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(54) **OPTIMIZED FIRE RING**

(57) The present invention pertains to a cylinder liner for a cylinder of a combustion engine as well as a combustion engine comprising at least one cylinder with a corresponding cylinder liner, in particular to reduce pressure differences between a combustion chamber and an upper part of a piston and/or to improve stiffness and fatigue strength of the cylinder liner. Accordingly, a cylinder liner (10) for a cylinder of a combustion engine is suggested, which comprises a longitudinally extending wall, wherein an inner diameter of the wall defines a bore (12) configured for receiving a piston and wherein the wall comprises a recess (14) facing the bore (12) and accommodating a ring-shaped element (16) extending into the bore (12) and beyond the wall in a radially inward direction. An inner diameter (20) of an upper wall portion (18) extending from the recess (14) to a combustion region end portion of the cylinder liner (10) is larger than an inner diameter (24) of a bottom wall portion (22) extending from the recess (14) to an opposing end portion of the cylinder liner (10).

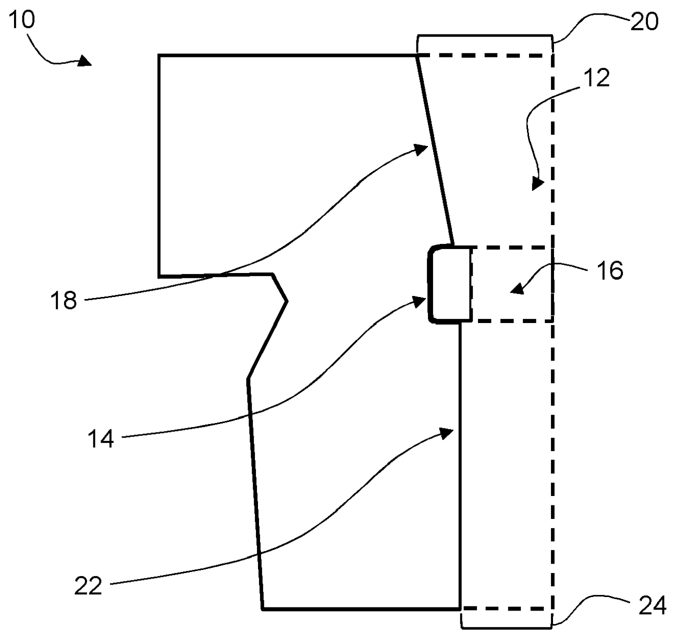

Fig. 1

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Description

Technical Field

[0001] The present invention pertains to a cylinder liner for a cylinder of a combustion engine as well as a combustion engine comprising at least one cylinder with a corresponding cylinder liner, in particular to reduce pressure differences between a combustion chamber and an upper part of a piston and/or to improve stiffness and fatigue strength of the cylinder liner.

Technological Background

[0002] Cylinder liners are commonly used in cylinders of a combustion engine in order to ensure proper functioning of a piston received therein, in particular by providing a sliding functionality during reciprocal action of the piston. Such cylinder liners generally comprise a fire ring or scraper ring, which extend from a top portion of the cylinder liner towards the intended position. The generally large dimensions of such scraper ring result in a significant reduction of the material thickness of the cylinder liner, which is furthermore already reduced at the level of an outer recess for mounting the cylinder liner in a respective cylinder. This reduces the stiffness of the cylinder liner and results in an increase of stresses, which increase the risk of fatigue cracks that hence reduce the longevity and durability of the cylinder liner.

[0003] Furthermore, the dimensioning of the ring-shaped element and a corresponding recess results in pressure differences, e.g. a loss of pressure, between an adjacent combustion area and the piston, e.g. at the top land thereof. These pressure differences are considered to be further detrimental for the material strength and furthermore reduce the functionality of the piston.

[0004] Accordingly, there is a need to improve the structural stability of the cylinder liner, in particular in the region of the scraper ring.

Summary of the invention

[0005] Starting from the prior art, it is an objective to provide a new and inventive cylinder liner for a cylinder of a combustion engine. In particular, it may be an objective to provide a cylinder liner which reduces pressure differences between a combustion chamber and an upper part of a piston and/or to improve stiffness and fatigue strength of the cylinder liner

[0006] This objective is solved by means of a cylinder liner for a cylinder of a combustion engine with the features of claim 1. Preferred embodiments are set forth in the present specification, the Figures as well as the dependent claims.

[0007] Accordingly, a cylinder liner for a cylinder of a combustion engine is suggested, which comprises a longitudinally extending wall, wherein an inner diameter of the wall defines a bore configured for receiving a piston and wherein the wall comprises a recess facing the bore and accommodating a ring-shaped element extending into the bore and beyond the wall in a radially inward direction. An inner diameter of an upper wall portion extending from the recess to a combustion region end portion of the cylinder liner is larger than an inner diameter of a bottom wall portion extending from the recess to an opposing end portion of the cylinder liner.

[0008] Furthermore, a combustion engine is suggested, which comprises at least one cylinder having a cylinder liner according to the invention.

Brief description of the drawings

[0009] The present disclosure will be more readily appreciated by reference to the following detailed description when being considered in connection with the accompanying drawings in which:

Figure 1 shows a schematic longitudinal section of a top portion of a cylinder liner;
Figure 2 shows a schematic longitudinal section of a top portion of a cylinder liner with an alternative ring-shaped element;
Figure 3 shows a detailed depiction of the ring-shaped element and cylinder liner according to Figure 2;
Figure 4 shows a detailed depiction of an alternative ring-shaped element and a cylinder liner;
Figure 5 shows a detailed depiction of another alternative ring-shaped element and an alternative cylinder liner;
Figure 6 shows a section of a ring-shaped element having a discontinuity from in a top schematic view; and
Figure 7 shows a section of an alternative ring-shaped element having a discontinuity from in a top schematic view.

Detailed description of preferred embodiments

[0010] In the following, the invention will be explained in more detail with reference to the accompanying figures. In the Figures, like elements are denoted by identical reference numerals and repeated description thereof may be omitted in order to avoid redundancies.

[0011] In Figure 1 a cylinder liner 10 for a cylinder of a combustion engine is shown in a schematic depiction and along a longitudinal section. The cylinder liner 10 is only shown for a top portion, wherein a combustion area may be present at the top end. The cylinder liner 10 may hence extend further towards a bottom end section, e.g. a gear section of a combustion engine. The cylinder liner 10 is formed of a solid material, preferably steel and is shaped and dimensioned so as to provide a liner for a cylinder of a combustion engine, wherein a corresponding outer recess (shown on the left side) and a top flange or annular portion is present to facilitate the mounting of the cylinder liner 10 in a cylinder.

[0012] The cylinder liner 10 is essentially formed as a longitudinally extending wall, which defines a continuous inner cavity formed as a bore 12, which is indicated with the dashed lines. The bore 12 is configured and adapted to receive and accommodate a piston of the combustion engine therein in a reciprocal arrangement. In Figure 1, the longitudinal section only depicts one radial end towards a longitudinal axis, which is delimited by the right dashed line in the Figure. Accordingly, the cylinder liner 10 is symmetrically formed and may be mirrored along said line to form an essentially cylindrical bore 12 and wall.

[0013] The wall of the cylinder liner 10 furthermore comprises a recess 14 facing the bore 12 and extending in a circumferential manner. The recess 14 accommodates and retains a ring-shaped element 16, which may be formed as a scraper ring or fire ring. In a mounted state, the ring-shaped element 16 may hence form a functionality for an adjacent piston or top land thereof and may e.g. ensure that cokes deposits are effectively removed so as to prevent clogging.

[0014] The recess 14 divides the wall into a lower or bottom wall portion 22 and an upper wall portion 18, wherein the bottom wall portion 22 may extend further downwards, as described above. The bottom wall portion 22 defines an inner diameter 24 which may essentially extend along an outer circumference of a piston received in the bore 12 of the cylinder liner 10.

[0015] The upper wall portion 18 also defines an inner diameter 20. As indicated in the Figure, the inner diameter 20 of the upper wall portion 18 is larger than the inner diameter 24 of the bottom wall portion 22. Starting from the recess 14, the inner diameter 20 gradually increases towards the top end portion of the cylinder liner 10, thereby forming a conical shape. Compared with the inner diameter 24 of the bottom wall section 22, the inner diameter 20 of the upper wall section 18 is enlarged already directly adjacent to the recess 14 (this is shown in further detail in Figures 3 to 5). The enlarged inner diameter 20 and the corresponding conical shape provide that pressure differences at the recess 14, ring-shaped element 16 and an adjacent piston may be minimized, which may be advantageous to reduce the risk of fatigue cracks.

[0016] In Figure 2 a schematic longitudinal section of a top portion of a cylinder liner 10 is shown, which is generally similar to the cylinder liner according to Figure 1. In this alternative, the upper wall portion 18 is not conically shaped, but extends essentially in parallel with the longitudinal axis of the cylinder liner 10 and/or the bottom wall portion 22.

[0017] The ring-shaped element 16 has an essentially semi-circular cross-section, which is tilted relative to the longitudinal axis. Thereby, the inner diameter of the uppermost portion of the ring-shaped element 16 corresponds to the inner diameter of the upper wall portion 18. This is in particular the case directly at the recess 14, since other shapes of the upper wall portion 18, e.g. the conical shape according to Figure 1, may be optionally provided. Furthermore, the inner diameter of the ring-shaped element 16 is gradually reduced towards the bottom wall portion 22, resulting in a protruding edge portion extending into the bore 12 at the interface between the recess 14 and the bottom wall portion 22. Thereby, pressure differences in the region of the ring-shaped element 16 may be further reduced.

[0018] Details of the cylinder liner 10 according to Figure 2 are schematically shown in Figure 3. Here it is well shown that the inner diameter 20 of the upper wall portion 18 is larger than the inner diameter 24 of the bottom wall portion 22, which is further facilitated by the added hashed lines. Furthermore, it is shown that the bottom portion of the ring-shaped element 16 forms a protruding edge defining a radially protruding length 30 beyond the wall into the bore 12.

[0019] A recess depth 28 or maximum inner diameter of the recess 14 is also depicted by the corresponding hashed line. The recess depth 30, i.e. the difference between the maximum inner diameter of the recess 14 and the minimum inner diameter 20 of the upper wall portion 18 is shown to exceed the penetration length 30 and the difference between the inner diameter 20 of the upper wall portion 18 and the inner diameter 24 of the bottom wall portion 22 between only two-fold and three-fold. This small recess depth 30 is nevertheless sufficient to securely retain the ring-shaped element 16 within the recess 14 and allows that the recess 14 and corresponding ring-shaped element 16 may be dimensioned smaller compared with known ring-shaped elements, which is advantageous for improving the stiffness and reducing stresses at this region of the cylinder liner 10.

[0020] An alternative configuration of the ring-shaped element 16 is depicted in Figure 4, wherein the surface of the ring-shaped element 16 facing the bore 12 comprises a concave shape, which is further advantageous in reducing pressure differences at this region. Furthermore, the shape of the ring-shaped element 16 provides that the ring-shaped element 16 is flush with the surface of the upper wall portion 18 defining the inner diameter 20. Thereby, a continuous flow path may be provided without significant flow disturbances.

[0021] Furthermore, the edge 30 in this exemplary configuration is formed having a blade shape, which may be essentially self-sharpening, e.g. depending on the material stiffness.

[0022] In Figure 5 another alternative ring-shaped element 16 is schematically depicted, wherein the cylinder liner 10 may have an alternative configuration. Compared with the configuration shown in Figure 2, the recess 14 may e.g. be positioned further upwards towards a combustion area, such that the recess 14 is longitudinally spaced apart from an outer recess of the cylinder liner 10 and may e.g. be arranged at a radially outward flange portion (not shown in Figure 4).

[0023] In such configuration, the ring-shaped element 16 may extend along the bottom wall portion 22, e.g.

along a conical portion of the bottom wall portion 22 having a gradually reduced inner diameter starting from the recess 14 and extending towards a portion of the bottom wall portion 22 defining the minimum inner diameter 24. Also in this configuration, the inner diameter 20 of the upper wall portion 18 is larger than the maximum inner diameter of the bottom wall portion 22, as indicated with the hashed line. This also applies, when the ring-shaped element 16 extends along the upper wall portion to some extent, as shown in Figure 4. However, such extension is considered optional, yet may be advantageous to facilitate securing the ring-shaped element 16 in the recess 14.

[0024] In Figures 6 and 7 two alternative configurations of a ring-shaped element 16 having a discontinuity are shown in a top schematic view and only for a section of the ring-shaped element 16. Accordingly, the discontinuity may be formed as a slit separating two adjacent end faces 32, which face each other and according to these examples have matching geometries, i.e. a polygonal or triangular geometry in Figure 6 and a convex and concave or ellipsoid geometry in Figure 7. Such discontinuity may facilitate the fitting and mounting of the ring-shaped element 16 into the recess of the cylinder liner, i.e. by compression and radial biasing, yet provides a secure fitting in the mounted state due to the dimensioning and a resilience of the material of the ring-shaped element. In the mounted state, the end faces 32 are in direct contact with each other, thereby closing the ring-shaped element 16 and ensuring its intended functionality in the bore of the cylinder liner.

[0025] It will be obvious for a person skilled in the art that these embodiments and items only depict examples of a plurality of possibilities. Hence, the embodiments shown here should not be understood to form a limitation of these features and configurations. Any possible combination and configuration of the described features can be chosen according to the scope of the invention.

[0026] This is in particular the case with respect to the following optional features which may be combined with some or all embodiments, items and/or features mentioned before in any technically feasible combination.

[0027] A cylinder liner for a cylinder of a combustion engine is provided.

[0028] Such cylinder liner comprises a longitudinally extending wall, wherein an inner diameter of the wall defines a bore configured for receiving a piston and wherein the wall comprises a recess facing the bore and accommodating a ring-shaped element extending into the bore and beyond the wall in a radially inward direction. An inner diameter of an upper wall portion extending from the recess to a combustion region end portion of the cylinder liner is larger than an inner diameter of a bottom wall portion extending from the recess to an opposing end portion of the cylinder liner.

[0029] The increase in the inner diameter directly above the ring-shaped element has the advantage that pressure differences in this region may be minimized. Since pressure differences may adversely affect the material strength of the cylinder liner, the increase in the inner diameter may hence result in an improved fatigue strength, such that the occurrence of cracks or risk thereof may be significantly reduced.

[0030] In this regard, the cylinder liner may be configured to receive a corresponding piston in a reciprocal manner, such that an upper end of the piston, e.g. a piston head, may be received along the upper wall portion of the cylinder liner, for example, after a compression stroke. Due to the increased inner diameter of the upper wall portion, the space between the upper portion or top land of the piston and the cylinder liner is hence larger than the space between the piston and the cylinder liner. The minimized pressure differences in this region is hence particularly advantageous upon combustion of a combustible mixture in the adjacent combustion chamber, resulting in a movement of the piston towards the bottom wall portion, e.g. a gear end portion of the cylinder,.

[0031] Preferably, the ring-shaped element is formed as a scraper ring, i.e. a cokes scraper ring, or fire ring and may hence ensure that deposits on the piston are not accumulated along the circumference thereof, so as to avoid clogging and impaired movement of the piston. To facilitate such function, the ring-shaped element hence extends into the bore and beyond the wall in a radially inward direction. The increased inner diameter of the upper wall portion hence still enables that such function may be provided.

[0032] Although the ring-shaped element is advantageously combined with the cylinder liner, the cylinder liner may also be provided as a separate component and/or the ring-shaped element may be accommodated in the recess after installing the cylinder liner in a respective cylinder.

[0033] Since the recess and the ring-shaped element are adapted to each other, both the recess and the ring-shaped element may be directly positioned at the intended position, such that the dimensioning of the recess in the longitudinal direction may be significantly reduced compared with common scraper rings, for example, and the strength and stiffness of the cylinder liner may be accordingly improved.

[0034] Preferably, the inner diameter of the upper wall portion gradually increases in a direction facing away from the recess. Thereby, a further flow and/or pressure optimization may be provided and an even larger inner diameter may be implemented, at least partially, for the upper wall portion. The gradual increase may be a linear, curvilinear and/or essentially stepless increase, which is further beneficial for optimizing the flow and/or pressure conditions.

[0035] By the same token, the inner diameter of the bottom wall portion may be gradually reduced in a direction facing away from the recess. In such configuration, the ring-shaped element may be formed and dimensioned so as to extend along the portion having a gradual reduction of the inner diameter and may extend beyond the wall directly adjacent to said portion defining the smallest inner diameter. Thereby, improved flexibility of the position of the recess may be provided so as to further adapt the cylinder liner to the requirements of the cylinder liner, e.g. the overall geometry and/or potential reductions in size or material thickness.

[0036] For example, the recess may be arranged at a position a position of the wall having a larger material thickness, e.g. an upper flange portion to be received by a cylinder. Due to the gradual reduction in diameter of the bottom wall portion and the enlarged inner diameter of the upper wall portion, potential pressure differences between the combustion area and the piston or top land thereof may be further reduced.

[0037] The upper wall portion and/or bottom wall portion may at least partially comprise a conical shape, funnel shape, concave shape, and/or parabolic shape in a longitudinal section of the cylinder liner. Such shape is advantageous to further reduce any potentially occurring pressure differences and avoid the presence of steps, which may be adverse for optimizing the flow and pressure conditions at the upper portion of the cylinder liner.

[0038] Such shape may furthermore facilitate the insertion of the ring-shaped element, e.g. a scraper or fire ring, by enabling a gradual biasing and compression of the element up to the recess, wherein the ring-shaped element is fully deployed with a larger radial extension upon the subsequent accommodation in the recess. For example, a conical shape of the upper wall portion may be particularly preferred when mounting the ring-shaped element from the top of the cylinder liner.

[0039] In order to reduce a loss of stiffness or strength of the material and the cylinder liner at the region of the recess, the recess preferably comprises a concave and/or semicircular shape in a longitudinal section of the cylinder liner. Thereby, the dimensioning of the recess may be significantly reduced while at the same time the recess provides the enlarged inner diameter and is hence adapted to minimize pressure differences without significantly affecting the structural stability of the cylinder liner.

[0040] This shape may furthermore be advantageous, when a similar or at least partially matching adjacent shape of the ring-shaped element is provided in the assembled state, such that the ring-shaped element may be equally biased by the surface of the recess and is securely held therein.

[0041] Preferably, a ratio between i) the difference between the maximum inner diameter of the recess and the minimum inner diameter of the upper wall portion and ii) a radially inward protruding length of the ring-shaped element extending beyond the minimum inner diameter of the bottom wall portion may be between 1:1 and 3:1, preferably between 1.5:1 and 2.5:1.

[0042] In other words, the extension of the ring-shaped element into the wall from a lowermost or bottom edge of the upper wall portion may be larger than the protrusion from the wall into the bore. Thereby, the portion being retained in the recess may be sufficient to securely retain the ring-shaped element in the recess while the extension may be minimized to reduce adverse stresses or the loss of stiffness of the cylinder liner at the region of the recess, which may be particularly enabled by an accordingly adapting the curvature or radius of the recess.

[0043] For example, the protruding length into the bore and beyond the wall may be between 0.05 mm and 0.015 mm while the extension into the wall may be between 0.10 mm and 0.20 mm. Accordingly, only small extensions of the ring-shaped element may be provided, both into the wall and from the wall, which are nevertheless sufficient to retain the ring-shaped element in the recess and provide a functionality in the bore, e.g. as a scraper ring or fire ring for an accommodated piston.

[0044] The ratio between i) the difference between the maximum inner diameter of the recess and the minimum inner diameter of the upper wall portion and ii) the difference between the minimum inner diameter of the upper wall portion and the maximum inner diameter of the bottom wall portion may be between 1:1 and 3:1, preferably between 1.5:1 and 2.5:1. Thereby, the increased inner diameter of the upper wall portion, in particular directly adjacent to the recess, may be relatively small, yet sufficient to minimize or even avoid a pressure reduction at an adjacent top land of a piston.

[0045] The ratio between i) a radially inward protruding length extending beyond the minimum inner diameter of the bottom wall portion and ii) the difference between the minimum inner diameter of the upper wall portion and the maximum inner diameter of the bottom wall portion may be between 0.5:1 and 2:1, preferably between 0.8:1 and 1.2:1. Accordingly, the protruding length of the ring-shaped element forming a functionality in the bore, such as a scraper edge, may have about the same radial length as a difference between the inner diameter of the bottom wall portion and the inner diameter of the upper wall portion, in particular at the corresponding regions directly adjacent to the recess.

[0046] Preferably, the ring-shaped element comprises a semi-circular, ellipsoid, or semi-lunar shaped cross-sectional area and/or the ring-shaped element may define a surface facing the bore having a concave shape in a longitudinal section of the cylinder liner. Thereby, the dimensioning of the ring-shaped element may be reduced, in particular the portion protruding into the bore from the wall. This further increases the space between the wall of the cylinder at the upper wall portion and the wall or top land of an accommodated piston, such that pressure differences and the corresponding risk of fatigue cracks at the region of the recess may be further reduced.

[0047] The shape of the ring-shaped element in the longitudinal section of the cylinder liner may be tilted or at an angle with a longitudinal axis of the cylinder liner extending from the top to the bottom of the cylinder liner, e.g. a central axis. Accordingly, the radially protruding length of the ring-shaped element from the wall may be larger at the bottom end of the recess compared with the top end of the recess.

[0048] Alternatively, or in addition, the ring-shaped element may comprise an asymmetric cross-sectional area. For example, and in particular in the case of a semi-circular, ellipsoid, or semi-lunar shaped cross-section of the ring-shaped element, a bottom section being adjacent to the bottom wall portion may be dimensioned larger so as to form the portion of the ring-shaped element extending into the bore and beyond the wall.

[0049] For example, such larger dimensioned portion may form an edge or scraper edge as a functionality for an accommodated piston in the bore. In particular in the case of a concave surface, such edge may be essentially formed as a blade or barb shape, which may optionally provide a self-sharpening function.

[0050] The asymmetry thereby facilitates that a space between the upper wall portion and an upper portion of an adjacent piston, e.g. a top land, may be provided also at the corresponding upper region of the ring-shaped element. Thus, the portion of the cylinder liner having an enlarged inner diameter may be further increased.

[0051] The ring-shaped element may comprise an inner diameter corresponding to the inner diameter of the directly adjacent upper wall portion, wherein the ring-shaped element preferably defines a surface facing the bore being flush with an adjacent surface of the upper wall portion. Alternatively, or in addition, the inner diameter of the ring-shaped element may gradually decrease directly adjacent from the upper wall portion towards the bottom wall portion.

[0052] Preferably, the surface of the ring-shaped element is flush with the adjacent surface of the upper wall portion, wherein the inner diameter gradually decreases directly adjacent from the upper wall portion towards the bottom wall portion. A flush arrangement provides that an essentially stepless configuration is provided from the upper wall portion to the bottom wall portion and a gradual decrease ensures that an enlarged inner diameter and corresponding spacing between an adjacent piston may be provided to a larger extent. While these features on itself are already advantageous in terms of reducing pressure differences, they are synergistically effective in combination.

[0053] The ring-shaped element may also extend beyond the recess along the wall in a longitudinal direction. This may be particularly preferably, when the recess is positioned above a position of an intended functionality of the ring-shaped element. For example, as described above, the ring-shaped element may be formed as a scraper ring defining a scraper edge for an accommodated piston. Due to mechanical and/or structural requirements, the position of the recess may, however, be preferably arranged above the position of the scraper edge, such that the recess may be provided at a portion of the cylinder liner having a larger thickness, e.g. an upper flange portion. Thereby a position of the recess at a level of an outer recess of the cylinder liner, resulting in a reduced thickness with a corresponding loss of stiffness and increase of stresses, may be effectively avoided.

[0054] In order to bridge the longitudinal distance between the recess and the portion of the ring-shaped element forming the functionality, e.g. the scraper edge, the ring-shaped element may hence extend from the recess along the corresponding portion of the wall before extending beyond the wall, i.e. the minimum inner diameter defined by the wall.

[0055] In order to facilitate such longitudinal extension, the bottom wall portion directly adjacent to the recess may be conically shaped towards the minimum inner diameter defined by the bottom wall portion or otherwise be shaped or dimensioned so as to provide a gradual decrease of the inner diameter. For improved stability, the ring-shaped element may also extend along the upper wall portion as long as the inner diameter is larger than the minimum inner diameter defined by the bottom wall portion, e.g. at the intersection of the bottom wall portion and a radially protruding edge into the bore defined by the ring-shaped element.

[0056] The ring-shaped element may be formed from a single piece, preferably formed of a resilient material. For example, the ring-shaped element may be formed as a scraper ring or fire ring and be formed of the same material as the cylinder liner. Preferably, the ring-shaped element is formed of steel or a steel alloy to ensure longevity and robustness and reduce wear during operation of the combustion engine.

[0057] The ring-shaped element may be mounted in the recess in a pre-cooled state in order to reduce the radial dimensioning. Thereby, the mounting of the ring-shaped element may be significantly facilitated and it is ensured that the ring-shaped element is properly fitted during and prior to operation of the combustion engine. Preferably, fitting tolerances as well operational conditions are considered in the dimensioning of the ring-shaped element. The ring-shaped element may be dimensioned so as to provide a transition fit, interference fit, or clearance fit, as long as the ring-shaped element is securely held and retained by the recess.

[0058] While a gradual reduction of the inner diameter of the upper wall portion may facilitate the mounting of the ring-shaped element, as described above, it may also be provided that the ring-shaped element is mounted in a funnel-shaped device or other radially inward biasing device so as to facilitate the insertion and mounting of the ring-shaped element into the recess.

[0059] In order to facilitate the correct mounting of the ring-shaped element, the ring-shaped element may be shaped and dimensioned to provide a buckling safety. Accordingly, it may be avoided that, in the fitted state, a misalignment or plastic deformation is present, which may impair the functioning of the ring-shaped element and may obstruct movement of other components such as a piston received in the cylinder liner. Alternatively, a predefined buckling of the ring-shaped element may be provided upon compression, which may bias the ring-shaped element in a predefined position during assembly, yet avoids a plastic deformation upon deployment.

[0060] The ring-shaped element may also comprise a discontinuity in a circumferential direction, wherein the ring-shaped element is preferably accommodated in the recess in a press-fitted manner closing said discontinuity. The discontinuity, e.g. formed as a slit, may hence be provided in such a manner, that a gap or spacing, which may optionally be present in the unmounted state, is closed to provide a sealing means and continuous protruding surface from the wall in the mounted state.

[0061] Preferably, an end face of the ring-shaped element at one end of the ring-shaped element may be received by the end face of the other end of the ring-shaped element in a circumferential direction, wherein the end faces preferably comprise matching geometries. This facilitates that the end faces are brought into contact with each other in the mounted state, although it is not necessary for the functioning of the ring-shaped element that the entire end faces are aligned. For example, the end faces may be formed as a convex and corresponding concave shape, e.g. having a semi-circular shape, or have a polygonal shape, e.g. triangular or pyramid shape, which may facilitate a biasing into a correct position upon deployment and mounting of the ring-shaped element.

[0062] Furthermore, a combustion engine is suggested, preferably a gas engine, comprising at least one cylinder fitted with a cylinder liner as described in the above.

[0063] For each cylinder, a piston may be provided, which is received within the respective cylinder liner. In order to facilitate the mounting of the piston, the ring-shaped element may be required to be removed prior to insertion of the piston, e.g. with a device retracting the ring-shaped element from the protruding extension, e.g. formed as a scraper edge. Such removal, however, is preferably only required when mounting the piston from the top side of the cylinder and may not be required when mounting the piston from the bottom side, e.g. a gear end of the cylinder.

Industrial Applicability

[0064] With reference to the Figures, a cylinder liner for a cylinder of a combustion engine as well as a corresponding combustion engine equipped with such cylinder liner are suggested. The suggested cylinder liner as mentioned above is applicable in a variety of engines, such as gas engines, wherein undesirable pressure differences may occur at the region of the scraper ring or fire ring, resulting in fatigue cracks. The geometry and mechanical aspects concerning the recess receiving such scraper ring furthermore reduce the stiffness and induce stresses in the material, which directly affects the longevity of the cylinder liner. The disclosed cylinder liner may be mounted into existing cylinders or may replace current cylinder liners as a replacement or retrofit part, which may be exchanged e.g. upon or prior to overhaul or prior to use.

List of reference numerals

[0065]

10	Cylinder liner
12	Bore
14	Recess
16	Ring-shaped element
18	Upper wall portion
20	Inner diameter
22	Bottom wall portion
24	Inner diameter
26	Protruding length
28	Recess depth
30	Edge
32	End face

Claims

1. A cylinder liner (10) for a cylinder of a combustion engine, comprising a longitudinally extending wall, wherein an inner diameter of the wall defines a bore (12) configured for receiving a piston and wherein the wall comprises a recess (14) facing the bore (12) and accommodating a ring-shaped element (16) extending into the bore (12) and beyond the wall in a radially inward direction, wherein an inner diameter (20) of an upper wall portion (18) extending from the recess (14) to a combustion region end portion of the cylinder liner (10) is larger than an inner diameter (24) of a bottom wall portion (22) extending from the recess (14) to an opposing end portion of the cylinder liner (10).

2. The cylinder liner (10) according to claim 1, wherein the inner diameter (20) of the upper wall portion (18) gradually increases in a direction facing away from the recess (14).

3. The cylinder liner (10) according to claim 1 or 2, wherein the inner diameter (24) of the bottom wall portion (22) gradually reduces in a direction facing away from the recess (14).

4. The cylinder liner (10) according to any of the preceding claims, wherein the upper wall portion (18) and/or bottom wall portion (22) at least partially comprises a conical shape, funnel shape, concave shape, and/or parabolic shape in a longitudinal section of the cylinder liner (10).

5. The cylinder liner (10) according to any of the preceding claims, wherein the recess (14) comprises a concave and/or semicircular shape in a longitudinal section of the cylinder liner (10).

6. The cylinder liner (10) according to any of the preceding claims, wherein

- a ratio between i) the difference between the maximum inner diameter of the recess (14) and the minimum inner diameter of the upper wall portion (18) and ii) a radially inward protruding length (26) of the ring-shaped element (16) extending beyond the minimum inner diameter of the bottom wall portion (22) lies between 1:1 and 3:1, preferably between 1.5:1 and 2.5:1;
- a ratio between i) the difference between the maximum inner diameter of the recess (14) and the minimum inner diameter of the upper wall portion (18) and ii) the difference between the minimum inner diameter of the upper wall portion (18) and the maximum inner diameter of the bottom wall portion (22) lies between 1:1 and 3:1, preferably between 1.5:1 and 2.5:1; and/or
- a ratio between i) a radially inward protruding length (26) extending beyond the minimum inner diameter of the bottom wall portion (22) and ii) the difference between the minimum inner diameter of the upper wall portion (18) and the maximum inner diameter of the bottom wall portion (22) lies between 0.5:1 and 2:1, preferably between 0.8:1 and 1.2:1.

7. The cylinder liner (10) according to any of the preceding claims, wherein the ring-shaped element (16) comprises a semi-circular, ellipsoid, or semi-lunar shaped cross-sectional area and/or wherein the ring-shaped element (16) defines a surface facing the bore (12) having a concave shape in a longitudinal section of the cylinder liner (10).

8. The cylinder liner (10) according to any of the preceding claims, wherein the ring-shaped element (16) comprises an asymmetric cross-sectional area.

9. The cylinder liner (10) according to any of the preceding claims, wherein the ring-shaped element (16) comprises an inner diameter corresponding to the inner diameter of the directly adjacent upper wall portion (18), wherein the ring-shaped element (16) preferably defines a surface facing the bore (12) being flush with an adjacent surface of the upper wall portion (18).

10. The cylinder liner (10) according to any of the preceding claims, wherein the inner diameter of the ring-shaped element (16) gradually decreases directly adjacent from the upper wall portion (18) towards the bottom wall portion (22).

11. The cylinder liner (10) according to any of the preceding claims, wherein the ring-shaped element (16) extends beyond the recess (14) along the wall in a longitudinal direction.

12. The cylinder liner (10) according to any of the preceding claims, wherein the ring-shaped element (16) is formed from a single piece, preferably formed of a resilient material.

13. The cylinder liner (10) according to any of the preceding claims, wherein the ring-shaped element (16) comprises a discontinuity in a circumferential direction, wherein the ring-shaped element (16) is preferably accommodated in the recess (14) in a press-fitted manner closing said discontinuity.

14. The cylinder liner (10) according to claim 13, wherein an end face (32) of the ring-shaped element (16) at one end of the ring-shaped element (16) is received by the end face (32) of the other end of the ring-shaped element (16) in a circumferential direction, the end faces (32) preferably comprising matching geometries.

15. A combustion engine, comprising at least one cylinder fitted with a cylinder liner (10) according to any of the preceding claims.

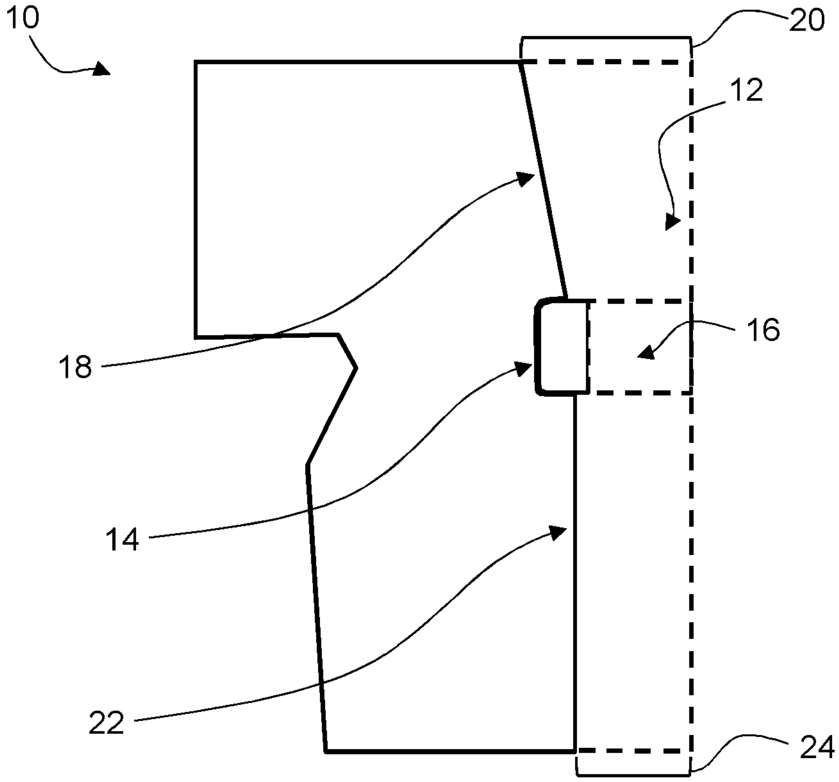

Fig. 1

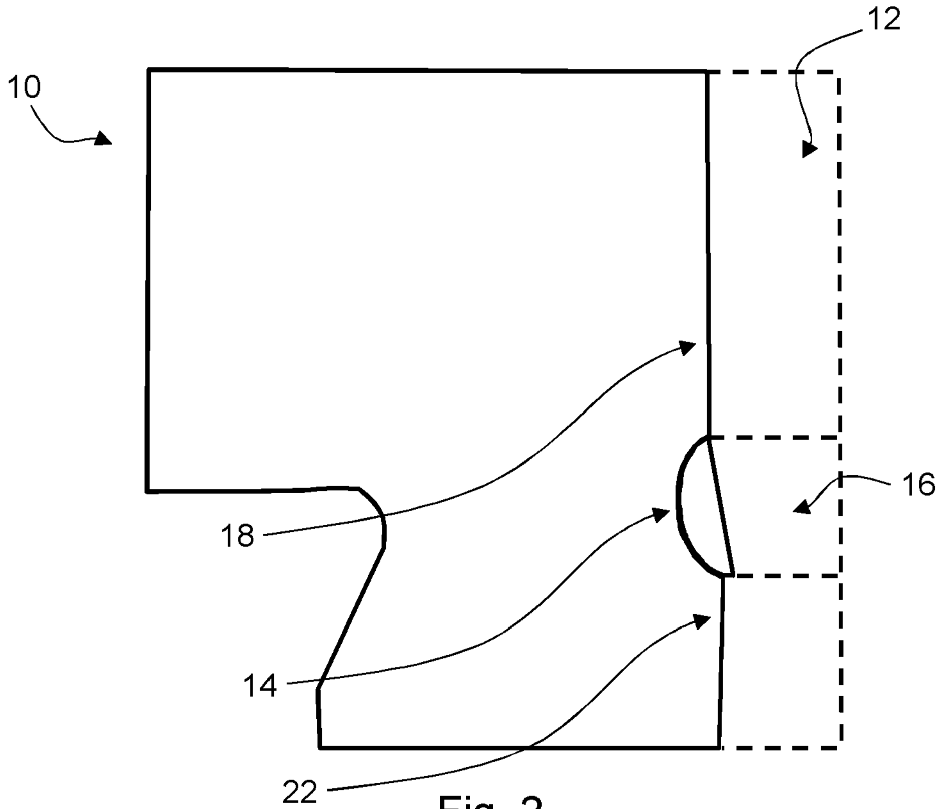

Fig. 2

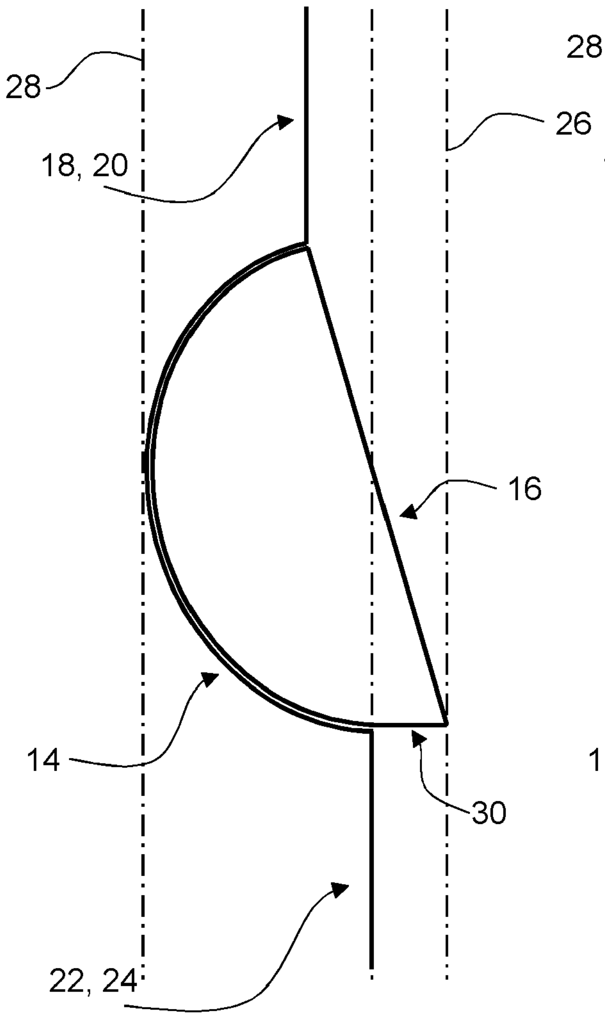

Fig. 3

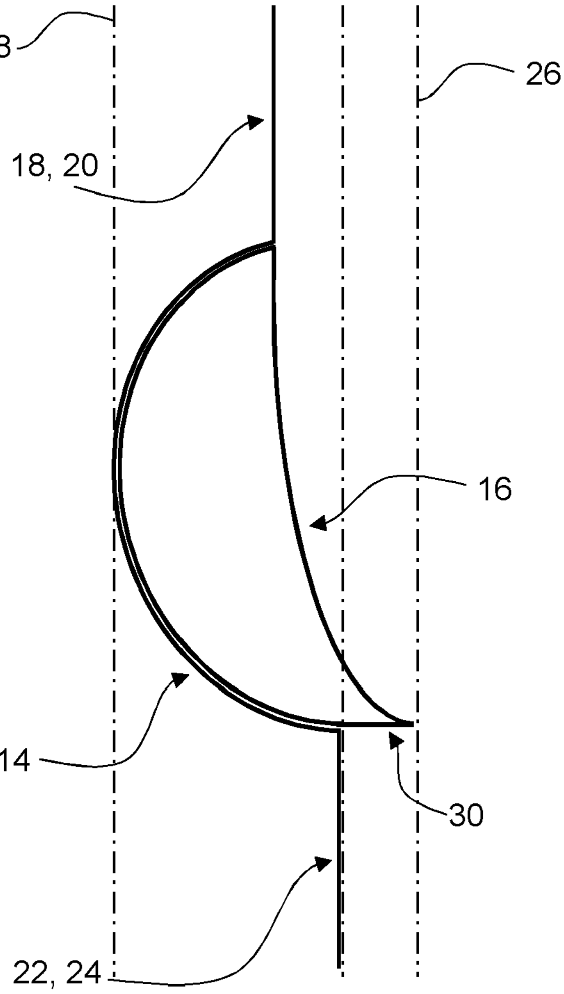

Fig. 4

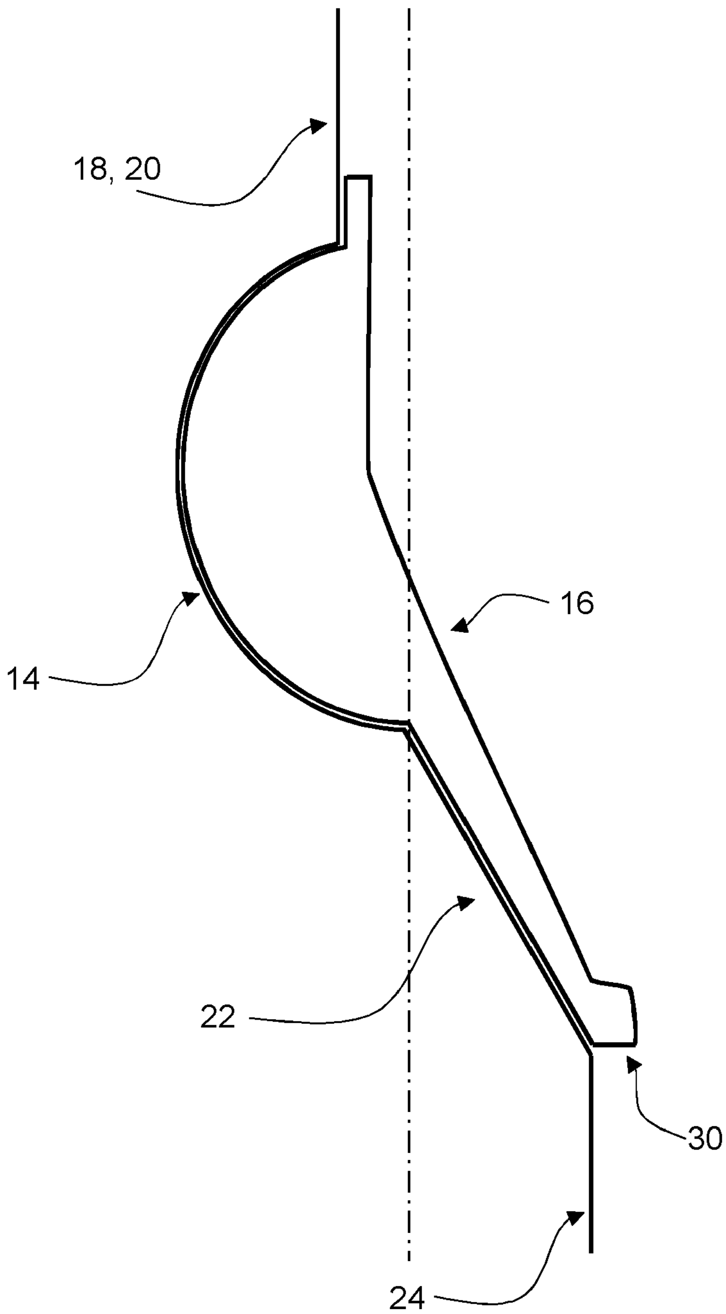

Fig. 5

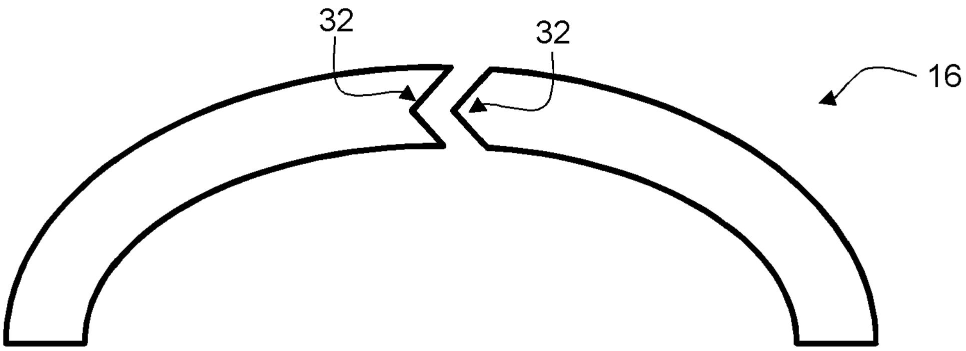

Fig. 6

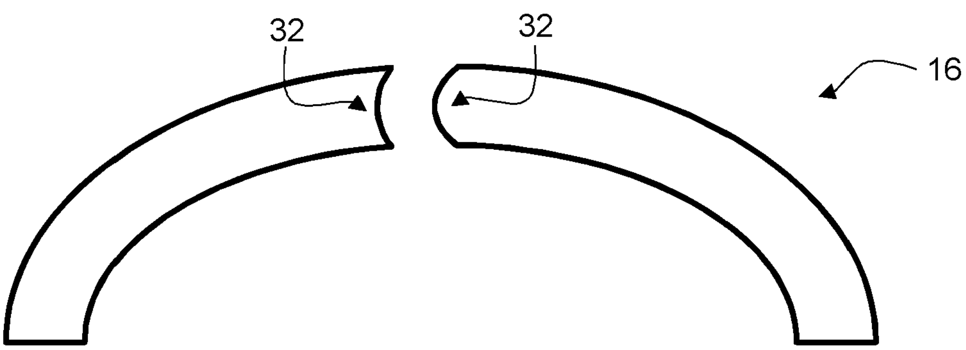

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 23 15 0814

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	24 May 2023	Matray, J

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