

FLUID BURNER HEAD AND USE OF FLUID BURNER HEAD

Technical field

The invention relates to a fluid burner head for a fluid combustion unit, and its design. The invention also relates to a use of such a fluid burner head in a fluid combustion unit for burning boil-off gas from a fuel tank onboard a ship.

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Background art

In different situations, combustion of a fluid, such as gas or a mixture of gas and liquid, may be required. For example, gas combustion units are typically installed onboard LNG carriers, i.e. tank ships arranged to transport liquefied natural gas, LNG. The LNG, which has a vaporization temperature of -160 degrees Celsius at atmospheric pressure, is contained in tanks. Even if these tanks are insulated, some evaporation of the LNG will inevitably take place and form so-called boil-off gas. This boil-off gas increases the pressure in the tanks and must be discharged from the tanks for the sake of safety. The boil-off gas removed from the tanks may be re-liquefied and returned to the tanks, used as fuel onboard the LNG carriers, or combusted by means of the gas combustion units.

A gas combustion unit may typically comprise a gas burner head extending into a combustion chamber. The gas to be combusted is fed, via the gas burner head, to the combustion chamber where it is ignited and burned. A known gas burner head comprises a perforated tube with an end closed by a cap. The gas is conveyed through the tube and, through the perforations of the tube, into the combustion chamber where the combustion takes place in a flame. When the gas pressure is relatively high, the gas will be fed through the perforations at a high velocity which will result in a flame at some distance from the gas burner head. Further, the gas flow inside the tube will cool the gas burner head. As a result, the temperature of the gas burner head will be kept low enough so as to avoid damages thereto. However, when the gas pressure is relatively low, the gas will be fed through the perforations at a low velocity which will result in a flame closer to the gas burner head. Further, the cooling of the gas burner head by the gas flow inside the tube will be reduced. This may

result in very high temperatures in, and damages to, the gas burner head, typically in areas close to the closed end of the tube.

Summary

5 An object of the present invention is to provide a fluid burner head and a use of a fluid burner head that at least partly solves the problem above. The basic concept of the invention is to provide the fluid burner head with means for forcing the fluid to be combusted, and thus the combustion flame, further away from the fluid burner head. The fluid burner head, and the use of a fluid burner
10 head, for achieving the object above is defined in the appended claims and discussed below.

 A fluid burner head for a fluid combustion unit according to the invention comprises a body. The body comprises a hollow tube or pipe for conveying a fluid to be combusted into a combustion chamber and a cap which at least
15 partly closes an upper end of the tube. The tube further comprises a lower end for receiving the fluid in the tube, i.e. in an interior of the tube. A wall of the tube comprises a plurality of rows of holes, which rows extend around a longitudinal center axis of the fluid burner head. The holes permit a flow of the fluid to be combusted from the interior to an exterior of the tube, i.e. through the wall of the
20 tube. The fluid burner head is characterized in that it further comprises an annular first projection or protrusion extending around the longitudinal center axis of the fluid burner head. The first projection is projecting obliquely from an outer surface of the body and in a direction away from the lower end of the tube, i.e. upwards, above an uppermost row of holes of the tube, with an angle α
25 relative to the longitudinal center axis of the fluid burner head, wherein $0 < \alpha < 90$ degrees. The uppermost row of holes is the row of holes being arranged closest to the cap.

 The first projection may comprise opposing first and second edges. The first and second edges may be annular and extend along each other. The first
30 projection may engage, directly or indirectly, with the body at and along the first edge and the second edge may be free.

Herein, “combust” and “burn” and variants thereof are used and intended to have the same meaning.

The fluid may be a gas or a mixture of a gas and a liquid. As an example, the fluid may be boil-off gas from a LNG tank, such as methane or a mixture of
5 methane and nitrogen.

The tube could comprise a mesh formed into a cylinder.

The tube could be a perforated tube and the openings could be perforations of the tube.

The tube may be elongate, have any suitable wall thickness and have
10 any suitable cross section, such as circular, oval or polygonal.

The tube may be made of any suitable material such as a metal, for example carbon steel, stainless steel or aluminum.

The longitudinal center axis of the fluid burner head may coincide with a longitudinal center axis of the tube.

15 By plurality of rows is here meant two or more rows.

The holes, openings, apertures or perforations of the tube may or may not all have the same size and/or shape, and they may have any suitable size and shape, such as circular, oval or polygonal. Further, the holes may or may not be equidistantly arranged.

20 “Annular” need not mean a circular longitudinal extension but could mean any closed longitudinal extension, such as an oval or polygonal extension.

Herein, “upper”, “uppermost”, “lower”, “lowermost”, “above”, “below” etc. are references made to the fluid burner head when this is orientated for its normal state of use. Further, by “uppermost”/“lowermost” is meant arranged
25 furthest from/closest to the ground or a surface on which a fluid combustion unit comprising the fluid burner head is arranged.

As said above, the cap closes the upper end of the tube at least partly. Here, an only partly closed upper end may for example mean that it is possible for gas to pass from within the tube to an outside thereof through an opening in
30 the cap or between the tube and the cap.

The first projection may or may not have a uniform cross section, for example a constant width and/or thickness, along its longitudinal extension. As

an example, the first projection could be formed as a skirt or flange. If the width and thickness is zero along one or more portions of the longitudinal extension, the first projection may be considered discontinuous.

The first projection is arranged to force the fluid to be combusted away
5 from the fluid burner head to reduce the temperature of the fluid burner head and, thereby, the risk of damages to the fluid burner head, also when the fluid is fed through the holes of the tube at a relatively low velocity.

The tube and the cap may be integrally formed. However, according to one embodiment of the invention, the tube and the cap are separately formed.
10 Thereby, the tube and the cap can be replaced independent of each other if needed.

The tube and the cap may be made of the same material. However, according to one embodiment of the invention, the cap and the tube are made of different materials. This may enable a more flexible construction of the fluid
15 burner head. The cap may be made of any suitable material, such as refractory concrete or a metal, for example carbon steel, stainless steel or aluminum.

The first projection may be arranged anywhere between the uppermost row of holes of the tube and an upper end of the fluid burner head. However, according to one embodiment of the invention, the first projection projects from
20 the outer surface of the body at a border between the tube and the cap. Without the first projection in place, the temperature locally at the border between the tube and the cap tends to be relatively high. Thus, by arranging the first projection at the tube-cap border, the risk of damages to the fluid burner head may be minimized.

25 The fluid burner head may be so constructed that the tube and the first projection are separately formed. Thereby, when the first projection is worn out it can be replaced with a new one without having to discard the tube and possibly the cap.

The tube may have a varying cross section along its longitudinal center
30 axis. However, according to one embodiment of the invention, an upper portion of the tube comprising the holes has an essentially uniform cross section along

the longitudinal center axis of the fluid burner head. This may facilitate production of the fluid burner head.

5 The fluid burner head may further comprise an annular support extending around the longitudinal center axis of the fluid burner head. The support may be connected to the first projection and engage with the body of the fluid burner head to fix the first projection to the body. Such a design may facilitate the arrangement of the first projection on the body. Just like the first projection, the support may or may not have a uniform cross section along its longitudinal extension, and be continuous or discontinuous.

10 The fluid burner head may further comprise an annular second projection extending around the longitudinal center axis of the fluid burner head. The second projection may project from the outer surface of the body between the uppermost row of holes of the tube and the first projection. The first projection may or may not project beyond the second projection. The second projection
15 may aid in forcing the fluid to be combusted away from the fluid burner head to further reduce the temperature of the fluid burner head and, thereby, the risk of damages to the fluid burner head, also when the fluid is fed through the holes of the tube at a relatively low velocity.

20 The second projection may project from an outer surface of the tube to shield the tube locally in an area where the temperature of the tube otherwise tends to be relatively high. The risk of damages to the tube may thereby be minimized.

25 As said above, the fluid burner head may comprise an annular support extending around the longitudinal center axis of the fluid burner head. The support may be connected to both the first projection and the second projection and engage with the body of the fluid burner head to fix the first and second projections to the body.

30 Irrespective of if the support is connected to only the first projection or also to the second projection, it may engage in different ways with the body. As an example, it may be threaded onto the body with a tight fit so as to stay in place by friction. However, according to one embodiment of the invention, the support is clamped between the cap and the tube. Thereby, a precise location

of the first projection and possibly also the second projection may be enabled, together with a reliable engagement between the support and the body of the fluid burner head.

The cap may be designed in many different ways. According to one
5 embodiment of the invention it comprises an upper portion and a bottom portion, wherein the bottom portion projects into the tube. Thereby, a safe and precise engagement between the cap and the tube may be enabled.

The bottom portion of the cap may comprise a part which is tapering in a direction away from the upper portion of the cap. For example, the bottom
10 portion may be conical, and possibly truncated conical. This may result in a flow area inside the tube, perpendicular to the longitudinal center axis of the tube, which is decreasing in a direction towards the cap, i.e. towards the upper end of the tube. In turn, this may result in a fluid flow velocity inside the tube which is increasing in a direction towards the cap, i.e. towards the upper end of the tube.
15 Consequently, this design may enable forcing of the fluid fed through upper holes of the tube, and thus the combustion flame, further away from the fluid burner head. Thereby, further lowering of the temperature of the fluid burner head, and the risk of damages to the fluid burner head, may be enabled, especially when the fluid is fed through the tube at a relatively low pressure.

20 The fluid burner head may be so designed that an outer circumference of the upper portion of the cap is larger than an inner circumference of the tube. Thereby, the upper portion of the cap is prevented from being received in the tube which may enable a precise and safe engagement between the cap and the tube.

25 A fluid burner head according to the present invention may be used in a fluid combustion unit for burning boil-off gas from a fuel tank onboard a ship.

The above discussed advantages of the different embodiments of the fluid burner head according to the invention are naturally transferable to different embodiments of the use according to the invention.

30 Still other objectives, features, aspects and advantages of the invention will appear from the following detailed description as well as from the drawings.

Brief description of the drawings

The invention will now be described in more detail with reference to the appended schematic drawings, in which

Fig. 1 schematically illustrates a cross section of a fluid combustion unit,

5 Fig. 2 is a schematic perspective view of a fluid burner head of the fluid combustion unit in Fig. 1,

Fig. 3 is a schematic side view of the fluid burner head in Fig. 2,

Fig. 4 is a schematic cross section of the fluid burner head in Fig. 2,

Fig. 5 is an enlargement of a part of the cross section in Fig. 4,

10 Fig. 6a is a schematic side view of an arrangement of the fluid burner head in Fig. 2,

Fig. 6b is a schematic top view of the arrangement in Fig. 6a, and

Fig. 6c is a schematic cross section of the arrangement in Fig. 6a.

15 Detailed description

In Fig. 1 a fluid combustion unit 1, more particularly a gas combustion unit, is illustrated. The fluid or gas combustion unit 1 is arranged onboard a ship (not illustrated), more particularly an LNG carrier, for burning boil-off gas from one or more LNG tanks of the ship. The fluid combustion unit 1 comprises a
20 fluid burner system 3, an air supply system (not illustrated), a combustion chamber 5 and a stack 7. Boil-off gas from the LNG tank(s) is fed to the fluid burner system 3 and further into the combustion chamber 5 wherein it is ignited and combusted. The combustion products leave the combustion chamber 5 to be mixed with cool air in the stack 7 before leaving the fluid combustion unit 1.

25 The construction and function of fluid combustion units are well-known within the art and will not be described in further detail herein.

The fluid burner system 3 comprises a fluid burner head 9, more particularly a gas burner head, which is illustrated in further detail in Figs. 2-6. The fluid burner head 9 comprises a body 11, which in turn comprises a hollow,
30 elongate stainless steel tube 13 and a solid cap 15 of refractory concrete. The tube 13 and the cap 15 are discrete separable elements having a circular outer periphery as seen along a longitudinal center axis C of the fluid burner head 9.

The tube 13 has a wall 17 of uniform thickness along and around the longitudinal center axis C of the fluid burner head 9. With reference to Fig. 4 it comprises a lower end 19, a lower portion 21, an upper portion 23 and an upper end 25 arranged in succession along the longitudinal center axis C. The upper
5 portion 23 of the tube 13 comprises a great number of circular holes 27 extending through the wall 17 of the tube 13. The holes 27 are equidistantly arranged in rows 29. The rows 29 of the holes 27 are parallel to each other and extend equidistantly around the longitudinal center axis C of the fluid burner head 9.

10 With reference to Fig. 5, the cap 15 comprises an upper portion 31 and a bottom portion 33 which are concentrically arranged with reference to the longitudinal center axis C of the fluid burner head 9. The border between the upper and bottom portions 31 and 33 of the cap 15 is illustrated with a broken line. The upper portion 31 has the essential shape of a circular plate with a
15 constant cross section along the longitudinal center axis C. The bottom portion has the essential shape of a truncated cone with a circular cross section which is decreasing along the longitudinal center axis C in a direction away from the upper portion 31 of the cap 15. The largest cross section of the bottom portion 33 is smaller than the cross section of the upper portion 31.

20 As is clear from the drawings, and especially Fig. 5, the cap 15 closes the upper end 25 of the tube 13. The bottom portion 33 of the cap 15 has a largest circumference which is smaller than an inner circumference of the tube 13 and it is accommodated inside the tube 13. The upper portion 31 of the cap 15 has a circumference which is essentially equal to an outer circumference of
25 the tube 13 and larger than the inner circumference of the tube 13. The upper portion 31 of the cap 15 is arranged outside the tube 13 and abuts an annular edge thereof defining the upper end 25 of the tube 13. Due to the above specified relative dimensions of the tube 13 and the cap 15, an annular groove 35 is formed between the bottom portion 33 of the cap 15 and the tube 13.

30 With reference to Figs. 5 and 6a-c, the fluid burner head 9 further comprises an annular support 37 in the form of a flat circular ring of stainless steel, an annular first projection 39 in the form of a circularly extending skirt of

stainless steel, and an annular second projection 41 in the form of a very short tube with circular cross section and of stainless steel. The support 37, the first projection 39 and the second projection 41 are concentrically arranged with reference to the longitudinal center axis C of the fluid burner head 9. The first projection 39 projects upwards and outwards from an outer edge of the support 37 while the second projection projects downwards from the outer edge of the support 37. The support 37, the first projection 39 and the second projection 41 are integrally formed into an arrangement designed to cooperate with the body 11 of the fluid burner head 9. More particularly, the support 37 is positioned and clamped between the tube 13 and the cap 15 with the first and second projections 39 and 41 projecting from an outer surface 43 of the body 11 (Fig. 3). The first projection 39 has annular longitudinal first and second edges 39a and 39b extending along each other (Fig. 6a). The first projection 39 engages with the body 11 indirectly, more particularly via the support 37, at and along the first edge 39a while the second edge 39b is free. The second projection 41 has annular longitudinal first and second edges 41a and 41b extending along each other (Fig. 6b). The second projection 41 encircles the body 11 and an inside thereof contacts the outer surface 43 of the body 11 between the first and second edges 41a and 41b. The tube 13 and the cap 15 are connected by means of elements not illustrated in the drawings. Thereby, the support 37 and the first and second projections 39 and 41 extend around the longitudinal center axis C of the fluid burner head 9 at a border 45 between the tube 13 and the cap 15 (Fig. 5), i.e. above an uppermost row 29a of the rows 29 of holes 27 (Fig. 3). Further, with special reference to Figs. 5 and 6c, the support 37 is clamped between the tube 13 and the cap 15 such that the first projection 39 projects obliquely upwards with an angle $\alpha = 30$ degrees in relation to the longitudinal center axis C of the fluid burner head 9, while the second projection 41 projects downwards and from an outer surface 47 of the tube 13 so as to enclose an uppermost portion of the tube 13.

The fluid burner head 9 is arranged to convey the boil-off gas to be combusted into the combustion chamber 5 of the fluid combustion unit 1 (Fig. 1). More particularly, with reference to Fig. 4, the boil-off gas is arranged to be

fed into an interior 49 of the tube 13 of the fluid burner head 9 via the lower end 19 of the tube 13, then upwards through the lower portion 21 of the tube 13, and then into the upper portion 23 of the tube 13 and further through the holes 27 of the tube wall 17 to an exterior 51 of the tube 13 and thus into the combustion chamber 5 (Fig. 1). Inside the combustion chamber 5, the boil-off gas is ignited and combusted in a flame, as previously discussed. The first and second projections 39 and 41 are arranged to force the boil-off gas, and consequently the combustion frame, away from the body 11 of the fluid burner head such that its temperature is kept low enough to avoid melting damages to the tube 13 and cracking damages to the cap 15, even when the boil-off gas pressure and the boil-off gas velocity through the holes 27 are relatively low. The frustoconical shape of the bottom portion 33 of the cap 15 is arranged to speed up the boil-off gas velocity through the holes 27 close to the upper end 25 of the tube 13 to aid in the lowering of the temperature of the body 11 and, thus, the minimization of damages to the body 11. The first and second projections 39 and 41 will protect and shield the body 11 of the fluid burner head 9 and will be subjected to an harsh environment. If and when the first and second projections 39 and 41 are damaged, the arrangement composed of the support 37 and the first and second projections 39 and 41 may be replaced with a new one while the tube 13 and cap 15 may be further used.

The above described embodiment of the present invention should only be seen as an example. A person skilled in the art realizes that the embodiment discussed can be varied in a number of ways without deviating from the inventive conception.

As an example, the fluid burner head need not comprise the second projection but could comprise the first projection only.

As another example, the fluid burner head need not comprise the support for fixing the first projection, and possibly the second projection, to the body of the fluid burner head. Instead, the first projection, and possibly the second projection, could be directly fixed to the body of the fluid burner head.

As yet another example, the support need not be fastened to the body of the fluid burner head by being clamped between the tube and the cap. In an

alternative embodiment of the invention, the support could be arranged on the outside of the tube and/or the cap, with a tight fit so as to stay in place by friction. Accordingly, the first and second projections need not be arranged at the border between the tube and the cap.

- 5 The first and second projections need not be formed separate from the tube and the cap but could be formed integrally with the tube and/or the cap. Such a design may destroy the possibility of replacing only the first and second projections, and the support if present, if these are damaged.

- 10 The angle α between the first projection and the longitudinal center axis of the fluid burner head need not have the above value but may be larger or smaller.

The tube and the cap need not be separately formed and made of different materials but could instead be integrally formed and/or made of the same material.

- 15 It should be stressed that a description of details not relevant to the present invention has been omitted and that the figures are just schematic and not drawn according to scale. It should also be said that some of the figures have been more simplified than others. Therefore, some components may be illustrated in one figure but left out in another figure. Finally, as used herein, the
20 prefixes "first", "second", etc. are used only to distinguish between different components and pose no requirements as regards relative positioning or orientation.

CLAIMS

1. A fluid burner head (9) for a fluid combustion unit (1) comprising a body (11) which in turn comprises a hollow tube (13) for conveying a fluid to be
5 combusted into a combustion chamber (5) and a cap (15) which at least partly closes an upper end (25) of the tube (13), the tube (13) further comprising a lower end (19) for receiving the fluid in the tube (13), a wall (17) of the tube (13) comprising a plurality of rows (29) of holes (27), which rows (29) extend around a longitudinal center axis (C) of the fluid burner head (9), wherein the holes (27)
10 permit a flow of the fluid to be combusted from an interior (49) to an exterior (51) of the tube (13), the fluid burner head (9) being **characterized in that** it further comprises an annular first projection (39) extending around the longitudinal center axis (C) of the fluid burner head (9) and projecting obliquely from an outer surface (43) of the body (11) and away from the lower end (19) of
15 the tube (13), above an uppermost row (29a) of holes (27) of the tube (13), with an angle α relative to the longitudinal center axis (C) of the fluid burner head (9), wherein $0 < \alpha < 90$ degrees, the uppermost row (29a) of holes (27) being the row of holes (27) arranged closest to the cap (15).

2. A fluid burner head (9) according to claim 1, wherein the tube (13)
20 and the cap (15) are separately formed.

3. A fluid burner head (9) according to any of the preceding claims, wherein the cap (15) and the tube (13) are made of different materials.

4. A fluid burner head (9) according to any of the preceding claims, wherein the first projection (39) projects from the outer surface (43) of the body
25 (11) at a border (45) between the tube (13) and the cap (15).

5. A fluid burner head (9) according to any of claims, wherein the tube (13) and the first projection (39) are separately formed.

6. A fluid burner head (9) according to any of the preceding claims, wherein an upper portion (23) of the tube (13) comprising said holes (27) has an
30 essentially uniform cross section along the longitudinal center axis (C) of the fluid burner head (9).

7. A fluid burner head (9) according to any of the preceding claims, further comprising an annular support (37) extending around the longitudinal center axis (C) of the fluid burner head (9), which support (37) is connected to the first projection (39) and engages with the body (11) of the fluid burner head (9) to fix the first projection (39) to the body (11).

8. A fluid burner head (9) according to any of claims 1-6, further comprising an annular second projection (41) extending around the longitudinal center axis (C) of the fluid burner head (9) and projecting from the outer surface (43) of the body (11) between the uppermost row (29a) of holes (27) of the tube (13) and the first projection (39).

9. A fluid burner head (9) according to claim 8, wherein the second projection (41) projects from an outer surface (47) of the tube (13).

10. A fluid burner head (9) according to any of claims 8-9, further comprising an annular support (37) extending around the longitudinal center axis (C) of the fluid burner head (9), which support (37) is connected to the first and second projections (39, 41) and engages with the body (11) of the fluid burner head (9) to fix the first and second projections (39, 41) to the body (11).

11. A fluid burner head (9) according to any of claims 7 or 10, wherein the support (37) is clamped between the cap (15) and the tube (13).

12. A fluid burner head (9) according to any of the preceding claims, wherein the cap (15) comprises an upper portion (31) and a bottom portion (33), wherein the bottom portion (33) projects into the tube (13).

13. A fluid burner head (9) according to claim 12, wherein the bottom portion (33) comprises a part which is tapering in a direction away from the upper portion of (31) the cap (15).

14. A fluid burner head (9) according to any of claims 12-13, wherein an outer circumference of the upper portion (31) of the cap (15) is larger than an inner circumference of the tube (13).

15. Use of a fluid burner head (9) according to any of claims 1-14 in a fluid combustion unit (1) for burning boil-off gas from a fuel tank onboard a ship.