

The invention relates to a method and an apparatus for reducing the concentration of nitrogen oxides in waste gases of combustion processes.

In order to reduce the concentration of nitrogen oxides in waste gases of combustion processes, it is known to introduce various chemicals, e.g. ammonia, sal ammoniac, urea or lime-nitrogen into the waste gases of a combustion plant. In all of these methods, special attention was hitherto focused on supplying chemicals within specific temperature ranges. In order to arrive at usable results, the chemicals were introduced at several points, the composition and concentration of the chemical solutions or chemical suspensions being adapted to the temperature conditions prevailing in the various inlet planes. A large number of inlet points or inlet nozzles were provided in order to obtain good distribution of the chemicals introduced. These measures are not only expensive from the point of view of construction, but also involve high expenditure from the point of view of control engineering.

The problem caused by the large number of inlet points is mitigated to a certain extent by the combustion plant with nozzles for injecting ammonia for the selective non-catalytic removal of nitrogen from exhaust gases known from DE-C-37 22 523. In this known combustion plant with a vertical waste gas offtake, the exhaust gases ascend in a uniform and uninfluenced manner. The lower ends of the front and rear boundary wall of the waste gas offtake are inclined, in that the cross section is narrowed, in order to collect the exhaust gases and are aligned in the vertical direction. Vertically adjustable nozzles for injecting treating agent are provided within the waste gas stream ascending in a uniform manner, a larger number

of fixedly installed nozzle planes being rendered superfluous as a result of the adjustability of the nozzles, thereby avoiding the need for the many supply lines to the individual nozzle planes. The adjustability of the nozzles is provided so that the inlet plane can be adapted to the prevailing temperature conditions in accordance with the load of the combustion plant. However, in order to cause a sufficient reaction between the ammonia and the exhaust gases in this exhaust gas stream ascending in a uniform manner, a nozzle carrier with several distributing pipes and many outlet nozzles is provided so that the treating agent is distributed over the entire surface of the exhaust gas, this nozzle carrier in addition being vertically adjustable, again involving high expenditure from the point of view of construction, measurement technology and control engineering, in order to adapt the position of the nozzle carrier to the prevailing temperature conditions.

In a method for the adsorptive removal of sulphur oxides and other harmful constituents from exhaust gases known from DE-A 35 10 669, a rotational flow having a certain turbulence in its interior is first produced in a means arranged outside the combustion plant in an inlet chamber having a circular cross section by the tangential admission of exhaust gases. A venturi means in the confusor of which the exhaust gases are compressed and accelerated vertically upwards is connected to this chamber. The treating agent is introduced at the point of the highest acceleration and compression formed by the throat of the venturi means, after which the mixture is expanded in the subsequent diffuser and is then advanced to an ascending pipe shaft in which the actual reaction takes place. The compression and upward acceleration pull the spiral flow apart,

leading to a uniform flow, so that the certain turbulence produced is no longer effective to the desired extent prior to the introduction of the medium. The compression zone is very short, so that no reaction will take place here that first takes place in the homogenised, stabilised flow. This known treatment method takes place in a device independent of the combustion plant, so that additional constructional expenditure is required specially for the exhaust gas treatment.

US-A-4 722 287 discloses a pulverised-coal furnace with a subsequent vertically ascending waste gas offtake which has a projection with a frusto-conical longitudinal section in its upper region in which the waste gas stream is deflected into the downwardly directed waste gas offtake, said projection projecting upwards in a flared manner into the waste gas offtake, the axis of symmetry being inclined, e.g. at an angle of 45° , so that the rear wall defining the descending waste gas offtake is perpendicular to the projection. Although this projection results in a baffle effect and thus associated compression of the waste gas stream, this projection is designed in general for substantially turbulence-free deflection of the waste gas stream. The introduction of a treating agent in order to reduce the sulphur oxide content is effected in the region of the waste gas stream ascending in a uniform manner before the subsequent compression by the projection. Nozzles are provided on opposing walls of the waste gas offtake for the introduction of a treating agent, the nozzles having an inner pipe with a deflector body arranged on the exterior around which an annular channel is formed. The treating agent is thus injected both through the annular channel and through the inner pipe into the waste gas stream. As a result of the deflector body placed on the inner pipe, the

outer annular jet is directed as close as possible to the walls of the waste gas offtake, while the inner pipe injects the treating agent far into the interior of the waste gas offtake, resulting in thorough mixing over the entire surface of the cross section of the waste gas offtake. Not only are a comparatively large number of nozzles required to this end in order to obtain thorough mixing over the entire surface, but the adjustment of the nozzles effected by displacement of the inner pipe provided with the deflector body with respect to the outer pipe involves correspondingly high expenditure from the point of view of control engineering.

The aim of the invention is, on the one hand, to reduce the expenditure from the point of view of construction and control engineering and, on the other hand, to further advance the reduction of the concentration of nitrogen oxides.

This problem is solved by the process steps specified in claim 1.

The fact that the treating agent is introduced as the high compression of the waste gas stream begins results in a higher density of the molecules to be influenced by the chemicals with respect to the waste gas volume, thereby increasing the probability of the chemicals introduced acting on the molecules to be influenced. As a result of the cross-sectional narrowing and the associated arcuate guiding of the waste gas stream, high transverse acceleration appears in this region of constantly increasing compression, so that thorough mixing of the two media can take place. The increasing compression with increasing transverse acceleration therefore leads to a substantially improved reaction between the treating agent and

the waste gas stream in this upper region of the upwardly directed waste gas offtake, this reaction then being intensified further by the subsequent expansion, with a substantial increase in turbulence. In this invention, particularly good reaction conditions, further intensified by the increasing compression and transverse acceleration in association with thorough mixing and subsequent expansion and increase in turbulence are provided not by a large number of nozzles, but by fluid technics measures achieved as a result of simple constructional designs for the waste gas offtake. By this means, it is possible to reduce the number of inlet points or inlet nozzles and the associated expenditure described at the outset.

The homogenisation of the waste gas stream can be further improved in a development of the invention in that the waste gas stream is introduced at an incline with respect to the vertical when it enters the waste gas offtake by inclining the rear boundary wall of the waste gas offtake, in that the cross section is widened, and is then aligned with the vertical in a further section with slight compression by a reduction of the cross section before it enters the section of high compression. As a result of the guiding of the waste gas according to the invention, with a substantially S-shaped course into the downwardly directed waste gas channel, the first arcuate course to the deflection edge of the ascending waste gas channel extending with a substantially softer curve than the subsequent deflection curve, the cross-sectional widening in the lowermost region of the waste gas offtake and the inclined introduction of the waste gas stream into the waste gas channel first cause a certain stabilisation and homogenisation of the waste gas.

The highest turbulence is advantageously achieved by deflecting the waste gas stream about the upper end of the rear boundary wall. The constructional expenditure to this end is particularly low as it is simply necessary to incline the upper part of the rear boundary wall, in that the cross section is narrowed, and to allow it to narrow with a smooth edge, thereby resulting in a sharp deflection curve, leading to the desired turbulence. As a result of the formation of a separation edge for the flow at the upper end of the rear boundary wall, the projection normally provided to suppress turbulence in known combustion plants can be dispensed with. The inclined position of the upper part of the rear boundary wall results in cross-sectional widening of the downwardly directed waste gas offtake, so that the space required for the desired expansion is provided without additional constructional measures. As the changes in direction of the waste gas stream can be achieved in a simple manner by means of an appropriate design of the combustion chamber or waste gas offtake, the expenditure for obtaining particularly strong turbulence and the subsequent expansion is extremely low.

However, it is also possible to produce the turbulence by introducing an additional gas into the waste gas stream.

It is furthermore possible by simple means to produce the turbulence by means of baffles within the flow path of the waste gas stream.

If, in a further embodiment of the invention, the treating agent is introduced in aqueous solution by means of a single-component nozzle, the energy required to introduce the treating agent by this means is reduced compared to introducing the

treating agent by means of two-component nozzles, as no additional carrier and spray medium requiring corresponding energy expenditure for its preparation is required.

In order to increase the possibility of the treating agent acting on the molecules to be reduced, the treating agent is advantageously introduced into the waste gas stream in drops of such a size as to allow for explosion-like evaporation of the solvent or carrier medium.

An apparatus, i.e. a combustion plant for carrying out the method, comprising an upwardly directed waste gas offtake arranged above a grate with an inlet for the material to be burnt and a slag outlet, a reversing space for the waste gas stream and a downwardly directed waste gas offtake is characterised according to the invention in that the ascending waste gas offtake is divided into three sections, in which the boundary wall directed towards the slag outlet is inclined in the first section, in that the cross section is widened, is substantially vertical in the second section and, in the third section, departing from the vertical, is inclined in the direction of the inlet for the material to be burnt, in that the cross section is narrowed, that the cross section of the first section is slightly widened in the direction of the second section and the cross section of the third section is narrowed sharply with respect to the cross section of the second section, and that spray nozzles for the introduction of a treating agent are arranged in the lower region of the third section.

A substantially S-shaped flow course for the waste gas stream departing from the grate to the downwardly directed waste gas

offtake is achieved by virtue of this simple constructional measure, the change in direction in the lower region of the waste gas offtake being much less sharp than is the case in the reversing space. The change in direction, in association with the sharp narrowing of the third section of the waste gas offtake, results in strong turbulence and thorough mixing of the waste gas stream and thus in the advantageous conditions for the action of the chemicals on the nitrogen monoxide.

If the front wall, i.e. the wall of the waste gas offtake directed towards the inlet for the material to be burnt is vertical for the sake of simplifying the construction, it is advisable in a further development of the invention for at least one injection opening for secondary air to be provided at the beginning of the first section of the waste gas offtake at the boundary wall directed towards the inlet for the material to be burnt, thereby assisting the substantially S-shaped course of the waste gas stream.

The invention will now be described in more detail with reference to an embodiment of a combustion plant shown in the accompanying single drawing.

As can be seen from the drawing, showing a highly diagrammatic section through a combustion plant, the latter has an inlet for the material to be burnt, designated in general by the reference numeral 1, including a feed hopper 2, a feed table 3 and feed pistons 4 reciprocating thereon. The material to be burnt, e.g. refuse, is fed by the feed pistons 4 to a grate 5 supplied from below with combustion air which is advanced to the grate via a supply line 7 by means of a blower 6.

The combustion of the material to be burnt, designated by the reference numeral 8, is effected on the grate 5, the combustion zone, which is simultaneously the zone in which the nitrogen monoxide to be reduced is produced, extending over approximately half the length of the grate. The remaining part of the grate serves to cool the slag which falls into a slag outlet 9 at the end of the grate.

The grate 5 is inclined in the direction of the slag outlet 9 departing from the inlet 1 for the material to be burnt and is preferably in the form of a reciprocating grate.

A waste gas offtake designated in general by the reference numeral 10 extends upwards over the combustion zone of the grate 5 and opens into a reversing space 11 to which a downwardly directed waste gas offtake 12 is connected. An upwardly directed waste gas offtake 13 is in turn connected to this waste gas offtake, the coarsest dust particles being discharged downwards on to the grate as a result of the strong deflection.

The first ascending waste gas offtake 10 which receives the flames produced during combustion in its lower region serves simultaneously as a combustion chamber and is divided substantially into three sections 14, 15 and 16 which are defined by the lines 17, 18 and 19. The boundary wall of the waste gas offtake directed towards the inlet 1 for the material to be burnt is designated by the reference numeral 20 and the rear boundary wall directed towards the slag outlet 9 is designated by the reference numeral 21.

The rear boundary wall of the waste gas offtake, designated in

general by the reference numeral 21, is inclined, departing from the vertical, in the direction of the slag outlet 9 in the first section 14 of the waste gas offtake in which it is designated by the reference numeral 22, resulting in widening of the cross section of the first section 14 in the direction of the second section 15. The second section 15 is substantially defined by parallel walls, while the rear wall of the third section 16, designated by the reference numeral 23, is inclined comparatively sharply relative to the vertical in the direction of the inlet 1 for the material to be burnt, resulting in increasingly sharp narrowing of the cross section of the third section 16. The cross section of the third section 16 is substantially narrowed with respect to the cross section of the section 15. This results in high compression of the waste gas stream. The end of the rear boundary wall 23 projects into the reversing space 11. The waste gas stream is thus deflected in a sharp bend around the edge 24 of the boundary wall 23 and enters the downwardly directed waste gas offtake 12. As the rear boundary wall 23 is simultaneously also the boundary wall for the downwardly directed waste gas offtake 12, the latter is wider in its upper part than in its lower part, the upper region of the waste gas offtake 12 having a substantially larger cross section than the upper region of the third section 16 of the upwardly directed waste gas offtake. This results in expansion and stabilisation of the waste gas stream after it flows around the edge 24.

The constructional design described results in a substantially S-shaped flow course for the waste gas stream departing from the combustion grate to the downwardly directed waste gas offtake 12, the flow course being indicated schematically by the dash-dotted line 25. As a result of this S-shaped course,

the waste gas stream is subjected to two changes in direction, the first change in direction being effected at the transition from the first section 14 to the second section 15, while the second change in direction is already started in the third section 16 and then continues in a sharp bend in the reversing space 11. The flow course is thus subjected to a smaller change in direction in the lower region than in the upper region.

Spray nozzles 26 are arranged in the lower region of the third section 16 in which compression of the waste gas stream begins as a result of the inclined boundary wall 23, said spray nozzles spraying chemicals in aqueous solution or suspension into the waste gas offtake in a finely distributed form and preferably being single-component nozzles. The atomisation of the aqueous chemical solution or suspension effected by means of the nozzles leads to explosion-like evaporation of the water, so that the chemicals introduced are present in solid form in the exhaust gas immediately after spraying. As already mentioned at the outset, ammonia, sal ammoniac, urea or lime-nitrogen can be sprayed in aqueous solution or suspension in order to reduce the nitrogen monoxide. As a result of the change in direction started in the third section in association with the high compression of the waste gas stream and the very sharp change in direction around the edge 24, particularly strong turbulence is imparted to the waste gas stream, in which the conditions for reducing nitrogen monoxide are particularly good, the density of the molecules to be influenced in relation to the gas volume being greater in the section 16 than in the remainder of the waste gas stream as a result of the compression, this also leading to an improvement in the conditions for the reduction of nitrogen monoxide. As a result

of the arcuate course of the flow path 25 in the section 15, the gas molecules are accelerated in the direction of the boundary wall 23, leading to acceleration of the gas particles in the opposite direction in association with the change in direction started by this boundary wall 23, resulting in thorough mixing of the gas molecules of the chemicals introduced. The compression of the gas stream and the production of particularly strong turbulence then lead to an even greater reduction of the nitrogen oxide content in the waste gas stream than was possible with the hitherto usual methods.

In order to guide the waste gas stream directly over the grate 5 in the desired direction, i.e. in the direction of the boundary wall 21, an outlet nozzle 27 for secondary air is provided at the lower end of the front boundary wall 20. The boundary wall 20 can thus be designed as a simple vertical boundary wall.

CLAIMS

1. Method for reducing the concentration of nitrogen oxides in waste gases of combustion processes, in which a treating agent is introduced into the ascending waste gas stream within a waste gas offtake of the combustion plant, in which the waste gas stream is deflected by inclining the uppermost section of the rear boundary wall, in that the cross section is narrowed sharply, and is thus subjected to thorough mixing by transverse acceleration with increasingly high compression, the treating agent being introduced in the region of the beginning of high compression, after which the highest turbulence is produced in the waste gas stream already loaded with treating agent at the end of compression, with expansion beginning simultaneously.
2. Method according to claim 1, characterised in that the waste gas stream is introduced at an incline with respect to the vertical when it enters the waste gas offtake by inclining the rear boundary wall of the waste gas offtake, in that the cross section is widened, and is then aligned with the vertical in a further section with slight compression by a reduction of the cross section before it enters the section of high compression.
3. Method according to claim 1 or claim 2, characterised in that the highest turbulence is produced by deflecting the waste gas stream about the upper end of the rear boundary wall.



4. Method according to one of claims 1 to 3, characterised in that the turbulence is produced by introducing an additional gas into the waste gas stream.
5. Method according to one of claims 1 to 4, characterised in that the turbulence is produced by means of baffles within the flow path of the waste gas stream.
6. Method according to one of claims 1 to 5, characterised in that the treating agent is introduced in aqueous solution by means of a single-component nozzle.
7. Method according to one of claims 1 to 6, characterised in that the treating agent is introduced into the waste gas stream in drops of such a size as to allow for explosion-like evaporation of the solvent or carrier medium.
8. Apparatus for reducing the concentration of nitrogen oxides in waste gases of combustion processes, comprising an upwardly directed waste gas offtake (10) arranged above a grate (5) with an inlet (1) for the material to be burnt and a slag outlet (9), a reversing space (11) for the waste gas stream and a downwardly directed waste gas offtake (12), characterised in that the ascending waste gas offtake (10) is divided into three sections (14, 15, 16), in which the boundary wall (21) directed towards the slag outlet (9) is inclined in the first section (14), in that the cross section is widened, is vertical in the second section (15) and, in the third section (16), departing from the vertical, is inclined in the direction of the inlet (1) for the material to be burnt, in that the cross section is narrowed, that the cross section of the first section (14)



is slightly widened in the direction of the second section (15) and the cross section of the third section (16) is narrowed sharply with respect to the cross section of the second section (15), and that spray nozzles for the introduction of a treating agent are arranged in the lower region of the third section (16).

9. Apparatus according to claim 8, characterised in that at least one injection opening (27) for secondary air is provided at the beginning of the first section (14) of the waste gas offtake (10) at the boundary wall (20) directed towards the inlet (1) for the material to be burnt.

