A burner tip (1) having a burner outlet opening (3) and at least one burner tip part (11) which surrounds the burner outlet opening (3) and has a burner tip wall (11A) with an end wall (47, 67, 147) forming a closed end of the burner tip part (11). The burner tip part (11) has in its interior a hollow space extending to the end wall (47), wherein the burner tip wall (11A) has an inner side facing towards the hollow space. A displacement body (5) arranged in the hollow space, has an outer side facing towards the inner side of the burner tip wall (11A). At least one flow channel (10) is formed between the inner side of the burner tip wall (11A) and the outer side of the displacement body.
FIG 1
BURNER TIP AND BURNER

[0001] The present invention relates to a burner tip, especially to a burner tip for high-temperature applications in synthesis gas production. In addition, the invention relates to a burner, especially to a burner for synthesis gas production.

[0002] A burner for a synthesis gas reactor is described schematically in DE 10 2008 006 572 A1. This comprises an outer burner element, in the tip of which provision is made for a cavity with a displacement body arranged therein. Guided around the displacement body is a cooling water passage which serves for cooling the burner tip. The burner also comprises an inner burner element which is arranged concentrically to the outer tube. Formed between the inner burner element and the outer burner element is a passage for the feed of pulverized fuel, for example pulverized coal. Also, the inner burner element, in the region of its tip, has a cavity with a displacement body arranged therein, around which is guided a cooling water passage by means of which the tip of the inner burner element is cooled. A pilot burner is arranged centrally to the inner burner element, wherein a feed passage for an oxygen/steam mixture is formed between the inner burner element and the pilot burner. Like the outer and the inner burner element the pilot burner is of a hollow walled design, wherein a displacement body is arranged in the region of the tip of the pilot burner and around which is guided a cooling water passage in order to be able to cool the pilot burner tip.

[0003] The tips of burners in synthesis gas reactors are subjected to high temperatures during operation of the reactor so that a considerable heat input into the burner tip takes place. The inputted heat is dissipated by means of the cooling water flowing in the described cooling water passages. In order to reduce the heat input, the burner tip can also be provided with a thermal barrier coating, as described in DE 10 2008 006 572 A1.

[0004] The respective burner elements are as a rule constructed from a plurality of tubes and a tip which interconnects the tubes and in which is also arranged the displacement body. The tip in this case is usually assembled from an outer annular part and an inner annular part, wherein the outer annular part is connected to the outer tube and the inner annular part is connected to the inner tube. Moreover, the annular parts are welded together by their ends facing away from the outer tube or the inner tube. The displacement body is connected to a centrally arranged tube which divides the interspace between the outer tube and the inner tube into an annular feed passage for cooling water and an annular discharge passage for cooling water. Each burner element therefore has a complex construction. Furthermore, the burner tips are relatively large, and therefore heavy, which reduces their manageability, for example in the course of a maintenance.

[0005] For production engineering reasons, the wall thicknesses of the tubes or of the tip parts are typically at least 3 mm, which makes heat dissipation difficult and increases the susceptibility to temperature fluctuations. Furthermore, suspended particles and cooling water can lead over time to a constriction of the cooling water passages in the region of the burner tip or even to blocking of the cooling water passages, which entails an increased maintenance requirement so that such obstructions can be discovered in good time.

[0006] Moreover, the materials from which the burner tips are produced are expensive and time consuming in processing since the parts of which the burner tips consist have to be welded together. The welding of the parts for forming the respective burner tip is not simple since the typically used nickel-based superalloys require special welding procedures.

[0007] Compared with the described prior art, it is the object of the present invention to provide an advantageous burner tip, especially for burner elements of a synthesis gas burner. In addition, it is an object of the present invention to provide an advantageous burner, especially for synthesis gas production.

[0008] The said object is achieved by a burner tip according to claim 1 and a burner according to claim 18. The dependent claims contain advantageous embodiments of the invention.

[0009] A burner tip according to the invention has a burner discharge orifice and at least one burner tip part which encompasses the burner discharge orifice. The burner tip part has a burner-tip wall with an end wall which forms a closed end of the burner tip part. In its interior, the burner tip part has a cavity which reaches up to the end wall. The burner-tip wall has an inner side pointing towards the cavity. A displacement body, with an outer side facing the inner side of the burner-tip wall, is arranged in the cavity, wherein the displacement body is of hollow design. At least one flow passage is formed between the inner side of the burner-tip wall and the outer side of the displacement body.

[0010] As a result of the hollow design of the displacement body, a saving can be made in weight and material in comparison to burner tips according to the prior art in which the displacement body is designed as a solid body. On account of the lower weight, the burner tip, which can have diameters of 50 cm and more, is easier to manage, for example in the course of a maintenance or repair process.

[0011] In a development of the burner tip according to the invention, the displacement body has a near end in relation to the end wall, a far end in relation to the end wall, an interior space, and, in the region of the far end, at least one opening which is open towards the interior space. In this way, it becomes possible to make the hollow displacement body accessible to a cooling fluid, for example cooling water, flowing through the flow passage between the outer side of the displacement body and the inner side of the burner-tip wall. To this end, for example a flow guiding element can be arranged in the displacement-body opening in such a way that it divides the displacement-body opening into an inflow section and an outflow section and in such a way that a flow path around the flow guiding element is formed between the inflow section and the outflow section. Alternatively, there is the possibility that the displacement body has at least one additional opening which is open towards the interior space. This is then arranged between the near end of the displacement body and the displacement-body opening which is arranged in the region of the far end. Between the displacement-body opening and the additional displacement-body opening, the displacement-body interior space forms a flow path for cooling fluid, such as cooling water.

[0012] If a flow path for cooling fluid is formed inside the displacement body, a collecting chamber, branching from the flow path, for foreign bodies in the fluid flowing through said flow path can be located in the displacement-body interior space. In this case, it is advantageous if the collecting chamber in the displacement-body interior space is located in a region of the flow path in which a change of flow direction takes place. It is especially advantageous if the change of flow direction entails a substantial flow reversal. In this case, the space in the hollow displacement body is sufficient in order to be able to provide an adequately large collecting chamber.
The collecting of foreign bodies, such as suspended particles, in the cooling fluid leads to the fluid passages leading around the outer side of the displacement body blocking more slowly and as a result a constriction of the flow cross section can be delayed for a longer period. This in turn has a favorable effect upon the maintenance intervals.

[0013] In a specific embodiment of the burner tip according to the invention, the displacement body is connected to the inner side of the burner-tip wall via support structures, for example via rib-like or pillar-like structures. The support structures in this case extend from the outer side of the displacement body to the inner side of the burner-tip wall. If the support structures are designed as rib-like or pillar-like structures, adjacent rib-like or pillar-like structures can converge to form arches on the outer side of the displacement body and/or on the inner side of the burner-tip wall, at least in the region of the burner tip end wall. These arches can especially be designed as pointed arches similar to the arches in gothic architecture. By means of the support structures, the position of the displacement body inside the burner-tip wall can be fixed. Furthermore, the entire structure consisting of burner-tip wall and displacement body can be of an altogether more stable design.

[0014] In a further embodiment of the burner tip with support structures, the density of support structures, which connect the displacement body to the burner-tip wall, is increased at least in the region of the end wall in comparison to other regions of the burner-tip wall. Where the density of the support structures is increased, the burner-tip wall can then be of thinner design in comparison to regions without increased density of support structures. They can especially have thicknesses of below 3 mm, especially thicknesses in the region of 0.5 mm to 2 mm. In this way, in regions which are subjected to especially high temperatures and/or to especially pronounced temperature fluctuations the heat which is absorbed by the burner-tip wall can be dissipated more rapidly to the cooling fluid, as a result of which the thinner wall can be kept cooler than a thicker wall, which in turn has a favorable effect upon the available operating period up to a maintenance.

[0015] Within the scope of the burner tip according to the invention, the displacement body can especially be formed in one piece with the support structures and the burner-tip wall. This allows a particularly stable structure and enables the production of a large number of structures at the outset.

[0016] The production can in this case be carried out by means of an additive manufacturing process, for example by means of selective laser melting.

[0017] The burner-tip wall can be lined with a thermal barrier coating, at least in the region of the end wall. In particular, if the burner-tip wall has thicker and thinner regions, an embodiment in which the thermal barrier coating is applied to the thinner regions, especially in the region of the end wall, is advantageous. Due to the fact that in this embodiment the burner-tip wall is thinner in the regions with a thermal barrier coating, it can achieve the effect of the entire wall thickness in these regions, despite the applied thermal barrier coating, not exceeding the thickness of the remaining regions without a thermal barrier coating.

[0018] In the burner tip according to the invention, swirl vanes, which project at least partially into the burner discharge orifice, can also be formed in one piece with the burner-tip wall. Previously, swirl vanes have been inserted from the burner side facing away from the burner tip into the burner discharge orifice which is encompassed by the burner-tip wall. With this insertion, damage to the swirl vanes and/or to the burner tip wall can occur. As a result of the one-piece design of the swirl vanes with the burner-tip wall, the insertion of swirl vanes is superfluous. Moreover, there is also the possibility that the flow passage which is formed between the inner side of the burner-tip wall and the outer side of the displacement body also extends at least partially through the swirl vanes. In this way, a common cooling of burner tip and swirl vanes is made possible.

[0019] With the aid of specific manufacturing processes (additive manufacturing processes), it can achieve the effect of the swirl vanes forming a blading assembly which has the form of a nozzle which reduces the flow cross section in specific regions of the blading assembly for an oxygen-steam mixture flowing through said blading assembly.

[0020] In the burner tip according to the invention, the burner-tip wall and the displacement body are of toroidal design.

[0021] A burner according to the invention is provided with a burner tip according to the invention. The characteristics and advantages associated therewith are gathered from those of the burner tip according to the invention.

[0022] Further features, characteristics and advantages of the present invention arise from the following description of exemplary embodiments with reference to the attached figures.

[0023] FIG. 1 shows a schematic diagram of a burner, as is used in synthesis gas reactors.

[0024] FIG. 2 shows the tip of a first burner element.

[0025] FIG. 3 shows the tip of a second burner element.

[0026] FIG. 4 shows the tip of pilot burner used in the burner.

[0027] FIG. 5 shows an alternative embodiment of the tip from FIG. 3.

[0028] FIG. 6 shows a further alternative embodiment of the tip from FIG. 3.

[0029] FIG. 7 shows yet another alternative embodiment from FIG. 3.

[0030] FIG. 8 shows the embodiment from FIG. 7 in a section along the line VIII-VIII.

[0031] The basic construction of a burner for synthesis gas reactors is described below with reference to FIG. 1.

[0032] The burner is constructed in a rotationally symmetrical manner around a burner axis A and comprises a tubular feed line section and a burner tip 1 which is connected to the feed line section and encompasses a burner orifice 3.

[0033] The burner comprises a first, outer burner element 2 which in the tubular section of the burner is formed from three inter-inserted tubes 4, 6, 8. Formed between the tubes are a cooling fluid feed passage 7 and a cooling fluid discharge passage 9, via which cooling fluid can be fed to the burner tip 1 and discharged from this respectively. As cooling fluid, water is especially a consideration. In the region of the burner tip 1, the outer burner element 2 deviates from the pure tubular shape and is inclined in the direction towards the center of the burner discharge orifice 3. Furthermore, in the region of the tip it has a cavity in which a displacement body 5 is arranged at a distance from the wall of the burner element 2 in this region. Formed in this case between the inner side of the wall 11A of the burner element 2 in the tip region and the outer side of the displacement body is a flow passage 10 by means of which the cooling fluid, for example water, is directed through the tip of the outer burner element 2 in order to cool this.
The part of the outer burner element 2 which deviates from the tubular shape constitutes an outer burner tip part 11 which is formed as an independent part and the wall 11A of which is welded to the tubular section of the outer burner element 2.

In this case, the wall 11A of the burner tip part 11 has an approximately U-shaped bend so that it can be connected both to the outer tube 4 and to the inner tube 8 of the tubular section of the outer burner element 2. The displacement body 5 is fitted onto the center tube 6. To this end, it has a groove 5A, the width of which is adapted to the wall thickness of the center tube 6 of the tubular section.

The burner furthermore comprises an inner burner element 12 which apart from in the region of the burner tip 1 is also formed from three inter-inserted tubes 14, 16, 18. In the region of the burner tip 1, an inner burner tip part 21, with a cavity located therein, is connected to the tubular section of the inner burner element 12. A displacement body 15 is arranged in this cavity, wherein the outer side of the displacement body has a distance from the inner side of the burner-tipped wall 21A in the region of the inner burner tip part 21 so that a flow passage is formed between the two. The feed of cooling fluid into the flow passage is carried out via a feed passage 17 which is formed between the inter-inserted tubes 14, 16, 18 of the tubular section of the inner burner element 12, and the discharge of the cooling fluid from the region of the inner burner tip part 21 is carried out via a discharge passage 19 which is formed between the inter-inserted tubes 16, 18. Also, the inner burner tip part is designed as an independent part, the wall 21A of which is welded to the outer tube 14 and to the inner tube 18 of the tubular section. To this end, the wall 21A in the widest sense is bent in a U-shaped manner so that it can be welded both to the outer tube 14 and to the inner tube 18 of the tubular section. The displacement body 15 is fitted onto the center tube 16 of the tubular section. To this end, it has a groove 15A, the width of which is adapted to the wall thickness of the center tube 16.

The inner burner element 12 has an outside diameter which is smaller than the inside diameter of the outer burner element 2 so that an annular passage is formed between the two, serving for the feed of a pulverized fuel, for example for the feed of pulverized coal.

This comprises a tubular section 22A which is formed from three tubes 24, 26, 28 and to which is connected a pilot burner tip part 31 in the region of the burner tip 1. The pilot burner tip part 31 has a cavity in which is arranged a displacement body 25, wherein the outer side of the displacement body has a distance from the inner side of the wall 31A of the pilot burner tip part 31 so that a flow passage 30 is formed between the two. As in the case of the outer burner element 2 and in the case of the inner burner element 12, the wall 31A of the tip part 31 is welded to the tubular section. The wall 31A of the pilot burner tip part is bent in this case in the widest sense in a U-shaped manner so that on one side it can be welded to the outer tube 24 of the tubular section of the pilot burner 22 and to the inner tube 28 of the tubular section of the pilot burner 22.

The displacement body 25 is fitted onto the center tube 26 of the tubular section. To this end, it has a groove 25A, the width of which is adapted to the wall thickness of the center tube 26.

The tubular section of the pilot burner 22 has an outside diameter which is smaller than the inside diameter of the inner burner element 12 so that an oxygen/steam passage 23 is formed between the two. This serves for the feed of water vapor which is required in the synthesis gas reactor for converting pulverized fuel into synthesis gas, and, if necessary, for the feed of oxygen or air. For promoting the synthesis gas reaction, the supplied water vapor, and, if necessary, the supplied oxygen or the supplied air, is swirled in order to promote the synthesis gas reaction.

To this end, swirl vanes 32 are arranged in the region of the burner tip 1 between the inner burner element 12 and the pilot burner 22.

The pilot burner 22 encloses an essentially cylindrical cavity in which are arranged an ignition burner and a device for flame monitoring. These two elements are shown in only a greatly schematized form in the figure and are grouped under the designation 33.

FIG. 2 shows the construction of the outer burner tip part 11. Also to be seen are the inter-inserted tubes 4, 6, 8 of the tubular section of the outer burner element 2. The outer burner tip part 11 terminates in an end wall 34 which constitutes the end of the outer burner tip part. A cavity, in which, as already described, the displacement body 5 is located, is formed in the outer burner tip part 11. This displacement body, as is shown in FIG. 2, is of hollow design. It has a near end 36 in relation to the end wall 34 and a far end 38 in relation to the end wall with a groove 5A for fitting onto the center tube 6 of the tubular section of the burner element. In the region of the far end 38, especially directly in front of the groove 5A in the far end, provision is made for a displacement-body opening 40 which is open towards the interior space 42 of the hollow displacement body 5 so that the interior space 42 is accessible through the displacement-body opening 40. The burner-tip wall 11A, which is bent in an approximately U-shaped manner, is connected both to the outer tube 4 and to the inner tube 8 of the tubular section of the outer burner element 2, whereas the displacement body 5 is connected to the center tube 6 of the tubular section of the outer burner element 2 in such a way that the displacement-body opening 40 is open towards the feed passage 7 which is formed between the outer tube 4 and the center tube 6. The displacement-body interior space 42 is consequently fluidically connected to the feed passage 7 for the cooling fluid.

The hollow displacement body 5, which consists in the main of a relatively thin wall 44, is connected to the inner side of the burner-tip wall 11A via support structures 46. These support structures can be of rib-like or pillar-like design so that they obstruct the flow in the flow passage 10 as little as possible and possibly even guide the flow.

FIG. 3 shows the construction of the inner burner tip part 21 and the inter-inserted tubes 14, 16, 18, adjoining it, of the tubular section of the inner burner element 12. The inner burner tip part 21 has a wall 21A with an end wall 47 which forms the closed end of the inner burner tip part 21. As has already been described with reference to FIG. 1, a displacement body 15 is located in the cavity of the inner burner tip part 21. This displacement body in turn is itself of hollow design and has a wall 54 enclosing an interior space 52. Furthermore, the displacement body 15 has a near end 48 in relation to the end wall 47 and a far end 49 in relation to the end wall 47 with a groove 15A for fitting onto the center tube 16 of the tubular section of the burner element. Arranged in the region of the far end 49, especially directly in front of the
groove 15A in the far end, is a displacement-body opening 50 via which the displacement-body interior space 52 is accessible. The wall 21A of the inner burner tip part 21 is bent in an approximately U-shaped manner, wherein the ends of the burner-tip wall 21A are connected to the outer tube 14 of the tubular section of the inner burner element 12 and to its inner tube 18. The displacement-body wall 54 is connected to the center tube 16 of the tubular section of the inner burner element 12 so that the displacement-body opening 50 is open towards the feed passage 17 formed between the outer tube 14 and the center tube 16 of the tubular section of the inner burner element 12. In this way, the displacement-body interior space 52 is fluidically connected to the feed passage 17 for the cooling fluid. The displacement-body wall 54 is connected via support structures, which for example can be of rib-like or pillar-like design, to the inner side of the burner-tip wall 21A so that a defined distance is provided between the outer side of the displacement body and the inner side of the burner-tip wall 21A in order to form the flow passage 20. As in the case of the outer burner tip part, the support structures can also be designed in such a way that they guide the flow through the flow passage, but in any case they are designed so that they obstruct the flow as little as possible.

Swirl vanes 32 are formed in one piece with the burner tip part 21 of the inner burner element 12. The swirl vanes 32 are hollow and have in each case an interior space 58 which via a cooling fluid inlet opening 59 and a cooling fluid outlet opening 60 is fluidically connected to the flow passage 20 which leads around the displacement body 15. The displacement-body interior space 58 is therefore part of the cooling circuit so that the swirl vanes 32 together with the inner burner tip part 21 are cooled by the cooling fluid.

A tube 62, which serves as a guide for inserting the pilot burner 22, is also formed in one piece with the inner burner tip part 21 and the swirl vanes 32 in the present exemplary embodiment. EXEMPLARY embodiments without a tube 62 for guiding the pilot burner 22 are also possible, however. The tube 62 which is shown in the figure therefore represents only one option.

The structure of the pilot burner 22 in the region of the burner tip 1 is shown in FIG. 4. The pilot burner tip part 31 and the tubular section of the pilot burner 22 which is formed from the three inter-inserted tubes 24, 26, 28 can be seen in the figure.

The pilot burner tip part 31 has a wall 31A which is bent in an approximately U-shaped manner and encloses an interior space of the pilot burner tip part 31. A displacement body 25 is arranged in the interior space. As in the case of the burner tip parts 11, 21 of the outer burner element 2 and of the inner burner element 12, the displacement body 25 located in the interior space of the pilot burner tip part 21 is also of hollow design. It has a near end 66 pointing towards the end side 76 and a far end 68 facing away from this with a groove 25A of fitting onto the center tube 26 of the tubular section of the burner element. Arranged in the region of the far end 68, especially directly in front of the groove 25A in the far end, is a displacement-body opening 70 via which the interior space 72 of the displacement body 25 is accessible. The displacement-body interior space 72 is enclosed by a wall 74 which via support structures 76, for example the already described pillar-like or rib-like structures, is connected to the inner side of the burner-tip wall 31A. Also in the case of the burner-tip wall of the pilot burner, the support structures 76 can be of a flow-guiding design. In any case, however, they are designed so that they do not obstruct the flow through the flow passage 30 which is formed between the outer side of the displacement body and the inner side of the burner-tip wall 31A.

The two ends of the wall 31A—which is bent in an approximately U-shaped manner—of the pilot burner tip part 31 are connected to the outer tube 24 and to the inner tube 28 of the tubular section of the pilot burner 22, and the displacement-body wall 74 is connected to the center tube 26 of the tubular section. The connection is constructed in this case at a point of the displacement-body wall 74 which is selected in such a way that the displacement-body opening 70 is open towards the feed passage which is formed between the outer tube 24 of the tubular section of the pilot burner 22 and its center tube 26. The displacement-body interior space 72 is consequently integrated into the cooling fluid circuit.

The outside diameter of the pilot burner 22 is selected so that it can be inserted into the tube 62 of the inner burner element 12. The pilot burner 22 also encloses a largely cylindrical interior space in which an ignition burner and a flame monitoring device can be arranged.

In the case of the outer burner tip part 21 and the inner burner tip part 21 and in the case of the pilot burner 22, the burner tip parts 11, 21, 31 are produced separately in each case from the tubular sections which are formed by the inter-inserted tubes. Subsequently, the inter-inserted tubes are then connected to the respective burner tip parts by means of a welding process, for example.

The burner tip parts can especially be produced in one piece in each case by means of an additive manufacturing process. As a result, the described complex structures, in which hollow displacement bodies are connected to the burner-tip walls via support structures, are made possible. In particular, the one-piece production of the swirl vanes 32 and the tube 62 with the inner burner tip part 21 can also be ensured by the additive production by means of an additive manufacturing process 5. As an additive manufacturing process, especially selective laser sintering can be applied.

A modification of the exemplary embodiment shown in FIG. 3 is described below with reference to FIG. 5. The modification is concentrated in the main upon the embodiment of the displacement body and its interior space. The remaining elements of the exemplary embodiment described in FIG. 3, such as the swirl vanes, are therefore not shown in FIG. 5. Elements which correspond to those from FIG. 3 are identified by the same designations as in FIG. 3 and are not explained again in order to avoid repetitions.

The displacement body of the exemplary embodiment shown in FIG. 5 differs from the displacement body of the exemplary embodiment shown in FIG. 3 mainly by the fact that its opening 50 is enlarged. Furthermore, a flow guiding element 80 projects from the inner side for the inner burner wall into the displacement-body opening 50 so that the flowing guiding element 80 divides the opening into an inflow section 81 and an outflow section 82.

A flow path 83 is formed around the flow guiding element 80. At the end of the flow guiding element 80, the flow through the flow path 83 experiences a flow reversal 84. In the region of the flow reversal 84, a collecting chamber 85 branches from the flow path 83, wherein the access to the collecting chamber is arranged in approximately the original flow direction, that is to say the flow direction before the flow reversal. Suspended particles present in the cooling fluid are not able to reproduce the abrupt direction change, on account of their inertia, during the flow reversal as easily as the fluid
itself so that the suspended particles make their way into the collecting chamber 85 and can be deposited there. In this way, some of the suspended particles can be removed from the fluid before flow passes through the flow passage 20 which is formed between the outer side of the displacement body and the inner side of the burner-tip wall 21A, as a result of which deposits of suspended particles in this flow passage can be reduced so that a constriction of the flow passage can be avoided or at least delayed.

[0057] Although the exemplary embodiment with the collecting chamber 85 has been described with regard to the burner-tip part 21 of the inner burner element 12, a corresponding embodiment can also be provided in the case of the burner tip part 11 of the outer burner element 2 and also in the case of the pilot burner tip part 31.

[0058] A further alternative to the exemplary embodiment from FIG. 3 is shown in FIG. 6. Elements which correspond to those from FIG. 3 are identified in this case by the same designations as in FIG. 3 and are not explained again in order to avoid repetitions. As in FIG. 5, in FIG. 6 the swirl vanes 32 and also the cylindrical tube 62 are not shown since these do not differ from the exemplary embodiment shown in FIG. 3.

[0059] The essential difference to the exemplary embodiment shown in FIG. 3 lies in the fact that the end wall 147 is of a thinner design than in the case of the exemplary embodiment shown in FIG. 3. In order to stabilize the thin end wall 147, the density of support structures 146 is increased in its region. The support structures 146 are designed as pillar-like structures which converge to form arches on the displacement body 15. In the present exemplary embodiment, the arches are designed as pointed arches so that the pillar-like support structures form a type of arch which has the shape of a gothic arch.

[0060] Although in the exemplary embodiment shown in FIG. 6 only the end wall 147 is of a thinner design, the thin wall can also extend beyond the end wall 147 and even form the entire burner-tip wall 21A. By reducing the thickness of the burner-tip wall 21A in thermally highly loaded regions a more rapid heat dissipation to the cooling fluid can be achieved. Furthermore, a thinner wall is less prone to heat fluctuations.

[0061] The described pointed arch-like design of the support structures can be realized by means of the already mentioned additive manufacturing process. The design of the support structures and of the wall thickness described with reference to FIG. 5 can also be realized in the case of the burner tip parts 11, 31 of the outer burner element 2 and of the pilot burner 22.

[0062] An alternative form of the support structures, which also enables a reduction of the wall thickness of the burner-tip wall, is shown in FIGS. 7 and 8. In this case, FIG. 8 shows a section along the line VIII-VIII shown in FIG. 7.

[0063] The support structures shown in FIGS. 7 and 8 have the form of ribs 86 which are formed between the displacement-body wall 54 and the burner-tip wall 21A and extend from the far end of the displacement body 15 around its near end and back towards the far end. In this case, the ribs 86 extend in parallel and converge to form arches both on the outer side of the displacement body and on the inner side of the burner wall. In the present exemplary embodiment, the arches are pointed arches so that between the individual ribs flow passages 20 are formed with cross sections which correspond to an ellipse running to a point at its ends. This design of the support structures also allows a reduction of the wall thickness with high stability of the thinner wall. The support structures described with reference to the FIGS. 7 and 8 can be used in the case of the burner tip part 11 of the outer burner element 2 and/or the burner tip part 21 of the inner burner element 12 and/or the pilot burner tip part 31. Although pointed arches have been described with reference to FIGS. 7 and 8, other arch shapes can also be used, wherein the respective arch shape inter alia can be selected with regard to the chosen production method.

[0064] The present invention has been explained in detail based on specific exemplary embodiments for illustration purposes. In this case, elements of the individual exemplary embodiments can also be combined with each other. The invention is therefore not to be limited to individual exemplary embodiments but is only to experience a limitation as a result of the appended claims.

1. A burner tip comprising:
   a burner discharge orifice;
   at least one burner tip part configured to encompass the burner discharge orifice, the tip part has a burner-tip wall with an end wall which forms a closed end of the burner tip part,
   the burner tip part includes an interior which has a cavity which reaches up to the end wall, and the burner-tip wall has an inner side pointing towards the cavity,
   a displacement body arranged in the cavity and having an outer side facing the inner side of the burner-tip wall;
   at least one flow passage between the inner side of the burner-tip wall and the outer side of the displacement body, and
   the displacement body is of hollow design.

2. The burner tip as claimed in claim 1, wherein the displacement body has a near end, which is nearer to the end wall and a far end which is further from the end wall and an interior space and, in the region of the far end, at least one opening which opens towards the interior space.

3. The burner tip as claimed in claim 2, further comprising:
   at least one flow guiding element arranged in the displacement-body opening and configured such that the guiding element divides the displacement-body opening into an inflow section and an outflow section and in such a way that a flow path is formed around the flow guiding element between the inflow section and the outflow section.

4. The burner tip as claimed in claim 2, further comprising:
   the displacement body has at least one additional opening which is open towards the interior space and is arranged between the near end of the displacement body and the displacement-body opening which is arranged in the region of the far end, and
   the displacement-body interior space forms a flow path between the displacement-body opening and the additional displacement-body opening.

5. The burner tip as claimed in claim 3, further comprising:
   a collecting chamber located in and the displacement-body interior space are moved, crossed out from original position and underlined in new position, branching from the flow path, for receiving foreign bodies separated out of a fluid flowing through the flow path.

6. The burner tip as claimed in claim 5, further comprising:
   an inlet for the collecting chamber located in a region of the flow path having a change of flow direction.

7. The burner tip as claimed in claim 1, further comprising:
   support structures connecting the displacement body to the inner side of the burner-tip wall, the support structures
extend from the outer side of the displacement body to the inner side of the burner-tip wall.

8. The burner tip as claimed in claim 7, further comprising: the support structures comprise rib-like or pillar-like structures, and adjacent rib-like or pillar-like structures which converge to form arches on an outer side of the displacement body and/or on the inner side of the burner-tip wall, at least in the region of the end wall.

9. The burner tip as claimed in claim 8, wherein the arches are pointed arches.

10. The burner tip as claimed in claim 7, wherein a density of the support structures which connect the displacement body to the burner-tip wall, is increased at least in the region of the end wall in comparison to other regions of the burner-tip wall.

11. The burner tip as claimed in claim 10, further comprising:
where the density of the support structures is increased, the burner-tip wall is of thinner design in comparison to regions without increased density of support structures.

12. The burner tip as claimed in claim 7, wherein the displacement body is formed in one piece with the support structures and the burner-tip wall.

13. The burner tip as claimed in claim 7, wherein the burner-tip wall is lined with a thermal barrier coating on its outer side, at least in the region of the end wall.

14. The burner tip as claimed in claim 7, further comprising:
swirl vanes, which project at least partially into the burner discharge orifice, are formed in one piece with the burner-tip wall.

15. The burner tip as claimed in claim 14, wherein the flow passage between the inner side of the burner-tip wall and the outer side of the displacement body extends at least partially through the swirl vanes.

16. The burner tip as claimed in claim 14, wherein the swirl vanes form a blading assembly which has the form of a nozzle which reduces the flow cross section in specific regions of the blading assembly configured for an oxygen-steam mixture flowing through the blading assembly.

17. The burner tip as claimed in claim 7, wherein the burner tip part and the displacement body are of toroidal design.

18. A burner with a burner tip as claimed in claim 1.