

**NOZZLE FOR BLOWING GAS INTO AN INCINERATOR WITH A PIPE AND A
SWIRL GENERATOR, FLUE GAS EXHAUST WITH A NOZZLE OF SUCH KIND,
AND METHOD FOR USING A NOZZLE OF SUCH KIND**

[01] The invention relates to a nozzle for blowing gas into an incinerator, with a pipe and a swirl generator, a flue gas exhaust with a nozzle of such kind, and a method for using a nozzle of such kind.

[02] According to the current state of the art, secondary air nozzles in waste incineration plants are designed as blast nozzles. For these purposes, the primary design parameters are pressure and nozzle diameter. While pressure is the most important factor affecting inlet velocity, the diameter affects volume flow. Total volume flow arises from the number of nozzles. The nozzle inserts may be produced as cast components.

[03] In waste incineration plants, a poorly mixed region with insufficient air is often encountered at the front wall, which can result in elevated CO concentrations and CO peaks, particularly if the combustible has a high calorific value, as may also occur for example when high-calory combustion materials and waste incineration plants with grate firing are used.

[04] EP 0611 919 A1 describes a nozzle for feeding a combustion gas, with which a secondary gas jet with induced swirl is generated, which intensively mixes a region close to the boiler wall and enriches it with oxygen. The quantity of the supplied volume flow is adjusted inside the gas nozzle with a control element which is arranged so as to be slidable axially on the longitudinal axis of the nozzle, at least partially blocking the nozzle cross section, and is equipped with a displacing device that can be extracted from the nozzle to enable velocity controlled feeding of the secondary gas. Spacer elements in the form of curved guide vanes are conformed as swirl plates on the slidable control element, and are guided along the inner wall of the nozzle.

[05] When such nozzles are used, flue gas may reach the control element arranged inside the nozzle cone, and deposits on the swirl plate can impair its mobility.

[06] US 5,727,480 describes a nozzle duct which is surrounded concentrically by a further

nozzle duct. A flow of air in the interior of the nozzle duct causes gas to be drawn in through the annular passage between the concentric ducts. Guide vanes are provided in this annular passage and guide the gas flowing through the annular passage from the inner duct to the outer duct, thus creating a very particular gas flow at the nozzle outlet.

[07] Use of the nozzle is complicated, since two controlled gas feeds must be provided.

[08] WO 2012/096319 A1 also describes concentric pipes for feeding gas in targeted manner. A swirl plate which is slidable along the longitudinal axis of the nozzle by means of a rod is arranged inside the pipe.

[09] When this solution is used, soiling of the pipes, and particularly of the swirl plate, which obstructs the flow of gas must be contended with.

[10] The object underlying the invention is therefore to advance the development of a nozzle for incinerators in such manner that it has a long service life in harsh operating conditions and produces a more pronounced stream diffusion for the same volume flow and pressure. A method for using nozzles of such kind is also presented.

[11] This object is solved with a nozzle having the features of Claim 1, a flue gas exhaust with a nozzle of such kind according to Claim 15, and a method having the features of Claim 17.

[12] The swirl nozzles developed result in a more pronounced stream diffusion for the same volume flow and pressure, and consequently reduced penetration depth. This is achieved by splitting the pulse input into an axial and a tangential component. In blast nozzles, the entire pulse input is directed axially. Through the use of swirl nozzles as secondary air nozzles, an insufficiency of air in the vicinity of the wall, particularly the front wall, may be reduced, particularly in waste incineration plants.

[13] The developed nozzle insert has a special injection characteristic. Similarly to the air outlets of ventilation systems which are installed in living room ceilings, when the nozzle according to the invention is used in an incinerator a uniform "air curtain" is created close to the boiler wall to prevent tendrils of CO from breaking through. Previously with known nozzle inserts, the input pulse of the injected medium was made as strong as possible, in order to ensure the most complete mixing of the flue gas with the least possible use of supplied

combustion air.

[14] Even when two different media (for example recirculated flue gas and air) are injected through one nozzle, a strong input pulse is still very important for effective missing of the flue gas over as much of the entire boiler cross-section as possible.

[15] However, a disadvantage which persists in the known methods is that, because of the distance between the individual nozzles and the fact that air streams are still poorly diffused close to the wall, zones are produced in which no mixing occurs. Here, CO-containing exhaust gas is able to pass through the secondary combustion level unchecked.

[16] The objective of the design is to construct a swirl insert which has a similar pressure-volume flow characteristic curve to a conventional blast nozzle while producing the strongest possible swirl effect. This is achieved with a pipe which is cylindrical over the entire length thereof. The inlet is preferably not rounded. If pressure loss were too great, the nozzle diameter would have to be very greatly increased in order to achieve sufficient volume flows in the conventional pressure range. Higher pressures would only be achievable with an additional fan/compressor. The costs of components for the larger swirl generator would also be higher. This is to be avoided for reasons of cost.

[17] A further objective of the design is to create a swirl flow which is as uniform as possible at the nozzle outlet, as far as possible without reverse flows into the nozzle pipe, in order to avoid infiltration by ash particles and hot flue gases. This is designed to prevent soiling and corrosion of the swirl generator. In this context, straight vanes are preferable to curved vanes, and vanes with a straight inflow section are preferable to vanes without a straight inflow section.

[18] Many factors influence the effectiveness of the nozzles in various ways. A diffuser or even a radius at the nozzle outlet reduce the pressure loss, although an adjoining flow is only to be expected in combination with a small swirl generator. Moreover, reverse flow regions form more readily, which increases the risk of soiling and corrosion of the nozzle interior.

[19] A hole in the middle of the swirl generator reduces formation of reverse flow regions, and also reduces the pressure loss. A connection of the vanes in the centre (e.g., as a pin or ring) is rather disadvantageous, since this the formation of reverse flow regions is favoured

thereby and the loss of pressure is also increased. A more rigid construction and production of the swirl generator without an outer connecting ring are advantageous in this context.

[20] A straight inflow section of the vanes reduces pressure loss and is therefore advantageous. The transition to the swirl generating portion of the vanes may be of various designs; for example as a radius or curved profile. The swirl generating portion of the vanes may also be curved. The vanes may also be designed further such that the height of the vane increases from the inlet to the nozzle outlet.

[21] The swirl generator should be offset slightly inwards to reduce the risk of soiling and corrosion. Unfortunately, this also has the effect of reducing the swirl effect. If excessive wear occurs during plant operation, the swirl generator may be moved further into the interior of the pipe, and this can be balanced out by a larger swirl angle. This does result in greater loss of pressure, but can be compensated with a larger nozzle diameter or a diffuser.

[22] The swirl generator may also be installed in a conically tapering part of a conventional blast nozzle insert. Swirl generation by introducing the air into the nozzle tangentially through a plurality of inlet channels distributed about the circumference is also advantageous. However, this necessitates a more complicated construction and complex design.

[23] For production engineering purposes, it is advantageous if the pipe is arranged inside an outer pipe. The swirl insert thus consists of a pipe in which the swirl generator is located. This pipe is welded into the outer pipe. This forms a nozzle insert which can be inserted in a nozzle pipe. The pipe preferably has a wall thickness of 2 to 5 mm. The inside diameter of the pipe is preferably 40 to 80 mm and in the exemplary embodiment has a value of about 50 mm.

[24] It has proven to be advantageous if the swirl generator has vane profiles with an angle from 15° to 60° and preferably from 40° to 50° for creating the swirl. An exemplary embodiment has an angle of 45° . The swirl effect increases for larger angles. However, this also results in greater pressure loss and formation of reverse flow regions.

[25] In order to protect the nozzle, it is suggested that the distance from the swirl generator to the pipe outlet, and thus also to the boiler outlet be about 10 to 30 mm. The swirl generator should consequently be offset inwards by at least 5 mm and preferably about 10 mm into the pipe interior.

[26] The swirl generator preferably has more than 4 and for example 6 swirl vanes distributed about the circumference thereof. The number of vanes is typically from 4 to 8.

[27] The vanes of the swirl generator should have an average vane profile thickness between 1 and 6 mm and preferably between 2 and 4 mm. Their length in the axial direction of the nozzle pipe should be in the range from 20 to 60 mm and preferably about 30 mm, of which 30 to 70 % and preferably about 50% should be constructed as a straight inflow section in order to reduce the pressure loss.

[28] Soiling of the vanes is reduced if the swirl generator is equipped with swirl vanes that form a free central passage whose diameter is greater than 20% of the inside diameter of the pipe. In such a case, it is advantageous if the vanes do not touch each other. In practice, the diameter of the free hold in the middle of the vanes should be in the range from 10 to 30 mm, for example 16 mm. This would then be equivalent to about 30% of the internal diameter of the pipe.

[29] A variable swirl setting is suggested as an additional option. This may be achieved either by means of a mechanically adjustable angle of attack of the swirl generator or by means of two concentric channels with different swirl angles (e.g. twist-free core jet and twisted annular passage). In this case, the media may flow through the channels with a variable volume flow ratio. Thus for example two collectors may each be provided with a collector with a pressure control via a control valve. Such a variation is mainly advantageous for a flexible mode of operation, and is useful for example in the event of shifts of the combustion zone due to variation of the average heat value of the waste or variation of the load. This make introducing and mixing different gases possible (e.g., air with recirculation gas or air with steam).

[30] A particular variation therefore provides that the swirl generator has movable swirl vanes.

[31] An alternative variation provides that the pipe has at least one and preferably multiple tangential inlet channels distributed around its circumference. Alternatively or additionally, the nozzle may also have a pipe with at least one and preferably multiple spiral gas supply channels distributed around its circumference.

[32] It is advantageous if the Mach number Ma of the nozzle is below 0.4.

[33] If the nozzle is installed in a furnace, it should be arranged in a wall of a flue gas exhaust, preferably on the front wall of a flue gas exhaust. It is advantageous if two of the nozzles are arranged side by side and impart swirls in opposite directions.

[34] Additionally, one nozzle for blowing in gas without a swirl, also referred to as the blast nozzle, may be arranged beside a nozzle for blowing gas with a swirl, which is also referred to as the swirl nozzle.

[35] A method for using a nozzle of such kind is used for blowing a gas, in particular such as air or oxygen for oxygen enrichment, for example against a wall and particularly the front wall of an incinerator, of a waste incineration plant for example, preferably in the first exhaust. This method is particularly suitable for use with a high calorific value (e.g., substitute fuel) and in the case of grate firing.

[36] The nozzles may be used to expand existing combustion air systems in the secondary combustion area. In this context, the swirl nozzles may replace individual nozzles or they may complement such nozzles. In such an arrangement, adjacent nozzles advantageously impart swirl in opposite directions.

[37] In this method, it is advantageous if the gas volume flow which is passed through the nozzle is adjusted to 100 to 1500 Nm^3/h for each nozzle. This yields an operating pressure in the collector of the nozzle plane of about 5 to 100 mbar, and the inlet velocity is in the order of 10 to 100 m/s. In one exemplary embodiment, the air volume flow has a value of 100 to 500 Nm^3/h for an operating pressure in collector of 10 to 60 mbar and an inlet velocity of 20 to 80 m/s.

[38] The nozzle may also be used for example for air, recirculation gas, steam, CO_2 , O_2 and N_2 and mixtures thereof. However, when the feed involves recirculation gas, which is usually charged with particles, or steam, heavier soiling and increased corrosion may be expected to cause greater wear.

[39] Nozzles of such kind may be manufactured as swirl inserts by 3D printing from stainless steel (e.g., 17-4PH or 1.4548) and otherwise also by precision casting or CNC milling for example.

[40] A swirl insert may be welded into an outer pipe. Or the swirl insert may also be produced as a welded construction with plates welded into a pipe for example – as an alternative to 3D-printing, precision casting or CNC milling.

[41] The risk of soiling and corrosion may be reduced further by rounded vanes, for example, or by a central lug or tip.

[42] Depending on the variant, the swirl nozzle may also produce a less powerful suction effect than blast nozzles, which results in less particle deposition on the corresponding boiler wall.

[43] Exemplary embodiments of the invention are represented in the drawing, and will be explained in greater detail in the following text. In the drawing:

Figure 1 shows a pipe with a swirl generator

Figure 2 shows a view into a swirl generator

Figure 3 shows a swirl insert in an outer pipe, arranged together in a nozzle pipe as a nozzle insert,

Figure 4 shows a gas distribution at the outlet from swirl nozzle arranged on the front boiler wall,

Figure 5 shows a gas distribution from a conventional blast nozzle arranged at the same location as in Figure 1 and operated with the same volume flow and pressure,

Figure 6 shows a flue gas exhaust with 4 blast nozzles and with a blast nozzle as small nozzle at bottom left,

Figure 7 shows the flue gas exhaust as in Figure 6 with a swirl nozzle as small nozzle at bottom right,

Figure 8 shows a flue gas exhaust with 4 blast nozzles and with a blast nozzle as small nozzle at top left,

Figure 9 shows the flue gas exhaust as in Figure 8 with a swirl nozzle as small nozzle at top right,

Figure 10 shows an outer pipe of a nozzle on the left, two swirl inserts with pipe and swirl generator in the middle, and a nozzle insert consisting of an outer pipe with a welded swirl insert on the right,

Figure 11 shows a nozzle with swirl generation by tangential introduction of the gas in a conical region of the nozzle and

Figure 12 shows a pipe with a swirl producing inner contour as nozzle or feed line to a nozzle.

[44] Figure 1 shows a nozzle 1 as swirl insert 26 consisting of a pipe 20, in which six swirl vanes 24 (numbered for exemplary purposes only) are arranged as swirl generator 21. The swirl vanes are entirely without deviation for a length of about 40 mm in the direction of flow of the gas, and thus form a straight inflow section 27. After this, they are angled and form a swirl angle 28 of about 45° with respect to the straight inflow section.

[45] Figure 2 shows a swirl insert from a different perspective, in which the central free passage 25 is visible.

[46] Figure 3 shows a nozzle pipe 28 in which a swirl insert 26 housed in an outer pipe 23 is arranged as nozzle insert 29.

[47] Die Figure 4 shows a nozzle 1 as swirl nozzle for blowing gas 2 into an incinerator 3. The incinerator is represented schematically as first flue gas exhaust 4. Below this, Figure 5 shows a conventional blast nozzle 5 which blows the same volume flow of gas into the flue gas exhaust 4. A comparison of the figures shows clearly that the gas 2 injected in Figure 4 remains on the front wall 6 of the flue gas exhaust 4 and does not advance as far into the flue gas exhaust 4 as in Figure 5, in which the gas 2 advances much farther, to the middle of the flue gas exhaust 4 and only spreads out in a fan pattern there.

[48] Figures 6 to 9 also show the advantage of the swirl nozzle in practice. In each of these figures, reference numerals 7 and 8 denote large blast nozzles on the rear wall 9 of the flue gas exhaust 4. In each of Figures 6 and 7, large blast nozzles 10 are arranged at the top on the front wall 6, with a large rear blast nozzle (not shown) below them, all of which blow gas 2 into the flue gas exhaust 4.

[49] Smaller nozzles are arranged horizontally beside the lower, obscured large blast nozzles, and are embodied in the example of Figure 6 as small blast nozzle 11 and in the example of Figure 7 as small swirl nozzle 12. A small nozzle 11, 12 differs from a large nozzle 8, 9, 10 in that a small nozzle 11, 12 blows a smaller volume flow of gas into the flue gas exhaust 4.

[50] While primary combustion gas 16 is introduced through the grate from the very bottom, in Figure 6 a region 14 with insufficient air forms on the front wall 6, and a region 15 with excess air forms in the vicinity of the rear wall 9. In contrast, Figure 7 shows that installation of the small swirl nozzle 12 in the flue gas exhaust 4 gives rise to a uniform air distribution and improved mixing of combustion gases and air.

[51] The effect is similar when smaller nozzles 13 and 14 are arranged horizontally beside the upper, obscured, large blast nozzles 10, as shown in Figures 8 and 9. In the example of Figure 8, these smaller nozzles 13 and 14 are embodied as small blast nozzle 13, and in the example of Figure 9, they are embodied on the right as small swirl nozzle 14. Large blast nozzles 15 and 16 are arranged below them in each case. This too leads to the result that in Figure 8 a region 14 with insufficient air forms on front wall 6, and a region 15 with excess air forms in the vicinity of the rear wall 9. In contrast, Figure 9 shows that installation of the small swirl nozzle 14 in the flue gas exhaust 4 gives rise to a uniform air distribution and improved mixing of combustion gases and air.

[52] Figure 10 then shows an outer pipe 23, a swirl insert 26 with the cylindrical pipe 20 and the swirl generator 21. The swirl generator 21 is located inside a pipe 20, which is welded to the inner side 22 of the outer pipe 23. The swirl insert 26 consists of the pipe 20 with swirl vanes 24 attached to the inside thereof as swirl generator 21. There is a central free passage 25 at the centre of the vanes, because the ends of the vanes do not meet there.

[53] The nozzle 30 shown in Figure 11 has a nozzle pipe 31 with tangential inlet channels 32, 33, 34 distributed about the circumference thereof. The inlet channels are distributed evenly over the circumference in a conical region 35 of the nozzle pipe 31, and allow a further gas to be supplied there in addition to the gas in nozzle pipe 31, in order to create a swirl in the nozzle 30. The inlet channels 32, 33, 34 thus function as a swirl generator which is attached to the inside of the nozzle pipe 31.

[54] Finally, Figure 12 shows a nozzle pipe 41 with a spiral gas feed 42 attached to the inner circumference thereof.

Claims

1. Nozzle (1) for blowing gas (2) into an incinerator (3), with a pipe (20, 31, 41) and a swirl generator (21), wherein the pipe (20, 31, 41) is cylindrical and the swirl generator (21) is attached to the inner side (22) of the pipe (20, 31, 41), wherein the swirl generator has swirl vanes with a straight inlet section *characterized in that* the swirl vanes (24) have a length of 20 to 60 mm, of which 30% to 70% and preferably approximately 50% is designed as a straight inlet section.
2. Nozzle according to Claim 1, *characterized in that* the pipe (20) is arranged inside an outer pipe (23).
3. Nozzle according to Claim 2, *characterized in that* the pipe (20) is welded into the outer pipe (23).
4. Nozzle according to Claims 2 or 3, *characterized in that* the pipe (20) has a wall thickness of 2 to 5 mm.
5. Nozzle according to any one of the preceding claims, *characterized in that* the inside diameter of the pipe (20, 31, 41) is 40 to 80 mm and preferably about 50 mm.
6. Nozzle according to any one of the preceding claims, *characterized in that* the swirl generator (21) has a swirl angle of 15° to 60° and preferably of 40° to 50°.
7. Nozzle according to any one of the preceding claims, *characterized in that* the swirl generator (21) is offset inwardly in the pipe (20, 31, 41) by at least 5 mm and preferably about 10 mm.
8. Nozzle according to any one of the preceding claims, *characterized in that* the swirl generator (21) has more than 4 and preferably 6 swirl vanes (24) distributed about the circumference.
9. Nozzle according to any one of the preceding claims, *characterized in that* the swirl generator (21) has swirl vanes (24) with an average thickness of the vane profile of between 1 and 6 mm and preferably between 2 and 4 mm.

10. Nozzle according to any one of the preceding claims, *characterized in that* the swirl vanes (24) form a free central passage (25) whose diameter is greater than 20% of the free inside diameter of the pipe (20, 31, 41).
11. Nozzle according to any one of the preceding claims, *characterized in that* the swirl generator (21) has movable swirl vanes (24).
12. Nozzle according to any one of the preceding claims, *characterized in that* the pipe (20, 31, 41) has at least one and preferably multiple tangential inlet channels (32, 33, 34) distributed about the circumference.
13. Nozzle according to any one of the preceding claims, *characterized in that* the pipe (20, 31, 41) has at least one and preferably multiple spiral gas feeds (42) distributed about the circumference.
14. Nozzle according to any one of the preceding claims, *characterized in that* the Mach number Ma of the nozzle is below 0.4.
15. Flue gas exhaust with a nozzle (1) according to any one of the preceding claims, *characterized in that* the nozzle is arranged in a wall of the flue gas exhaust (4).
16. Flue gas exhaust according to Claim 15, *characterized in that* the nozzle (1) is arranged on the front wall (6) of the flue gas exhaust (4).
17. Flue gas exhaust according to Claim 15 or 16, *characterized in that* two of the nozzles (1) are arranged side by side and produce swirls in opposite directions.
18. Flue gas exhaust according to any one of Claims 15 to 17, *characterized in that* a nozzle for blowing gas (2) without a swirl, also referred to as a blast nozzle, is arranged beside a nozzle for blowing gas (2) with a swirl according to any one of Claims 1 to 14, also referred to as a swirl nozzle.
19. Method for using a nozzle according to any one of the preceding Claims 1 to 14, *characterized in that* a volume flow made from air and/or flue gas, which is transported through the nozzle (1) is adjusted to 100 to 1500 Nm³/h.