FIG. 1 is a schematic view showing a punch for riveting 10 according to an embodiment of the present invention.

FIG. 2A is a front view of a device 1000 according to an embodiment, FIG. 2B is a side view of a device 1000 according to an embodiment.

FIG. 3 is a schematic view showing a method for joining members using the punch 10 for riveting according to an embodiment of the present invention.

FIG. 4 is a schematic view showing a method for joining members using the punch 10 for riveting according to an embodiment of the present invention.

FIG. 5 is a schematic view showing a method for joining members by a conventional spin riveting method.

FIG. 6 is a schematic view showing the method for joining the members by the conventional spin riveting method.

FIG. 7A is a top view of a member of Comparative example 1 in which a rivet is riveted, FIG. 7B is an optical microscopic image of a cross section of the member of the Comparative example 1 in which the rivet is riveted.

FIG. 8 is an optical microscope image of a cross section of a member of Example 1 in which a rivet is riveted.

FIG. 9A is a diagram showing a top surface of a member of Example 2 in which a rivet is riveted, FIG. 9B is an optical micrograph of a cross section of the member of the Example 2 in which the rivet is riveted.

FIG. 10A is a top view of a product 100 of an example.

FIG. 10B is a cross-sectional end view of the product 100.

DESCRIPTION OF EMBODIMENTS

[0022]

Hereinafter, an embodiment of the present invention will be described with reference to the drawings. The following embodiments are examples of embodiments of the present invention, and the present invention is not limited

diameter smaller than the maximum diameter of the enlarged diameter portion of the through hole, a ring-shaped gap in which the material of the rivet is not filled in the edge portion of the enlarged diameter portion is generated, which is not preferable. The punch 10 for riveting has a length parallel to the center axis A, but is not particularly limited as long as the length is in a range in which necessary strength can be obtained and a range in which it can be handled. In addition, in the specification, the length of the punch 10 for riveting is defined as a distance from the upper surface 15 to a point on the contact surface 13 that is furthest away.

[0033]

[Device in which Punch for Riveting is disposed]

A device for performing riveting using the punch 10 for riveting described above will be described. FIG. 2 is a schematic diagram showing a device 1000 according to an embodiment of the present invention, FIG. 2A is a front view of the device 1000, and FIG. 2B is a side view of the device 1000. The device 1000 includes a main shaft 1111 that holds the punch 10 for riveting, and a table 1151 that is disposed to face the main shaft 1111 and is capable of holding the rivet 130, the first member 110, and the second member 120. The punch 10 for riveting and the rivet 130 are arranged so that the center axis A of the punch 10 for riveting coincides with the center axis B of the rivet 130. The main shaft 1111 has a chuck for detachably holding the punch 10 for riveting, and rotates the punch 10 for riveting around the center axis A of the punch 10 for riveting.

[0034]

In an embodiment, the device 1000 includes, for example, a main shaft head 1113 that rotatably supports the main shaft 1111, a column 1123 that supports the main shaft head 1113, and a bed 1121 that supports the column 1123. The main shaft head 1113 is movably supported by a main shaft stage 1141. Further, the main shaft stage 1141 is movably supported by the column

1123. Here, in FIG. 4, a left-right direction of a paper surface is defined as an X-axis direction, and an up-down direction of the paper surface perpendicular to the X-axis direction is defined as a Z-axis direction.

[0035]

Two rails 1143 are arranged parallel to the Z-axis direction between the main shaft head 1113 and the main shaft stage 1141. The main shaft head 1113 movably engages with the two rails 1143 to slide in the Z-axis direction. For example, a ball screw (not shown) is arranged between the two rails 1143, and the ball screw is connected to the main shaft head 1113. Further, one end of the ball screw is connected to a Z-axis driving device 1147 to move the main shaft head 1113 in the Z-axis direction. The Z-axis driving device 1147 is a motor for rotating the ball screw. The main shaft head 1113 is displaceable in the Z-axis direction by such a mechanism while rotating the main shaft 1111. That is, the main shaft head 1113 can be moved in the Z-axis direction while rotating the main shaft 1111 in a state in which the main shaft 1111 holds the punch 10 for riveting.

[0036]

Two rails 1133 are arranged parallel to the X-axis direction between the main shaft stage 1141 and the column 1123. The main shaft stage 1141 movably engages with the two rails 1133 to slide in the X-axis direction. For example, a ball screw 1135 is arranged between the two rails 1133, and the ball screw 1135 is connected to the main shaft stage 1141. Further, one end of the ball screw 1135 is connected to an X-axis driving device 1137, and moves the main shaft stage 1141 in the X-axis direction. The X-axis driving device 1137 is a motor for rotating the ball screw 1135.

[0037]

In FIG. 2B, a left-right direction of a paper surface is defined as the Y-axis direction, and an up-down direction of the paper surface perpendicular to

image of the cross section. Further, no deformation occurred in a portion of the rivet 130 in contact with the through hole.

[0049]

[Example 2]

The rivet used in the Example 1 and three types of members in which the enlarged diameter portion 145 is inclined by 30° with respect to the center axis B were used. The punch 10 for riveting of Example 1 having the contact surface 13 inclined by 5° with respect to the center axis A and having a diameter of 6 mm was connected to the machining center in a state in which the center axis A of the punch 10 for riveting coincides with the center axis B of the rivet 130, and the rivet 130 was riveted to the member at a feed rate of 50 mm/min. Thereafter, the riveted member and a surface of the rivet were cut using an end mill.

[0050]

FIG. 9A is a diagram showing a top surface of the member of Example 2 riveted with the rivet, FIG. 9B shows an optical microscopic image of the cross section. In Example 2, the material of the rivet 130 was completely filled in the through hole 140 and the enlarged diameter portion 145, and even if a surface was cut and flattened, good bonding between the member and the rivet was confirmed.

[0051]

[Evaluation of adhesion]

The product 100 was manufactured by joining the first member 110 composed of a disk-shaped aluminum (A6061-T6) material having a diameter of 60 mm and a thickness of 4 mm having the enlarged diameter portion 145 inclined by 30° with respect to the center axis B and the through hole 140 having a diameter of 2.7 mm with the second member 120 composed of a plate-shaped aluminum (A6061-T6) material having a diameter of 100 mm × 100 mm on each

CLAIMS

1. A punch for riveting for joining a first member having a convex part and a second member having a through hole fitting with the convex part by plastically deforming the convex part,

wherein a contact surface with the convex part is inclined in a range of 80° to 89° with respect to a center axis of the punch for riveting,

the contact surface has an elliptical shape in which a direction inclined is set to a major axis, and

a rotation axis of the punch for riveting coincides with the center axis of the punch for riveting.

2. The punch for riveting according to claim 1, wherein the punch for riveting contains a cemented carbide alloy.

3. The punch for riveting according to claim 1 or 2, wherein the contact surface has an arithmetic average roughness Ra of 3.2 or less.

4. The punch for riveting according to any one of claims 1 to 3, wherein the punch for riveting further comprises a coating composed of diamond-like carbon arranged on the contact surface.

5. A device which, when assembled, comprises:

a main shaft holding the punch for riveting according to any one of claims 1 to 4; and

a table arranged opposite to the main shaft, the table capable of holding the first member and the second member,

wherein the punch for riveting and the first member are arranged so that

the center axis of the punch for riveting corresponds to a center axis of the first member, and

the main shaft is configured to rotate the punch for riveting around the center axis of the punch for riveting.

6. A method for joining a first member and a second member comprising:

fitting a convex part of the first member and a through hole of the second member; and

rotating and pressing a punch having a contact surface with the convex part inclined in a range of 80° to 89° with respect to a center axis,

wherein the contact surface has an elliptical shape in which a direction inclined is set to a major axis, and

a rotation axis of the punch for riveting coincides with the center axis of the punch for riveting.

7. The method according to claim 6, wherein the first member and the second member are joined by plastically deforming the convex part.

8. The method according to claim 6 or 7, wherein the punch contains a cemented carbide alloy.

9. The method according to any one of claims 6 to 8, wherein the contact surface is polished.

10. The method according to any one of claims 6 to 9, wherein the contact surface is coated with diamond-like carbon.

11. The method according to any one of claims 6 to 10, wherein a center of the convex part is arranged in the center axis.

12. The method according to any one of claims 6 to 11, wherein an inner surface of the through hole includes an area parallel to or inclined with respect to the center axis.