Patent Document 6: JP 2001-50292 A
Patent Document 7: JP 2006-281493 A

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0011] The conventional Hardlock Nuts and HLSs are designed such that, with a fit established between the protrusion 112 and recess 122, the tapered outer peripheral surface of the protrusion 112 and the tapered inner peripheral surface of the recess 122 slightly interfere with each other along part of their circumference, as shown in FIG. 7, such that the eccentric fit between the protrusion 112 and recess 122 produces a powerful wedge effect.

[0012] As such, when the lower nut 110 including the protrusion 112 is tightened on the threaded shaft S and then the upper nut 120 including the recess 122 is tightened, the upper nut 120 is inclined relative to the threaded shaft S and lower nut 110 in an actual tightened state, as shown in FIG. 9, as already discussed in Patent Documents 1 and 5.

[0013] If the protrusion 112 is fitted into the recess 122 with the upper nut 120 thus inclined, contact pressures between the outer peripheral surface of the protrusion 112 and the inner peripheral surface of the recess 122 are concentrated near the distal end of the protrusion 112, making it difficult to disperse, over a wide axial range of the lower nut 110, forces acting in directions perpendicular to the axial direction for producing the above-discussed wedge effect.

[0014] Moreover, in the upper nut 120 tightened in an inclined state, the conditions of contact between the female thread of the threaded hole 121 and the male thread of the threaded shaft S are non-uniform depending on the axial location such that the forces acting in directions perpendicular to the axial direction for producing the wedge effect are not dispersed uniformly over a wide axial range of the upper nut 120.

[0015] Although the conventional Hardlock Nuts sufficiently exhibit the anti-loosening effect, a large gap is created between the lower and upper nuts 110 and 120 since the upper nut 120 is inclined when tightening is completed. Such a large gap is not preferable from the viewpoint of construction management.

[0016] Embodiments of the present invention seek to minimize the inclination of the first and second threaded members relative to each other when they have

been tightened.

MEANS FOR SOLVING THE PROBLEMS

According to an aspect of the present invention, there is provided an anti-loosening device including a first threaded member having a thread adapted to be screwed to a mounted member, and a second threaded member having a thread adapted to be screwed to the mounted member,

wherein the first threaded member includes a protrusion protruding in an axial direction toward the second threaded member, the protrusion having an outer peripheral surface including a tapered outer peripheral surface portion with a predetermined taper angle;

the second threaded member includes a recess adapted to allow the protrusion to be fitted therein, the recess having an inner peripheral surface including a tapered inner peripheral surface portion with a predetermined taper angle; and

the tapered outer peripheral surface portion of the protrusion is eccentric from the thread on the first threaded member and the tapered inner peripheral surface portion of the recess is concentric with the thread on the second threaded member, or the tapered inner peripheral surface portion of the recess is eccentric from the thread on the second threaded member and the tapered outer peripheral surface portion of the protrusion is concentric with the thread on the first threaded member;

in the tightened state with the first and second threaded members screwed to the mounted member and an eccentric fit established between the protrusion of the first threaded member and the recess in the second threaded member, the tapered outer peripheral surface and the tapered inner peripheral surface interfere with each other along part of a circumference so as to produce a pressing force in a direction of eccentricity of the eccentric fit in the first and second threaded members, and the larger a depth of fitting of the protrusion into the recess, the larger the pressing force;

wherein the outer peripheral surface of the protrusion of the first threaded member further includes a distal-end outer peripheral surface portion located closer to a distal end of the protrusion than the tapered outer peripheral surface portion is,

the inner peripheral surface of the recess in the second threaded member further includes a closer-to-bottom inner peripheral surface portion

located closer to a bottom of the recess than the tapered inner peripheral surface portion is,

the outer peripheral surface of the protrusion and the inner peripheral surface of the recess are constructed in such a manner that, in the tightened state with the first and second threaded members screwed to the mounted member and an eccentric fit established between the protrusion of the first threaded member and the recess in the second threaded member, the tapered outer peripheral surface portion of the protrusion interferes with the tapered inner peripheral surface portion of the recess along part of the circumference while a gap is formed between the distal-end outer peripheral surface portion of the protrusion and the closer-to-bottom inner peripheral surface portion of the recess along the entire circumference,

the outer peripheral surface of the protrusion is a taper surface having a predetermined taper angle along an entire axial range including the tapered outer peripheral surface portion and the distal-end outer peripheral surface portion,

the tapered inner peripheral surface portion of the recess has the same taper angle as the outer peripheral surface of the protrusion and the closer-to-bottom inner peripheral surface portion of the recess has a smaller taper angle than the outer peripheral surface of the protrusion, and

the tapered inner peripheral surface portion of the recess and the closer-to-bottom inner peripheral surface portion of the recess are constructed in such a manner that, with the eccentric fit established between the protrusion and the recess, the tapered inner peripheral surface portion interferes with the tapered outer peripheral surface portion of the protrusion along part of the circumference and the closer-to-bottom inner peripheral surface portion is gradually radially distanced further from the distal-end outer peripheral surface portion of the protrusion toward the bottom of the recess, wherein the closer-to-bottom inner peripheral surface portion of the recess is a straight cylindrical surface with a taper angle of 0°.

[0017] An anti-loosening device according to the present invention includes: a first threaded member having a thread adapted to be screwed to a member to which an object is to be attached (hereinafter "mounted member"), and a second threaded member having a thread adapted to be screwed to the mounted member.

[0018] The first threaded member includes a protrusion protruding in an

axial direction toward the second threaded member. The protrusion includes an outer peripheral surface including a tapered outer peripheral surface portion with a predetermined taper angle. If the first threaded member is constituted by a nut, the threaded hole may extend through the protrusion in the axial direction.

[0019] The second threaded member includes a recess adapted to allow the protrusion to be fitted therein. The recess includes an inner peripheral surface including a tapered inner peripheral surface portion with a predetermined taper angle. If the second threaded member is constituted by a nut, the threaded hole may be open in the bottom surface of the recess.

[0020] In the anti-loosening device according to the present invention, (1) the tapered outer peripheral surface portion of the protrusion may be eccentric from the thread on the first threaded member and the tapered inner peripheral surface portion of the recess may be concentric with the thread on the second threaded member, or (2) the tapered inner peripheral surface portion of the recess may be eccentric from the thread on the second threaded member and the tapered outer peripheral surface portion of the protrusion may be concentric with the thread on the first threaded member.

[0021] The anti-loosening device according to the present invention is constructed in such a manner that, with the first and second threaded members screwed to the mounted member and an eccentric fit established between the protrusion of the first threaded member and the recess in the second threaded member, the tapered outer peripheral surface and the tapered inner peripheral surface interfere with each other along part of a circumference so as to produce a pressing force in a direction of eccentricity of the eccentric fit in the first and second threaded members, and the larger a depth of fitting of the protrusion into the recess, the larger the pressing force.

between the protrusion and the recess, the tapered inner peripheral surface portion interferes with the tapered outer peripheral surface portion of the protrusion along part of the circumference and the closer-to-bottom inner peripheral surface portion is gradually radially distanced further from the distal-end outer peripheral surface portion of the protrusion toward the bottom of the recess.

[0026] The closer-to-bottom inner peripheral surface portion of the recess may be a straight cylindrical surface with a taper angle of 0°.

[0027] In one example, the mounted member may be a threaded shaft with a male thread provided on its outer periphery, each of the first and second threaded members may be a nut into which the threaded shaft is to be screwed, and each of the threads on the first and second threaded members may be constituted by a female thread.

[0028] In another example, the mounted member may include a threaded hole with a female thread provided on its inner periphery, each of the first and second threaded members may be a screw that screws into the threaded hole, and each of the threads on the first and second threaded members may be constituted by a male thread.

EFFECTS OF THE INVENTION

[0029] The present invention will minimize the inclination of the first threaded member relative to the screwed threaded member. This will mitigate stress concentration upon eccentric fitting between the protrusion and recess to efficiently produce pressing forces in radial directions generally along the direction of eccentricity in the first and second threaded members, thereby further increasing the anti-loosening effect.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] [FIG. 1] FIG. 1 is a cross-sectional view of an anti-loosening device according to a first embodiment.

[FIG. 2] FIG. 2 shows views of the upper nut of the anti-loosening device according to the first embodiment as seen from four different directions.

[FIG. 3] FIG. 3 is an enlarged cross-sectional view of the upper nut taken along line A-A of FIG. 2.

[FIG. 4] FIG. 4 is a perspective view of the upper nut of the

CLAIMS

1. An anti-loosening device including a first threaded member having a thread adapted to be screwed to a mounted member, and a second threaded member having a thread adapted to be screwed to the mounted member,

wherein the first threaded member includes a protrusion protruding in an axial direction toward the second threaded member, the protrusion having an outer peripheral surface including a tapered outer peripheral surface portion with a predetermined taper angle;

the second threaded member includes a recess adapted to allow the protrusion to be fitted therein, the recess having an inner peripheral surface including a tapered inner peripheral surface portion with a predetermined taper angle; and

the tapered outer peripheral surface portion of the protrusion is eccentric from the thread on the first threaded member and the tapered inner peripheral surface portion of the recess is concentric with the thread on the second threaded member, or the tapered inner peripheral surface portion of the recess is eccentric from the thread on the second threaded member and the tapered outer peripheral surface portion of the protrusion is concentric with the thread on the first threaded member;

in the tightened state with the first and second threaded members screwed to the mounted member and an eccentric fit established between the protrusion of the first threaded member and the recess in the second threaded member, the tapered outer peripheral surface and the tapered inner peripheral surface interfere with each other along part of a circumference so as to produce a pressing force in a direction of eccentricity of the eccentric fit in the first and second threaded members, and the larger a depth of fitting of the protrusion into the recess, the larger the pressing force;

wherein the outer peripheral surface of the protrusion of the first threaded member further includes a distal-end outer peripheral surface portion located closer to a distal end of the protrusion than the tapered outer peripheral surface portion is,

the inner peripheral surface of the recess in the second threaded member further includes a closer-to-bottom inner peripheral surface portion located closer to a bottom of the recess than the tapered inner peripheral surface portion is,

the outer peripheral surface of the protrusion and the inner peripheral surface of the recess are constructed in such a manner that, in the tightened state with the first and second threaded members screwed to the mounted member and an eccentric fit established between the protrusion of the first threaded member and the recess in the second threaded member, the tapered outer peripheral surface portion of the protrusion interferes with the tapered inner peripheral surface portion of the recess along part of the circumference while a gap is formed between the distal-end outer peripheral surface portion of the protrusion and the closer-to-bottom inner peripheral surface portion of the recess along the entire circumference,

the outer peripheral surface of the protrusion is a taper surface having a predetermined taper angle along an entire axial range including the tapered outer peripheral surface portion and the distal-end outer peripheral surface portion,

the tapered inner peripheral surface portion of the recess has the same taper angle as the outer peripheral surface of the protrusion and the closer-to-bottom inner peripheral surface portion of the recess has a smaller taper angle than the outer peripheral surface of the protrusion, and

the tapered inner peripheral surface portion of the recess and the closer-to-bottom inner peripheral surface portion of the recess are constructed in such a manner that, with the eccentric fit established between the protrusion and the recess, the tapered inner peripheral surface portion interferes with the tapered outer peripheral surface portion of the protrusion along part of the circumference and the closer-to-bottom inner peripheral surface portion is gradually radially distanced further from the distal-end outer peripheral surface portion of the protrusion toward the bottom of the recess, wherein the closer-to-bottom inner peripheral surface portion of the recess is a straight cylindrical surface with a taper angle of 0°.

2. The anti-loosening device according to claim 1, wherein the mounted member is a threaded shaft, each of the first and second threaded members is a nut into which the threaded shaft is to be screwed, and each of the threads on the first and second threaded members is a female thread.

3. The anti-loosening device according to claim 1, wherein the mounted member includes a threaded hole, each of the first and second

threaded members is a screw that is adapted to screw into the threaded hole, and each of the threads on the first and second threaded members is a male thread.