A bushing can include a load bearing substrate having a first major surface, an adhesive film overlying the first major surface, and a friction reducing layer overlying the adhesive film. A method can include extruding an adhesive film, laminating a friction reducing layer to a load bearing substrate with the adhesive film therebetween to form a composite, and shaping the composite to form a bushing. The adhesive film can include a first adhesive layer, such as a fluoropolymer layer. The adhesive layer can include a modified ethylene tetrafluoroethylene, and the fluoropolymer layer can include an ethylene tetrafluoroethylene.
ADHESIVE FILM FOR BUSHINGS

TECHNICAL FIELD

The present disclosure generally relates to bushings, and more particularly relates to an adhesive film for bushings.

BACKGROUND ART

Sliding bearing composite materials consisting of a load bearing substrate and a friction reducing layer overlay are generally known.

Sliding bearing composite materials can be used to form a variety of bearings, such as plain bearing bushing used, for example, by the automotive industry. Such plain bearing bushings can be used for door, hood, and engine compartment hinges, seats, steering columns, flywheels, balancer shaft bearings, etc. Additionally, plain bearing bushings formed from the sliding bearing composite materials can also be used in non-automotive applications.

One method of enhancing the adhesion between a load bearing substrate and the friction reducing layer is to apply a surface treatment to the load bearing substrate, such as chromate or a chromic acid treated phosphate. However, surface treatment can include the use of toxic compounds such as hexavalent chromium. Thus, there is an ongoing need for improved bearings that do not rely upon surface treatments such as chromate.

DISCLOSURE OF THE INVENTION

In an exemplary embodiment, a bushing can include a load bearing substrate having a first major surface, an adhesive film overlying the first major surface, and a friction reducing layer overlying the adhesive layer. The adhesive film can include an adhesive layer and a fluoropolymer layer.
In another exemplary embodiment, a composite can include a metal substrate having a first major surface, an adhesive film overlying the first major surface, and a friction reducing layer overlying the adhesive layer. The adhesive film can include an adhesive layer and a fluoropolymer layer. The adhesive layer can have a thickness of not greater than about 7.5 microns.

In yet another embodiment, a method can include extruding an adhesive film comprising an adhesive layer and a fluoropolymer layer. The method can further include laminating a friction reducing layer to a load bearing substrate with the adhesive film therebetween to form a composite, and shaping the composite to form a bushing.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure may be better understood, and its numerous features and advantages made apparent to those skilled in the art by referencing the accompanying drawings.

FIGs. 1 and 2 include illustrations of the layer structure of exemplary bushings.

FIG. 3 includes an illustration of various embodiment of bushing.

FIGs. 4, 5, and 6 include illustrations of exemplary hinges.

FIG. 7 includes an illustration of an exemplary bicycle headset.

The use of the same reference symbols in different drawings indicates similar or identical items.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

In an exemplary embodiment, a bushing can include a load bearing substrate having a first major surface, an adhesive film overlying the first major surface, and a friction reducing layer overlying the adhesive layer. The adhesive film can include a first adhesive layer and a fluoropolymer layer. In a particular embodiment, the adhesive film can include a second adhesive layer with the fluoropolymer layer.
between the two adhesive layers. The bushing can provide a sliding engagement between two components and reduce surface wear of the two components.

FIG. 1 shows a cross section illustrating the various layers of the vibration damping bushing, generally designated 100. Bushing 100 can include a load bearing substrate 102. The load bearing substrate 102 can be a metallic support layer. The metallic support layer can include a metal or metal alloy such as steel including carbon steel, spring steel, and the like, iron, aluminum, zinc, copper, magnesium, or any combination thereof. In a particular embodiment, the load bearing substrate 102 can include a stainless steel. Further, the load bearing substrate can be substantially free of chromate.

A friction reducing layer 104 can be applied to the load bearing substrate 102 with an adhesive film 106. The friction reducing layer 104 can include a polymer. Examples of polymers that can be used in friction reducing layer 104 include fluoropolymer, polyacetal, polybutylene terephthalate, polyimide, polyetherimide, polyetheretherketone (PEEK), polyethylene, polysulfone, polyamide, polyphenylene oxide, polyphenylene sulfide (PPS), polyurethane, polyester, or any combination thereof. Examples of fluoropolymers can include polytetrafluoroethylene (PTFE), fluorinated ethylene-propylene (FEP), polyvinylidenfluoride (PVDF), polychlorotrifluoroethylene (PCTFE), ethylene chlorotrifluoroethylene (ECTFE), perfluoroalkoxy polymer (PFA), or any combination thereof. In a particular embodiment, the friction reducing layer 104 can include PTFE, such as, cast, paste extruded, or skived PTFE. In an embodiment, the friction reducing layer 104 can have a coefficient of friction of not greater than about 0.4, such as not greater than about 0.2, even not greater than about 0.15.

Additionally, friction reducing layer 104 can include fillers, such as a friction reducing filler. Examples of fillers that can be used in the friction reducing layer 102 include glass fibers, carbon fibers, silicon, graphite, PEEK, molybdenum disulfide, aromatic polyester, carbon particles, bronze, fluoropolymer, thermoplastic fillers, silicon carbide, aluminum oxide, polyamidimide (PAI), PPS, polyphenylene sulfone (PPS02), aromatic polyesters including liquid crystal polymers (LCP), and mineral particles such as wollastonite and barium sulfate, or any combination thereof. An LCP is a partially oriented aromatic polyester capable of forming highly oriented
regions while in the liquid phase. Fillers can be in the form of beads, fibers, powder, mesh, or any combination thereof.

Adhesive film 106 can include an adhesive layer 108 and a fluoropolymer layer 110. In a particular embodiment, the adhesive film 104 can be in direct contact with the load bearing substrate 102.

The adhesive layer 108 can include a modified fluoropolymer. The modified fluoropolymer can include a functional group, such as a carboxy group, a carboxy anhydride group, a carboxylic halide group, an ester group, a carbonate group, an epoxy group, a sulfate group, a phosphate group, an amide group, a silyl group, or any combination thereof. In a particular embodiment, the functional group can include maleic anhydride, acrylic acid, or another suitable material. Additionally, fluoropolymer layer 110 can include a melt processible fluoropolymer, such as ETFE, ethylene fluorinated ethylene-propylene (EFEP) terpolymer, polychlorotrifluoroethylene (PCTFE), ethylene chlorotrifluoroethylene (ECTFE), or any combination thereof. In an embodiment, the polymer of the adhesive layer 108 can be a modified variant of the fluoropolymer in the fluoropolymer layer 110. For example, the fluoropolymer layer 110 can include ETFE and the adhesive layer 108 can include a modified ETFE, such as a maleic anhydride modified ETFE or other modified ETFE.

In an embodiment, the adhesive film 106 can have a thickness of about 25 microns to about 75 microns, such as about 30 microns to about 50 microns. Further, the first adhesive layer can have a thickness of about 1 micron to about 7.5 microns, such as about 1.5 microns to about 5 microns. Additionally, the fluoropolymer layer can have a thickness of about 20 microns to about 70 microns, such as about 24 microns to about 45 microns. The ratio of the thickness of the adhesive layer 108 to the thickness of the fluoropolymer layer 110 can be not less than about 1:20, such as not less than about 1:15, even not less than about 1:10. In a particular embodiment, the ratio of the thickness of the adhesive layer to the thickness of the fluoropolymer layer can be not greater than 1:2, such as not greater than 1:4.

In an alternative embodiment illustrated in FIG. 2, the adhesive film 104 can include a second adhesive layer 110. Fluoropolymer layer 106 can be located
between adhesive layers 106 and 110. In an embodiment, the thickness of each adhesive layer can be substantially the same and the ratio of each adhesive layer to the fluoropolymer layer can be not less than 5:90, such as not less than 7.5:85, even not less than 10:80.

Turning to the method of forming the bushing, an adhesive film can be formed by coextruding an adhesive layer and a fluoropolymer layer. Coextruding the adhesive layer and the fluoropolymer layer can include extruding onto a casting drum.

A friction reducing layer, such as a skived fluoropolymer, can be laminated to a load bearing substrate with the adhesive film to form a laminate sheet having the adhesive film between the friction reducing layer and the load bearing substrate. In a particular embodiment, a surface of the friction reducing layer can be etched to enhance bonding between the friction reducing layer and the adhesive film. The laminate sheet can be cut into strips or blanks that can be formed into the bushing. The blanks can be formed into the bushing, such as by rolling and flanging the laminate to form a semi-finished bushing of a desired shape.

In an embodiment, the bushing can have a cylindrically shaped portion. In another embodiment, the bushing can have a conical shape. Further, the bushing can have a flanged portion on one or more ends. Additionally, the friction reducing layer can be on an inner surface of the bushing or on an outer surface of the bushing.

FIGs. 3A through 3F illustrates a number of bushing shapes that can be formed from the blanks. FIG. 3A illustrates a cylindrical bushing that can be formed by rolling. FIG. 3B illustrates a flanged bushing that can be formed by rolling and flanging. FIG. 3C illustrates a flanged bushing having a tapered cylindrical portion that can be formed by rolling a tapered portion and flanging an end. FIG. 3D illustrates a flanged bushing mounted in a housing with a shaft pin mounted through the flanged bushing. FIG. 3E illustrates a two-sided flanged bushing mounted in a housing with a shaft pin mounted through the two-sided flanged bushing. FIG. 3F illustrates an L type bushing that can be formed using a stamping and cold deep drawing process, rather than rolling and flanging.
In a particular example, the bushing can be used in a hinge. For example, FIG. 4 and 5 illustrate an exemplary hinge 400, such as an automotive door hinge, hood hinge, engine compartment hinge, and the like. Hinge 400 can include an inner hinge portion 402 and an outer hinge portion 404. Hinge portions 402 and 404 can be joined by rivets 406 and 408 and bushings 410 and 412. Bushings 410 and 412 can be vibration-damping bushings, as previously described. FIG. 5 illustrates a cross section of hinge 400, showing rivet 408, and bushing 412 in more detail.

FIG. 6 illustrates another exemplary hinge 600, such as an automotive door hinge, hood hinge, engine compartment hinge, and the like. Hinge 600 can include a first hinge portion 602 and a second hinge portion 604 joined by a pin 606 and a bushing 608. Bushing 608 can be a vibration damping bushing as previously described.

In another example, the bushing can be used in a headset. For example, FIG. 7 illustrates an exemplary headset 700 for a two-wheeled vehicle, such as a bicycle. A steering tube 702 can be inserted through a head tube 704. Bushings 706 and 708 can be placed between the steering tube 702 and the head tube 704 to maintain alignment and prevent contact between the steering tube 702 and the head tube 704. Additionally, seals 710 and 712 can prevent contamination of the sliding surface of the bushing by dirt and other particulate matter.

Particular embodiments of the above bushing provide advantageous technical features. In particular, Applicants use of an adhesive film with a modified polymer adhesive, such as modified ETFE, can result in improved adhesion between the friction reducing layer and the load bearing substrate without the use of a surface treatment including chromate or chromic acid. As a result, manufacturing of the bushing can have a reduced impact on the environment and reduced cost for disposal of toxic chemicals.

Note that not all of the activities described above in the general description or the examples are required, that a portion of a specific activity may not be required, and that one or more further activities may be performed in addition to those described. Still further, the order in which activities are listed are not necessarily the order in which they are performed.
In the foregoing specification, the concepts have been described with reference to specific embodiments. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of invention.

As used herein, the terms "comprises," "comprising," "includes," "including," "has," "having" or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, 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 process, 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).

Also, the use of "a" or "an" are 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 or at least one and the singular also includes the plural unless it is obvious that it is meant otherwise.

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.

After reading the specification, skilled artisans will appreciate that 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 subcombination. Further, references to values stated in ranges include each and every value within that range.
CLAIMS:

1. A bushing comprising:
   a load bearing substrate having a first major surface;
   an adhesive film overlying the first major surface and comprising a first
   adhesive layer and a fluoropolymer layer; and
   a friction reducing layer overlying the adhesive layer.

2. The bushing of claim 1, wherein the adhesive layer includes a modified
   ethylene tetrafluoroethylene.

3. The bushing of claim 2, wherein the modified ethylene tetrafluoroethylene
   includes maleic anhydride.

4. The bushing of claim 1, wherein the fluoropolymer layer includes an
   ethylene tetrafluoroethylene.

5. The bushing of claim 1, wherein the fluoropolymer layer includes a
   fluoropolymer and the adhesive layer including a modified form of the fluoropolymer.

6. The bushing of claim 1, wherein the adhesive film has a thickness of about
   25 microns to about 75 microns.

7. The bushing of claim 6, wherein the thickness of the adhesive film is about
   30 microns to about 50 microns.

8. The bushing of claim 1, wherein the first adhesive layer has a thickness of
   about 1 microns to about 7.5 microns.

9. The bushing of claim 8, wherein the thickness of the first adhesive layer is
   about 1.5 microns to about 5 microns.

10. The bushing of claim 1, wherein the fluoropolymer layer has a thickness
    of about 20 microns to about 70 microns.
11. The bushing of claim 10, wherein the thickness of the fluoropolymer layer is about 24 microns to about 45 microns.

12. The bushing of claim 1, wherein a thickness ratio of the first adhesive layer and the fluoropolymer layer is not less than 1:20.

13. The bushing of claim 12, wherein the thickness ratio is not less than 1:15.

14. The bushing of claim 13, wherein the thickness ratio is not less than 1:10.

15. The bushing of claim 12, wherein the thickness ratio is not greater than 1:2.

16. The bushing of claim 15, wherein the thickness ratio is not greater than 1:4.

17. The bushing of claim 1, wherein the load bearing substrate is in direct contact with the first adhesive layer.

18. The bushing of claim 1, wherein the adhesive film further includes a second adhesive layer.

19. The bushing of claim 18, wherein the fluoropolymer layer is located between the first and second adhesive layers.

20. The bushing of claim 18, wherein a thickness of the first adhesive layer and a thickness of the second adhesive layer is substantially similar.

21. The bushing of claim 18, wherein a thickness ratio of the second adhesive layer and the fluoropolymer layer is not less than 5:90.

22. The bushing of claim 21, wherein the thickness ratio of the second adhesive layer and the fluoropolymer layer is not less than 7.5:85.
23. The bushing of claim 22, wherein the thickness ratio of the second adhesive layer and the fluoropolymer layer is not less than 10:80.

24. The bushing of claim 1, wherein the load bearing substrate is a metal or metal alloy.

25. The bushing of claim 24, wherein the metal or metal alloy is selected from the group consisting of aluminum, steel, iron, zinc, copper, magnesium, or any combination thereof.

26. The bushing of claim 25, wherein the steel includes stainless steel.

27. The bushing of claim 24, wherein the load bearing substrate is substantially free of chromate.

28. The bushing of claim 1, wherein the friction reducing layer includes a polymer.

29. The bushing of claim 28, wherein the polymer includes a fluoropolymer, a polyacetal, a polybutylene terephthalate, a polyimide, a polyetherimide, a polyetheretherketone (PEEK), a polyethylene, a polysulfone, a polyamide, a polyphenylene oxide, a polyphenylene sulfide (PPS), a polyurethane, a polyester, or any combination thereof.

30. The bushing of claim 29, wherein the fluoropolymer is selected from the group consisting of polytetrafluoroethylene, fluorinated ethylene-propylene, polyvinylidenfluoride, polychlorotrifluoroethylene, ethylene chlorotrifluoroethylene, perfluoroalkoxy polymer, and any combination thereof.

31. The bushing of claim 28, wherein the friction reducing layer includes a friction reducing filler.

32. The bushing of claim 31, wherein the friction reducing filler is selected from the group consisting of glass fibers, carbon fibers, silicon, graphite, polyetheretherketone, molybdenum disulfide, aromatic polyester, carbon particles,
bronze, fluoropolymer, thermoplastic fillers, mineral fillers, and any combination thereof.

33. The bushing of claim 1, wherein the friction reducing layer has a coefficient of friction of not greater than about 0.4.

34. The bushing of claim 33, wherein the friction reducing layer has a coefficient of friction of not greater than about 0.2.

35. The bushing of claim 34, wherein the friction reducing layer has a coefficient of friction of not greater than about 0.15.

36. The bushing of claim 1, wherein the bushing has a cylindrically shaped portion.

37. The bushing of claim 1, wherein the bushing has a conical shape.

38. The bushing of claim 1, wherein the bushing has a flanged portion at one end.

39. The bushing of claim 38, wherein the bushing has a second flanged portion at the other end.

40. The bushing of claim 1, wherein the friction reducing layer is on an inner surface of the bushing.

41. The bushing of claim 1, wherein the friction reducing layer is on an outer surface of the bushing.

42. A composite comprising:
a metal substrate having a first major surface; and
an adhesive film overlying the first major surface and comprising a modified ethylene tetrafluoroethylene layer and an ethylene tetrafluoroethylene layer, the modified ethylene tetrafluoroethylene layer having a thickness of not greater than about 7.5 microns; and
a friction reducing layer overlying the adhesive layer.

43. The composite of claim 42, wherein the modified ethylene tetrafluoroethylene includes maleic anhydride.

44. The composite of claim 42, wherein the adhesive film has a thickness of about 25 microns to about 75 microns.

45. The composite of claim 44, wherein the thickness of the adhesive film is about 30 microns to about 50 microns.

46. The composite of claim 42, wherein the thickness of the modified ethylene tetrafluoroethylene layer is at least about 1 microns.

47. The composite of claim 42, wherein the ethylene tetrafluoroethylene layer has a thickness of about 20 microns to about 70 microns.

48. The composite of claim 42, wherein a thickness ratio of the modified ethylene tetrafluoroethylene layer and the ethylene tetrafluoroethylene layer is not less than 1:20.

49. The composite of claim 48, wherein the thickness ratio is not greater than 1:2.

50. The composite of claim 42, wherein the load bearing substrate is in direct contact with the adhesive layer modified ethylene tetrafluoroethylene layer.

51. The composite of claim 42, wherein the modified ethylene tetrafluoroethylene layer includes a first modified ethylene tetrafluoroethylene layer and a second modified ethylene tetrafluoroethylene layer.

52. The composite of claim 51, wherein the ethylene tetrafluoroethylene layer is located between the first and second modified ethylene tetrafluoroethylene layer.
53. The composite of claim 51, wherein a thickness ratio of the second modified ethylene tetrafluoroethylene layer and the ethylene tetrafluoroethylene layer is not less than 5:90.

54. The composite of claim 42, wherein the metal substrate is a metal or metal alloy.

55. The composite of claim 54, wherein the metal or metal alloy is selected from the group consisting of aluminum, steel, iron, zinc, copper, magnesium, or any combination thereof.

56. The composite of claim 55, wherein the steel includes stainless steel.

57. The composite of claim 54, wherein the load bearing substrate is substantially free of chromate.

58. The composite of claim 42, wherein the friction reducing layer includes a fluoropolymer.

59. The composite of claim 58, wherein the friction reducing layer includes a friction reducing filler.

60. The composite of claim 42, wherein the friction reducing layer has a coefficient of friction of not greater than about 0.4.

61. A method comprising
extruding an adhesive film comprising a first modified ethylene tetrafluoroethylene layer and an ethylene tetrafluoroethylene layer;
laminating a friction reducing layer to a load bearing substrate with the adhesive film therebetween to form a composite;
shaping the composite to form a bushing.

62. The method of claim 61, wherein the load bearing substrate is in direct contact with the modified ethylene tetrafluoroethylene layer.
63. The method of claim 61, wherein the adhesive film is extruded onto a casting drum.

64. The method of claim 61, wherein the modified ethylene tetrafluoroethylene includes maleic anhydride.

65. The method of claim 61, wherein the adhesive film has a thickness of about 25 microns to about 75 microns.

66. The method of claim 65, wherein the thickness of the adhesive film is about 30 microns to about 50 microns.

67. The method of claim 61, wherein the first modified ethylene tetrafluoroethylene layer has a thickness of about 1 microns to about 7.5 microns.

68. The method of claim 67, wherein the thickness of the first modified ethylene tetrafluoroethylene layer is about 1.5 microns to about 5 microns.

69. The method of claim 61, wherein the ethylene tetrafluoroethylene layer has a thickness of about 20 microns to about 70 microns.

70. The method of claim 69, wherein the thickness of the ethylene tetrafluoroethylene layer is about 24 microns to about 45 microns.

71. The method of claim 61, wherein a thickness ratio of the first modified ethylene tetrafluoroethylene layer and the ethylene tetrafluoroethylene layer is not less than 1:20.

72. The method of claim 71, wherein the thickness ratio is not greater than 1:2.

73. The method of claim 61, wherein the adhesive layer further includes a second modified ethylene tetrafluoroethylene layer.
74. The method of claim 73, wherein the ethylene tetrafluoroethylene layer is located between the first and second modified ethylene tetrafluoroethylene layer.

75. The method of claim 73, wherein a thickness ratio of the first modified ethylene tetrafluoroethylene layer, the ethylene tetrafluoroethylene layer, and the second modified ethylene tetrafluoroethylene layer is not less than 5:90:5.

76. The method of claim 61, wherein the friction reducing layer is a skived fluoropolymer.

77. The method of claim 76, wherein the fluoropolymer is selected from the group consisting of polytetrafluoroethylene, fluorinated ethylene-propylene, polyvinylidenfluoride, polychlorotrifluoroethylene, ethylene chlorotrifluoroethylene, perfluoroalkoxypolymer, and any combination thereof.

78. The method of claim 61, further comprising etching the friction reducing layer

79. The method of claim 61, wherein shaping the composite includes rolling and flanging.