Abstract: A clamp and a method for installing the clamp into at least two work pieces is provided. The clamp has a shank keyed to an expander. The expander engages the core bolt such that rotation of the core bolt bulbs the expander to clamp the work pieces. A spacer engages the shank to prevent rotation of the shank during installation. The shank has a flange fracturing at a predetermined compression load. The core bolt optionally has a first and second break groove fracturing at predetermined compression loads. A nut is optionally provided to engage the spacer.
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TITLE
DUAL-ACTION DISPOSABLE CLAMP

[0001] This application claims priority from U.S. Provisional Patent Application No. 60/849,515 entitled "DUAL-ACTION DISPOSABLE CLAMP" filed on October 5, 2006; U.S. Provisional Patent Application No. 60/857,700 entitled "DUAL-ACTION DISPOSABLE CLAMP" filed on November 8, 2006; and U.S. Provisional Patent Application No. 60/901,171 entitled "DUAL-ACTION DISPOSABLE CLAMP WITH CLUTCH NUT" filed on February 13, 2007, which are each hereby incorporated by reference in their entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to a temporary fastener, and more specifically to a disposable clamp.

BACKGROUND OF THE INVENTION

[0003] Modern aircraft are manufactured from numerous panels and other parts that are fastened together with rivets, screws, bolts, and other permanent fasteners. To aid in assembly, parts are typically held together with temporary clamps and fixtures until permanent fasteners can be installed. Parts that incorporate sealant on the mating surfaces require that the temporary clamps exert sufficient force to squeeze excessive sealant from the joint while pulling parts together before the sealant fully cures. Heavy structures fastened with 5/16"-size permanent fasteners, for example, require in excess of 500 pounds clamp load to squeeze the sealant out to an acceptable
thickness and hold the components together. Other applications, such as in wing-to-body joints, require upwards of 1500 pounds with 5/16"-size fasteners to temporarily secure components. The clamp load requirements for other sizes are generally proportional to the cross-sectional area of the basic fastener diameter.

[0004] Blind hole clamps are desirable for airframe assembly, because their installation and removal can be more easily automated than the installation and removal of conventional bolts and nuts. However, existing blind hole clamps do not have a blind head large enough to avoid surface damage on the blind side panel when high clamp loads are imparted.

[0005] Oftentimes, one or more work pieces are joined with clamps to maintain part orientation during an autoclave curing cycle. Threaded-type reusable blind clamps are capable of high clamp loads, but lack the smooth shank needed to avoid clogging with resin as the parts are cured. As a result, the clamps are difficult to remove and may damage the work pieces upon removal. Blind tack rivets may have the required smooth shank but are incapable of imparting sufficient clamp load to maintain parts in the required orientation. Conventional slave bolts are not capable of automated installation and removal.

[0006] In addition, threaded temporary blind clamps are easily clogged with sealant and resins, making removal from assemblies difficult and necessitating cleaning before they may be reused. Another problem with threaded temporary fasteners is that they protrude above the accessible panel surface by a relatively large amount. Accordingly, robotic assembly equipment must retract or back away from each panel.
to avoid collisions with installed clamps. As a result, installation of threaded temporary fasteners requires additional time to traverse from one location to another.

[0007] Finally, the clamping capability of threaded temporary clamps is limited, because the blind head is discontinuous and high clamp loads result in surface damage to the work pieces. Temporary blind tack rivets have a low profile but must be removed by drilling through the manufactured head. Drilling through the head, however, generates metal chips that frequently damages panel surfaces. Oftentimes, for example, the rivet spins in the hole during the drilling operation, halting the advance of the drill bit through the tack rivet and prolonging the removal cycle time. Tack rivets also have very low clamp loads and produce a blind-side upset that is not suitable for use in laminated composite panels.

[0008] Slave bolts may consist of a conventional nut and bolt or a pull-type lock bolt with a swage collar. Slave bolts may provide a non-clogging shank, non-drill out removal and high clamp loads. However, slave bolts require access to both sides of the work pieces and, in many cases, two operators to install. Two-sided installations are difficult and costly to automate.

[0009] Therefore, a need exists for a clamp, or a temporary fastener, having a smooth cylindrical shank without grooves, threads and other discontinuities that may become clogged with sealant or cured resin and which is capable of high clamp loads (greater than 500 pounds for a 5/16” size clamp) without damaging fragile panel surfaces. In addition, a need exists for a low profile temporary clamping fastener capable of installation and removal from a single accessible side of the work pieces, preferably
by robotic equipment, in a manner that does not generate drilling debris. A one-sided installation and removal process is desired for saving labor costs over a conventional two-person operation using nuts and bolts. Finally, a need exists for a temporary fastener having a predetermined geometry to control installation clamp loads rather than allowing the installation force to be controlled by outside influences, such as, operator skill.

SUMMARY OF INVENTION

[0010] A clamp may having a core bolt in threaded engagement with an expander is provided. The clamp may have a smooth shank positioned between the expander and a wrenching end of the core bolt. The shank may have an integral flange adjacent the fracturing at a predetermined compression load. The core bolt may have a first and a second break groove capable of fracturing at predetermined compression loads. A spacer may be engaged with the shank to prevent rotation of the shank during installation of the clamp. A nut may optionally be provided. The nut may be in threaded engagement with the core bolt and may rotate with the core bolt during installation.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

[0011] Objects and advantages together with the operation of the invention may be better understood by reference to the following detailed description taken in connection with the following illustrations, wherein:

[0012] Figures IA, IB and IC illustrate a side view, a perspective view, and a cross-sectional view along line A-A of a clamp in an embodiment of the present invention.
[0013] Figures 2A, 2B and 2C illustrate a side view, a perspective view, and a cross-sectional view along line B-B of the clamp of Figures 1A-1C at least partially installed in a work piece in an embodiment of the present invention.

[0014] Figures 3A, 3B and 3C illustrate a side view, a perspective view and a cross-sectional view along line C-C of the clamp of Figures 1A-1C in an installed condition in an embodiment of the present invention.

[0015] Figures 4A and 4B illustrate a side view and a cross-sectional view along line D-D of a clamp having a clutch nut in an embodiment of the present invention.

[0016] Figures 5A and 5B illustrate a side view and a cross-sectional view along line E-E of the clamp of Figures 4A and 4B with a wrenching tool engaged in an embodiment of the present invention.

[0017] Figures 6A and 6B illustrate a side view and a cross-sectional view along line F-F of the clamp of Figures 4A and 4B with a wrenching tool engaged where the clamp may be removed from the work piece in an embodiment of the present invention.

[0018] Figure 7 illustrates a power tool engaged with the clamp of Figures 1A through 1C in an embodiment of the present invention.
[0019] Figure 8 shows a representative perspective view of an un-crimped expander component in an embodiment of the present invention.

[0020] Figure 9 shows a representative perspective view of an expander component as crimped in an embodiment of the present invention.

[0021] Figure 10 shows a representative perspective view of an expander component as partially formed in an embodiment of the present invention.

[0022] Figure 11 shows a representative perspective view of an expander component as completely formed in an embodiment of the present invention.

[0023] Figure 12 illustrates a graph of a predictable load curve of an expander in an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0024] Referring now to the drawings, and in particular to Figures 1A-3C, a clamp 10 has a core bolt 14 in threaded engagement with an expander 12. The expander 12 is positioned at a first end of the core bolt 14 such that the core bolt 14 is movable through the expander 12. Specifically, applying torque to the core bolt 14 drives the core bolt 14 through the expander 12. The core bolt 14 may have wrenching portions 8 that are sized and shaped to be rotated by, for example, a wrenching tool. In one embodiment, the expander 12 is internally threaded and is in meshing engagement with external threads of the core bolt 14.
In a preferred embodiment, a first break groove 24 is positioned at a second end of the core bolt 14, opposite the expander 12. A second break groove 26 is positioned between the first break groove 24 and the first end of the core bolt 14. The first break groove 24 and the second break groove 26 may be weakened portions of the core bolt 14 that fail at predetermined torque or compression loads. In an exemplary embodiment, the first break groove 24 is sized to fail prior to the second break groove 26, as shown in Figures 3A-3C. For example, at a torque sufficient to clamp work pieces 30a, 30b together a desired amount, the first break groove 24 fractures and a portion of the core bolt 14 is severed. The second break groove 26 will remain intact until it is desired to remove the core bolt 14 from the work pieces 30a, 30b. To do so, additional torque may be provided on the core bolt 14 to fracture the core bolt 14 at the second break groove 26.

A shank 16 may be positioned between the first end of the core bolt 14 and the expander 12. In a preferred embodiment, the expander 12 may be rotationally keyed to the shank 16 such that rotation of the shank 16 rotates the expander 12, as shown in Figures 1A-1C. The threaded core bolt 14 slides inside the shank 16 along the length of the core bolt 14. As torque is applied to the core bolt 14, the core bolt 14 rotates in the shank 16 and threads into the expander 12 as shown in Figures 2A-3C. The core bolt 14 moves through the expander 12 causing the expander 12 to bulb or to expand to a size in which the expander 12 has a larger diameter than the diameter of the shank 16 and the diameter of the core bolt 14.

The shank 16 has a flange 28 extending outward from the outer diameter of the shank 16. The flange 28 may be an enlarged portion extending in a direction
perpendicular to the length of the shank 16. In a preferred embodiment, the flange 28 is integrally formed with the shank 16. The flange 28 may be sized such that the flange 28 limits the amount of the clamp 10 that may be inserted into the work pieces 30a, 30b. At a predetermined axial load, the flange 28 shears loose from the shank 16 and may allow the clamp 10 to move further into the work pieces 30a, 30b.

[0028] A spacer 18 may be positioned at an end of the shank 16. In en embodiment, the spacer 18 engages a head 28 of the shank 16 and may prevent rotation of the shank 16 when torque is applied to the core bolt 14. The spacer 18 may have wrenching flats 40 for engagement with wrenching tools, for example, a tool to prevent rotation of the shank 16. The spacer 18 may have a bore 31 in which the core bolt 14 may extend there through.

[0029] A protuberance or boss 29 may extend from an end of the shank 16 opposite the expander 12. The spacer 18 may be positioned at an end of the shank 16 adjacent the protuberance 29. The bore 31 of the spacer 18 may be an interference fit with the protuberance 29 of the shank 16 such that the shank 16 is rotationally restrained. The protuberance 29 of the shank 16 extends into and frictionally fits within the spacer 18. In an embodiment, the protuberance 29 and the bore 31 in the spacer 18 are non-circular to rotationally key the shank 16 and the spacer 18 together. For example, the bore 31 and the protuberance 29 may have corresponding shapes such that relative rotation is prevented. The spacer 18 may be positioned such that the underside of the spacer 18 abuts the flange 28 of the shank 16.
[0030] A washer 21 may be positioned between the spacer 18 and an end of the core bolt 14. In one embodiment, the washer 21 may be a thrust washer to spread the compressive stresses over a larger area than without the washer 21. Bearing surfaces 80 of the core bolt 14 may bear against a top side 82 of the washer 21, as best illustrated in Figures 3B. In another embodiment, the washer 21 may be bowed to act as a spring washer, for example, to maintain compressive loads on the work pieces 30a, 30b.

[0031] The clamp 10 may be installed by an automated process or by automated equipment, such as robotic equipment. For example, after inserting the clamp 10 into aligned apertures in the work pieces 30a, 30b, a tool 100 may engage the spacer 18 and the wrenching surfaces 40 of the spacer 18. In one embodiment, the clamp 10 may be inserted into a top surface 30c of the work piece 30a and may extend through to a blind side 30d of the work piece 30b as illustrated in Figure 5A. Of course, if the clamp 10 is inserted into the blind side 30d, then the top surface 30c may be referred to as the blind side. In one embodiment, the tool 100 may have a first component 54 for rotationally restraining the spacer 18, which, in turn, prevents the shank 16 from rotating as illustrated in Figure 7. The tool 100 may have a second component 56 to provide torque to the core bolt 14. The tool 100 may be used by or incorporated into robotic or other automated equipment to thread the core bolt 14 into the expander 12 and cause the expander 12 to bulb or otherwise enlarge. Once the expander 12 is fully bulbed, as shown in an embodiment in Figures 3A-3C, the compressive load on the shank 16 increases until the flange 20 on the shank 16 shears loose at a predetermined compressive load. In one embodiment, the flange 20 shears at a load of 1000 pounds for a 5/16" size fastener. Continued rotation of the core bolt 14 causes the shank 16,
with the expander 12 attached, to translate into the spacer 18 until the expander 12 contacts and clamps against the far side of the work pieces 30a, 30b. If the flange 20 shears loose, the torque required to drive the core bolt 14 may drop to a negligible amount or nearly zero, but the torque required to drive the core bolt 14 may increase as the expander 12 contacts and clamps the work pieces 30a, 30b together.

[0032] The installation of the clamp 10 may be controlled by controlling the installation torque, or by use of the first break groove 24 and the second break groove 26. For example, when the torsion required to continue rotating the core bolt 14 exceeds the strength of the first break groove 24, a portion 15 of the core bolt 14 severs as shown in Figures 3A-3C; and the installation may be complete as shown in Figures 4A and 4B. To facilitate removal of the clamp 10, the tool 100 may be applied to the core bolt 14 to apply torque and rotate the core bolt 14. At a predetermined amount of torque, the second break groove 26 fails and the spacer 18, the washer 21, and the shank 16 are discarded from the accessible-side of the work pieces 30a, 30b. The expander 12 and remaining portion of the core bolt 14 may be pushed through the work pieces 30a, 30b and discarded or otherwise moved through the work pieces 30a, 30b.

[0033] Advantageously, the tool 100 may be used to install and to remove the clamp 10. To this end, the clamp 10 may effectively be used as a temporary fastener for clamping panels and other objects together. In addition, drilling to remove the clamp 10 is eliminated. Accordingly, the damage caused by off-center drilling and the generation of metal chips caused by drilling are eliminated.
In addition, the bulbing nature of the expander 12 ensures that clamp loads are spread over a relatively large area to avoid damaging the work pieces 30a, 30b. The pre-bulbed geometry of the expander 12 ensures that the apertures of the work pieces 30a, 30b do not become rounded or otherwise damaged. In an embodiment, the expander 12 may have a flanged end 32, as illustrated in Figures 8-11. The flanged end 32 may be cramped inwardly during manufacture as best shown in Figure 9. In a preferred embodiment, the expander 12 may have a thicker-walled leading edge 50 that resists buckling and a thin-walled bulbing region 52 that begins bulbing slightly inside the apertures of the work pieces 30a, 30b such that edge interference is avoided, as illustrated in Figures 10 and 11. Figure 12 illustrates a predicted load curve with bulbing of the expander 12 indicated at approximately eight hundred pounds for a 5/16" size clamp. Of course, the clamp 10 may be modified to change the load in which bulbing occurs as will be appreciated by one of ordinary skill in the art.

Advantageously, the clamp 10 avoids clogging with resins and other sealants due to the cylindrical and smooth shape of the shank 16. The design, shape and size of the clamp 10 allows incorporation of the clamp 10 into many applications where known rivets and clamps are not suitable, such as, in use with composite material cured in autoclave.

The grip range of the clamp 10 may correspond to or may be controlled by the length of the spacer 18. For example, the spacer 18 may have a length sufficient to receive the shank 16 after the flange 20 shears loose. A low profile for efficient robotic applications is possible by limiting the grip range. For example, a 5/16"-size
clamp having a 3/8" gripping range may have an installed protrusion approximately one inch above the accessible-side of the work pieces 30a, 30b.

[0037] In another embodiment, the clamp 10 has a nut 60 that is at least partially engaged with the core bolt 14 as illustrated in Figures 4A-6B. In such an embodiment, the core bolt 14 may be threaded from the end adjacent the expander 12 to the wrenching portions 8. Accordingly, the nut 60 may be in threaded engagement with the core bolt 14. The nut 60 may be, for example, cylindrical and internally-threaded. In one embodiment, the nut 60 may be positioned between the flange 20 of the shank 16 and the spacer 18. Upon installation, the nut 60 may freely rotate with the core bolt 14 and may act as an extension of a head portion 19 of the core bolt 14. In a preferred embodiment, the nut 60 is threaded in one direction.

[0038] During removal of the clamp 10, the nut 60 may be fixed and prevented from rotation by, for example, a clutch. An outer surface 41 of the nut 60, for example, may be engaged by a one-way clutch, a roller-type clutch or other structure that allows rotation of the nut 60 during installation but prevents rotation of the nut 60 when the core bolt 14 is rotated in the removal direction. Upon removal, the core bolt 14 unthreads from the nut 60 and the expander 12. The expander 12 may remain keyed to the shank 16 which remains keyed to the spacer 18.

[0039] In such an embodiment, the first break groove 24 may be incorporated into the clamp 10 and may be dependent upon whether the clamp 10 is configured for installation with torque-controlled tools. The second break groove 26 may be absent in this embodiment since removal may be accomplished by unthreading the core bolt.
14 from the assembly, rather than fracturing the core bolt 14 to separate components of the clamp 10. Of course, the first break groove 24 and the second break groove 26 may be incorporated in such an embodiment as will be appreciated by one of ordinary skill in the art.

[0040] Although the preferred embodiment of the present invention has been illustrated in the accompanying drawings and described in the foregoing detailed description, it is to be understood that the present invention is not to be limited to just the preferred embodiment disclosed, but that the invention described herein is capable of numerous rearrangements, modifications and substitutions without departing from the scope of the claims hereafter.
CLAIMS

Having thus described the invention, I claim:

1. A blind clamp capable of insertion through aligned apertures of a plurality of work pieces, said clamp comprising:
   a core bolt having a length defined between a first end and a second end;
   an expander threadingly engaged with the core bolt at the first end of the core bolt; and
   a shank positioned between the expander and the second end of the core bolt, the shank having an integral flange adapted to separate from the shank at a predetermined compression load, the integral flange having a diameter greater than the shank.

2. The clamp of claim 1 wherein the shank is keyed to the expander such that preventing the shank from rotation prevents the expander from rotation.

3. The clamp of claim 1 wherein the expander bulbs as the core bolt is threaded into the expander.

4. The clamp of claim 1 wherein the core bolt has a first break groove that is sized to fracture at a predetermined amount of torque.

5. The clamp of claim 4 wherein the core bolt has a second break groove that is sized to fracture at a different amount of torque than the first break groove.

6. The clamp of claim 5 wherein the first break groove fractures at a lower amount of torque applied to the core bolt than the second break groove.

7. The clamp of claim 1 further comprising:
a spacer adjacent the integral flange of the shank, the shank extending through the spacer and keyed to the spacer.

8. The clamp of claim 7 wherein fracturing the second break groove separates the core bolt from the spacer.

9. The clamp of claim 8 wherein the core bolt, the shank and the expander extract from the work pieces together upon fracturing the second break groove.

10. The clamp of claim 7 wherein the spacer has a wrenchable outer surface.

11. The clamp of claim 7 wherein the shank has a protuberance extending from the shank and engage the spacer to rotationally key the shank and spacer together.

12. The clamp of claim 7 wherein the spacer has an outer diameter substantially similar to the diameter of the flange of the shank.

13. A clamp capable of insertion through aligned apertures of two or more work pieces, said clamp comprising:

   a core bolt;

   an expander in threaded engagement with said core bolt, the expander capable of expanding to a diameter larger than said core bolt; and

   a nut in threaded engagement with the core bolt, the core bolt extending through the nut, wherein rotation of the core bolt in a first direction rotates the nut in the same direction and wherein rotation of the core bolt in a second direction opposite the first direction unthreads the core bolt from the nut.

14. The clamp of claim 13 wherein the core bolt has at least one wrenchable surface on one end and external threads extending from said wrenchable surface to the opposite end thereof.

15. The clamp of claim 14 further comprising:
a spacer adjacent the nut, the spacer having a bore wherein the core bolt
extends through the bore of the spacer.

16. The clamp of claim 15 further comprising:

a shank positioned between the spacer and the expander, the shank
rotationally keyed to the spacer and the expander.

17. The clamp of claim 14 wherein the shank has a flange portion adjacent
the spacer, the flange portion fracturing at a predetermined compression load.

18. The clamp of claim 14 wherein the spacer having a bore sized to receive
the shank there through, said bore preventing rotation of the shank during rotation of
the core bolt while said spacer is rotationally restrained.

19. A method of clamping at least two work pieces together, the method
comprising the steps of:

inserting a clamp into the work pieces, the clamp comprising:

a core bolt having a first break groove;
an expander in threaded engagement with the core bolt;
a shank positioned between the expander and the wrenching end of the core bolt, the shank keyed to the expander such that the shank is capable of preventing the expander from rotating, the shank having an integral flange; and

a spacer having a wrenching outer surface and a bore formed therein, the shank having a protuberance engaging the bore of the spacer, the spacer capable of preventing rotation of the shank and the expander;

placing the integral flange of the shank into contact with at least one of the work pieces;
preventing rotation of the spacer;
rotating the core bolt into the expander to bulb the expander; and
fracturing the flange at a predetermined compression load, such that said shank is movable into said spacer and the expander clamps the work pieces against the spacer.

20. The method of claim 18 wherein the core bolt has a first break groove.

21. The method of claim 19 further comprising the step of:
rotating the core bolt to fracture the core bolt at the first break groove to terminate the clamping of the work pieces to one another.

22. The method of claim 19 wherein the core bolt has a second break groove adapted to fracture at an applied torque that is greater than the torque required to clamp the work pieces to one another.

23. The method of claim 20 further comprising the step of:
removing the core bolt from the work pieces by further rotating the core bolt to fracture the core bolt at the second break groove.

24. The method of claims 19 further comprising the step of:
unthreading the core bolt from said expander; and
removing the clamp from the work pieces.