

FASTENING STRUCTURE AND FASTENING METHOD

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to a structure and method for fastening first and second components to each other.

DESCRIPTION OF THE BACKGROUND ART

[0002] In recent years, some devices such as drum type washing machines, solar power generators, natural refrigerant heat pump water heaters (EcoCute®) have been gaining popularity in households. However, these devices have a problem that the vibration during the operation would generate looseness of the bolt-and-nut joining inside and outside the devices, resulting in inducing the falling of bolts and nuts, or, just in case, the fall accident of devices.

[0003] As to measures against looseness of joints, it was proposed in Patent Document 1 that adhesive is applied to clearance in a joint, and it was proposed in Patent Document 2 that adhesive is applied to surfaces to mutually contact between a bolt or nut and objects to be fastened to each other.

[0004] There has been a problem, however, of: the unevenness in amount of adhesive manually applied to a joint clearance; and the deterioration of adhesive over time in such a joint clearance.

[0005] As a joining method free of problems such as unevenness in amount of adhesive and deterioration of adhesive over time, a method of swaging a collar to locking grooves of a pin, through the use of a two-piece swage type fastener containing such pin and collar, was proposed in Patent Document 3 and Non-Patent Document 1.

[0006] The pin, described in Patent Document 3 and Non-Patent Document 1, has a groove area to be swaged with the collar by exerting a relative force in an axial direction between the pin and collar, through the use of a tool, so that such components could be mutually joined. High levels of strength and resistance to vibration have, therefore, been provided.

[0007] (Prior Art Document)
(Patent Document)

Patent Document 1: Japanese Patent Application Publication No. H6-294419

Patent Document 2: Japanese Patent Application Publication No. 2005-315363

Patent Document 3: Japanese Patent No. 4686130

(Non-Patent Document)

Non-Patent Document 1: Alcoa Fastening Systems, Business Operation, "The Unshakable World of Huck Fastening Systems" at <http://www.asia.afshuck.net/jp/Fasteners.html> (visited on January 4, 2017).

[0008] (Problem to be solved)

The pin described in Patent Document 3 and Non-Patent Document 1 requests that objects to be joined be perforated with preparatory holes for inserting the pin through such objects (see preparatory holes (614a, 614b) in FIG. 17A), which places restrictions on the objects to be joined. The problem will be explained more specifically below with reference to FIGS. 18 to 20.

[0009] FIG. 18 depicts an explanatory view for explaining a method for fastening two components (416a, 416b) to each other, through the use of the pin and collar described in Patent Document 3 or Non-Patent Document 1. In this method, there have been needed the steps of: perforating one component (416a) with a preparatory hole (616a) and perforating the other component (416b) with another preparatory hole (616b); stacking the two components (416a, 416b) such that the two preparatory holes (616a, 616b) are aligned with a conventional pin (2), respectively, and inserting the conventional pin (2) into such aligned preparatory holes (616a, 616b) in a direction from an upper side of the preparatory hole (616a) to a lower side of the preparatory hole (616b); fitting a collar (304) around an axis-portion of the conventional pin (2) in an opposite direction of the conventional pin (2) being inserted through the preparatory holes (616a, 616b); and thereafter, fitting the collar (304) securely onto the axis-portion of the conventional pin (2) by swaging together through the use of a tool (not shown). If the conventional pin (2) attempts to be inserted into the preparatory hole (616b) from a lower side, there have been probabilities that the components (416) would be separated apart before completion of secure fixing of the collar (304).

[0010] FIG. 19 depicts an explanatory view for a case of fastening: an H-shaped steel component (400a); and a U-shaped (C-shaped cross-section) steel component or part member (400b), to each other, in such a manner that their respective centerlines are aligned with each other. The U-shaped component or part member (400b) allows to be perforated with a preparatory hole (600) on the centerline; however, the H-shaped component (400a) does not allow to be perforated with a preparatory hole on the centerline due to its own web is formed on the same centerline. For this reason, such a fastening structure could not be realized.

[0011] FIG. 20 depicts an explanatory view for a case of fastening: a metal pipe (400a); and a U-shaped (C-shaped cross-section) steel component or part member (400b), to each other, in such a manner that their respective centerlines are aligned with each other. The metal pipe (400a) allows to be performed with a preparatory hole (600a). There have been some probabilities, however, that, after having aligned the two preparatory holes (600a, 600b) with each other, it would be difficult to insert the conventional pin (2) from a lower side of the preparatory hole (600a) to the upper side of the preparatory hole (600b) if the metal pipe (400a) is long and its insertion point is positioned far from its ends.

[0012] In addition to the above-described restrictions placed on the objects to be joined, there are other problems that, as a result of perforating objects to be joined with a preparatory hole for inserting a pin in advance, water leakage and sound leakage from the preparatory hole would be generated, and level of strength would decrease due to a localized area around the preparatory hole. There are further problems in long-length of components that labor and cost would increase for perforating such components with a

large number of pairs of preparatory holes (see FIGS. 21 to 24). There is a still further problem that one-point fastening by perforating the components with one preparatory hole would cause the components to rotate with respect to the pin.

[0013] Furthermore, the pins in Patent Document 3 and Non-Patent Document 1 would not be suitable for arranging a plurality of fastened products such that their respective pins face each other due to the mutual interference between pinheads (see FIG. 25). This is the case, when e.g. installing a natural refrigerant heat pump water heater or an air conditioner outdoor unit.

SUMMARY OF THE INVENTION

[0014] In view of the above-described problems, there is provided the present invention whose objective is to provide a fastening member, when fastening a plurality of components, capable of: ensuring a high degree of freedom in terms of fastening positions and objects to be fastened; reducing the number of preparatory holes; and preventing the components from rotating with respect to the fastening member in one-point fastening, and, after fastening the plurality of components, capable of maintaining high levels of strength and resistance to vibration.

[0015] (Means for Solving Problems)

[1] The present invention provides a fastening structure comprising: a first component; a pin having a plurality of non-helical groove portions formed respectively on a periphery thereof in a circumferential direction and aligned along a longitudinal direction, the pin having one end in the longitudinal direction fitted securely to the first component, and thereby the pin is bonded to the first component; a second component having an insertion hole configured to allow the pin to be inserted therein; and a collar configured to be fitted around the pin and to be fitted securely onto the pin such that the second component is positioned between the collar and the first component, wherein said fastening structure for fastening the first and second components to each other is configured such that the second component is prevented from rotating with respect to the pin.

[0016] The fastening structure according to the present invention comprises a pin and a collar configured to cover the pin to fasten the first and second components to each other. The axis-portion of the pin has a plurality of groove portions formed in a circumferential direction, and the plurality of groove portions do not have a helical structure. The adjacent pair of such a plurality of groove portions are not connected with each other (i.e., formed non-helically), and the axis-portion of such a pin is different from that of a conventional screw/bolt with a helical groove formed continuously (i.e., a helically-formed groove) in a longitudinal direction. Conventionally, a single groove continues from a distal end to pinhead of the pin of a helical structure. On the other hand, the pin according to the present invention of a non-helical structure has the plurality of groove portions in independent lanes, respectively, of which the adjacent pair are not connected with each other (not continuing to or from each other). According to the groove portions of such a structure, after having engaged the pin with the collar, which will be described later, the engaged pin and collar could be free from a risk of looseness to be generated for an ordinary screw in a direction opposite to a screw direction, even at a high level of vibrating place.

[0017] One end of both ends of the pin opposite to each other in a longitudinal direction thereof according to the present invention has a securely-fitting portion (tip) instead of a head portion (pinhead portion) included typically in an ordinary bolt or the like. The securely-fitting includes, e.g., weld-fitting or the like. For fastening the first and second components together, as an initial step, the securely-fitting portion of the pin is fitted securely to a part (area to be fastened with the second component) of the first component by welding or the like, and the second component is positioned with respect to the pin in such a manner that an insertion hole formed in advance in the second component allows the other end (opposite end to the end welded to the first component) of the pin to be inserted therinto. As a next step, the collar is fitted around the groove portions of the pin protruding through the insertion hole of the second component. Subsequently, the collar is reduced in diameter in such a manner that an inner wall of the collar is engaged with the groove portions of the pin. As a result, the first and second components are fastened together through the use of the above-described pin. It is to be noted, in this specification, that "welding" will occasionally be described as being indicative of "securely-fitting."

[0018] The pin welded to the first component inserted via the insertion hole into the second component as described above does not rotate with respect to the second component. As a result, the components to be fastened (first and second components) and a fastening member (the pin and collar), even after having fastened the components through the use of the fastening member, never rotate with respect to each other or loosen the pin due to vibration or the like.

[0019] "A plurality of non-helical groove portions formed respectively on a periphery of the pin in a circumferential direction and aligned along a longitudinal direction" is described as being indicative of "a plurality of non-helical grooves, each of which is substantially concentric with a central axis of the pin and is formed on a periphery of the pin in a circumferential direction." "Not rotating" is described as indicating that the pin welded to the first component in a state of being inserted via the insertion hole into the second component could not rotate to be screwed into (or loosened from) the insertion hole of the second component. This could be realized by a configuration that: the pin welded to the first component could never be screwed into the first component; and, unlike an ordinary screw, the pin has a non-circular shape in axial cross-section, more specifically, has a polygonal e.g. quadrangular shape in axial cross-section as well as one of the components to be fastened (second component) is perforated with the corresponding hole to such a shape. In this specification, "axial cross-section" is described as being indicative of cross-section perpendicular to an axial direction of the pin.

[0020] According to the foregoing, the components to be fastened and the fastening member could be prevented from being loosened and rotating with respect to each other, due to vibration or the like, after having fastened the components through the use of the fastening member.

[0021] In the present invention, the pin is fitted securely to the first component, and therefore, there is no need at least to perforate the first component with a preparatory hole. Accordingly, the components to be fastened (first and second components) could

be fastened together, through the use of the pin according to the present invention, even at an area having difficulty in being perforated with a preparatory hole.

[0022] Furthermore, unlike a conventional bolt, the pin according to the present invention does not have a pinhead portion; however, it could be used as a pin integrated with the component to be fastened (first component) as a result of being fitted securely to the first component. Therefore, as long as the component to be fastened is that capable of being fitted securely with the pin, fastening could be achieved between: the first component not needed to be perforated with an insertion hole; and the second component perforated with the corresponding insertion hole to the pin, according to the present invention.

[0023] [2] In the fastening structure of the above [1], a part or entirety of a portion of the pin positioned at least inside the insertion hole of the second component has a non-circular shape in cross-section along a direction crossing the longitudinal direction.

[0024] The axial cross-section of the pin according to the present invention has a shape designed to prevent the pin, inserted into the insertion hole of the component to be fastened, from rotating inside such an insertion hole. The "shape designed to prevent the rotation inside the insertion hole" is described as indicating that the maximum diameter of the axial cross-section of the pin is greater than the minimum diameter of the insertion hole, which prevents the pin from rotating inside the insertion hole. The axial cross-section of the pin and the insertion hole of the component both have such a non-circular and substantially congruent shape, e.g., that the pin is allowed to be inserted into the insertion hole. The "non-circular shape" is described as being indicative of, e.g., "angular shape" that may include a curved segment and should include at least a straight-line segment. More specifically, the axial cross-section of the pin and the insertion hole of the component both may not have circular shapes but have substantially congruent quadrangular shapes. It is to be noted that a "cross-section along a direction crossing a longitudinal direction" is described as being indicative of "axial cross-section" (i.e., cross-section along a direction perpendicular to an axial direction of the pin).

[0025] [3] The present invention provides a fastening method for fastening first and second components to each other, the fastening method comprising the steps of: integrating a pin and the first component with each other by fitting one end of the pin in a longitudinal direction securely to the first component, wherein the pin has a plurality of non-helical groove portions formed in a circumferential direction and aligned along the longitudinal direction, and has a non-circular longitudinal portion in a non-circular shape in cross-section along a direction crossing the longitudinal direction; positioning the second component with respect to the non-circular longitudinal portion of the pin integrated with the first component, in such a manner that an insertion hole of the second component allows the pin to be inserted therein from the other end of the pin in the longitudinal direction, and is fitted around the non-circular longitudinal portion; and fitting a collar around the pin, from the other end of the pin inserted into the insertion hole of the second component, so as to fit the collar securely onto the pin.

[0026] In the fastening of the first and second components together, by the method according to the present invention, the pin is integrated with one component out of the

first and second components as a result of fitting the pin securely to the one component, and the other component perforated with the insertion hole is positioned in a state that the pin is inserted into the insertion hole. In such a state, the other component and the inserted pin are not allowed to rotate with respect to each other. Furthermore, the collar is fitted around the other end (opposite end to the securely fitted one end) of the pin in the longitudinal direction, and subsequently, the pin is swaged with the collar. As a result, the components to be fastened (first and second components) and the pin could be prevented from rotating with respect to each other, while they could be maintained at high levels of strength and resistance to vibration.

[0027] In the selection of one component to be fitted securely with the pin from the components to be fastened (first or second components), it is preferred that the pin be fitted securely to one having more difficulty, due to e.g. an annular-shape cross-section component or the like, than the other, in being perforated with an insertion hole so as to be inserted with the pin via the insertion hole at a side, as well as, being swaged with the collar at a side opposite to the side inserted with the pin.

[0028] It is to be noted, in similar to the above [1], that "a plurality of non-helical groove portions formed respectively on a periphery of the pin in a circumferential direction and aligned along a longitudinal direction" is described as being indicative of "a plurality of non-helical grooves, each of which is substantially concentric with a central axis of the pin and is formed on a periphery of the pin in a circumferential direction." Furthermore, it is to be noted, in similar to the above [2], that a "cross-section along a direction crossing a longitudinal direction" is described as being indicative of "axial cross-section" (i.e., cross-section along a direction perpendicular to an axial direction of the pin).

[0029] (Advantageous Effects of the Invention)

According to the present invention, there could be provided a fastening member, when fastening the first and second components, capable of: ensuring a high degree of freedom in terms of fastening positions and objects to be fastened; reducing the number of preparatory holes; and preventing the components from rotating with respect to the fastening member in one-point fastening, and, after fastening the plurality of components, capable of maintaining high levels of strength and resistance to vibration.

[0030] When fastening the first and second components together in particular, in the widely adopted method of two-point fastening through the use of bolts and nuts, the first and second components both need to be perforated with four preparatory holes in total. In contrast, according to the fastening method of the present invention, the perforation of the second component with only one preparatory hole is sufficient for fastening. Such a drastic reduction in the number of the preparatory holes to one-fourth is advantageous effects of significant impact, achieved by the fastening member and method according to the present invention.

BRIEF DESCRIPTIONS OF THE DRAWINGS

[0031] For more thorough understanding of the present invention and advantages thereof, the following descriptions should be read in conjunction with the accompanying drawings in which:

FIG. 1 depicts a view of a fastening member (a pin and collar) in an embodiment

according to the present invention.

FIG. 2 depicts a perspective view of the fastening member (the pin and collar) in an embodiment according to the present invention.

FIG. 3 depicts a view showing schematically the steps of fastening components to be fastened, through the use of a fastening member, in an embodiment according to the present invention.

FIG. 4 depicts another view showing schematically the steps (subsequent to the steps in FIG. 3) of fastening the components to be fastened, through the use of the fastening member, in an embodiment according to the present invention.

FIG. 5 depicts a view of a fastening structure in an embodiment according to the present invention.

FIG. 6 depicts a view of another fastening structure in an embodiment according to the present invention.

FIG. 7 depicts a view of an example obtained by a fastening method, through the use of pins, in an embodiment according to the present invention.

FIG. 8 depicts an enlarged view of a part X in FIG. 7 indicated by a circle made in a dotted dashed line.

FIG. 9 depicts a view of a plurality of pins weld-fitted securely to a first component to be fastened.

FIG. 10 depicts another view of a plurality of pins weld-fitted securely to another first component to be fastened.

FIG. 11 depicts a view of a fastening structure in an embodiment according to the present invention.

FIG. 12 depicts a view of a modified example of a pin in an embodiment according to the present invention.

FIG. 13 depicts another view of another modified example of a pin in an embodiment according to the present invention.

FIG. 14 depicts a view of other plurality of modified examples of a securely-fitting portion of a pin in an embodiment according to the present invention.

FIG. 15 depicts a view of a plurality of modified examples of a pin in an embodiment according to the present invention.

FIG. 16 depicts a view of a plurality of modified examples of a collar in an embodiment according to the present invention.

FIG. 17 depicts a schematic view showing the steps of fastening components to be fastened, through the use of a conventional fastening member.

FIG. 18 depicts a schematic view of the fastening of components to be fastened through the use of a conventional pin.

FIG. 19 depicts a schematic view showing a problem in fastening components to be fastened through the use of a conventional pin.

FIG. 20 depicts another schematic view showing another problem in fastening components to be fastened through the use of a conventional pin.

FIG. 21 depicts a view of a component perforated with preparatory holes for using conventional pins.

FIG. 22 depicts another view of another component perforated with preparatory holes for using conventional pins.

FIG. 23 depicts a schematic view showing a two-point fastening through the use of conventional pins.

FIG. 24 depicts an enlarged view of a part Y in FIG. 23 indicated by a circle made

in a dotted dashed line.

FIG. 25 depicts still another schematic view showing still another problem in fastening components to be fastened through the use of a conventional pin.

DESCRIPTIONS OF EMBODIMENTS OF THE INVENTION

[0032] An explanation of a fastening member (1) in an embodiment of the present invention will be provided below, with reference to FIGS. 1, 2. As shown in FIG. 1, the fastening member (1) includes a pin (10) and a collar (30). The pin (10) has a securely-fitting portion (12) and an axis-portion (14). The securely-fitting portion (12) in a cone shape has a protrusion formed on a top of the cone shape. The securely-fitting portion (12) serves as a tip for welding, and for this reason, it is not particularly restricted on a shape thereof (which will be described in detail later). The axis-portion (14) has at least a plurality of groove portions (18) and a distal-end ridge portion (20). It is to be noted that the distal-end ridge portion (20) is formed with a part of the groove portions (18), which corresponds to approximately three ridges at the distal end. A method of fastening components to be fastened (4) together through the use of the pin (10) and the collar (30) will be described later.

[0033] FIG. 2 depicts a perspective view of the fastening member (1) in an embodiment according to the present invention. More specifically, FIG. 2A depicts a perspective view of the pin (10), and FIG. 2B depicts a perspective view of the collar (30). As shown in FIG. 2A, the axis-portion (14) of the pin (10), in this embodiment has a quadrangular-shaped axial cross-section.

[0034] A pillar portion (16) does not need to be formed with grooves because the pillar portion (16) is not engaged with the collar (30) which will be described later. The pillar portion (16) may be formed with some grooves from a base thereof (see FIG. 12).

[0035] Unlike an ordinary screw, the plurality of groove portions (18) in this embodiment are not helically formed. In other words, the grooves are in independent lanes, respectively, of which the adjacent pair are not connected and each has an annular shape in axial cross-section. The grooves are formed lengthwise to in the vicinity of the distal end of the axis-portion (14), in accordance with the length of the axis-portion (14).

[0036] The groove portions (18) are shaped to have adjacent pair thereof not connected with each other, and are in their respective lanes independent of each other. At least two members to be fastened (components to be fastened (4), which will be described later, in this embodiment) fastened together through the use of the fastening member (1) (the pin (10) and the collar (30)) could prevent the pin (10) from rotating in a direction opposite to a screw direction, resulting in looseness, due to vibration or the like.

[0037] The collar (30) shown in FIG. 2B has an inner wall in a quadrangular-shaped axial cross-section corresponding to the shape of the pin (10). As to a shape of the collar (30), it is sufficient if the groove portions (18) of the pin (10) could be engaged with the collar (30) having such a shape by the swaging which will be described later. Possible variations of the collar (30) will be described later (see FIG. 16).

[0038] Explanations will be provided about the steps of fastening the components to be

fastened (4), through the use of the fastening member (1), in an embodiment according to the present invention, more specifically, the steps of fastening the first and second components to be fastened (4a, 4b), through the use of the pin (10) and the collar (30), with reference to FIGS. 3, 4. For convenience of explanations, these figures show the cross-section of the components to be fastened (4) (the cross-section is simply shown without hatching or the like). It is to be noted that, in this embodiment, the first and second components to be fastened (4a, 4b) are collectively referred to as "components to be fastened (4)."

[0039] The first component to be fastened (4a) is a planar-plate component capable of being weld-connected with the securely-fitting portion (12) of the pin (10). The second component to be fastened (4b) is a planar-plate component perforated with an insertion hole (6) configured to allow the pin (10) to be inserted therein. The insertion hole (6) has the corresponding shape to the cross-section of the pin (10) (more specifically, the pillar portion (16)). The "corresponding shape" is described as indicating that, when the pin (10) is inserted into the insertion hole (6), an outer circumferential surface of the pin (10) (more specifically, the pillar portion (16)) matches an inner circumferential surface of the insertion hole (6) to such an extent that both are substantially in contact with each other.

[0040] It is to be noted that, in this embodiment, the first and second components to be fastened (4a, 4b) are planar-plate components, which is however not the sole limitation, and that those components may have a planar-plate part which allows welding or insertion with the pin (10), or that those components may have a part so shaped, without any planar-plate part, as to allow welding or insertion with the pin (10).

[0041] Firstly, as shown in FIG. 3A, the pin (10) is welded to a fixation position (5) of the first component to be fastened (4a). In this embodiment, the securely-fitting portion (12) of the pin (10) is directed toward and welded to the fixation position (5) of the first component to be fastened (4a) such that the axis-portion (14) of the pin (10) stands in an upright position in substantially a vertical direction to a surface of the component to be fastened (4a). It is to be noted that the fixation position (5) is determined in accordance with a part at which the first and second components to be fastened (4a, 4b) are fastened together. The welding is performed by momentary energization through the use of an instant welding machine (not shown) such as a stud welding machine.

[0042] As shown in FIG. 3B, the pin (10) is integrated with the first component to be fastened (4a) by welding the securely-fitting portion (12) to the fixation position (5) such that the axis-portion (14) of the pin (10) stands in an upright position in substantially a vertical direction to the surface of the first component to be fastened (4a), and the second component to be fastened (4b) is positioned in such a manner that the axis-portion (14) of the pin (10) is inserted into the insertion hole (6) of the second component to be fastened (4b).

[0043] An important point is a shape of the insertion hole (6) of the second component to be fastened (4b) for preventing a relative rotation of the second component to be fastened (4b) and the pin (10) with respect to each other. If the minimum distance from the center of the insertion hole (6) to the inner circumferential surface of the insertion

hole (6) is greater than the maximum distance from the center of the axis-portion (14) of the pin (10) to the outer circumferential surface of the axis-portion (14) of the pin (10), for example, even by fastening the first and second components to be fastened (4a, 4b) through the use of the pin (10) and the collar (30), there are probabilities that the second component to be fastened (4b) would rotate with respect to the pin (10) (i.e., the first component to be fastened (4a)).

[0044] In contrast, it is preferred that the insertion hole (6) correspond in shape to the pillar portion (16), as described above. There may be a clearance (e.g., 0 to 2.0 mm) between the pin (10) and the insertion hole (6) to such an extent that the pin (10) inserted into the insertion hole (6) does not rotate. In other words, an idle rotation of the second component to be fastened (4b) with respect to the pin (10) may be prevented, when the pin (10) is inserted into the second component to be fastened (4b).

[0045] Secondary, when the pin (10) is inserted into the insertion hole (6) of the second component to be fastened (4b), the collar (30) is fitted around the groove portions (18) protruding through the second component to be fastened (4b), as shown in FIGS. 3C, 4D. An inner wall of the collar (30), at this timing, does not have anything like concave-convex structures having been engaged with the groove portions (18). In other words, in a state that the collar (30) is merely fitted around the groove portion (18), it is allowed to come off the pin (10).

[0046] FIGS. 4E to 4G depicts an explanatory view of the swaging of the collar (30). For convenience of explanations, FIGS. 4E to 4G partially show the cross-section of the insertion hole (6) and the collar (30) (the cross-section is simply shown without hatching or the like). The swaging tool is not shown in detail.

[0047] As an example of an installation tool for swaging, BobTail® (Alcoa Fastening Systems, USA) is used. The installation tool (40) has a grabber (not shown) for grabbing the distal-end ridge portion (20) of the pin (10) so as dragging it to a side of the installation tool (40). As a result of such operations, the pin (10) is elongated.

[0048] As shown in FIG. 4F, a swaging anvil (not shown) wraps around the collar (30) and swages it in a direction of the groove portions (18) of the pin (10) (inward). As a result of such operations, a gap between the collar (30) and the pin (10) is closed, and the collar (30) is swaged to the pin (10) such that the groove portions (18) of the pin (10) bite into the inner wall of the collar (30) (swaging). By such a swaging operation, the collar (30) is reduced in diameter. The collar (30) is deformed to be thinner in diameter and longer in length, and the pin (10) is elongated as described above, thereby generating an axial force in the fastening member (1).

[0049] After finalizing swaging the collar (30) to the pin (10) through the use of the installation tool (40) (see an enlarged view of FIG. 4G), the installation tool (40) is taken off the pin (10), as shown in FIG. 4G. Through the steps described above, the fastening of the first and second components to be fastened (4a, 4b) through the use of the pin (10) and the collar (30) is completed.

[0050] As explained above, the pin (10) is integrated with the first component to be

fastened (4a) by welding the pin (10) to the first component to be fastened (4a) in this embodiment. Accordingly, only one of the components to be fastened (4) (the second component to be fastened (4b) in this embodiment) perforated with a preparatory hole (the insertion hole (6)) is sufficient. Further, the pin (10) (i.e., the first component to be fastened (4a)) inserted into the insertion hole (6) could be prevented from rotating with respect to the second component to be fastened (4b). Still further, after the pin (10) is engaged with the collar (30), the non-helical structure of the groove portions (18) of the pin (10) could prevent the pin (10) from looseness to be generated for an ordinary screw. Still further, the swaging of the collar (30) to the pin (10) allows the firm fixation to be maintained even at a high level of vibrating place.

[0051] An embodiment according to the present invention provides a fastening structure including: a first component to be fastened (4a) (first component); a pin (10) having a plurality of non-helical groove portions formed respectively on a periphery thereof in a circumferential direction and aligned along a longitudinal direction, the pin (10) having one end in the longitudinal direction fitted securely to the first component to be fastened (4a) (first component), and thereby the pin (10) is bonded to the first component to be fastened (4a) (first component); a second component to be fastened (4b) (second component) having an insertion hole (6) configured to allow the pin (10) to be inserted thereinto; and a collar (30) configured to be fitted around the pin (10) and to be fitted securely onto the pin (10) such that the second component to be fastened (4b) (second component) is positioned between the collar (30) and the first component to be fastened (4a) (first component), wherein said fastening structure for fastening the first component to be fastened (4a) (first component) and the second component to be fastened (4b) (second component) to each other is configured such that the second component to be fastened (4b) (second component) is prevented from rotating with respect to the pin (10).

[0052] Furthermore, a part or entirety of a portion of the above-described pin (10), in another embodiment according to the present invention, positioned at least inside the insertion hole (6) of the second component to be fastened (4b) (second component) has a non-circular shape in cross-section along a direction crossing the longitudinal direction.

[0053] According to the fastening structure, the first component to be fastened (4a) (the pin (10)) and the second component to be fastened (4b) could be prevented from rotating with respect to each other, after having been fastened together. As a result, there is no need for two-point fastening.

[0054] Even by one-point fastening of the first component to be fastened (4a) and the second component to be fastened (4b) through the use of the pin (10) and the collar (30), the first and second components to be fastened (4a, 4b) could be prevented from rotating with respect to each other. The looseness of the pin (10) is not generated with respect to the components to be fastened (4), and therefore, the firm fixation is allowed to be maintained between the first component to be fastened (4a) and the second component to be fastened (4b) after having been fastened together.

[0055] It is to be noted that, not to mention, the above-described fastening structure could not only be applied to fastening between two components to be fastened (the first and second components to be fastened (4a, 4b) in this embodiment) but also be applied

to fastening among three components to be fastened.

[0056] An embodiment according to the present invention provides a fastening method for fastening a first component to be fastened (4a) (first component) and a second component to be fastened (4b) (second component) to each other, including the steps of: integrating a pin (10) and the first component to be fastened (4a) (first component) with each other by fitting one end of the pin (10) in a longitudinal direction securely to the first component to be fastened (4a) (first component), wherein the pin (10) has a plurality of non-helical groove portions formed in a circumferential direction and aligned along the longitudinal direction, and has a non-circular longitudinal portion (pillar portion (16)) in a non-circular shape in cross-section along a direction crossing the longitudinal direction; positioning the second component to be fastened (4b) (second component) with respect to the non-circular longitudinal portion (pillar portion (16)) of the pin (10) integrated with the first component to be fastened (4a) (first component), in such a manner that an insertion hole (6) of the second component to be fastened (4b) (second component) allows the pin (10) to be inserted therein from the other end of the pin (10) in the longitudinal direction, and is fitted around the non-circular longitudinal portion (pillar portion (16)); and fitting a collar (30) around the pin (10), from the other end of the pin (10) inserted into the insertion hole (6) of the second component to be fastened (4b) (second component), so as to fit the collar (30) securely onto the pin (10).

[0057] According to the fastening method, as a result of integrating the first component to be fastened (4a) and the pin (10) with each other, the perforation of only the second component to be fastened (4b) with an insertion hole (6) (preparatory hole) is sufficient. This could reduce labor for forming preparatory holes, and prevent cost increase and strength deterioration due to the forming of preparatory holes. Even by one-point fastening of the first component to be fastened (4a) and the second component to be fastened (4b) through the use of the pin (10) and the collar (30), the first and second components to be fastened (4a, 4b) could be prevented from rotating with respect to each other.

[0058] FIGS. 5 to 8 show examples of the fastening method for fastening the first component to be fastened and the second component to be fastened through the use of the pin (10) and the collar (30) in this embodiment. In FIG. 5, an example of the fastening is provided in a case where: an H-shaped steel component is used as the first component to be fastened (400a); and a U-shaped (C-shaped cross-section) steel component or part member is used as the second component to be fastened (400b). As shown in FIG. 5, the first and second components to be fastened (400a, 400b) could be fastened together through the use of the pin (10) and the collar (30) in an embodiment according to the present invention, without perforating the first component to be fastened (400a) (H-shaped steel component) with a preparatory hole (insertion hole) on the center of the first component to be fastened (400a).

[0059] In FIG. 6, an example of the fastening is provided in a case where: a metal pipe is used as the first component to be fastened (402a); and a U-shaped (C-shaped cross-section) steel component is used as the second component to be fastened (402b). As shown in FIG. 6, the first component to be fastened (402a) (metal pipe with a closed cross-section) and the second component to be fastened (402b) (U-shaped steel

component) could be fastened together through the use of the pin (10) and the collar (30) in an embodiment according to the present invention.

[0060] In FIG. 7, an example of the fastening is provided in a case where a one-point fastening of components, and FIG. 8 depicts an enlarged view of a part X to be fastened in FIG. 7 (an area surrounded by a dotted dashed line) in FIG. 7. In FIGS. 7, 8, the pin (10) having a non-circular cross-section (square cross-section in FIGS. 7, 8) is integrated with the first component to be fastened (404a) by welding the pin (10) to the first component to be fastened (404a) such that the pin (10) is positioned to be substantially perpendicular to a surface of the first component to be fastened (404a). The second component to be fastened (404b) is positioned with respect to the pin (10) in such a manner that the pin (10) is inserted into an insertion hole (60) (not shown) of the second component to be fastened (404b) having a cross-sectional shape corresponding to that of the pin (10), and subsequently, the pin (10) is swaged with the collar (30). As a result, even by one-point fastening of the first component to be fastened (404a) and the second component to be fastened (404b), the pin (10) (i.e., the first component to be fastened (404a)) and the second component to be fastened (404b) could be prevented from rotating with respect to each other, thereby capable of reducing the number of fasteners as well as construction time and cost.

[0061] FIGS. 9, 10 depict views of a plurality of pins (10) weld-fitted securely to the first component to be fastened (406a, 408a). By adopting the fastening method through the use of the pins (10) and collars (30) in this embodiment, it is made possible to determine the accurate positioning of the pins (10) not at a site for the fastening operation but in a factory in advance. It is to be noted that the pins (10) shown in FIGS. 9, 10 are similar to the above-described pins (10), and therefore, each of such pins (10) has a quadrangular cross-section along a direction crossing the longitudinal direction.

[0062] In FIG. 11, each of the pins (10), in this embodiment, is integrated with the first component to be fastened (410a) by welding the pins (10) to the first component to be fastened (410a) such that the pins (10) are positioned to be substantially perpendicular to a surface of the first component to be fastened (410a). The second component to be fastened (410b) is positioned with respect to the first component to be fastened (410a) in such a manner that the pins (10) are inserted into insertion holes (602) of the second component to be fastened (410b) each having a cross-sectional shape corresponding to that of each of the pins (10), and subsequently, the pins (10) are swaged with their respective collars (30). According to such structures, the first component to be fastened (410a) of one of fastened products (500) could have a flat surface opposite to a surface welded with the pin (10), and as a result, the other of the fastened products (500) also having such a flat surface could be arranged with respect to the one of the fastened products (500) such that the two flat surfaces are adjacent to each other as shown in FIG. 11.

[0063] (Other Embodiments)

The pin (10) in the above embodiments has an axis-portion (14) including a pillar portion (16) as shown in FIGS. 1 to 4, which is however not the sole limitation. For example, as shown in FIG. 12, the axis-portion (142) may be formed with the groove portions (182) over an entire length thereof. As a result of the groove portions (182)

being formed on the entire axis-portion (142), by the fastening method in this embodiment, even thin-plate components (e.g., with a plate thickness of 0.1 to 2.3 mm) could be fastened together.

[0064] In a state that the pin (10) is inserted into the insertion hole (6) (see FIG. 3), a portion (the groove portions (184) and the distal-end ridge portion (204) in FIG. 13) of the axis-portion (14) protruding from the first component to be fastened (4a) does not necessarily have an angular-shaped axial cross-section, but may have a non-angular shaped axial cross-section. In a state that the pin (104) is inserted into the insertion hole (6) of the second component to be fastened (4b), the rotation of the second component to be fastened (4b) with respect to the pin (104) could be prevented, as long as a portion (the pillar portion (164) or the axis-portion (144)) being in contact with the second component to be fastened (4b) via the insertion hole (6) has a quadrangular-shaped axial cross-section.

[0065] It is to be noted that the groove portions (184), in particular, of the pin (104) protruding from the first component to be fastened (4a) may have a shape, in axial cross-section, to be easily engaged with the collar (30), e.g., a circular shape in axial cross-section. The matter of concern is that the groove portions (184) are shaped so as to be engaged with the collar (30), but not any possible rotation of the second component to be fastened (4b) with respect to the pin (104).

[0066] As shown in FIG. 14, the securely-fitting portion (12) of the pin (10) may have a shape other than those shown in FIGS. 1 to 3. A shape of the securely-fitting portion (12) may be selected as a shape suitable for welding the pin (10) to the first component to be fastened (4a) through the use of an instant welding machine such as a stud welding machine (an easy-to-energize shape), and more specifically, may be selected from possible examples, 14A to 14F, as shown in FIG. 14.

[0067] In the above embodiments, the instant welding machine such as the stud welding machine is used for fitting the pin (10) securely to the first component to be fastened (4a), which is however not the sole limitation. Any method may be used as long as the pin (10) is fitted securely to the first component to be fastened (4a).

[0068] In FIGS. 1 to 4, the pin (10) has an angular shape, and more specifically, a quadrangular shape in axial cross-section, which is however not the sole limitation. As long as the pin (10) could be engaged with the collar (30) as a result of the swaging operation, the axial cross-section of the pin (10) may be in other shapes. As shown in FIG. 15, the axial cross-section of the pin (10) may be in a triangular shape (15A), pentagonal shape (15C), hexagonal shape (15D), octagonal shape (15E), and so forth. The angular shape of the axis-portion (14) of the pin (10) may include, in part, a circular shape. In other words, a shape of the pin (10) may be so designed at least as to prevent the rotation of the second component to be fastened (4b) (second component) with respect to the pin (10) in a state that the pin (10) is inserted into the insertion hole (6) (including a state after having been fastened).

[0069] Depending on the axial cross-section of the pin (10), an inner circumference of the collar (30) may be changed in shape, as shown in FIG. 16. It is to be noted that, in a

similar manner to the axis-portion (14) of the pin (10), an outer circumference of the collar (30) may be, e.g., in a triangular shape (16A), pentagonal shape (16C), hexagonal shape (16D), octagonal shape (16E), and so forth as long as no problem would occur in the swaging operation. Furthermore, as shown in 16F, the inner and outer circumferences both may be changed in shape depending on the axial cross-section of the pin (10).

[0070] The swaging method and device in the above embodiments are not only the possible choices but also other choices as long as the diameter of the collar (30) could be reduced by them. The swaging method and device may be changed depending on the shape of the collar (30). For example, an angular-shaped collar may be reduced in diameter by pressing one pair of faces opposite to each other and subsequently pressing another pair of faces opposite to each other. It is to be noted that, in this embodiment, the diameter reduction of the collar is referred to as "swaging" which expression covers other process names having the same meaning.

[0071] In the above embodiments, the first and second components to be fastened (4a, 4b) are planar-plate components, which is however not the sole limitation. More specifically, the first component to be fastened (4a) may include a planar-plate part, and the second component to be fastened (4b) may include a planar-plate part or part member (small parts). One of the first and second components to be fastened (4a, 4b) may have a part so shaped as to allow the securely fixing (welding) with the pin (10), and the other may have a part so shaped as to be perforated with the insertion hole (6).

[0072] In the fastening method in an embodiment according to the present invention, more specifically, in the method for fastening the first and second components to be fastened (4a, 4b) through the use of the pin (10) and the collar (30), steps different in order from the above-described steps may be adopted. For example, in the above embodiments, the first and second components to be fastened (4a, 4b) are to be gaplessly fastened, and for this purpose, the swaging of the collar (30) should be performed in the final step. If the first and second components to be fastened (4a, 4b) are to be fastened, with some allowance for a gap, together, the swaging of the collar (30) may be performed, before the pin (10) is inserted into the insertion hole (6) of the second component to be fastened (4b) and the securely-fitting portion (12) of the pin (10) is fitted securely (welded or the like) to the first component to be fastened (4a).

[0073] (Industrial Applicability)

The present invention is applicable to fastening members in various industries such as electric machines, automobiles, homes, railways, furniture (racks).

[0074] (Reference Numerals)

1	Fastening member
2	Conventional pin
4a	First component to be fastened
400a, 402a, 404a, 406a, 408a, 410a, 412a, 414a	First component to be fastened
416a	First component to be fastened
4b	Second component to be fastened
400b, 402b, 404b, 406b, 408b, 410b, 412b, 414b	Second component to be fastened
416b	Second component to be fastened

5	Fixation position
6, 60, 602	Insertion hole
10	Pin
12, 112, 122, 124	Securely-fitting portion
14, 142, 144	Axis-portion
16, 164	Pillar portion
18, 182, 184	Groove portion
20, 202, 204	Distal-end ridge portion
30, 304	Collar
40	Installation tool
500	Fastened product
600, 600a, 600b, 614a, 614b, 616a, 616b	Preparatory hole

WHAT IS CLAIMED IS:

1. A fastening structure comprising:
 - a first component;
 - a pin having a plurality of non-helical groove portions formed respectively on a periphery thereof in a circumferential direction and aligned along a longitudinal direction, the pin having one end in the longitudinal direction fitted securely to the first component, and thereby the pin is bonded to the first component;
 - a second component having an insertion hole configured to allow the pin to be inserted therein; and
 - a collar configured to be fitted around the pin and to be fitted securely onto the pin such that the second component is positioned between the collar and the first component, whereinsaid fastening structure for fastening the first and second components to each other is configured such that the second component is prevented from rotating with respect to the pin.
2. The fastening structure according to claim 1, wherein
 - a part or entirety of a portion of the pin positioned at least inside the insertion hole of the second component has a non-circular shape in cross-section along a direction crossing the longitudinal direction.
3. A fastening method for fastening first and second components to each other, the fastening method comprising the steps of:
 - integrating a pin and the first component with each other by fitting one end of the pin in a longitudinal direction securely to the first component, wherein the pin has a plurality of non-helical groove portions formed in a circumferential direction and aligned along the longitudinal direction, and has a non-circular longitudinal portion in a non-circular shape in cross-section along a direction crossing the longitudinal direction;
 - positioning the second component with respect to the non-circular longitudinal portion of the pin integrated with the first component, in such a manner that an insertion hole of the second component allows the pin to be inserted therein from the other end of the pin in the longitudinal direction, and is fitted around the non-circular longitudinal portion; and
 - fitting a collar around the pin, from the other end of the pin inserted into the insertion hole of the second component, so as to fit the collar securely onto the pin.