism analysis, or the like, and interference is determined based on variations in load, torque, contact, friction, or the like.

[0088] (Joining Determination Step)

In step ST45 as a joining determination step, the determination unit 212 determines whether or not the joining between the male joint 11 and the female joint 12 is completed in the threaded joint 10. In a case where the determination unit 212 determines that the joining between the male joint 11 and the female joint 12 is completed (step ST45: Yes), the processing proceeds to step ST47.

[0089] In step ST47, the determination unit 212 outputs information indicating that the threaded joint 10 to be measured has passed, and stores the pass information as the clearance information in the clearance database 221. The clearance calculation unit 211 can derive the clearance c with respect to the entire circumference of the male thread 13 and the female thread 14 until the state where the joining between the male joint 11 and the female joint 12 is virtually disengaged. Thus, the clearance measurement step ends.

[0090] On the other hand, in a case where the determination unit 212 determines in step ST45 that the male joint 11 and the female joint 12 are not rotated to a predetermined position and the joining is not completed (step ST45: No), the processing proceeds to step ST46.

[0091] (Rotation State Setting Step)

In step ST46 as a rotation state setting step, the clearance calculation unit 211 sets a state in which the joined male joint 11 and female joint 12 are rotated by a predetermined rotation angle, specifically, for example, 90° or 45°, in a rotation direction in which the male joint

and the female joint advance in a joining direction. Here, the rotation state setting step executed in step ST46 will be described in detail.

[0092] That is, it is considered that the male joint 11 and the female joint 12, which are converted into data, are rotated in the rotation direction at the time of joining from the initial state to complete the joining. In the case of the joining virtually executed in this data, in a case where the interference does not occur in all the cross sections in all the thread portions of the male thread 13 and the female thread 14, it can be determined that the male joint 11 and the female joint 12 can be joined. Conversely, in a case where interference occurs at least partially, that is, in a case where the clearance c is equal to or less than a predetermined value, it can be determined that joining is impossible.

[0093] In this manner, first, it is preferable to perform determination by setting a predetermined initial state of the male joint 11 and the female joint 12 and starting the rotation such that the male joint 11 and the female joint 12 advance in the joining direction, which is an important feature in the present embodiment. In a case where the degree of interference is derived while the male thread 13 and the female thread 14 are rotated such that the male joint 11 and the female joint 12 advance in the joining direction from the joining start state in which the male joint 11 and the female joint 12 are separated in the threaded joint 10, when the rotational joining is simply started from the position where the male joint 11 and the female joint 12 are brought into contact with each other, it cannot be checked whether or not the position where the rotational joining is finally completed can be reached unless the rotation is advanced. In this case, it is

necessary to repeatedly change the positions of the male joint 11 and the female joint 12 to search for a position that reaches a position where the rotational joining is actually completed. On the other hand, as in the present embodiment, in a case where the male joint 11 and the female joint 12 are rotated from a predetermined initial state using the joining completion state as the criterion, the initial positions of the male joint 11 and the female joint 12 are determined at one position, so that the search for the position can be omitted. Here, in a case where the joining check is performed in the threaded joint 10 as the actual object, which is not converted into data, it is possible to specify the initial position of the joining start while moving the initial position. In a case where the joining check is virtually performed on the virtual data, it is necessary to examine and search for a plurality of settings of the initial state, that is, settings of the initial position of the joining start in the circumferential direction, the axial direction, and the like, and it is extremely difficult to rotationally join the male joint 11 and the female joint 12 in the virtual data. On the other hand, it is relatively easy to specify the joining completion position. As a result, it is possible to simplify and improve the efficiency of the measurement processing of the threaded joint 10 by setting, as the predetermined initial state, a state in which the male joint 11 is loosened by performing the vertical movement and the rotational movement to a predetermined position in the female joint 12 based on the threading theory described above with the joining completion state as the criterion, and then checking the presence or absence of interference while performing the joining by rotating the male joint.

[0094] Next, a specific procedure executed by the clearance calculation unit 211 in step ST46 will be described. First, as illustrated in Figs. 2A and 2B, the male joint 11 and the female joint 12 which are converted into data are virtually arranged at the initial positions set in step ST42.

[0095] For this purpose, first, the rotation axes of the male joint 11 and the female joint 12 are extracted. Specifically, for example, a plurality of points such as four or eight points are selected for the outer diameter of the distal end portion in the male joint 11 and the inner diameter of the distal end portion in the female joint 12.

[0096] Next, a fitting circle having the minimum deviation from the selection point is created, and the center of the fitting circle is set to the rotation axis.

[0097] The rotation axes of the male joint 11 and the female joint 12 are aligned, and a shoulder-touch state is derived by matching the position of the eye mark (finely adjusting the position and angle of the rotation axis such that the distance between shoulders is within the set value in a plurality of cross sections such as four or eight points). This state is defined as the joining completion position. Note that any method can be adopted for the setting of the rotation axis and the setting of the joining completion position, and various methods can be adopted other than the above-described methods.

[0098] Next, with the joining completion state in which the rotation axes of the male joint 11 and the female joint 12 are aligned and shoulder touched as the criterion, the predetermined initial state is set by performing vertical movement and rotation based on the threading theory (vertical movement by one thread pitch per (1/number of thread leads) rotation).

[0099] In this state, the minimum clearance along the radial direction of the rotation axis with respect to all the thread crests 13a and 14a is derived in the longitudinal section (refer to Figs. 7A to 7C) equal to or less than a predetermined angular interval such as 45° or 90°. Here, a portion where the clearance becomes negative is also measured. Note that a value at which the clearance of the thread portions of the male joint 11 and the female joint 12 in each longitudinal section is minimum in the radial direction of the rotation axis is extracted by measurement software. More specifically, an overall minimum value is derived, or a minimum value is derived for each of a plurality of thread crests of the thread crests 13a and 14a. Furthermore, it is also possible to perform visual observation, examination using representative points, and the like depending on conditions. In addition, the distance may be measured in the normal direction for each point or line connecting points in the male joint 11, that is, for each mesh, and the distance when the male joint 11 is in contact with the female joint 12 in the joined state, that is, the shortest distance may be set as the clearance c. Conversely, the distance may be measured in a direction from the female joint 12 toward the male joint 11.

[0100] Thereafter, rotation is performed in the joining direction by a preset rotation angle. Here, the rotation angles are, for example, 45° intervals or 90° intervals, but are not limited thereto. The movement amount in the axial direction according to the rotation angle is determined by the thread pitch P of the male thread 13 and the female thread 14. Note that the reason why the setting of the cross section and the setting of the interval of rotation to 45° or less or 90° or less for deriving the

clearance is that the threaded joint 10 is continuous in the circumferential direction, local deformation is less likely to occur, and the presence or absence of interference can be sufficiently detected even in a case where the checking is performed at an interval of about 45° to 90°.

[0101] In a case where interference occurs in the rotation, a state is set in which the rotation axis of the male joint 11 is moved to the side where the clearance along the radial direction of the rotation axis is larger, and the presence or absence of interference is checked at that stage. In the case of further interference, a state is set in which the male joint 11 and the female joint 12 are moved along the axial direction of the rotation axis, and a position where the male joint and the female joint do not interfere is searched for. In the case of further interference, a state is set in which the angle of the rotation axis is adjusted as necessary, and a position where the male joint and the female joint do not interfere is searched for. In a case where a position where the male joint and the female joint do not interfere is specified, rotation is started again from the specified position. Note that the order of movement of the rotation axis is not limited to the above procedure, and may be performed by an arbitrary procedure. In addition, the presence or absence of interference may be determined by setting an appropriate criterion value without moving the rotation axis. In addition, by comparing the clearance between the target cross section and the cross section at the 180 degree-target position with the determination criterion, the determination can be made without actually performing the movement.

[0102] The above procedure is repeatedly executed until

the male joint 11 and the female joint 12 are rotated and the joining is completed. In these procedures, in a case where the clearances between all of the male threads 13 and the female threads 14 are larger than the predetermined value, for example, zero, it is determined that joining is possible, and in a case where the clearances are equal to or less than the predetermined value, it is determined that joining is impossible.

[0103] After the rotation state setting step in step ST46 is completed, the processing proceeds to step ST43, and the clearance c of the joined portion at a preset point is derived. The control unit 21 repeatedly executes steps ST43 to ST46 until the clearance c becomes equal to or less than the predetermined value (step ST44: Yes) or the joining between the male joint 11 and the female joint 12 is completed (step ST45: Yes). Thereafter, the determination unit 212 stores the information on the pass or fail of the threaded joint 10 to be measured, as the clearance information in the clearance database 221. Thus, the clearance measurement step ends. According to the clearance measurement step according to the first embodiment, by determining the fail when the clearance c becomes equal to or less than the predetermined value, it is possible to shorten the time required for finding the defective product in the threaded joint 10.

[0104] Thereafter, the processing proceeds to step ST5 illustrated in FIG. 5, and the control unit 21 outputs the information on the pass or fail of the threaded joint 10 to be measured, to the input/output unit 23. Note that the threaded joint 10 determined to be failed may be marked on the threaded joint 10 that is the actual object. Note that it is possible to appropriately select whether to execute an adjustment step to be described later or discard the

threaded joint 10 determined to be failed. Thus, the measurement processing of the threaded joint ends.

[0105] It is possible to manage the quality of the threaded joint 10 based on the threaded joint measurement method described above.

[0106] That is, in the quality management method of the threaded joint 10, first, in step ST1, the threaded joint 10 is manufactured by the joint manufacturing step. Next, the thread shapes of the male thread 13 and the female thread 14 of the threaded joint 10 are measured by a joint measurement step in step ST3.

[0107] Thereafter, in step ST4, by measuring the clearance using the measurement result obtained in the joint measurement step, it is possible to manage the quality of the threaded joint 10 as a quality management step.

[0108] (First Modification Example)

Next, a first modification example of the clearance measurement step according to the first embodiment will be described. FIG. 10 is a flowchart for describing a clearance measurement step according to the first modification example. In the clearance measurement method according to the first embodiment, the clearance measurement step is completed when a point where the clearance is equal to or less than a predetermined value is found. On the other hand, in the clearance measurement step according to the first modification example, unlike the clearance measurement step according to the first embodiment, a case is assumed in which the entire circumferences of the male joint 11 and the female joint 12 of the threaded joint 10 are measured regardless of whether the measurement of the clearance is passed or failed.

[0109] That is, as illustrated in FIG. 10, steps ST421

to ST423 are similar to steps ST41 to ST43 according to the first embodiment described above, respectively. In the first modification example, after execution of step ST423, the processing proceeds to step ST424. In step ST424, the clearance calculation unit 211 stores a result of the clearance c derived at a plurality of positions, for example, four or eight positions set in advance, as the clearance information in the clearance database 221. Thereafter, the processing proceeds to step ST425. Steps ST425 and ST426 are similar to steps ST45 and ST46 according to the first embodiment, respectively. In addition, in the first modification example, the processing of determining whether the clearance is equal to or less than the predetermined value is not executed. The other processing is similar to that of the first embodiment, and thus description thereof is omitted.

[0110] (Second Modification Example)

Next, a second modification example of the clearance measurement step according to the first embodiment will be described. FIG. 11 is a flowchart for describing a clearance measurement step according to the second modification example. In the clearance measurement method according to the first embodiment, the clearance measurement step is completed when a point where the clearance is equal to or less than a predetermined value is found. On the other hand, in the clearance measurement step according to the second modification example, unlike the clearance measurement step according to the first embodiment, a case is assumed in which the determination based on the comparison with the predetermined value is collectively performed after the entire circumferences of the male joint 11 and the female joint 12 of the threaded joint 10 are measured regardless of whether the measurement

of the clearance is equal to or less than the predetermined value.

[0111] That is, as illustrated in FIG. 11, steps ST431 to ST434 are similar to steps ST421 to ST424 according to the first modification example described above, respectively. In the second modification example, after execution of step ST434, the processing proceeds to step ST435. In step ST435, the clearance calculation unit 211 executes step ST435, which is a rotation state setting step similar to step ST46 according to the first embodiment. The processing proceeds to step ST436.

[0112] In step ST436, the determination unit 212 determines whether or not the joining is completed in the same manner as in step ST45.

[0113] In a case where the determination unit 212 determines in step ST436 that the joining of the threaded joint 10 is not completed (step ST436: No), the processing proceeds to step ST433, and steps ST433 to ST436 are repeatedly executed.

[0114] In a case where the determination unit 212 determines in step ST436 that the joining of the threaded joint 10 is completed (step ST436: Yes), the processing proceeds to step ST437.

[0115] In step ST437, the determination unit 212 determines whether or not the clearance c between the male joint 11 and the female joint 12 is equal to or less than the predetermined value, similarly to step ST44 according to the first embodiment. In a case where the determination unit 212 determines in step ST437 that there is no portion where the clearance c between the male joint 11 and the female joint 12 is equal to or less than the predetermined value (step ST437: No), the clearance measurement step ends. In a case where the determination unit 212

determines in step ST437 that the clearance c between the male joint 11 and the female joint 12 is equal to or less than the predetermined value (step ST437: Yes), the processing proceeds to step ST438 as an interference information assignment step. In step ST438 as the interference information assignment step, the determination unit 212 sets a flag at a point where the clearance c is equal to or less than the predetermined value as an interference point. Next, the determination unit 212 stores the flag regarding the interference point as the clearance information in the clearance database 221 of the storage unit 22. Thus, the clearance measurement step ends.

[0116] According to the clearance measurement step according to the first modification example and the second modification example, it can be used in a case where it is desired to set the clearance at the manufacturing site or in a case where it is less necessary to obtain the determination result of the clearance in real time or in a short time. In particular, in the clearance measurement step according to the second modification example, it is possible to provide, to a third party, the clearance information such as a position where the clearance is equal to or less than the predetermined value and the fact that there is no portion where the clearance is equal to or less than the predetermined value. Therefore, it is easy to cope with a case where the clearance measurement step is executed at a place different from the manufacturing site.

[0117] With the measurement method of the threaded joint 10 according to the first embodiment of the present invention described above, it is possible to check the feasibility of the joining of the threaded joint 10 after the manufacture of the threaded joint 10 is completed or

before the threaded joint 10 is implemented. In addition, it has been determined whether or not the male joint 11 and the female joint 12 are rotated in the related art, but since interference between the thread crests 13a and 14a can be checked as the clearance between the threads by the information based on the measurement result, accuracy can be secured. In addition, since the measurement is started from the predetermined initial state with the joining completion state of the threaded joint 10 as the criterion, it is not necessary to search for the joining start position, furthermore, it is possible to find the interference point early, and it is possible to efficiently start the measurement of the clearance of the threaded joint 10. Furthermore, it is possible to safely and easily perform the joining check in advance at a site such as a factory regardless of the thread state such as an outer diameter, a length, and a weight. The location where the measurement method of the threaded joint 10 according to the present embodiment is used is not limited to a factory or the like, and the measurement method can also be used at a place of a construction site or the like. Specifically, for example, at a construction site, in a case where deformation of the threaded joint 10 is concerned due to the damaged caused by attachment of welding of an additional member, transportation, or the like, or excessive exposure to direct sunlight, it is possible to measure the shapes of the male joint 11 and the female joint 12 by the measurement unit 35 at a place of a construction site and to perform the joining determination before actual joining. Therefore, it is possible to minimize the occurrence of on-site work stoppages due to trouble.

[0118] (Second Embodiment)

Next, a threaded joint measurement method according to a second embodiment of the present invention will be described. FIG. 12 is a flowchart for describing a measurement method of the threaded joint 10 according to the second embodiment. In the measurement method of the threaded joint 10 according to the second embodiment, after the clearance c is determined in the entire thread circumferences of the thread crests 13a and 14a in the male joint 11 and the female joint 12, the pass/fail determination is executed for each threaded joint 10. In addition, unlike the first embodiment, step ST44 (refer to FIG. 6A) as the clearance determination step is separated as a pass/fail determination step from the clearance measurement step (step ST4).

[0119] That is, as illustrated in FIG. 12, in the measurement method of the threaded joint 10 according to the second embodiment, steps ST1 to ST4 are executed as in the first embodiment. Thereafter, instead of step ST5 according to the first embodiment, a pass/fail determination step is executed in step ST6. In addition, in the second embodiment, it is preferable to adopt the clearance measurement step according to the first modification example or the second modification example as the clearance measurement step in step ST4.

[0120] Specifically, in the pass/fail determination step in step ST6, the determination unit 212 determines the pass or fail of the joining of the threaded joint 10 based on the clearance information of the entire circumferences of the male thread 13 and the female thread 14, which is derived by the clearance calculation unit 211 executing, for example, steps ST423 and ST433 of step ST4. That is, the determination unit 212 reads and acquires the clearance information from the clearance database 221 of the storage

unit 22, and determines the pass or fail of the joining of the threaded joint 10 based on the acquired clearance information. Various criteria can be employed as the determination criterion for the pass or fail by the determination unit 212. A method similar to that in step ST44 (refer to FIG. 6A) as the clearance determination step described above can be used. Specifically, for example, it is determined whether the clearance c is equal to or less than a predetermined value. Here, the predetermined value is, for example, zero. In a case where a point where the clearance c is equal to or less than the predetermined value, that is, a point having zero or less is set as the interference point, it is possible to determine a case where the number of points is equal to or more than the preset number of points as fail, and determine a case other than that as pass. Alternatively, it is possible to adopt the determination in which a case where there is even one point having zero or less or one point flagged as the interference point is determined to be fail and a case where there is no such point is determined to be pass. That is, in the clearance measurement step according to a third modification example, the pass/fail can be determined according to the number of points where the clearance c is equal to or less than the predetermined value and the number of flags of the interference points.

[0121] In addition, in the pass/fail determination step, similarly to step ST438 according to the second modification example, a flag may be set to a point where the clearance c is equal to or less than the predetermined value that is set in advance, as the interference point based on not only the pass/fail of the threaded joint 10 but also the measured clearance c included in the clearance information. In this case, it is possible to determine a

case where the number of flags is equal to or more than a predetermined number set in advance as fail, and determine a case where the number of flags is less than the predetermined number as pass.

[0122] In a case where it is determined as pass in the pass/fail determination step (step ST6: Yes), the processing proceeds to step ST61, and it is possible to output the fact that the threaded joint 10 has passed to the input/output unit 23 and the like or transmit the fact to the outside via the communication unit 24 and the network 2. Accordingly, the threaded joint 10 determined to have passed becomes eligible for shipment. On the other hand, in a case where it is determined as fail in the pass/fail determination step (step ST6: No), the processing proceeds to step ST62. The threaded joint 10 determined to have failed can be discarded or adjusted again. In this case, the clearance information of the target threaded joint 10 can be transmitted to the thread processing devices 40 and 40A in association with the identification ID of the threaded joint as necessary.

[0123] According to the second embodiment, the same effects as those of the first embodiment can be obtained. Furthermore, according to the second embodiment, it is possible to determine the pass/fail by an external processing device via the network 2 using the clearance information and to share information on an inspection result of the threaded joint 10.

[0124] (Third Embodiment)

Next, a threaded joint measurement method according to a third embodiment of the present invention will be described. FIG. 13 is a flowchart for describing a measurement method of the threaded joint 10 according to the third embodiment. A measurement method of the threaded

joint 10 according to the third embodiment is a method of executing the adjustment step after performing the clearance measurement step in step ST4, unlike the first embodiment.

[0125] That is, as illustrated in FIG. 13, in the measurement method of the threaded joint 10 according to the third embodiment, steps ST1 to ST4 are executed as in the first embodiment. Thereafter, instead of step ST5 according to the first embodiment, an adjustment step is executed in step ST7. In addition, in the third embodiment, it is possible to adopt the clearance measurement step according to the first embodiment, the first modification example, or the second modification example as the clearance measurement step in step ST4.

[0126] (Adjustment step)

Next, the adjustment step in step ST7 will be described. As illustrated in FIG. 13, after the clearance measurement step, the adjustment step is executed on the threaded joint 10 which is determined to have fail based on the measured clearance c or in which an interference point is present. The adjustment step includes an adjustment step to be described later. Note that, for example, in a case where there is no output of information indicating the pass or fail in the clearance measurement step executed in the preceding stage, step ST6 (pass/fail determination step) according to the second embodiment may be executed before each adjustment step described later in step ST7.

[0127] (Adjustment Step)

Until the set of threaded joints 10 for which adjustment is needed is determined to have passed in the adjustment step for the threaded joint 10 in step ST7, the shape measurement step, the clearance measurement step, and the adjustment step can be repeatedly executed.

Furthermore, in the adjustment step, the pass/fail determination step can be executed before the adjustment step. As the adjustment step, for example, an appropriate method can be appropriately selected and adopted from the above-described methods according to the specification and purpose of the threaded joint 10.

[0128] That is, a first method in the adjustment step is a method of, in a case where there is a plurality of joining start positions of the threaded joint 10 such as a multi-start thread, changing the joining start positions virtually and executing the pass/fail determination step by the determination unit 212 to perform the pass/fail determination. Here, at the time of passing in the pass/fail determination step, the completion and start positions are marked at positions corresponding to the actual object.

[0129] Next, a second method in the adjustment step is a method of executing the pass/fail determination step again on the threaded joint 10 of which the thread shape is corrected in consideration of virtual cutting of a part of the threaded joint 10 within a range satisfying the yield strength required for the male joint 11 and the female joint 12, to perform the pass/fail determination. In a case where the interference is small, for example, it is possible to cut the actual object with a grinder or the like at the time of virtually passing in consideration of the cutting within a range of a safety factor of about 1.2. The first method and the second method described above are methods that do not require the measurement unit 35 to perform a 3D scan again.

[0130] Next, a third method in the adjustment step is a method of correcting a part of the threaded joint that is the actual object by correction by thermal deformation,

performing measurement again by the measurement unit 35, and performing the pass/fail determination step again to perform the pass/fail determination. The correction by thermal deformation is performed by welding heat, burner heating, compression or tension using a jack as necessary, or the like.

[0131] Next, a fourth method in the adjustment step is a method of newly manufacturing the threaded joint 10, performing measurement again by the measurement unit 35, and then performing the pass/fail determination step again to perform the pass/fail determination. Note that the new manufacture of the threaded joint 10 includes not only the new manufacture but also a case where the threaded joint 10 is detached from the pipes 15 and 16 and attached again in the case of the steel pipe with the joint. Note that, in a case where there is a plurality of the same threaded joints 10, the combination of the corresponding male joint and female joint can be changed to obtain the threaded joint that has passed the pass/fail determination step.

[0132] According to the third embodiment, the same effects as those of the first embodiment can be obtained. Furthermore, according to the third embodiment, since the adjustment step is provided, the threaded joint 10 can be newly adjusted to a passed product by the adjustment step.

[0133] (Fourth Embodiment)

Next, a fourth embodiment will be described. In the fourth embodiment, as the measurement system of the threaded joint, the threaded joint measurement system 1A according to the second example of the embodiment is adopted, and the clearance measurement step according to the first embodiment is adopted. In the fourth embodiment, the clearance measurement device 20A can include a fixed information processing device or a server that can

communicate with the measurement terminal 30A via the network 2. In this case, the measurement terminal 30A is configured as a terminal including an independent measurement unit 35 capable of communicating with the clearance measurement device 20A via the communication unit 34 and the network 2.

[0134] Here, the control unit 31 of the measurement terminal 30A can output the clearance information transmitted from the clearance measurement device 20A by displaying the clearance information on the input/output unit 33 or the like. Note that, as the clearance information to be displayed on the input/output unit 33, it is possible to output various kinds of information such as a result of the pass or fail of the threaded joint 10 and an enlarged display of a cross-sectional view of the interference point of the male thread 13 of the male joint 11 and the female thread 14 of the female joint 12.

[0135] In addition, the control unit 31 can select various kinds of information received from the clearance measurement device 20A via the network 2 and output the selected information from the input/output unit 33. For example, even in a case where the clearance information including both information of pass and fail is transmitted from the clearance measurement device 20A to the measurement terminal 30A, the control unit 31 can perform control so as to output the fact of fail from the input/output unit 33 only in a case where the information of fail is transmitted. Furthermore, since the measurement terminal 30A can communicate with the thread processing device 40A via the communication unit 34 and the network 2, the thread processing device 40A can supply the clearance information from the measurement terminal 30A to the thread processing device 40A via the clearance measurement device

20A to correct the interference point.

[0136] (Fifth Embodiment)

Next, a fifth embodiment will be described. In the fifth embodiment, as the measurement system of the threaded joint, the threaded joint measurement system 1A according to the second example of the embodiment is adopted. In addition, as the measurement method of the threaded joint 10, the threaded joint measurement method according to the second embodiment illustrated in FIG. 12 is adopted. In this case, it is preferable to adopt the clearance measurement step according to the first modification example or the second modification example. In the fifth embodiment, the clearance measurement device 20 can include a fixed information processing device or a server that can communicate with the measurement terminal via the network 2. In this case, the measurement terminal 30A includes an independent terminal capable of communicating with the clearance measurement device 20 via the communication unit 34 and the network 2.

[0137] In the fifth embodiment, the control unit 31 of the measurement terminal 30A has a function similar to that of the determination unit 212 in the control unit 21 of the clearance measurement device 20A. Note that processing similar to that of the determination unit 212 of the clearance measurement device 20A may be executable by communication with the clearance measurement device 20A. In this case, the control unit 31 of the measurement terminal 30A can execute the joining determination step in step ST6 illustrated in FIG. 12 based on the clearance information received from the clearance measurement device 20A.

[0138] In the fourth and fifth embodiments, since the measurement terminal 30A can be used independently, the

measurement and the pass/fail determination of the threaded joint 10 can be executed at various sites.

[0139] Although the embodiments of the present invention have been specifically described above, the present invention is not limited to the above-described embodiments, and various modifications based on the technical idea of the present invention are possible. For example, the numerical values and materials mentioned in the above-described embodiments are merely examples, and numerical values and materials different from these may be used as necessary.

[0140] For example, in each of the above-described embodiments and modification examples, the determination unit 212 performs determination based on whether the clearance c between the male thread 13 of the male joint 11 and the female thread 14 of the female joint 12 is equal to or less than the predetermined value as the predetermined criterion, but the invention is not limited thereto, and the determination may be performed based on whether the clearance c is less than the predetermined value as the predetermined criterion. Similarly, "Yes" and "No" in step ST44 or step ST437 may be interchanged based on whether or not the clearance is equal to or greater than the predetermined value or exceeds the predetermined value as the predetermined criterion. Even in these cases, the predetermined value can be set to a value of zero or more.

[0141] For example, in the threaded joint measurement method according to the above-described embodiments, the processing can be performed manually or automatically using shape measurement software applied to a handheld 3D scanner, high-end CAD, or the like. In a case where the processing is automatically executed, the repetitive processing such as steps ST43 to ST46 and steps ST423 to

ST426 described above can be executed using a software program by the control unit 21 of the clearance measurement device 20. As a result, it is possible to further improve the efficiency of the threaded joint measurement method.

Reference Signs List

[0142]

1, 1A threaded joint measurement system
2 network
10 threaded joint
11 male joint
12 female joint
13 male thread
13a, 14a thread crest
13b, 14b thread root
14 female thread
15 pipe
20, 20A clearance measurement device
21, 31, 41 control unit
22, 32, 42 storage unit
23, 33, 43 input/output unit
24, 34, 44 communication unit
30A measurement terminal
35 measurement unit
40, 40A thread processing device
45 thread processing unit
211 clearance calculation unit
212 determination unit
221 clearance database
222 pipe type database
311 measurement control unit
411 processing control unit

CLAIMS

1. A clearance measurement method for measuring, for a set of threaded joints including a male joint and a female joint corresponding to the male joint, a clearance between a thread of the male joint and a thread of the female joint, the method comprising:

an initial state setting step of setting an initial state of the male joint and the female joint based on data on a thread shape of each of the male joint and the female joint;

a clearance measurement step of measuring the clearance between the thread of the male joint and the thread of the female joint corresponding to the thread of the male joint in the initial state; and

a rotation state setting step of setting a state rotated by a predetermined angle in a direction in which joining is performed in a case where the joining between the male joint and the female joint is not completed after the clearance measurement step, wherein

processing from the clearance measurement step to the rotation state setting step is repeatedly executed until the joining is completed.

2. The clearance measurement method according to claim 1, further comprising at least one of:

a step of determining pass or fail regarding the set of the threaded joints based on the clearance measured in the clearance measurement step and a predetermined criterion; and

an interference information assignment step of assigning information on an interference point to a point that is determined to be the interference point based on the clearance measured in the clearance measurement step

and the predetermined criterion.

3. A threaded joint measurement method comprising:

a shape measurement step of measuring, for a set of threaded joints including a male joint and a female joint corresponding to the male joint, each of a thread shape of the male joint and a thread shape of the female joint; and

a clearance measurement step of measuring a clearance for each set of the threaded joints using the clearance measurement method according to claim 1 or 2 based on data on the thread shape measured in the shape measurement step.

4. A threaded joint manufacturing method for manufacturing a set of threaded joints including a male joint and a female joint corresponding to the male joint, the threaded joint manufacturing method comprising:

a joint manufacturing step of manufacturing the threaded joint; and

a joint measurement step of executing the threaded joint measurement method according to claim 3 on the set of the threaded joints including the male joint and the female joint manufactured by the joint manufacturing step.

5. A threaded joint quality management method for managing a quality of a set of threaded joints including a male joint and a female joint corresponding to the male joint, the threaded joint quality management method comprising:

a joint manufacturing step of manufacturing the threaded joint;

a joint measurement step of measuring, for the set of the threaded joints manufactured by the joint manufacturing step, a thread shape of the threaded joint using the

threaded joint measurement method according to claim 3; and

a quality management step of managing the quality of the manufactured threaded joint using a result obtained from the joint measurement step.

6. A clearance measurement device for measuring, for a set of threaded joints including a male joint and a female joint corresponding to the male joint, a clearance between a thread of the male joint and a thread of the female joint, the clearance measurement device comprising:

a control unit configured to repeatedly execute processing until joining is completed, the processing including

joining completion state setting processing of setting a joining completion state in which the joining between the male joint and the female joint is completed based on data on a thread shape of each of the male joint and the female joint, and

rotation state setting processing of measuring the clearance between the thread of the male joint and the thread of the female joint corresponding to the thread of the male joint in the joining completion state and then setting a state rotated by a predetermined angle in a direction in which the joining is performed in a case where the joining between the male joint and the female joint is not completed.

7. The clearance measurement device according to claim 6, wherein the control unit is configured to execute clearance measurement step of measuring the clearance between the thread of the male joint and the thread of the female joint corresponding to the thread of the male joint in the initial state before the rotation state setting processing.

8. The clearance measurement device according to claim 6, further comprising:

a communication unit, wherein

the communication unit is configured to execute, by the control unit, at least one of acquisition processing of data on the thread shape of each of the male joint and the female joint and output processing of information regarding the clearance obtained by the clearance measurement step.

9. A threaded joint measurement system comprising:

a measurement unit configured to measure, for a set of threaded joints including a male joint and a female joint corresponding to the male joint, each of a thread shape of the male joint and a thread shape of the female joint; and

the clearance measurement device according to any one of claims 6 to 8 configured to measure a clearance for each set of the threaded joints based on data on the thread shape measured by the measurement unit.

10. A measurement terminal configured to measure, for a set of threaded joints including a male joint and a female joint corresponding to the male joint, a clearance between a thread of the male joint and a thread of the female joint and controlled by a control unit, the measurement terminal comprising:

a measurement unit configured to measure each of a thread shape of the male joint and a thread shape of the female joint by control of the control unit;

a communication unit configured to execute, by control of the control unit, at least one of output processing of outputting the measured thread shape as data to the clearance measurement device according to any one of claims

6 to 8 and acquisition processing of acquiring information regarding the clearance for each set of the threaded joints from the clearance measurement device; and

an output unit configured to output the acquired information in a predetermined format by control of the control unit.

11. The measurement terminal according to claim 10, wherein the control unit is configured to execute at least one of:

processing of determining pass or fail regarding the set of the threaded joints based on the acquired information regarding the clearance and a predetermined criterion; and

interference information assignment processing of assigning information on an interference point to a point that is determined to be the interference point based on the acquired information regarding the clearance and the predetermined criterion.

12. A threaded joint measurement system comprising:

the measurement terminal according to claim 10; and

the clearance measurement device according to any one of claims 6 to 8 configured to measure a clearance for each set of the threaded joints based on data on a thread shape measured by the measurement terminal.

13. A threaded joint quality management method for managing a quality of a threaded joint for a set of threaded joints including a male joint and a female joint corresponding to the male joint, the threaded joint quality management method comprising:

managing the quality of the set of the threaded joints

using information regarding a clearance obtained from the clearance measurement step executed by the control unit of the clearance measurement device according to any one of claims 6 to 8.