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Push-on fastener, assembly, and method of making and using the same

Abstract

A push-on fastener including a push-on fastener body including an annular base defining an aperture, first and second opposing major surfaces, and a plurality of radial tabs extending from the annular base, the radial tabs terminating radially inwardly or radially outwardly and providing a peripheral surface; and a low friction layer overlying the first major surface of the push-on fastener body, wherein the peripheral surface is free of low friction layer.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION(S) (1) This application claims priority under 35 U.S.C. § 119(e) to U.S. Patent Application No. 62/774,565 entitled “PUSH-ON FASTENER, ASSEMBLY, AND METHOD OF MAKING AND USING THE SAME,” by Benjamin KUEMMEL et al., filed Dec. 3, 2018, which is assigned to the current assignee hereof and incorporated herein by reference in its entirety.

FIELD OF THE DISCLOSURE

(1) The present disclosure relates to push-on fasteners, and more particularly to push-on fasteners installed on shafts or similar components.

RELATED ART

(2) A push-on fastener may be disposed to distribute load of an inner member, e.g., a shaft in an assembly or mechanism. Specific types of push-on fasteners may be used to axially fix itself to an inner member and interact with another component of the assembly.

(3) In a number of assemblies, the inner member may be rotating during usage where the push-on fastener may move against the side of other components of the assembly, such as an outer member, which may cause friction, vibration, and noise. There continues to be a need for push-on fasteners for use in applications to fix to inner members and provide decreased friction, vibration, and noise while simplifying assemblies, increasing assembly lifetimes.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) Embodiments are illustrated by way of example and are not limited in the accompanying figures.

(2) FIG. **1** includes a method of producing a push-on fastener in accordance with an embodiment;

(3) FIG. **2**A includes a cross-sectional view of a push-on fastener in accordance with an embodiment;

(4) FIG. **2**B includes a cross-sectional view of a push-on fastener in accordance with an embodiment;

(5) FIG. **2**C includes a cross-sectional view of a push-on fastener in accordance with an embodiment;

(6) FIG. **3**A includes a side view of a push-on fastener in accordance with an embodiment;

(7) FIG. **3**B includes a side view of a push-on fastener in accordance with an embodiment;

(8) FIG. **3**C includes a side view of a push-on fastener in accordance with an embodiment;

(9) FIG. **3**D includes a side view of a push-on fastener in accordance with an embodiment;

(10) FIG. **4** includes a top view of a push-on fastener in accordance with an embodiment;

(11) FIG. **5** includes a cross-sectional view of a push-on fastener in accordance with an embodiment;

(12) FIG. **6** includes a perspective top view of a push-on fastener in accordance with an embodiment;

(13) FIG. **7**A includes a top view of a push-on fastener in accordance with an embodiment;

(14) FIG. **7**B includes a cross-sectional view of a push-on fastener in accordance with the first embodiment;

(15) FIG. **7**C includes a perspective view of a push-on fastener in accordance with an embodiment;

(16) FIG. **8**A includes a top view of a push-on fastener within an assembly in accordance with an embodiment;

(17) FIG. **8**B includes a side view of a push-on fastener within an assembly in accordance with an embodiment;

(18) FIG. **8**C includes a side view of a push-on fastener within an assembly in accordance with an embodiment;

(19) FIG. **8**D includes a top cutout view of a push-on fastener within an assembly in accordance with an embodiment;

(20) FIG. **8**E includes a cross-sectional view of a push-on fastener within an assembly in accordance with an embodiment;

(21) FIG. **9**A includes a top view of a push-on fastener in accordance with an embodiment;

(22) FIG. **9**B includes a cross-sectional view of a push-on fastener in accordance with the first embodiment; and

(23) FIG. **9**C includes a perspective view of a push-on fastener in accordance with an embodiment.

(24) Skilled artisans appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help to improve understanding of embodiments of the invention.

DETAILED DESCRIPTION

(25) The following description in combination with the figures is provided to assist in understanding the teachings disclosed herein. The following discussion will focus on specific implementations and embodiments of the teachings. This focus is provided to assist in describing the teachings and should not be interpreted as a limitation on the scope or applicability of the teachings. However, other embodiments can be used based on the teachings as disclosed in this application.

(26) The terms "comprises," "comprising," "includes," "including," "has," "having" or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a method, article, or apparatus that comprises a list of features is not necessarily limited only to those features but may include other features not expressly listed or inherent to such method, article, or apparatus. Further, unless expressly stated to the contrary, "or" refers to an inclusive-or and not to an exclusive-or. For example, a condition A or B is satisfied by any one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

(27) Also, the use of "a" or "an" is employed to describe elements and components described herein. This is done merely for convenience and to give a general sense of the scope of the invention. This description should be read to include one, at least one, or the singular as also including the plural, or vice versa, unless it is clear that it is meant otherwise. For example, when a single embodiment is described herein, more than one embodiment may be used in place of a single embodiment. Similarly, where more than one embodiment is described herein, a single embodiment may be substituted for that more than one embodiment.

(28) Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. The materials, methods, and examples are illustrative only and not intended to be limiting. To the extent not described herein, many details regarding specific materials and processing acts are conventional and may be found in textbooks and other sources within the push-on fastener and push-on fastener assembly arts.

(29) Embodiments described herein are generally directed to a push-on fastener and methods of creating and using a push-on fastener within an assembly. In particular embodiments, the push-on fastener may have an annular base and a plurality of radial tabs extending from the annular base. The radial tabs may provide at least one peripheral surface that is free of low friction layer.

(30) For purposes of illustration, FIG. **1** includes a diagram showing a forming process **10** for forming a push-on fastener. The forming process **10** may include a first step **12** of providing a base material, a second step **14** of coating the base material with a low friction coating to form a composite material and a third step **16** of forming the composite material into a push-on fastener.

(31) Referring to the first step **12**, the base material may be a substrate. In an embodiment, the substrate can at least partially include a metal. According to certain embodiments, the metal may include iron, copper, titanium, tin, aluminum, alloys thereof, or may be another type of material. More particularly, the substrate can at least partially include a steel, such as, a stainless steel, carbon steel, or spring steel. For example, the substrate can at least partially include a 301 stainless steel. The 301 stainless steel may be annealed, ¼ hard, ½ hard, ¾ hard, or full hard. The substrate may include a woven mesh or an expanded metal grid. Alternatively, the woven mesh can be a

woven polymer mesh. In an alternate embodiment, the substrate may not include a mesh or grid.

(32) FIG. **2**A includes an illustration of the composite material **1000** that may be formed according to first step **12** and second step **14** of the forming process **10**. For purposes of illustration, FIG. **2**A shows the layer by layer configuration of a composite material **1000** after second step **14**. In a number of embodiments, the composite material **1000** may include a substrate **1119** (i.e., the base material provided in the first step **12**) and a low friction layer **1104** (i.e., the low friction coating applied in second step **14**). As shown in FIG. **2**A, the low friction layer **1104** can be coupled to at least a portion of the substrate **1119**. In a particular embodiment, the low friction layer **1104** can be coupled to a surface of the substrate **1119** so as to form a low friction interface with another surface of another component. The low friction layer **1104** can be coupled to the radially inner surface of the substrate **1119** so as to form a low friction interface with another surface of another component. The low friction layer **1104** can be coupled to the radially outer surface of the substrate **1119** so as to form a low friction interface with another surface of another component.

(33) In a number of embodiments, the low friction layer **1104** can include a low friction material. Low friction materials may include, for example, for example, a polymer, such as a polyketone, a polyaramid, a polyimide, a polytherimide, a polyphenylene sulfide, a polyetherslfone, a polysulfone, a polypheylene sulfone, a polyamideimide, ultra high molecular weight polyethylene, a fluoropolymer, a polyamide, a polybenzimidazole, or any combination thereof. In an example, the low friction layer **1104** includes a polyketone, a polyaramid, a polyimide, a polyetherimide, a polyamideimide, a polyphenylene sulfide, a polyphenylene sulfone, a fluoropolymer, a polybenzimidazole, a derivation thereof, or a combination thereof. In a particular example, the low friction/wear resistant layer includes a polymer, such as a polyketone, a thermoplastic polyimide, a polyetherimide, a polyphenylene sulfide, a polyether sulfone, a polysulfone, a polyamideimide, a derivative thereof, or a combination thereof. In a further example, the low friction/wear resistant layer includes polyketone, such as polyether ether ketone (PEEK), polyether ketone, polyether ketone ketone, polyether ketone ether ketone, a derivative thereof, or a combination thereof. In an additional example, the low friction/wear resistant layer may be an ultra high molecular weight polyethylene. An example fluoropolymer includes fluorinated ethylene propylene (FEP), polytetrafluoroethylene (PTFE), polyvinylidene fluoride (PVDF), perfluoroalkoxy (PFA), a terpolymer of tetrafluoroethylene, hexafluoropropylene, and vinylidene fluoride (THV), polychlorotrifluoroethylene (PCTFE), ethylene tetrafluoroethylene copolymer (ETFE), ethylene chlorotrifluoroethylene copolymer (ECTFE), polyacetal, polybutylene terephthalate (PBT), polyethylene terephthalate (PET), polyimide (PI), polyetherimide, polyetheretherketone (PEEK), polyethylene (PE), polysulfone, polyamide (PA), polyphenylene oxide, polyphenylene sulfide (PPS), polyurethane, polyester, liquid crystal polymers (LCP), or any combination thereof. The low friction layer **1104** may include a solid based material including lithium soap, graphite, boron nitride, molybdenum disulfide, tungsten disulfide, polytetrafluoroethylene, carbon nitride, tungsten carbide, or diamond like carbon, a metal (such as aluminum, zinc, copper, magnesium, tin, platinum, titanium, tungsten, lead, iron, bronze, steel, spring steel, stainless steel), a metal alloy (including the metals listed), an anodized metal (including the metals listed) or any combination thereof. Fluoropolymers may be used according to particular embodiments. As used herein, a “low friction material” can be a material having a dry static coefficient of friction as measured against steel of less than 0.5, such as less than 0.4, less than 0.3, or even less than 0.2. A “high friction material” can be a material having a dry static coefficient of friction as measured against steel of greater than 0.6, such as greater than 0.7, greater than 0.8, greater than 0.9, or even greater than 1.0.

(34) In a number of embodiments, the low friction layer **1104** may further include fillers, including glass fibers, carbon fibers, silicon, PEEK, aromatic polyester, carbon particles, bronze, fluoropolymers, thermoplastic fillers, aluminum oxide, polyamidimide (PAI), PPS, polyphenylene sulfone (PPSO2), LCP, aromatic polyesters, molybdenum disulfide, tungsten disulfide, graphite, grapheme, expanded graphite, boron nitride, talc, calcium fluoride, or any combination thereof.

Additionally, the filler can include alumina, silica, titanium dioxide, calcium fluoride, boron nitride, mica, Wollastonite, silicon carbide, silicon nitride, zirconia, carbon black, pigments, or any combination thereof. Fillers can be in the form of beads, fibers, powder, mesh, or any combination thereof.

(35) In an embodiment, the low friction layer **1104** can have an axial height T.sub.FL in a range of 0.01 mm and 0.4 mm, such as in a range of 0.15 mm and 0.35 mm, or even in a range of 0.2 mm and 0.3 mm. The axial height of the low friction **1104** may be uniform, i.e., an axial height at a first location of the low friction layer **1104** can be equal to an axial height at a second location therealong. The low friction layer **1104** may overlie one major surface of the substrate **1119**, shown, or overlie both major surfaces. In a number of embodiments, the substrate **1119** may extend at least partially along a length of the composite material **1000**. The substrate **1119** may be at least partially encapsulated by the low friction layer **1104**. That is, the low friction layer **1104** may cover at least a portion of the substrate **1119**. Axial surfaces of the substrate **1119** may or may not be exposed from the low friction **1104**. In an embodiment, the composite material **1000** can have an axial height T.sub.SW in a range of 0.01 mm and 5 mm, such as in a range of 0.15 mm and 2.5 mm, or even in a range of 0.2 mm and 1 mm.

(36) FIG. **2**B includes an illustration of an alternative embodiment of the composite material that may be formed according to first step **12** and second step **14** of the forming process **10**. For purposes of illustration, FIG. **2**B shows the layer by layer configuration of a composite material **1002** after second step **14**. According to this particular embodiment, the composite material **1002** may be similar to the composite material **1000** of FIG. **2**A, except this composite material **1002** may also include at least one adhesive layer **1121** that may couple the low friction layer **1104** to the substrate **1119** (i.e., the base material provided in the first step **12**) and a low friction layer **1104** (i.e., the low friction coating applied in second step **14**). In another alternate embodiment, the substrate **1119**, as a solid component, woven mesh or expanded metal grid, may be embedded between at least one adhesive layer **1121** included between the low friction layer **1104** and the substrate **1119**.

(37) The adhesive layer **1121** may include any known adhesive material common to the fastener arts including, but not limited to, fluoropolymers, epoxy resins, polyimide resins, polyether/polyamide copolymers, ethylene vinyl acetates, ethylene tetrafluoroethylene (ETFE), ETFE copolymer, perfluoroalkoxy (PFA), or any combination thereof. Additionally, the adhesive can include at least one functional group selected from —C═O, —C—O—R, —COH, —COOH, —COOR, —CF.sub.2═CF—OR, or any combination thereof, where R is a cyclic or linear organic group containing between 1 and 20 carbon atoms. Additionally, the adhesive can include a copolymer. In an embodiment, the hot melt adhesive can have a melting temperature of not greater than 250° C., such as not greater than 220° C. In another embodiment, the adhesive may break down above 200° C., such as above 220° C. In further embodiments, the melting temperature of the hot melt adhesive can be higher than 250° C. or even higher than 300° C. The adhesive layer **1121** can have an axial height of about 1 to 50 microns, such as about 7 to 15 microns.

(38) FIG. **2**C includes an illustration of an alternative embodiment of the composite material that may be formed according to first step **12** and second step **14** of the forming process **10**. For purposes of illustration, FIG. **2**C shows the layer by layer configuration of a composite material **1003** after second step **14**. According to this particular embodiment, the composite material **1003** may be similar to the composite material **1002** of FIG. **2**B, except this composite material **1003** may also include at least one corrosion protection layer **1704**, **1705**, and **1708**, and a corrosion resistant coating **1124** that can include an adhesion promoter layer **1127** and an epoxy layer **1129** that may couple to the substrate **1119** (i.e., the base material provided in the first step **12**) and a low friction layer **1104** (i.e., the low friction coating applied in second step **14**).

(39) The substrate **1119** may be coated with corrosion protection layers **1704** and **1705** to prevent corrosion of the composite material **1003** prior to processing. Additionally, a corrosion protection

layer **1708** can be applied over layer **1704**. Each of layers **1704**, **1705**, and **1708** can have an axial height of about 1 to 50 microns, such as about 7 to 15 microns. Layers **1704** and **1705** can include a phosphate of zinc, iron, manganese, or any combination thereof, or a nano-ceramic layer. Further, layers **1704** and **1705** can include functional silanes, nano-scaled silane based primers, hydrolyzed silanes, organosilane adhesion promoters, solvent/water based silane primers, chlorinated polyolefins, passivated surfaces, commercially available zinc (mechanical/galvanic) or zinc-nickel coatings, or any combination thereof. Layer **1708** can include functional silanes, nano-scaled silane based primers, hydrolyzed silanes, organosilane adhesion promoters, solvent/water based silane primers. Corrosion protection layers **1704**, **1706**, and **1708** can be removed or retained during processing.

(40) The composite material **1003** may further include a corrosion resistant coating **1125**. The corrosion resistant coating **1125** can have a axial height of about 1 to 50 microns, such as about 5 to 20 microns, and such as about 7 to 15 microns. The corrosion resistant coating **1125** can include an adhesion promoter layer **1127** and an epoxy layer **1129**. The adhesion promoter layer **1127** can include a phosphate of zinc, iron, manganese, tin, or any combination thereof, or a nano-ceramic layer. The adhesion promoter layer **1127** can include functional silanes, nano-scaled silane based layers, hydrolyzed silanes, organosilane adhesion promoters, solvent/water based silane primers, chlorinated polyolefins, passivated surfaces, commercially available zinc (mechanical/galvanic) or Zinc-Nickel coatings, or any combination thereof. The epoxy layer **1129** can be a thermal cured epoxy, a UV cured epoxy, an IR cured epoxy, an electron beam cured epoxy, a radiation cured epoxy, or an air cured epoxy. Further, the epoxy layer **1129** can include polyglycidylether, diglycidylether, bisphenol A, bisphenol F, oxirane, oxacyclopropane, ethylenoxide, 1,2-epoxypropane, 2-methyloxirane, 9,10-epoxy-9,10-dihydroanthracene, or any combination thereof. The epoxy layer **1129** can further include a hardening agent. The hardening agent can include amines, acid anhydrides, phenol novolac hardeners such as phenol novolac poly[N-(4-hydroxyphenyl)maleimide] (PHPMI), resole phenol formaldehydes, fatty amine compounds, polycarbonic anhydrides, polyacrylate, isocyanates, encapsulated polyisocyanates, boron trifluoride amine complexes, chromic-based hardeners, polyamides, or any combination thereof. Generally, acid anhydrides can conform to the formula R—C═O—O—C═O—R′ where R can be C.sub.XH.sub.YX.sub.ZA.sub.U as described above. Amines can include aliphatic amines such as monoethylamine, diethylenetriamine, triethylenetetraamine, and the like, alicyclic amines, aromatic amines such as cyclic aliphatic amines, cyclo aliphatic amines, amidoamines, polyamides, dicyandiamides, imidazole derivatives, and the like, or any combination thereof.

(41) In an embodiment, under step **14** of FIG. **1**, any of the layers on the composite material **1000**, **1002**, **1003**, as described above, can each be disposed in a roll and peeled therefrom to join together under pressure, at elevated temperatures (hot or cold pressed or rolled), by an adhesive, or by any combination thereof. Any of the layers of the composite material **1000**, as described above, may be laminated together such that they at least partially overlap one another. Any of the layers on the composite material **1000**, **1002**, **1003**, as described above, may be applied together using coating technique, such as, for example, physical or vapor deposition, spraying, plating, powder coating, or through other chemical or electrochemical techniques. In a particular embodiment, the low friction layer **1104** may be applied by a roll-to-roll coating process, including for example, extrusion coating. The low friction layer **1104** may be heated to a molten or semi-molten state and extruded through a slot die onto a major surface of the substrate **1119**. In another embodiment, the low friction layer **1104** may be cast or molded.

(42) In other embodiments, under step **14** of FIG. **1**, any of the layers on the composite material **1000**, **1002**, **1003**, as described above, may be applied by a coating technique, such as, for example, physical or vapor deposition, spraying, plating, powder coating, or through other chemical or electrochemical techniques. In a particular embodiment, the low friction layer **1104** may be applied by a roll-to-roll coating process, including for example, extrusion coating. The low friction layer

1104 may be heated to a molten or semi-molten state and extruded through a slot die onto a major surface of the substrate **1119**. In another embodiment, the low friction layer **1104** may be cast or molded.

(43) Referring now to the third step **16** of the forming process **10** as shown in FIG. **1**, according to certain embodiments, forming the composite material **1000**, **1002**, **1003** into a push-on fastener may include a cutting operation. In an embodiment, the cutting operation may include use of a stamp, press, punch, saw, or may be machined in a different way. In a number of embodiments, the cutting operation may form a peripheral surface on the push-on fastener. The cutting operation may define a cutting direction initiated from a first major surface to a second major surface, opposite the first major surface, to form the peripheral surfaces or edges. Alternatively, the cutting operation may define a cutting direction initiated from the second major surface to the first major surface to form the peripheral surfaces or edges.

(44) For purposes of illustration, FIGS. **3**A-**3**D include an illustration showing a cutting operation to form a push on fastener **100**. The push on fastener **100** may have a first major surface **107** and a second major surface **109**. The push-on fastener **100** may further have an annular base **104**. The push-on fastener **100** may further include at least one radial tab **110**. As shown in FIGS. **3**A-**3**B, the at least one radial tab **110** may include an inner radial edge **123**. In an embodiment, the at least one radial tab **110** may define a peripheral surface **112***a*. As shown in FIGS. **3**C-**3**D, the at least one radial tab **110** may include an outer radial edge **125**. In an embodiment, the at least one radial tab **110** may define a peripheral surface **112***b*. In a number of embodiments, as shown in FIGS. **3**A-**3**D, the push-on fastener **100** may be cut by a cutting operation to form one of the peripheral surfaces **112***a*, **112***b* after the low friction layer **1104**, **1104′** is formed on the substrate **1119**. In a number of embodiments, two low friction layers **1104**, **1104′** may be coupled to the substrate **1119**. FIG. **3**A shows an upward cutting direction against an angle α on a push-on fastener **100** with inwardly facing radial tabs **110**. FIG. **3**B shows a downward cutting direction toward the angle α on a push-on fastener **100** with inwardly facing radial tabs **110**. FIG. **3**C shows an upward cutting direction against the angle α on a push-on fastener **100** with outwardly facing radial tabs **110**. FIG. **3**D shows a downward cutting direction toward the angle α on a push-on fastener **100** with outwardly facing radial tabs **110**. In a number of embodiments, the cut may form an exposed surface **175** free of low friction layer **1104** on the push-on fastener **100**. As shown in FIGS. **3**A-**3**B, the cut may form an exposed surface **175** free of low friction layer **1104** on the inner radial edge **123** of the at least one radial tab **110** of the push-on fastener **100**. As shown in FIGS. **3**C-**3**D, the cut may form an exposed surface **175** free of low friction layer **1104** on the outer radial edge **125** of the at least one radial tab **110** of the push-on fastener **100**. In a number of embodiments, as shown in FIGS. **3**A-**3**D, the first major surface **107** may intersect at least one peripheral surface **112***a*, **112***b* to form a sharp corner **192** while the second major surface **109** may intersect the peripheral surface **112***a*, **112***b* to form a radiused corner **194**. The sharp corner **192** may have burr **193** or have an extreme slope to otherwise form a sharp edge. The sharp corner **192** has a radius of curvature in the range of 0.0 mm to 0.2 mm. The radiused corner **194** may have a more gradual slope to otherwise form a smooth edge. The radiused corner **194** has a radius of curvature in the range of 0.0 mm to 0.2 mm.

(45) Turning now to the push-on fastener formed according to embodiments described herein, FIG. **4** includes a top view illustration of a push-on fastener **100**. For purposes of illustration, FIG. **4** shows a top view of a push-on fastener **100** in accordance with embodiments described herein, which can include a push-on fastener body **102** oriented about a central axis A. The push-on fastener **100** may further have an annular base **104**. The annular base **104** may include an inner radial edge **103** and an outer radial edge **105**. The inner radial edge **103** may at least partially define an aperture **180** in the push-on fastener **100**. The push-on fastener **100** may further include at least one radial tab **110** disposed along at least one of the inner radial edge **103** of the annular base **104**.

(46) In a number of embodiments, the annular base **104** may have a particular outer radius OR.sub.AB. For purposes of embodiments described herein and as shown in FIG. **4**, the outer

radius OR.sub.AB of the annular base **104** is the distance from the central axis A to the outer radial edge **105**. According to certain embodiment, the outer radius OR.sub.AB of the annular base **104** may be at least about 1 mm, such as, at least about 10 mm or at least about 20 mm or at least about 30 mm or at least about 40 mm or even at least about 50 mm. According to still other embodiments, the outer radius OR.sub.AB of the annular base **104** may be not greater than about 100 mm, such as, not greater than about 50 mm or even not greater than about 25 mm. It will be appreciated that the outer radius OR.sub.AB of the annular base **104** may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the outer radius OR.sub.AB of the annular base **104** may be any value between any of the minimum and maximum values noted above. For example, the outer radius OR.sub.AB of the annular base **104** may be 23 mm.
(47) In a number of embodiments, the annular base **104** may have a particular inner radius IR.sub.AB. For purposes of embodiments described herein and as shown in FIG. **4**, the inner radius, IR.sub.AB of the annular base **104** is the distance from the central axis A to the inner radial edge **103**. According to certain embodiment, the inner radius IR.sub.AB of the annular base **104** may be at least about 1 mm, such as, at least about 10 mm or at least about 20 mm or at least about 30 mm or at least about 40 mm or even at least about 50 mm. According to still other embodiments, the inner radius IR.sub.AB of the annular base **104** may be not greater than about 90 mm, such as, not greater than about 50 mm or even not greater than about 25 mm. It will be appreciated that the inner radius IR.sub.AB of the annular base **104** may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the inner radius IR.sub.AB of the annular base **104** may be any value between any of the minimum and maximum values noted above. For example, the inner radius IR.sub.AB of the annular base **104** may be 23 mm.
(48) For purposes of illustration, FIG. **5** includes a cross-sectional view of a push-on fastener **100**, as shown in FIG. **4**, in accordance with embodiments described herein. As shown in FIG. **5**, the annular base **104** can include a first axial surface **106** and a second axial surface **108** opposite the first axial surface **106** oriented down the central axis A and spaced apart by a axial height T.sub.AB. The annular base **104** may have a polygonal, oval, circular, semi-circular, or substantially circular cross-section when viewed in a plane perpendicular to the central axis A.
(49) In a number of embodiments, the annular base **104** may have a particular axial height T.sub.AB. For purposes of embodiments described herein and as shown in FIG. **5**, the axial height T.sub.AB of the annular base **104** is the distance from the first axial surface **106** to the second axial surface **108**. According to certain embodiment, the axial height T.sub.AB of the annular base **104** may be at least about 0.01 mm, such as, at least about 0.1 mm or at least about 0.2 mm or at least about 0.3 mm or at least about 0.4 mm or even at least about 0.5 mm. According to still other embodiments, the axial height T.sub.AB of the annular base **104** may be not greater than about 2 mm, such as, not greater than about 0.9 mm or even not greater than about 0.8 mm. It will be appreciated that the axial height T.sub.AB of the annular base **104** may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the axial height T.sub.AB of the annular base **104** may be any value between any of the minimum and maximum values noted above. For example, the axial height T.sub.AB of the annular base **104** may be 0.7 mm.
(50) Referring back to FIG. **4**, the push-on fastener **100** may include at least one radial tab **110**. In a number of embodiments, the radial tab **110** may run the entire circumference of the push-on fastener **100**. According to still other embodiments, the push-on fastener **100** may include a plurality of radial tabs **110**, each extending from the annular base **104**. According to yet other embodiments, the at least one radial tab **110** may project radially inwardly from the annular base **104**.
(51) According to still other embodiments, the at least one radial tab **110** may include an inner

radial edge **123** and an outer radial edge **125**. The outer radial edge **125** may be contiguous with the inner radial edge **103** of the annular base **104**. The at least one radial tab **110** may include a first circumferential edge **127** and a second circumferential edge **129** along an arc length measured as an angle θ with respect to the central axis A, as shown best in FIG. **4**. The inner radial edge **123** may at least partially define the aperture **180** in the push-on fastener **100** and/or annular base **104**. As shown in FIG. **5**, the at least one radial tab **110** can include a first axial surface **126** and a second axial surface **128** opposite the first axial surface **126**.

(52) As shown in both FIGS. **4** and **5**, the radial tabs **110** can be circumferentially offset from one another. In embodiments with a plurality of radial tabs **110**, the radial tabs **110** can be circumferentially offset from one another by a plurality of radial slots **137**. The radial slots **137** may be gaps defining the first circumferential edge **127**, and the second circumferential edge **129** of neighboring radial tabs **110**. The at least one radial tab **110** may have a polygonal, oval, circular, semi-circular, or substantially circular cross-section when viewed in a plane generally perpendicular to the central axis A.

(53) In a number of embodiments, as shown in FIG. **4**, the at least one radial tab **110** may have a width W.sub.RT, as measured in an arc length from the first circumferential edge **127** to the second circumferential edge **127**. Width W.sub.RT can be calculated by the formula W.sub.RT=Cθ/360, where θ is the angle formed between the first circumferential edge **127** and the second circumferential edge **127** with respect to the central axis A, and C is the circumference of the push-on fastener **100** along a best fit circle formed by inner radial edges **123** of the radial tabs **110** of the push-on fastener **100**. According to certain embodiment, the width W.sub.RT of the at least one radial tab **110** may be at least about 1 mm, such as, at least about 10 mm or at least about 30 mm or at least about 40 mm or at least about 50 mm or even at least about 60 mm. According to still other embodiments, the width W.sub.RT of the at least one radial tab **110** may be not greater than about 100 mm, such as, not greater than about 50 mm or even not greater than about 25 mm. It will be appreciated that the width W.sub.RT of the at least one radial tab **110** may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the width W.sub.RT of the at least one radial tab **110** may be any value between any of the minimum and maximum values noted above. For example, the width W.sub.RT of the at least one radial tab **110** may be 25 mm.

(54) In a number of embodiments, as shown in FIG. **5**, the at least one radial tab **110** can have an axial height T.sub.RT. For purposes of embodiments described herein, the axial height T.sub.RT of the at least one radial tab **110** is the distance from the first axial surface **126** to the second axial surface **128**. According to certain embodiment, the axial height T.sub.RT of the at least one radial tab **110** may be at least about 0.1 mm, such as, at least about 0.2 mm or at least about 0.3 mm or at least about 0.4 mm or even at least about 0.5 mm. According to still other embodiments, the axial height T.sub.RT of the at least one radial tab **110** may be not greater than about 2 mm, such as, not greater than about 0.9 mm or even not greater than about 0.8 mm. It will be appreciated that the axial height T.sub.RT of the at least one radial tab **110** may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the axial height T.sub.RT of the at least one radial tab **110** may be any value between any of the minimum and maximum values noted above. For example, the axial height T.sub.RT of the at least one radial tab **110** may be 0.7 mm.

(55) In a number of embodiments, as shown in FIG. **5**, the at least one radial tab **110** can have a length L.sub.RT. For purposes of embodiments described herein, the length L.sub.RT of the at least one radial tab **110** is the distance from the inner radial edge **123** to the outer radial edge **125**. According to certain embodiment, the length L.sub.RT of the at least one radial tab **110** may be at least about 1 mm, such as, at least about 10 mm or at least about 30 mm or at least about 40 mm or at least about 50 mm or even at least about 60 mm. According to still other embodiments, the length L.sub.RT of the at least one radial tab **110** may be not greater than about 100 mm, such as,

not greater than about 50 mm or even not greater than about 25 mm. It will be appreciated that the length L.sub.RT of the at least one radial tab **110** may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the length L.sub.RT of the at least one radial tab **110** may be any value between any of the minimum and maximum values noted above. For example, the length L.sub.RT of the at least one radial tab **110** may be 25 mm.

(56) In an embodiment, as shown in FIG. **5**, the at least one radial tab **110** can include a bridge portion **135** connecting the inner radial edge **123** of the at least one radial tab **110** to the annular base **104**. In certain embodiments, the bridge portion **135** can cant relative to the central axis A. As stated above and now shown in FIG. **5**, the bridge portion **135** can form an angle α with respect to the plane parallel to the annular base **104** and perpendicular to the central axis A. By way of a non-limiting embodiment, the angle α between the bridge portion **135** and the annular base **104** in the unloaded state can be at least 0.1°, such as at least 2°, at least 4°, at least 5°, or even at least 10°. In another embodiment, the angle α can be no greater than 45°, such as no greater than 40°, no greater than 35°, no greater than 30°, no greater than 25°, or even no greater than 20°. In still another embodiment, the angle α can be no less than or equal to 30°. It will be appreciated that the angle α may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the angle α may be any value between any of the minimum and maximum values noted above. For example, the angle α may be 43°.

(57) In a number of embodiments, the angles α of the radial tabs **110** can all be uniform. In another embodiment, an angle α of at least one radial tab **110** may differ. In a particular embodiment, each angle α can be no less than 60°, such as no less than 90°, no less than 120°, or even no less than 150°. In a further embodiment, each angle α can be less than 180°, such as no greater than 170°, no greater than 160°, no greater than 150°, no greater than 140°, no greater than 130°, no greater than 120°, or even no greater than 110°. In a particular embodiment, the angles α can all lie along straight lines that extend in a substantially parallel direction. As used herein, “substantially parallel direction” refers to a deviation of no greater than 5° between the measured directions of two lines, such as no greater than 4°, no greater than 3°, or even no greater than 2°. In a more particular embodiment, the angles α can all lie along lines that extend in parallel. As used herein, “extend in parallel” refers to a deviation of no greater than 0.5° between the measured directions of two lines.

(58) Per FIGS. **3**A-**3**B, and as now shown in more detail in FIGS. **4** and **5**, in an embodiment, the at least one radial tab **110** may define an inner peripheral surface **112***a*. In an embodiment, the inner radial edge **123** of at least one radial tab **110** may define the inner peripheral surface **112***a*. In this way, the radial tabs **110** project radially inwardly and forms the inner peripheral surface **112***a*. In a particular embodiment, at least one of the radial tabs **110** may have an exposed surface **175** defined as being free of the low friction layer **1104**. As shown in FIG. **5**, this exposed surface **175** may be the inner peripheral surface **112***a* at the inner radial end **123** of the radial tab **110**.

(59) As stated previously, and as shown in FIGS. **4** and **5**, the inner radial edge **103** of the annular body **14**, and the inner radial edge **123** of the at least one radial tab **110** may at least partially define an aperture **180** in the push-on fastener **100**. The aperture **180** may have a polygonal, oval, circular, semi-circular, or substantially circular cross-section when viewed in a plane generally perpendicular to the central axis A. The aperture **180** may be non-uniform in shape.

(60) In a number of embodiments, as shown in FIG. **4**, the aperture **180** may have a radius, R.sub.A. For purposes of embodiments described herein, the aperture radius R.sub.A is the distance from the central axis A to the outermost point of either the inner radial edge **103** of the annular base **104**, or the inner radial edge **123** of the at least one radial tab **110**. According to certain embodiment, the aperture radius R.sub.A may be at least about 1 mm, such as, at least about 10 mm or at least about 30 mm or at least about 40 mm or at least about 50 mm or even at least about 60 mm. According to still other embodiments, aperture radius R.sub.A may be not greater than about 100 mm, such as, not greater than about 50 mm or even not greater than about 25 mm. It will be

appreciated that the aperture radius R.sub.A may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the aperture radius R.sub.A may be any value between any of the minimum and maximum values noted above. For example, the aperture radius R.sub.A may be 25 mm.

(61) In a number of embodiments, as shown in FIG. **5**, the push-on fastener **100** can have an axial height T.sub.W. For purposes of embodiments described herein, the axial height T.sub.W of the push-on fastener **100** is the distance from the more axially distant of either the first axial surface **106** of the annular base **104** or the second axial surface **154** of the axial flange **150**, and second axial surface **128** of the innermost radial tab **110**. According to certain embodiment, the axial height T.sub.W of the push-on fastener **100** may be at least about 0.1 mm, such as, at least about 0.2 mm or at least about 0.3 mm or at least about 0.4 mm or even at least about 0.5 mm. According to still other embodiments, the axial height T.sub.W of the push-on fastener **100** may be not greater than about 100 mm, such as, not greater than about 90 mm or even not greater than about 80 mm. It will be appreciated that the axial height T.sub.W of the push-on fastener **100** may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the axial height T.sub.W of the push-on fastener **100** may be any value between any of the minimum and maximum values noted above. For example, the axial the axial height T.sub.W of the push-on fastener **100** may be 0.7 mm.

(62) In a number of embodiments, as shown in FIG. **4**, the push-on fastener **100** may have an overall outer radius OR.sub.W. For purposes of embodiments described herein, the outer radius OR.sub.W of the push-on fastener **100** is the distance from the central axis A to the radially outermost periphery of the push-on fastener **100**, which may be either the outer radial edge **155** of the axial flange **150**, the outer radial edge **105** of the annular base **104**, or the outer radial edge **125** of the at least one radial tab **110**. According to certain embodiment, the outer radius OR.sub.W of the push-on fastener **100** may be at least about 1 mm, such as, at least about 10 mm or at least about 20 mm or at least about 30 mm or at least about 40 mm or even at least about 50 mm. According to still other embodiments, the outer radius OR.sub.W of the push-on fastener **100** may be not greater than about 100 mm, such as, not greater than about 50 mm or even not greater than about 25 mm. It will be appreciated that the outer radius OR.sub.W of the push-on fastener **100** may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the outer radius OR.sub.W of the push-on fastener **100** may be any value between any of the minimum and maximum values noted above. For example, the outer radius OR.sub.W of the push-on fastener **100** may be 23 mm.

(63) In a number of embodiments, as shown in FIG. **4**, the push-on fastener **100** may have an overall inner radius IR.sub.W. For purposes of embodiments described herein, the inner radius IR.sub.W of the push-on fastener **100** is the distance from the central axis A to the radially innermost periphery of the push-on fastener **100**, which may be either the inner radial edge **123** of the innermost radial tab **110**, the inner radial edge **153** of the axial flange **150**, or the inner radial edge **103** of the annular base **104**. According to certain embodiment, the inner radius IR.sub.W of the push-on fastener **100** may be at least about 1 mm, such as, at least about 10 mm or at least about 20 mm or at least about 30 mm or at least about 40 mm or even at least about 50 mm. According to still other embodiments, the inner radius IR.sub.W of the push-on fastener **100** may be not greater than about 100 mm, such as, not greater than about 50 mm or even not greater than about 25 mm. It will be appreciated that the inner radius IR.sub.W of the push-on fastener **100** may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the inner radius IR.sub.W of the push-on fastener **100** may be any value between any of the minimum and maximum values noted above. For example, the inner radius IR.sub.W of the push-on fastener **100** may be 23 mm.

(64) For purposes of illustration, FIG. **6** includes a perspective top view of a push-on fastener **100** in accordance with alternative embodiments described herein. It will be appreciated that

corresponding components between FIG. **6** and FIGS. **4** and **5** (i.e., components having the same reference number) may be described as having any of the characteristics or features described in reference to FIGS. **4** and **5**.

(65) Referring now to FIG. **6**, according to certain embodiments, the push-on fastener **100** can include a push-on fastener body **102** oriented about a central axis A. The push-on fastener **100** may further have an annular base **104**. The push-on fastener **100** may further include at least one radial tab **110** disposed along at least one of the inner radial edge **103** of the annular base **104**. As shown in these alternative embodiments, the push-on fastener **100** and/or annular base **104** may include an axial flange **150**. The axial flange **150** may have a first axial surface **152** and a second axial surface **154** opposite the first axial surface **152**. The axial flange **150** may have a polygonal, oval, circular, semi-circular, or substantially circular cross-section when viewed in a plane perpendicular to the central axis A. In certain embodiments, the axial flange **150** can cant relative to a line parallel to the central axis A.

(66) In a number of embodiments, as shown in FIG. **6**, the axial flange **150** can have an axial height T.sub.AF. For purposes of embodiments described herein, the axial height T.sub.AF of the axial flange **150** is the distance from the first axial surface **152** to the second axial surface **154**. According to certain embodiment, the axial height T.sub.RT of the axial flange **150** may be at least about 0.1 mm, such as, at least about 0.2 mm or at least about 0.3 mm or at least about 0.4 mm or even at least about 0.5 mm. According to still other embodiments, the axial height T.sub.RT of the axial flange **150** may be not greater than about 15 mm, such as, not greater than about 10 mm or even not greater than about 5 mm. It will be appreciated that the axial height T.sub.RT of the axial flange **150** may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the axial height T.sub.RT of the axial flange **150** may be any value between any of the minimum and maximum values noted above. For example, the axial the axial height T.sub.RT of the axial flange **150** may be 0.7 mm.

(67) For purposes of illustration, FIGS. **7**A-**7**C includes a top view, a cross-sectional view, and a perspective view respectively of a push-on fastener **100** in accordance with alternative embodiments described herein. It will be appreciated that corresponding components between FIGS. **7**A-**7**C and FIGS. **4**, **5**, and **6** (i.e., components having the same reference number) may be described as having any of the characteristics or features described in reference to FIGS. **4**, **5**, and **6**.

(68) Referring now to FIGS. **7**A-**7**C, according to certain embodiments, the push-on fastener **100** can include a push-on fastener body **102** oriented about a central axis A. The push-on fastener **100** may further have an annular base **104**. The push-on fastener **100** may further include at least one radial tab **110** disposed along the outer radial edge **105** of the annular base **104**. As shown in these alternative embodiments, the at least one radial tab **110** may project radially outward from the annular base **104**. In these embodiments, the at least one radial tab **110** may include an inner radial edge **123** and an outer radial edge **125**. In this embodiment, the inner radial edge **123** of the radial tab **110** may coincide with the outer radial edge **105** of the annular base **104**. In this embodiment the at least one radial tab **110** can define an outer radial edge **125** and a bridge portion **135** connecting the outer radial edge **125** to the annular base **104**.

(69) Per FIGS. **3**C-**3**D and as now shown in more detail in FIGS. **7**A-**7**C, in an embodiment, the at least one radial tab **110** may define an outer peripheral surface **112***b*. In this alternative embodiment, the outer radial edge **125** of at least one radial tab **110** may define the outer peripheral surface **112***b*. In this way, the radial tabs **110** project radially outwardly and forms the outer peripheral surface **112***b*. In a particular embodiment, at least one of the radial tabs **110** may have an exposed surface **175** defined as being free of the low friction layer **1104**.

(70) In an embodiment, as shown in FIGS. **7**A-**7**C, the axial flange **150** may include an inner radial edge **153** and an outer radial edge **155**. The axial flange **150** can have a length L. For purposes of embodiments described herein, the length L.sub.AF of the axial flange **150** is the distance from the

inner radial edge **153** to the outer radial edge **155**. According to certain embodiment, the length L.sub.AF of the axial flange **150** may be at least about 1 mm, such as, at least about 10 mm or at least about 30 mm or at least about 40 mm or at least about 50 mm or even at least about 60 mm. According to still other embodiments, the length L.sub.AF of the axial flange **150** may be not greater than about 100 mm, such as, not greater than about 50 mm or even not greater than about 25 mm. It will be appreciated that the length L.sub.AF of the axial flange **150** may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the length L of the axial flange **150** may be any value between any of the minimum and maximum values noted above. For example, the length the length L of the axial flange **150** may be 25 mm.

(71) For purposes of illustration, FIGS. **8**A-**8**E includes a top view, a side view, a side view, a top cutout view, and a cross-sectional view respectively of a push-on fastener **100** within an assembly **500** in accordance with alternative embodiments described herein. It will be appreciated that corresponding components between FIGS. **8**A-**8**E (i.e., components having the same reference number) may be described as having any of the characteristics or features described in reference to FIGS. **8**A-**8**E. In a number of embodiments, the push-on fastener **100** can be disposed adjacent to, or contacting, an inner member **528** (such as a shaft) in an assembly **500**. The assembly **500** may also include an outer member **530** (such as a bearing, housing, a side member, or other structural member) fitted on the inner member **528**. In an embodiment, the outer member **530** may be adapted to rotate relative to the inner member **528**. In another embodiment, the inner member **528** may be adapted to rotate relative to the outer member **530**. The push-on fastener **100** can be disposed adjacent to, or contacting, an inner member **528** in an assembly **500**. In a number of embodiments, the push-on fastener **100** may be installed on the inner member **528** in the assembly **500**. In a number of embodiments, the at least one radial tab **110** of the push-on fastener **100** may fix the push-on fastener **100** to the inner member **528** in the assembly **500**.

(72) During and after installation, the at least one radial tab **110** may be adapted to radially deform. The at least one radial tab **110** can operate in an elastic zone of deformation, i.e., the at least one radial tab **110** can be capable of deforming upon application of a force and returning to its original shape after removal of the force. In a further embodiment, at least one at least one radial tab **110** can operate in a plastic zone of deformation, i.e., the at least one radial tab **110** can be incapable of fully returning to its original shape after removal the force. It may be possible, by including at least one radial tab **110** of different deformation characteristics on the annular base **104**, to yet further alter the characteristics of the push-on fastener **100**, e.g., stiffness, sliding capability, or tolerance absorption.

(73) Referring to FIG. **8**A, a non-limiting embodiment of an assembly **500** is shown. In an embodiment, the assembly **500** may be a seat assembly **500** for a vehicle. The seat assembly **500** generally includes a seat **502** having a bottom portion **504** and a seat back **506**. The seat back **506** may be pivotally connected with the bottom portion **504**. The bottom portion **504** may include a frame **508**, a cover **510**, and a cushion or support disposed therebetween. The seat back **506** may include an internal support **512**. The seat assembly **500** may provide a location whereby a vehicle passenger may sit. The seat assembly **500** may include at least one sliding assembly **525**, **525′**. The seat assembly **500** can include at least one inner member **528**, **528′**, **528″**. The seat assembly can include at least one outer member **530**. The seat assembly can include at least one push-on fastener **100**. FIG. **8**B shows a side view of a push-on fastener **100** within an assembly **500** as shown in FIG. **8**A. In a number of embodiments, the inner member **528** may be a cross-tube of the seat assembly **500** and part of the frame **508** of the bottom portion **504** of the seat assembly **500**. FIG. **8**C shows a side view of a plurality of push-on fasteners **100**, **100′** within an assembly having multiple inner members **528**, **528′**. FIG. **8**C shows a cut-out top view of a push-on fastener **100** within an assembly. FIGS. **8**C-D show the inner member **528**, as it may be coupled to a side plate **527**, **527′** of the frame **508** of the bottom portion **504**.

(74) Referring now to FIG. **8**E, in a number of embodiments, a push-on fastener **100** in accordance with one or more of the embodiments described herein can be disposed onto an inner member **528** (such as a shaft) to form an assembly **500** with the push-on fastener **100** in an installed state. The inner member **528** may be a cross-tube for a seat assembly **500** for a vehicle. In a number of embodiments, the assembly **500** may further include a side seat member **550**. In a number of embodiments, the assembly **500** may further include a bearing **560**. As shown in FIG. **8**E, in a number of embodiments, at least one of the radial tabs **110** of the push-on fastener **100** may engage and/or contact at least one of the inner member **528** or the outer member **530**. In another embodiment, the first major surface **107** of the push-on fastener **100** may define an axially interior surface and the second major surface **109** of the push-on fastener **100** may define an axially exterior surface while the plurality of radial tabs **110** project axially outwardly along the central axis A of the assembly **500**. In an embodiment, the annular base **104** may include a bearing surface **165** that the outer member **530** contacts.

(75) As shown in FIG. **8**E, the axial flange **150** can form an angle β with respect to the plane parallel to the annular base **104** and perpendicular to the central axis A. By way of a non-limiting embodiment, the angle β between the axial flange **150** and the annular base **104** in the unloaded state can be at least 0°, such as at least 45°, at least 65°, at least 75°, or even at least 90°. In another embodiment, the angle β can be no greater than 180°, such as no greater than 135°, no greater than 120°, no greater than 90°, no greater than 75°, or even no greater than 45°. It will be appreciated that the angle β may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the angle β may be any value between any of the minimum and maximum values noted above. For example, the angle β may be 43°.

(76) For purposes of illustration, FIGS. **9**A-C show a top side, cross-sectional, and perspective view of a push-on fastener **100** within an assembly **500** respectively. In a number of embodiments, as shown in FIG. **9**B, at least one of the inner radial edges **123** of the radial tabs **110** of the push-on fastener **100** may be keyed to the inner member **528** through matching or otherwise corresponding grooves **29** found in the inner member **528**. In a number of variations, the grooves **529** may have a polygonal, oval, circular, semi-circular, or substantially circular cross-section and may coincide with the shape of at least one of the radial tabs **110** to form an interference fit preventing or restricting the relative movement of the push-on fastener **100** with at least one of the inner member **528**.

(77) In a number of embodiments, at least one of the first major surface **107** or a second major surface **109** of the push-on fastener **100** may be engaged with the outer member **530** so as to prevent or restrict relative movement between the push-on fastener **100** and the inner member **528**. The movement may be prevented or restricted in a rotational, axial, or radial direction with respect to the central axis A. According to a particular embodiment, relative axial movement may be prevented. In a number of embodiments, at least one of the peripheral surfaces **112***a*, **112***b* of the push-on fastener **100** may form an interlock with at least one of the inner member **528** or the outer member **530**. In a number of embodiments, the interlock may be a corner **192**, **194** of at least one of the peripheral surfaces **112***a*, **112***b* contacting at least one of the inner member **528** or the outer member **530**. In a number of embodiments, the sharp corner **192** may be adapted to contact at least one of the inner member **528** or the outer member **530** in an assembly **500**.

(78) In an embodiment, the push-on fastener **100** can provide a retention force on the inner member **528** of at least 1 N under a strain of less than 10 mm.

(79) In an embodiment, the metal substrate **1119** and the low friction layer **1119** on the push-on fastener exhibit a peel strength (measured according to Standard ISO 4578 of greater than 20 N/cm, such as greater than 40 N/cm, greater than 50 N/cm, greater than 75 N/cm. In an embodiment, the metal substrate **1119** and the low friction layer **1119** on the push-on fastener exhibit a peel strength (measured according to Standard ISO 4578 of less than 100 N/cm, such as less than 75 N/cm, less than 50 N/cm, or less than 25 N/cm.

(80) In an embodiment, the assembly **500** can be installed or assembled by an assembly force of at least 10 N a longitudinal direction relative to the inner member **528**, such as at least 20 N, at least 30 N, at least 40 N, at least 50 N, at least 100 N, or even at least 150 N. In a further embodiment, the assembly **500** can be installed or assembled by an assembly force of at least 1 kgf in a longitudinal direction relative to the inner member **528**, such as no greater than 1500 N, no greater than 1000 N, no greater than 750 N, or even no greater than 250 N.

(81) Use of the push-on fastener **100** or assembly **500** may provide increased benefits in several applications such as, but not limited to, vehicle tail gates, door frames, seat assemblies, or other types of applications. Notably, the use of the push-on fastener **100** may provide a simplification of the assembly **500** by eliminating components. Further, use of the push-on fastener **100** may improve assembly forces required, compensate for axial tolerances between the inner and outer members **28**, **30**, and provide noise reduction and vibration decoupling within the assembly **500** by preventing undesired movement between the inner and outer members **28**, **30**. Further, the push-on fastener **100** may be a simple installation and be retrofit and cost effective across several possible assemblies of varying complexity. Further, the low friction layer **1104** on the push-on fastener **100** may provide low friction properties and act as an axial bearing while still being a fixation element against a component of the assembly **500**. This can improve the friction performance between the push-on fastener **100** and other components of the assembly **500**. Lastly, the use of the push-on fastener **100** may maintain the improved stiffness and tensile strength between the inner and outer members **28**, **30**, increasing the lifetime of the assembly **500**.

(82) Many different aspects and embodiments are possible. Some of those aspects and embodiments are described below. After reading this specification, skilled artisans will appreciate that those aspects and embodiments are only illustrative and do not limit the scope of the present invention. Embodiments may be in accordance with any one or more of the embodiments as listed below.

Embodiment 1

(83) A push-on fastener comprising: a push-on fastener body comprising an annular base defining an aperture, first and second opposing major surfaces, and a plurality of radial tabs extending from the annular base, the radial tabs terminating radially inwardly or radially outwardly and providing a peripheral surface; and a low friction layer overlying the first major surface of the push-on fastener body, wherein the peripheral surface is free of low friction layer.

Embodiment 2

(84) An assembly comprising: an inner member comprising a shaft; an outer member fitted on the inner member, wherein at least one of the inner member and the outer member is adapted to rotate relative to the other; and a push-on fastener comprising: a push-on fastener body comprising an annular base defining an aperture, first and second opposing major surfaces, and a plurality of radial tabs extending from the annular base, the radial tabs terminating radially inwardly or radially outwardly and providing a peripheral surface; and a low friction layer overlying the first major surface of the push-on fastener body, wherein the peripheral surface is free of low friction layer.

Embodiment 3

(85) The push-on fastener or assembly of any of the preceding embodiments, wherein the first major surface intersects the peripheral surface to form a sharp corner, wherein the second major surface intersects the peripheral surface to form a radiused corner.

Embodiment 4

(86) The push-on fastener or assembly of embodiment 3, wherein the radiused corner has a radius of curvature in the range of 0.0 mm to 1.5 mm.

Embodiment 5

(87) The push-on fastener or assembly of embodiment 3, wherein the sharp corner has a radius of curvature in the range of 0.0 mm to 1.5 mm.

Embodiment 6

(88) The push-on fastener or assembly of embodiment 3, wherein the sharp corner is adapted to contact the inner member or outer member.
Embodiment 7
(89) The push-on fastener or assembly of any of the preceding embodiments, wherein at least one of the radial tabs is adapted to radially deform.
Embodiment 8
(90) The push-on fastener or assembly of any of the preceding embodiments, wherein the peripheral surface is formed by a cutting operation.
Embodiment 9
(91) The push-on fastener or assembly of embodiment 8, wherein the cutting operation defines a cutting direction initiated from the second major surface to the first major surface to form the peripheral surface.
Embodiment 10
(92) The assembly of embodiment 2, wherein the annular base comprises a bearing surface against which the outer member contacts.
Embodiment 11
(93) The assembly of embodiment 2, wherein the outer member comprises at least one of a bearing or a side member.
Embodiment 12
(94) The assembly of embodiment 2, wherein the push-on fastener provides a retention force on the inner member of at least 1 N under a strain of less than 10 mm.
Embodiment 13
(95) The push-on fastener or assembly of any of the preceding embodiments, wherein the push-on fastener body comprises a metal, such as iron, copper, titanium, tin, aluminum, or an alloy thereof.
Embodiment 14
(96) The push-on fastener or assembly of embodiment 13, wherein the push-on fastener body comprises stainless steel or carbon steel.
Embodiment 15
(97) The push-on fastener or assembly of any of the preceding embodiments, wherein the low friction layer comprises a fluoropolymer.
Embodiment 16
(98) The push-on fastener or assembly of any of the preceding embodiments, wherein the push-on fastener further comprises an adhesive layer disposed between the push-on fastener body and the low friction layer.
Embodiment 17
(99) The push-on fastener or assembly of any of the preceding embodiments, wherein the plurality of radial tabs are circumferentially spaced apart from one another by a plurality of radial slots.
Embodiment 18
(100) The push-on fastener or assembly of any of the preceding embodiments, wherein the first major surface defines an axial interior surface, the second major surface defines an axial exterior surface, and the plurality of radial tabs project axially outwardly.
Embodiment 19
(101) The push-on fastener or assembly of any of the preceding embodiments, wherein at least one of the radial tabs forms an angle α with a cross-sectional plane of the annular base in the axial direction, wherein $\alpha \leq 30°$.
Embodiment 20
(102) The push-on fastener or assembly of any of the preceding embodiments, wherein the aperture has a radius within the range of between 5 mm and 25 mm.
Embodiment 21
(103) The push-on fastener or assembly of any of the preceding embodiments, wherein the push-on

fastener body and the low friction layer exhibit a peel strength (measured according to Standard ISO 4578 of greater than 20 N/cm.

Embodiment 22

(104) The assembly of embodiment 2, wherein the assembly comprises a seat assembly for a vehicle.

Embodiment 23

(105) The push-on fastener or assembly of any of the preceding embodiments, wherein the push-on fastener further comprises an axial flange.

Embodiment 24

(106) The push-on fastener or assembly of any of the preceding embodiments, wherein the radial tabs project radially outwardly and the peripheral surface forms an outer peripheral surface.

Embodiment 25

(107) The push-on fastener or assembly of embodiment 24, wherein the annular base defines an inner peripheral surface opposite the outer peripheral surface.

Embodiment 26

(108) The push-on fastener or assembly of embodiment 24, wherein the inner peripheral surface is free of the low friction layer.

Embodiment 27

(109) The push-on fastener or assembly of any of embodiments 1-22, wherein the radial tabs project radially inwardly and the peripheral surface forms an inner peripheral surface.

Embodiment 28

(110) The push-on fastener or assembly of embodiment 26, wherein the annular base defines an outer peripheral surface opposite the inner peripheral surface.

Embodiment 29

(111) The push-on fastener or assembly of embodiment 27, wherein the outer peripheral surface is free of the low friction layer.

(112) Note that not all of the features described above are required, that a portion of a specific feature may not be required, and that one or more features may be provided in addition to those described. Still further, the order in which features are described is not necessarily the order in which the features are installed.

(113) Certain features are, for clarity, described herein in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features that are, for brevity, described in the context of a single embodiment, may also be provided separately or in any subcombinations.

(114) Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments, however, the benefits, advantages, solutions to problems, and any feature(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature of any or all the claims.

(115) The specification and illustrations of the embodiments described herein are intended to provide a general understanding of the structure of the various embodiments. The specification and illustrations are not intended to serve as an exhaustive and comprehensive description of all of the elements and features of apparatus and systems that use the structures or methods described herein. Separate embodiments may also be provided in combination in a single embodiment, and conversely, various features that are, for brevity, described in the context of a single embodiment, may also be provided separately or in any subcombination. Further, reference to values stated in ranges includes each and every value within that range. Many other embodiments may be apparent to skilled artisans only after reading this specification. Other embodiments may be used and derived from the disclosure, such that a structural substitution, logical substitution, or any change may be made without departing from the scope of the disclosure. Accordingly, the disclosure is to be regarded as illustrative rather than restrictive.

Claims

1. A push-on fastener comprising: a push-on fastener body comprising a substrate comprising spring steel and forming an annular base defining an aperture, first and second opposing major surfaces, and a plurality of radial tabs extending from the annular base, the radial tabs terminating radially inwardly or radially outwardly; and a low friction layer comprising a polymer overlying and laminated to the substrate, wherein the annular base further defines an inner peripheral surface and an outer peripheral surface opposite the inner peripheral surface, wherein 1) the radial tabs terminate radially inwardly providing the inner peripheral surface, or **2**) the radial tabs terminate radially outwardly providing the outer peripheral surface, wherein the low friction layer has an axial height T.sub.FL in a range of 0.1 mm and 0.4 mm, wherein the low friction layer is overlying and laminated to the substrate 1) along the first major surface but not the second major surface of the push-on fastener body, or 2) along the second major surface but not the first major surface of the push-on fastener body.
2. An assembly comprising: an inner member comprising a shaft; an outer member fitted on the inner member, wherein at least one of the inner member and the outer member is adapted to rotate relative to the other; and a push-on fastener comprising: a push-on fastener body comprising a substrate comprising spring steel and forming an annular base defining an aperture, first and second opposing major surfaces, and a plurality of radial tabs extending from the annular base, the radial tabs terminating radially inwardly or radially outwardly; and a low friction layer comprising a polymer overlying and laminated to the substrate, wherein the annular base further defines an inner peripheral surface and an outer peripheral surface opposite the inner peripheral surface, wherein 1) the radial tabs terminate radially inwardly providing the inner peripheral surface, or 2) the radial tabs terminate radially outwardly providing the outer peripheral surface, wherein the low friction layer has an axial height T.sub.FL in a range of 0.1 mm and 0.4 mm. wherein the low friction layer is overlying and laminated to the substrate 1) along the first major surface but not the second major surface of the push-on fastener body, or 2) along the second major surface but not the first major surface of the push-on fastener body.
3. The push-on fastener of claim 1, wherein the second major surface intersects the peripheral surface to form a radiused corner, wherein the radiused corner has a radius of curvature in the range of 0.0 mm to 1.5 mm.
4. The push-on fastener of claim 1, wherein the first major surface intersects the peripheral surface to form a sharp corner, wherein the sharp corner has a radius of curvature in the range of 0.0 mm to 1.5 mm.
5. The push-on fastener of claim 1, wherein the first major surface intersects the peripheral surface to form a sharp corner, wherein the sharp corner is adapted to contact the inner member or outer member.
6. The push-on fastener of claim 1, wherein at least one of the radial tabs is adapted to radially deform.
7. The push-on fastener of claim 1, wherein the peripheral surface is formed by a cutting operation.
8. The push-on fastener of claim 7, wherein the cutting operation defines a cutting direction initiated from the second major surface to the first major surface to form the peripheral surface.
9. The push-on fastener of claim 1, wherein the low friction layer comprises a fluoropolymer.
10. The push-on fastener of claim 1, wherein the plurality of radial tabs are circumferentially spaced apart from one another by a plurality of radial slots.
11. The push-on fastener of claim 1, wherein at least one of the radial tabs forms an angle α with a cross-sectional plane of the annular base in the axial direction, wherein $\alpha \leq 30°$.
12. The push-on fastener of claim 1, wherein the push-on fastener body and the low friction layer exhibit a peel strength (measured according to Standard ISO 4578) of greater than 20 N/cm.

13. The push-on fastener of claim 1, wherein the first major surface intersects the peripheral surface to form a sharp corner having an extreme slope to form a sharp edge, wherein the second major surface intersects the peripheral surface to form a radiused corner having a smaller slope than the sharp corner to form a smooth edge.
14. The push-on fastener of claim 13, wherein the first major surface intersects the peripheral surface to form a sharp corner, wherein the sharp corner comprises a burr.
15. The push-on fastener of claim 1, wherein the low friction layer comprises polytetrafluoroethylene.
16. The push-on fastener of claim 1, wherein at least one radial tab of the plurality of radial tabs forms an angle α with a cutting direction of the fastener.