

DESCRIPTION

TITLE OF THE INVENTION: SERRATED METAL GASKET

TECHNICAL FIELD

[0001] The present invention relates to a serrated metal gasket. More particularly, the present invention relates to a serrated metal gasket and a kammprofile gasket having the serrated metal gasket. The serrated metal gasket and the kammprofile gasket having the serrated metal gasket according to the present invention can be suitably applied to, for example, a pipe flange in which a fluid such as steam having a high temperature and a high pressure is used, a tower, a tank, a heat exchanger, an autoclave, a bonnet of a valve, a metal sealing mechanism, and the like.

BACKGROUND ART

[0002] A serrated gasket has concentric serrated recesses and protrusions on both surfaces of the gasket so that an effective area contacted with a flange or the like is reduced, in order to improve sealing efficiency. The serrated gasket has been commonly applied to, for example, a bonnet of a valve, a pipe flange, a cover gasket of a pressure vessel, and the like.

[0003] As a serrated gasket showing a high reduction effect in cost, a serrated gasket which is interposed between a first flange member and a second flange member, showing sealing performance by intruding serrated recesses and protrusions formed on a gasket body into a sealing surface of the first flange member and a sealing surface of the second flange member, wherein the gasket body is composed of a metal seal body on which the serrated recesses and protrusions are formed, and a metal positioning part formed on the outer peripheral surface of the seal part body, and wherein

the metal positioning part is composed of plural divided bodies being divided in a circumferential direction, has been proposed (see, for example, Patent Literature 1).

[0004] A serrated gasket provided with a sheet layer including expanded graphite and the like, which can prevent fine particles of the sheet layer, such as expanded graphite, which are generated by crushing the gasket in compression from entering into a fluid passage has been proposed (see, for example, Patent Literature 2). The serrated gasket is provided with a gasket body and sheet layers, in which concentric serrated protrusions and recesses are formed on both surfaces of the gasket body, and the sheet layers are formed on the surfaces of the serrated gasket so that the serrated convex and concave portions are covered with the sheet layers. The serrated gasket in which the gasket body is integrated with the sheet layer is provided at a joint of a fluid passage. When the serrated gasket is tightened between a first member and a second member of the joint, the serrated protrusions and recesses of the serrated gasket are fitted with the first member and the second member through the sheet layer, and therefore, sealability is imparted to the joint. When a distance between a first convex closest to the fluid passage and a second convex adjacent to the first convex is regarded as “a”, and each of a distance between the first convex and a second convex adjacent to the first convex, a distance between the second convex and a third convex adjacent to the second convex, a distance between the third convex and a fourth convex adjacent to the third convex, a distance between the fourth convex and a fifth convex adjacent to the fourth convex, and a distance between a “n-1-th” convex and a “n-th” convex adjacent to the “n-1-th” convex is regarded as “b”, the distance “a” and the distance “b” satisfy the formula represented by $a \geq 2b$. The end point of a diameter of the sheet layer is arranged between the first convex

and the second convex.

[0005] The serrated gasket exhibits excellent cost reduction effects. The serrated gasket having the sheet layer exhibits an excellent effect such that fine particles of the sheet layer generated by crushing the gasket in compression can be prevented from entering into the fluid passage.

[0006] In recent years, in order to prevent leakage of a fluid from a boundary between flanges even when a kammprofile gasket is placed between the flanges of pipes, and a high-pressure fluid is introduced into the pipes, it has been desired that a surface pressure between the flanges is 80 MPa or more, and therefore, it has been desired to develop a kammprofile gasket being excellent in durability at the above surface pressure and also excellent in sealing performance.

[0007] However, when a kammprofile gasket represented by a conventional serrated gasket having a sheet layer of which thickness is 0.6 to 1.5 mm is placed between, for example, flanges of pipes, and the flanges are tightened so that a surface pressure of the kammprofile gasket being contacted with the flanges is 80 MPa or more, sealing performance between a convex of the serrated gasket and the flanges cannot be sufficiently secured because the sheet layer existing on the convex of the serrated gasket is thick.

PRIOR ART LITERATURES

PATENT LITERATURES

[0008] Patent Literature 1: Japanese Patent No. 4842023

Patent Literature 2: Japanese Patent No. 4877673

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0009] The present invention has been made in view of the above-mentioned prior art. An object of the present invention is to provide a kammprofile gasket and a serrated metal gasket which can be suitably used in the kammprofile gasket, which enables to sufficiently secure sealing performance between a protrusion of the serrated metal gasket and a flange even when the kammprofile gasket having an elastic sheet of which thickness is 0.6 to 1.5 mm is placed between flanges of a pipe, and the flanges are tightened so that a surface pressure on the surface of the kammprofile gasket in contact with the flange is 80 MPa or more, and which is excellent in durability at the above surface pressure.

MEANS FOR SOLVING THE PROBLEMS

[0010] The present invention relates to:

- (1) a serrated metal gasket including concentric serrated protrusions and recesses on both surfaces, wherein a pitch of the protrusions constituting the serrated protrusions and recesses is 1.2 to 1.8 mm; a flat area having a width of 50 to 180 μm is formed on an apex of the protrusions; a depth of recesses constituting the serrated protrusions and recesses is 0.3 to 0.8 mm; and a circular arc having a radius of 0.2 to 0.6 mm is formed on the bottom of the recesses,
- (2) the serrated metal gasket according to the above item (1), wherein a groove area in the cross section of the recess constituting the serrated protrusions and recesses is 0.25 to 0.80 mm^2 , and
- (3) a kammprofile gasket including the serrated metal gasket according to the above item (1) or (2), wherein an elastic sheet having a thickness of 0.6 to 1.5 mm is attached to the serrated protrusions and recesses formed on both surfaces of the serrated metal gasket.

EFFECTS OF THE INVENTION

[0011] According to the present invention, a kammprofile gasket and a serrated metal gasket which can be suitably used in the kammprofile gasket, which enables to sufficiently secure sealing performance between a protrusion of the serrated metal gasket and a flange even when the kammprofile gasket having an elastic sheet of which thickness is 0.6 to 1.5 mm is placed between flanges of a pipe, and the flanges are tightened so that a surface pressure on the surface of the kammprofile gasket in contact with the flange is 80 MPa or more, and which is excellent in durability at the above surface pressure are provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Fig. 1 is a schematic plan view showing one embodiment of a serrated metal gasket according to the present invention.

Fig. 2 is a schematic cross-sectional view taken along line A-A of the serrated metal gasket shown in Fig. 1.

Fig. 3 is a partial enlarged view of the serrated protrusions and recesses shown in the cross-sectional view of the serrated metal gasket shown in Fig. 2.

Fig. 4 is a schematic plan view showing one embodiment of a kammprofile gasket according to the present invention.

Fig. 5 is a schematic cross-sectional view in the B-B part of the kammprofile gasket shown in Fig. 4.

MODE FOR CARRYING OUT THE INVENTION

[0013] The serrated metal gasket according to the present invention is a metal gasket in which concentric serrated protrusions and recesses are formed on both surfaces of the metal gasket.

[0014] The serrated metal gasket according to the present invention is characterized in that a pitch of the protrusions constituting the serrated protrusions and recesses is 1.2 to 1.8 mm, that a flat area having a width of 50 to 180 μm is formed on the apex the protrusions, that a depth of recesses constituting the serrated protrusions and recesses is 0.3 to 0.8 mm, and that a circular arc having a radius of 0.2 to 0.6 mm is formed on the bottom of the recesses.

[0015] The serrated metal gasket according to the present invention has the above configuration. Therefore, the serrated metal gasket is excellent in durability even when a surface pressure is 80MPa in fastening flanges and the like, and is also excellent sealing performance.

[0016] The serrated metal gasket according to the present invention will be more specifically described below with reference to drawings. However, the present invention is not limited only to embodiments illustrated in the drawings.

[0017] Fig. 1 is a schematic plan view of one embodiment of the serrated metal gasket according to the present invention. Fig. 2 is a schematic cross-sectional view taken along line A-A of the serrated metal gasket shown in Fig. 1. Fig. 3 is a partial enlarged view of the serrated protrusions and recesses of the serrated metal gasket shown in the cross-sectional view of the serrated metal gasket of Fig. 2.

[0018] As shown in Fig. 1, the serrated metal gasket 1 according to the present invention has concentric serrated protrusions and recesses 1a and a flat plate-like flange area 2, in which the flange area 2 is formed integrally with the serrated protrusions and recesses 1a. The planar shape of the serrated metal gasket 1 is a disk.

[0019] The material of the serrated metal gasket 1 cannot be absolutely determined because the material differs depending on uses of the serrated

metal gasket 1. Accordingly, it is preferred that the material is appropriately determined in accordance with the uses of the serrated metal gasket 1. The material of the serrated metal gasket 1 is preferably a metal selected from the group consisting of aluminum, aluminum alloy, stainless steel, Inconel, carbon steel, lead, gold, silver, copper, nickel, tantalum, chromium molybdenum steel, Monel, titanium and magnesium alloy, more preferably a metal selected from the group consisting of aluminum, aluminum alloy, stainless steel and Inconel, and furthermore preferably aluminum or stainless steel, from the viewpoint of ensuring sealing performance based on the serrated metal gasket 1.

[0020] The aluminum alloy includes, for example, aluminum-iron alloy, aluminum-copper alloy, aluminum-manganese alloy, aluminum-magnesium alloy, aluminum-zinc alloy, aluminum-nickel alloy and the like, and the present invention is not limited only to those exemplified ones.

[0021] The stainless steel includes, for example, SUS304, SUS316, SUS430, SUS630, SUS631, SUS633, SUS420J2 and the like, and the present invention is not limited only to those exemplified ones.

[0022] A metal other than magnesium used in the magnesium alloy includes, for example, lithium, calcium, aluminum, zinc, titanium, manganese, zirconium, yttrium, tantalum, neodymium, niobium and the like, and the present invention is not limited only to those exemplified ones.

[0023] In the schematic plan view of the serrated metal gasket 1 shown in Fig. 1, it is preferred to appropriately determine the outer diameter and the inner diameter of the opening of the central part of the serrated metal gasket 1 in accordance with uses of the serrated metal gasket 1, because the outer diameter and the inner diameter differ depending on uses of the serrated metal gasket 1. In the schematic cross-sectional view of the serrated metal gasket shown in Fig. 2, it is preferred that the thickness t

(thickness of the flange area) of the serrated metal gasket 1 is appropriately determined in accordance with uses of the serrated metal gasket 1, because the thickness t differs depending on uses of the serrated metal gasket 1. The thickness t is usually 1.5 to 15 mm or so.

[0024] The planar shape of the serrated metal gasket 1 shown in Fig. 1 is circular. The circular shape is a concept including not only a true circle but also a longitudinal elliptical shape, a laterally long elliptical shape and a track elliptical shape. The planar shape of the serrated metal gasket 1 can be appropriately determined in accordance with uses of the serrated metal gasket 1.

[0025] As shown in Fig. 2, concentric serrated recesses and protrusions 1a, 1b are formed on both sides of the serrated metal gasket 1. A plurality of the serrated recesses and protrusions 1a, 1b are respectively provided concentrically in the diameter direction of the serrated metal gasket 1.

[0026] As shown in Fig. 3, the serrated protrusions and recesses 1a are formed on the upper surface of the serrated metal gasket 1 shown in Fig. 2. A flat area L is formed on the apex T of the protrusion 3 constituting the serrated protrusions and recesses 1a in the diameter direction of the serrated metal gasket 1. Accordingly, the protrusion 3 has a trapezoidal cross-sectional shape as shown in Fig. 3. Although the flat area L is a plane formed in a direction parallel to the diameter of the serrated metal gasket 1, the flat area L may have an inclination (taper) rather than being formed in a direction parallel to the diameter of the serrated metal gasket 1 within a scope which would not hinder an object of the present invention. It is preferred that the shape of the serrated protrusions and recesses 1b formed on the lower surface of the serrated metal gasket 1 shown in Fig. 2 is the same as that of the serrated protrusions and recesses 1a formed on the upper surface.

[0027] In Fig. 3, the width W (width in the diameter direction of the serrated metal gasket 1) of the flat area L formed on the apex T of the protrusion 3 depends on, for example, a tightening pressure when the kammprofile gasket having an elastic sheet (not shown in the figure) attached to the serrated protrusions and recesses 1a, 1b of the serrated metal gasket 1 is sandwiched between two flanges, and is tightened. The width W is 50 to 180 μm , preferably 60 to 150 μm , and more preferably 80 to 120 μm , from the viewpoint of preventing the elastic sheet from breaking on the flat area L formed on the apex T of the protrusion 3, and improvement in sealing performance of the serrated metal gasket 1.

[0028] In Fig. 3, the pitch P of the protrusion 3 constituting the serrated protrusions and recesses 1a of the serrated metal gasket 1 is a distance between the center of the flat area L formed on the apex T of the protrusion 3 and the center of the flat area L formed at the apex T of another protrusion 3 adjacent to the above protrusion 3. The pitch P between the protrusion 3 and another protrusion 3 adjacent to the above protrusion 3 is usually constant respectively in plural protrusions and recesses 1a.

However, there can be included a pitch which is not constant within a scope which would not hinder an object of the present invention. The pitch P is from 1.2 to 1.8 mm from the viewpoint of improvement in sealing performance based on the serrated metal gasket 1. It is preferred that the pitch (not shown) of the protrusion 3 constituting the serrated protrusions and recesses 1b formed on the lower surface of the serrated metal gasket 1 shown in Fig. 2 is the same as the above pitch P.

[0029] In Fig. 3, the depth D of the protrusion 3 constituting the serrated protrusions and recesses 1a of the serrated metal gasket 1 is a height from the deepest position (bottom) B of the recess 4 constituting the serrated protrusions and recesses 1a of the serrated metal gasket 1 to the apex T of

the protrusion 3. The depth D is 0.3 to 0.8 mm, and preferably 0.4 to 0.75 mm, from the viewpoint of improvement in sealing performance based on the serrated metal gasket 1. It is preferred that the depth (not shown) of the protrusion formed on the lower surface of the serrated metal gasket 1 shown in Fig. 2 is the same as that of the above depth D.

[0030] In Fig. 3, an arc is formed on the bottom B of the recess 4 constituting the serrated protrusions and recesses 1a of the serrated metal gasket 1 in the diameter direction of the serrated metal gasket 1. Accordingly, the recess 4 has a cross-sectional shape similar to an inverted trapezoid having an arc on the bottom B. The radius of the arc is 0.2 to 0.6 mm, and preferably 0.3 to 0.5 mm, from the viewpoint of improvement in sealing performance based on the serrated metal gasket 1. It is preferred that the shape of the bottom (not shown in the figure) of the recess constituting the serrated protrusions and recesses 1b of the serrated metal gasket 1 shown in Fig. 2 is the same as the shape of the bottom B of the above recess 4.

[0031] In Fig. 3, an area of a groove in the cross section of the recess 4 constituting the serrated protrusions and recesses 1a is preferably 0.25 to 0.80 mm², and more preferably 0.28 to 0.72 mm², from the viewpoint of improvement in sealing performance based on the serrated metal gasket 1. In Fig. 3, the area of the groove is a cross-sectional area of a space surrounded by a straight line connecting a flat area L formed on the apex T of the protrusion 3 with a flat area L formed on the apex T of another protrusion 3 adjacent to the above protrusion 3, and a line of the recess 4. The area of the groove of the cross section of the recess 4 constituting the serrated protrusions and recesses 1a, 1b is a value as determined by preparing a test piece having a groove shape of the above space, determining the volume of the test piece on the basis of the mass and the

density of the test piece, and dividing the volume of the test piece by the thickness of the test piece. It is preferred that the groove area in the cross section of the recess (not shown in the figure) constituting the serrated protrusions and recesses 1b of the serrated metal gasket 1 shown in Fig. 2 is the same as the groove area in the cross section of the above recess 4.

[0032] In Fig. 3, an angle θ formed by the inclined surface adjacent to the recess 4 constituting the serrated protrusions and recesses 1a is not particularly limited. The angle θ is preferably from 60 to 120°, more preferably from 80 to 100°, and furthermore preferably from 85 to 95°, from the viewpoint of improvement in sealing performance based on the serrated metal gasket 1. It is preferred that the angle (not shown in the figure) formed by the inclined surface adjacent to the recess constituting the serrated protrusions and recesses 1b of the serrated metal gasket 1 shown in Fig. 2 is the same as the above angle θ .

[0033] In Fig. 3, the protrusion 3 formed on the serrated protrusions and recesses 1a protrudes from the flat plate-like flange area 2 by a height H in order to enhance sealing performance of the serrated metal gasket 1. The height H of the protrusion 3 from the flat plate-like flange area 2 is preferably 0.3 to 0.8 mm, and more preferably 0.4 to 0.75 mm, from the viewpoint of improvement in sealing performance based on the serrated metal gasket 1. It is preferred that the height (not shown in the figure) from the plate-like flange area 2 of the serrated protrusion of the serrated metal gasket 1 shown in Fig. 2 is the same as the above height H.

[0034] In Fig. 3, the number of protrusions 3 formed on the serrated protrusions and recesses 1a cannot be absolutely determined because the number differs depending on uses of the serrated metal gasket 1, and is preferably at least 3, and more preferably at least 5, from the viewpoint of improvement in sealing performance of the serrated metal gasket 1. In

addition, the upper limit of the number of protrusions 3 cannot be absolutely determined because the number differs depending on uses of the serrated metal gasket 1, and is usually 10 or so. It is preferred that the number of protrusions formed on the serrated protrusions and recesses 1b of the serrated metal gasket 1 shown in Fig. 2 is the same as the number of the above protrusions 3.

[0035] The serrated protrusions and recesses 1a, 1b of the serrated metal gasket 1 shown in Fig. 2 can be formed by machining a metal gasket with, for example, a lathe or the like.

[0036] The serrated metal gasket 1 obtained in the above can be suitably used in a kammprofile gasket, because the serrated metal gasket 1 can improve sealing performance with a flange or the like when the serrated metal gasket 1 used in the kammprofile gasket.

[0037] The kammprofile gasket of the present invention will be specifically described below based on drawings. However, the present invention is not limited only to embodiments shown in the drawings.

[0038] Fig. 4 is a schematic plan view showing one embodiment of the kammprofile gasket of the present invention. Fig. 5 is a schematic cross-sectional view taken along line B-B of the kammprofile gasket shown in Fig. 4.

[0039] As shown in Fig. 4, the kammprofile gasket 5 according to the present invention is characterized in that the kammprofile gasket 5 has a serrated metal gasket 1, and that an elastic sheet 6 is attached to the serrated protrusions and recesses (not shown in the figure) formed on both surfaces of the serrated metal gasket 1.

[0040] Since the kammprofile gasket 5 has the above-described configuration, the kammprofile gasket 5 can improve sealing performance. For example, when the kammprofile gasket 5 is placed between two flanges,

and tightened by the flanges, since a part of the elastic sheet 6 enters into the recesses 4 constituting the serrated protrusions and recesses 1a, 1b formed on both surfaces of the serrated metal gasket 1 shown in Fig. 2 and Fig. 3, a surface pressure of the elastic sheet 6 existing on the flat area L formed on the apex T of the protrusions 3 increases, and thereby sealing performance is improved.

[0041] It is preferred that the elastic sheet 6 is an elastic sheet 6 containing an organic binder and an inorganic powder from the viewpoint of improvement in sealing performance and mechanical strength of the elastic sheet 6.

[0042] It is preferred that the organic binder is a rubber binder from the viewpoint of improvement in sealing performance and mechanical strength of the elastic sheet 6. The rubber binder includes, for example, acrylonitrile-butadiene rubber, natural rubber, isoprene rubber, chloroprene rubber, acrylonitrile rubber, styrene-butadiene rubber, butyl rubber, fluorocarbon rubber, silicone rubber, ethylene-propylene rubber and the like, and the present invention is not limited only to the exemplified ones. These rubber binders can be used alone, or in combination of at least two kinds thereof.

[0043] The content of the organic binder in the elastic sheet 6 is preferably 5 % by mass or more, more preferably 10 % by mass or more, furthermore preferably 15 % by mass or more, and even furthermore preferably 20 % by mass or more, from the viewpoint of improvement in sealing performance based on the elastic sheet 6, and is preferably 97 % by mass or less, more preferably 95 % by mass or less, and furthermore preferably 90 % by mass or less, from the viewpoint of improvement in heat resistance of the elastic sheet 6. Accordingly, the content of the organic binder in the elastic sheet 6 is preferably 5 to 97 % by mass, more

preferably 10 to 95 % by mass, furthermore preferably 15 to 90 % by mass, and even furthermore preferably 20 to 90 % by mass.

[0044] The inorganic powder has a property for enhancing flexibility of the elastic sheet 6 and shape retention property of the elastic sheet 6 at a high temperature. The inorganic powder remains and does not disappear even when the elastic sheet 6 is heated to a high temperature. Therefore, the inorganic powder can enhance sealing performance of the kammprofile gasket 5 of the present invention.

[0045] The inorganic powder includes, for example, talc, barium sulfate powder, clay, mica powder, titanium oxide powder, aluminum oxide powder, zinc oxide powder, magnesium oxide powder, silicate powder, silica powder, calcium carbonate powder, sodium carbonate powder, calcium hydroxide powder, aluminum hydroxide powder, magnesium carbonate powder, graphite powder, metal powder, glass powder and the like, and the present invention is not limited only to those exemplified ones. These inorganic powders can be used alone or in combination of at least two kinds thereof.

[0046] The average particle diameter of the inorganic powder is preferably 2 μm or more from the viewpoint of improvement in shape maintenance property of the elastic sheet 6, and is preferably 25 μm or less from the viewpoint of improvement in sealing performance. Incidentally, the particle diameter of the inorganic powder is a value when the particle diameter is determined by using a laser diffraction particle size analyzer. The average particle diameter of the inorganic powder is a value (median diameter) of the particle size when the cumulative number of particles of the inorganic powder is 50% in a particle size distribution as determined by using the laser diffraction particle size analyzer.

[0047] The content of the inorganic powder in the elastic sheet 6 is preferably 3 % by mass or more, more preferably 5 % by mass or more, and

furthermore preferably 10 % by mass or more, from the viewpoint of improvement in heat resistance of the elastic sheet 6, and is preferably 95 % by mass or less, more preferably 90 % by mass or less, furthermore preferably 85 % by mass or less, and even furthermore preferably 80 % by mass or less, from the viewpoint of improvement in sealing performance based on the elastic sheet 6. Accordingly, the content of the inorganic powder in the elastic sheet 6 is preferably 3 to 95 % by mass, more preferably 5 to 90 % by mass, furthermore preferably 10 to 85 % by mass, and even furthermore preferably 10 to 50 % by mass.

[0048] The elastic sheet 6 may contain a fiber from the viewpoint of improvement in mechanical strength and flexibility of the elastic sheet 6. The fiber includes an inorganic fiber and an organic fiber.

[0049] The inorganic fiber includes, for example, an alumina fiber, a glass fiber, a zirconia fiber, a rock wool, a basalt fiber, a biosoluble fiber, a silica fiber, a ceramic fiber and the like, and the present invention is not limited only to those exemplified ones. These inorganic fibers can be used alone or in combination of at least two kinds thereof.

[0050] The organic fiber includes, for example, synthetic fibers such as a polyamide fiber, an aramid fiber, a polyester fiber, a polyurethane fiber, a polyethylene fiber, an acrylic fiber and a polyvinyl alcohol fiber; vegetable fibers such as cotton, hemp and a cellulose fiber; animal fibers such as wool; regenerated fibers such as rayon; and the like. The present invention is not limited only to those exemplified ones. These organic fibers can be used alone or in combination of at least two kinds thereof.

[0051] The average fiber diameter of the fibers is preferably 3 to 20 μm from the viewpoint of improvement in mechanical strength of the elastic sheet 6. The fiber length of the fiber is preferably 0.01 mm or more, and more preferably 0.1 to 20 mm, from the viewpoint of improvement in

dispersibility of the fiber in the elastic sheet 6 and improvement in mechanical strength of the elastic sheet 6 as well. Incidentally, the average fiber diameter is a value as determined by measuring a fiber diameter of the fibers included in an image obtained by photographing the fibers with a scanning electron microscope, and calculating an average value of the fiber diameter of the fibers.

[0052] The content of the fiber in the elastic sheet 6 is preferably 3 % by mass or more, and more preferably 5 % by mass or more, from the viewpoint of improvement in mechanical strength of the elastic sheet 6, and is preferably 30 % by mass or less, more preferably 20 % by mass or less, and furthermore preferably 10 % by mass or less, from the viewpoint of improvement in sealing performance based on the elastic sheet 6.

Accordingly, the fiber content in the elastic sheet 6 is preferably 30 % by mass or less, more preferably 3 to 30 % by mass, furthermore preferably 5 to 20 % by mass, and even more preferably 5 to 10 % by mass.

[0053] There is no particular limitation in a method for producing the elastic sheet 6. The elastic sheet 6 can be produced, for example, by mixing an organic binder, an inorganic powder, and optionally a component such as a fiber and an organic solvent to give a mixture having a uniform composition, and molding the resulting mixture so as to have a predetermined shape.

[0054] The density of the elastic sheet 6 is preferably 0.8 to 1.2 g/cm³, and more preferably 0.9 to 1.1 g/cm³, from the viewpoint of improvement in sealing performance and mechanical strength.

[0055] The thickness of the elastic sheet 6 depends on a fastening pressure when the kammprofile gasket 5 is clamped between two flanges. The thickness is preferably 0.6 to 1.5 mm, and more preferably 0.8 to 1.2 mm, from the viewpoint of prevention of the elastic sheet 6 from being

broken at the flat part L formed on the apex T of the protrusion part 3 and improvement in sealing performance as well.

[0056] The elastic sheet 6 is usually attached to both surfaces of the serrated metal gasket 1 so as to cover the serrated protrusions and recesses 1a, 1b formed on both surfaces of the serrated metal gasket 1. The elastic sheet 6 can be attached to the surfaces of the serrated metal gasket 1, for example, by means of an adhesive agent, a double-sided adhesive tape or the like. The adhesive agent includes, for example, a rubber-based adhesive agent and the like, and the present invention is not limited only to those exemplified ones.

[0057] The kammprofile gasket 5 according to the present invention is configured as mentioned above. The elastic sheet 6 can be present in a thin layer state on the flat area L formed on the apex T of the protrusion 3 formed on both surfaces of the serrated metal gasket 1 used in the kammprofile gasket 5, even when the kammprofile gasket 5 according to the present invention is sandwiched between two flanges, and the kammprofile gasket is tightened so that the surface pressure of the kammprofile gasket becomes a high pressure of 80 MPa or more. For example, when the elastic sheet 6 having a thickness of 0.6 to 1.5 mm or so is used in the kammprofile gasket 5, and the kammprofile gasket 5 is sandwiched between two flanges and tightened at a surface pressure of 80 MPa or more, the elastic sheet 6 existing on the flat area L formed on the apex T of the protrusion 3 is thinned to a thickness of 0.05 to 0.1 mm or so, and the amount of fluid which permeates the thin elastic sheet 6 becomes very small. Therefore, the sealing performance of the kammprofile gasket 5 can be improved.

[0058] In addition, an inorganic filler such as talc has been generally included in a large amount in a heat-resistant elastic sheet used in a conventional kammprofile gasket in order to impart heat resistance to the

kammprofile gasket. In accordance with the content of the inorganic filler in the heat-resistant elastic sheet increase, the amount of a fluid which passes through the heat-resistant elastic sheet increases as compared with the case where the inorganic filler is not included in the elastic sheet. Therefore, there is a necessity to increase a surface pressure of the kammprofile gasket when the kammprofile gasket is tightened.

[0059] On the other hand, when the kammprofile gasket 5 according to the present invention is sandwiched between two flanges, and the surface pressure at the time of tightening the kammprofile gasket 5 is adjusted to a high pressure of 80 MPa or more, the elastic sheet 6 remains under a condition of a thin layer on the flat area L formed on the apex T of the protrusion 3 formed on both surfaces of the serrated metal gasket 1 used in the kammprofile gasket 5. Therefore, the flange can be prevented from damaging due to the exposure of the serrated metal gasket 1, because the serrated metal gasket is prevented from exposing by the elastic sheet 6.

[0060] Accordingly, even when the kammprofile gasket 5 according to the invention is placed between flanges of a pipe, and the kammprofile gasket 5 is tightened so that a surface pressure of the kammprofile gasket 5 being contacted with the flanges becomes 80 MPa or more, sufficient sealing performance can be ensured between the protrusion 3 of the serrated metal gasket 1 and the flanges, and therefore, the kammprofile gasket 5 according to the present invention is excellent in durability at this surface pressure. Thus, the kammprofile gasket 5 according to the present invention is suitable for uses in which a fluid having a high temperature and a high pressure used, and therefore, the kammprofile gasket 5 can be suitably used as a kammprofile gasket for high temperatures and high pressures, which is used in, for example, a pipe flange in which a fluid having a high temperature and a high pressure, such as steam is used, a tower, a tank, a

heat exchanger, an autoclave, a bonnet of a valve, a metal sealing mechanism and the like.

[0061] From the above, the kammprofile gasket 5 in which the serrated metal gasket 1 of the present invention is used can be suitably used when pipes in which a fluid having a high temperature and a high pressure is used are connected to each other, for example, in a thermal power plant, a nuclear power plant, a steam engine of a steam turbine ship, a petroleum refining line, a process line of a petroleum chemical industry, a semiconductor manufacturing line and the like.

EXAMPLES

[0062] Next, the present invention will be more specifically described based on working examples. However, the present invention is not limited only to those working examples.

[0063] Examples 1 to 14 and Comparative Examples 1 to 6

A metal gasket made of stainless steel (SUS316) having an outer diameter of 110 mm and an inner diameter of the central opening of 75 mm was machined with a lathe, to produce a serrated metal gasket 1 having a shape shown in Fig. 1 to Fig. 3, in which an outer diameter of concentric serrated protrusions and recesses was 90 mm, an inner diameter was 75 mm, a thickness of flange area was 2 mm, and an angle of an inclined surface adjacent to the recesses was 90°. Details of the serrated protrusions and recesses formed on the serrated metal gasket 1 are shown in Table 1.

[0064] An annular elastic sheet 6 having an outer diameter of 90 mm, an inner diameter of the opening of the center of 75 mm and a thickness of 0.9 mm, including an organic binder (acrylonitrile-butadiene rubber), an inorganic powder (talc) and fibers (alumina fiber and cellulose fiber) as

materials, and having a density of 1 g/cm^3 was bonded to the concentric serrated protrusions and recesses surface formed on both surfaces of the serrated metal gasket 1 obtained in the above with an adhesive agent (styrene-butadiene-butadiene-based adhesive agent), to give a kammprofile gasket 5. Incidentally, in Example 13, the thickness of the elastic sheet 6 was changed to 0.8 mm, and in Example 14, the thickness of the elastic sheet 6 was changed to 1.2 mm.

[0065] Next, using the kammprofile gasket 5 obtained above, sealing performance at high surface pressure tightening, adhesion state of the elastic sheet 6 to the protrusions formed on the serrated protrusions and recesses face as an index of durability, and a thickness of the elastic sheet 6 on protrusion were evaluated in accordance with the following methods. The results are shown in Table 1.

[0066] [Sealing performance at high surface pressure tightening]

The kammprofile gasket 5 was sandwiched between flanges of pipes, and a fastening surface pressure was adjusted to 100 MPa to tighten the flanges.

[0067] Next, nitrogen gas of 25°C was introduced into the pipes, and an internal pressure of the pipes was adjusted to 4 MPa. A leaked amount of the nitrogen gas was measured by means of a submergence test method, and the sealing performance at high surface pressure tightening was evaluated in accordance with the following evaluation criteria. The results are shown in the column "Sealability" of Table 1. Incidentally, the measurement limit in measuring the leaked amount of nitrogen gas is $1.7 \times 10^{-5} \text{ Pa} \cdot \text{m}^3/\text{s}$.

[0068] (Evaluation criteria)

S: Leaked amount of nitrogen gas is $1.7 \times 10^{-5} \text{ Pa} \cdot \text{m}^3/\text{s}$ or less (pass).

©: Leaked amount of nitrogen gas exceeds $1.7 \times 10^{-5} \text{ Pa} \cdot \text{m}^3/\text{s}$, and 1.7×10^{-4}

Pa · m³/s or less (pass).

○: Leaked amount of nitrogen gas exceeds 1.7×10^{-4} Pa · m³/s, and 1.7×10^{-3} Pa · m³/s or less (pass).

△: Leaked amount of nitrogen gas exceeds 1.7×10^{-3} Pa · m³/s, and 1.7×10^{-2} Pa · m³/s or less (failure).

×: Leaked amount of nitrogen gas is exceeds 1.7×10^{-2} Pa · m³/s (failure).

[0069] [Adhesive state of the elastic sheet on protrusion]

After evaluating the sealing performance at high surface pressure tightening in the above, the kammprofile gasket 5 was taken out from the flanges.

[0070] The elastic sheet attached to the kammprofile gasket was observed by naked eyes, and the adhesive state of the elastic sheet on the protrusion was evaluated in accordance with the following evaluation criteria. The results are shown in column "Adhesive state of elastic sheet" of Table 1.

[0071] (Evaluation criteria)

○: No abnormality is observed in the elastic sheet.

×: Tear is observed in the elastic sheet.

[0072] [Thickness of the elastic sheet on protrusion]

The thickness of the elastic sheet attached to the protrusion obtained in the above adhesive state of the elastic sheet on the protrusions was measured by means of a micrometer, and the thickness of the elastic sheet on the protrusions was evaluated in accordance with the following evaluation criteria. The results are shown in column "Thickness of elastic sheet" of Table 1.

[0073] (Evaluation criteria)

◎: Thickness of elastic sheet attached to protrusions is 150 μm or less (pass).

○: Thickness of elastic sheet attached to protrusions exceeds 150 μm and is 200 μm or less (pass).

×: Thickness of elastic sheet attached to protrusions exceeds 200 μm (failure).

[0074]

[Table 1]

Ex. and Comp. Ex.	Protrusions and recesses formed on serrated metal gasket						Evaluation of properties		
	Pitch of protrusions (mm)	Width W of flat area (μm)	Recess		Groove area (mm ²)	Height of protrusion from flange area (mm)	Sealability	Adhesive state of elastic sheet	Thickness of elastic sheet
			Depth D (mm)	Radius R of arc of bottom (mm)					
Ex. 1	1.5	100	0.53	0.4	0.47	0.53	S	○	◎
Ex. 2	1.4	100	0.48	0.4	0.41	0.48	S	○	◎
Ex. 3	1.8	100	0.73	0.4	0.71	0.73	S	○	◎
Ex. 4	1.2	100	0.43	0.4	0.29	0.43	S	○	◎
Ex. 5	1.5	90	0.53	0.4	0.47	0.53	S	○	◎
Ex. 6	1.5	110	0.53	0.4	0.47	0.53	S	○	◎
Ex. 7	1.5	70	0.53	0.4	0.47	0.53	◎	○	○
Ex. 8	1.5	125	0.53	0.4	0.47	0.53	◎	○	○
Ex. 9	1.5	100	0.53	0.3	0.48	0.53	S	○	◎
Ex. 10	1.5	100	0.53	0.5	0.46	0.53	S	○	◎
Ex. 11	1.5	100	0.53	0.25	0.49	0.53	◎	○	○
Ex. 12	1.5	100	0.53	0.55	0.43	0.53	◎	○	○
Ex. 13	1.5	100	0.53	0.4	0.47	0.53	S	○	◎
Ex. 14	1.5	100	0.53	0.4	0.47	0.53	S	○	◎
Comp. Ex. 1	1.1	100	0.32	0.4	0.23	0.32	×	○	×
Comp. Ex. 2	2.0	100	0.83	0.4	0.89	0.83	△	×	◎
Comp. Ex. 3	1.5	100	0.53	0.8	0.47	0.53	×	○	○
Comp. Ex. 4	1.5	100	0.53	0.1	0.47	0.53	△	○	×
Comp. Ex. 5	1.5	40	0.53	0.4	0.47	0.53	×	×	◎
Comp. Ex. 6	1.5	200	0.53	0.4	0.47	0.53	×	○	×

[0075] From the results shown in Table 1, it can be seen that the serrated metal gasket 1 and the kammprofile gasket, which were obtained in each comparative example are disadvantageous in at least one physical property of durability and sealing performance, whereas the serrated metal gasket 1 and the kammprofile gasket 5, which were obtained in each example are not only excellent in sealing performance, but also excellent in durability because no abnormality is observed in the elastic sheet even when the surface pressure is 100 MPa.

DESCRIPTION OF SYMBOLS

- [0076] 1: Serrated metal gasket
1a: Protrusions and recesses
1b: Protrusions and recesses
2: Flange area
3: Protrusion
4: Recess
5: Kammprofile gasket
6: Elastic sheet
B Bottom of recess
D: Depth of recess
L: Flat area at apex section of protrusion
T: Apex of protrusion

CLAIMS

1. A serrated metal gasket comprising concentric serrated protrusions and recesses on both surfaces, wherein a pitch of the protrusions constituting the serrated protrusions and recesses is 1.2 to 1.8 mm; a flat area having a width of 50 to 180 μm is formed on an apex of the protrusions; a depth of recesses constituting the serrated protrusions and recesses is 0.3 to 0.8 mm; and a circular arc having a radius of 0.2 to 0.6 mm is formed on the bottom of the recesses.
2. The serrated metal gasket according to claim 1, wherein a groove area in the cross section of the recess constituting the serrated protrusions and recesses is 0.25 to 0.80 mm^2 .
3. A kammprofile gasket comprising the serrated metal gasket according to claim 1 or 2, wherein an elastic sheet having a thickness of 0.6 to 1.5 mm is attached to the serrated protrusions and recesses formed on both surfaces of the serrated metal gasket.