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METHOD FOR BURNING FUELS, PARTICULARLY FOR INCINERATING GARBAGE

The invention relates to a method for burning fuels, particularly for incinerating garbage, in incinerators with a grate firing, for which the primary air is supplied into the fuel layer below the grate firing and the secondary air is supplied above the fuel layer.

Methods of this general type have been known for a long time.

Because of political objectives, garbage must be incinerated so that contamination of the environment is largely avoided. The previously customary procedure for achieving this objective is the optimization of the incinerating process on the grate firing by supplying combustion air selectively with respect to amount and distribution along the grate firing and also in the region of the secondary combustion zone, as well as by the use of constantly more extensive and more expensive facilities for downstream gas purification. Admittedly, this has already led to drastic reductions in the emissions from such installations. However, it also brings about a great increase in the disposal costs, which are associated with the operation of these installations and an out-of-proportion expansion of the gas purification section compared to the conventional part of the facility consisting of the furnace and the energy utilization, such as the generation of steam. In the meantime, a standard has been attained for waste gas purification installations, which permits further improvements in the deposition performance to be anticipated only if very high additional costs are accepted, since purification efficiencies of 99% are being attained. Experience has shown that there is an exponential relationship between expenditure and purification



performance, so that technical exertion no longer is justifiable for increasing the purification efficiency further. With the presently known measures, the technically justifiable limit of purifying waste gases has been reached. Particularly in recent years, additional attempts have been made to achieve further improvements by modifying the combustion process.

From the DE 39 15 992 A1, it is known how the formation of nitrogen oxides can be prevented, in order to make possible therewith savings in the downstream purification installations. The basic principle of this known method consists primarily of modifying the oxygen content of the primary air by admixing recycled waste gases from the combustion process, so that the combustion on the grate proceeds in a damped form with the objective of keeping the temperature in the tips of the flame below 1300°C, because it is known that the formation of the nitrogen oxide sets in to a greater degree above this temperature. For this known method, the secondary air is introduced in two stages, one above the other. In the lower stage, essentially recycled waste gas is introduced, in order to generate a turbulence, while air from the surroundings is supplied to the second stage, in order to achieve the necessary combustion of the waste gases. In the case of the selectively retarded combustion reactions, however, there is a distinct deterioration in the ignition of solid garbage components on the incinerator grate. As a direct consequence, the proportion of uncombusted materials in the combustion residue increases and there is a greater possibility that pollutants will be bound in the residue, that is, in the slag, because of the lower combustion bed temperatures. Admittedly, the proportion of nitrogen oxides is reduced by this method. However, the proportion of uncombusted pollutants is increased because of the decrease in the oxidation potential.

For a different known method of DE 40 27 908 A1, the proportion of oxygen in the primary combustion air as well as in the secondary combustion air is



varied, this variation extending from an increase in the proportion of oxygen above that of the surrounding air to a decrease in the proportion of oxygen below that of the surrounding air. For this purpose, the oxygen, obtained in an air fractionation plant and the nitrogen, also obtained there, are used in order to increase the proportion of oxygen in the combustion air by supplying oxygen and to decrease the proportion of oxygen in the combustion air by supplying nitrogen. This procedure can improve the course of the combustion in important areas of the furnace or the combustion chamber. However, it does not lead to a decrease in the amount of waste gas flowing through the installation as a whole and especially also not in the amount of gas flowing through the waste gas purification installation.

Until now, the concentration of pollutants in the waste gas has generally been the starting point for evaluating the relevance of garbage incinerators to the environment. The presently valid emission guidelines, namely the 17. Bundesimissionsschutzverordnung (17th Federal Emission Protection Regulation) or the EC Guidelines for Incinerating Garbage, as well as the Provisional Regulations hereto, govern the conditions imposed on such installations by limiting concentration values. This mode of consideration reflects the pollutants emitted into the environment only incompletely, since only relative and not actual amounts, which leave an emission source, can be identified. On the other hand, the evaluation of the pollutant loading describes the ecological significance of an emission source more comprehensively.

Experience from operating modern waste gas purification installations show that the attainable concentrations of pollutants and purified gas practically do not depend any more on the concentrations of pollutants in the waste gas entering the purification installation. Instead, the concentrations at the end of the waste gas purification remain constant. This is explained by the exponential



relationship, already alluded to above, between the degree of deposition and the expenditure for or the dimensioning of aggregates to be used.

It is therefore an object of the invention to achieve a significant decrease, beyond the previously obtained findings with respect to the attainable purification efficiencies, in the pollutant loading emitted to the environment, with a higher technical efficiency and smaller dimensioning of the aggregates connected downstream from the incineration.

Pursuant to the invention, this objective is accomplished, starting out from a method of the initially mentioned type for combusting fuels, owing to the fact that the combustion intensity of the fuel on the furnace grate is increased at least partially by increasing the proportion of oxygen in the primary air and that the combustion intensity in the secondary combustion zone is choked by decreasing the proportion of oxygen in the secondary air. Preferably, waste gas recycled from the combustion process is used to decrease the proportion of oxygen in the secondary air.

The increase in the proportion of oxygen in the primary combustion air depends on the reaction zones, that is, on whether it is the warming-up zone, the main combustion zone or the final combustion zone. Due to this partly significant increase in the proportion of oxygen in the primary combustion air, the proportion of nitrogen is necessarily decreased. As a result, the intensity of the combustion is increased significantly and the volume of air required is decreased greatly, since the nitrogen content, which acts only as a ballast, is decreased. With that, there are already significant savings in the volume of combustion air required. These savings make it possible not only to reduce the dimensioning of the primary air blower and ducts, but also to decrease in size the downstream aggregates, such as the steam generator, the waste gas purification facility, the



induced-draft blower and the chimney. The appreciable increase in the intensity of the primary combustion usually leads to an increase in the temperature of the combustion bed on the combustion grate and of the flame in the secondary combustion zone. The higher combustion bed temperatures have the advantageous effect of an improved total combustion of the solid parts of the fuel and an improved tying up of the pollutants in the ash because of sintering. On the other hand, the higher temperature of the secondary combustion results in the increased formation of nitrogen oxides (thermal NO_x). In the case of the known method, which has been mentioned above, the combustion process is choked appreciably for this reason already on the furnace grate. The invention thus initially follows a path, which should be regarded as wrong according to previous findings in that the combustion initially is fanned beyond the usual extent on the firing grate, in order to achieve thereby a considerable reduction in the amount of primary air, an improvement in the slag quality and a decrease in the combustible, that is, oxidizable pollutants, and then corrects this path in the secondary combustion zone, so that there is no increased formation of nitrogen oxides, the removal of which would entail a considerable expense. The further measure of the invention thus sets in here. Said measure consists of choking the combustion process above the combustion layer at the start of the secondary combustion zone in such a manner, that the formation of nitrogen oxides, which usually sets in, does not take place or takes place only to a greatly reduced extent. This damping measure thus commences at a point in time, at which the elimination of oxidizable pollutants is already largely concluded due to the strongly fanned combustion process. Because the oxygen content of the primary air has been increased greatly, this air still contains enough oxygen after passing through the combustion layer, so as to make the desired, throttled combustion in the secondary combustion region possible. Said throttled combustion is to be controlled so that those temperatures, at which nitrogen oxides are formed, do not arise. Pursuant to the invention, preferably waste gas



from this combustion process is used to achieve the choking. Waste gas, the oxygen content of which is greatly reduced, is used in the inventive method to dampen the after-burning. Due to the use of waste gas, it is thus no longer necessary to supply additional, oxygen deficient gas or inert gas. For this reason, the amount of gas does not have to be increased despite adequate combustion in the secondary combustion region, whereas it does have to be increased in the case of the previously known method, for which additional combustion air, in the form of air from the environment, was supplied over secondary air nozzles in the region of the secondary combustion zone. Even in the case of methods for which no pure combustion air was supplied, the amount of gas was nevertheless increased, because a mixture of the surrounding air and waste gas or an inert gas, such as nitrogen, was supplied, which increased the total amount of gas. The damping measures in the secondary combustion zone are thus produced for the present invention preferably with the help of waste gases, which arise during the primary combustion, that is, during the combustion of the combustion layer on the furnace grate, so that additional amounts of gas either are no longer required or are required to a lesser extent.

Modern garbage incinerators usually are operated with a division of the combustion air into 65% primary air and 35% secondary air. If, for example, the whole of the secondary air is replaced by recycled waste gas, that is, by recirculated gas, in order to achieved the aimed for damping process in the secondary combustion zone, then 35% of the total amount of gas flowing through the installation is saved by this measure. Together with the measure of increasing the oxygen content of the primary air, the amount of gas flowing through the downstream aggregates can be reduced by these means by two thirds. However, if, as noted above, the concentrations of the pollutants at the end of the waste gas purification are independent of the pollutant concentrations before the waste gas is purified, the amount of pollutants arising, that is, the



amount of pollutants emitted from one source, can be decreased by the reduction in the total gas volume by up to two thirds compared to previously operated plants in a manner that was not possible by means of the traditional mode of operating incinerators because of the exponential increase in costs mentioned above.

Starting out from the general, basic teachings explained above, a special further development of the invention consists therein that the oxygen content of the primary air is increased locally, above the oxygen content of the surrounding air, as a function of the combustion behavior or the burning intensity of the fuel layer on the furnace grate, that the oxygen content of the secondary air is decreased below the oxygen content of the surrounding air by admixing recycled waste gas, and that the secondary air is adjusted locally with respect to the composition, the amount, the supplying site and a high turbulence in the secondary combustion zone, so that the formation of nitrogen oxides above the fuel layer is largely avoided. By adaptation to the local circumstances, that is, by taking into consideration the different states of the fuel along the furnace grate, the primary air can be adapted to the particular circumstances and adjusted so that the desired, intensified combustion effect and, with that, the combustion of oxidizable pollutants sets in. For this purpose, for example, known thermocouple elements are used to measure the temperature or infrared cameras are used to determine the solid-state radiation, which is emitted directly from the combustion layer and permits conclusions to be drawn concerning the temperature of the combustion bed, that is, the temperature of the fuel mass in the process of combustion, in order to adjust the oxygen percentage, which is necessary to bring about a greater combustion intensity, at the particular site in the combustion grate, which is possible, for example, by appropriately subdividing the underblast guiding system for the combustion grate. For this purpose, the DE 38 25 931 C2 already makes a relevant proposal. In this



connection, what is of decisive importance is not the known fact that the percentage of oxygen basically can be controlled, but rather that the oxygen percentage is increased in the case of the present invention to such an extent, that a combustion intensity and the decrease in oxidizable pollutants associated therewith is attained, which previously was not pursued because of the anticipated disadvantages. These disadvantages, which are to be seen, for example, in the thermal formation of nitrogen oxides and in the overheating of the protective lining of the combustion chamber, are, however, avoided in the case of the present invention owing to the fact that selective damping measures with respect to the temperature development and the adjustment of other conditions are initiated over the combustion layer, so that the anticipated disadvantages do not occur. These damping measures include basically the reduction in the oxygen percentage, as was already explained further above. In this connection, the amounts of secondary air and the place in relation to the combustion layer or the combustion chamber and the turbulence, with which the amount of gas referred to as secondary air is supplied over the secondary air nozzles, are of great importance. The generation of a high turbulence has a particularly advantageous effect, since a frequently nonuniform distribution of oxygen is levelled out by these means and the oxygen that is present can be utilized better, as a result of which the desired course of the combustion can be achieved at relatively low temperatures in the secondary combustion region. It is possible to adjust the conditions in the secondary combustion region with the help of temperature measurements and observations by means of infrared cameras or of flame monitors in such a manner, that temperatures harmful for the lining of the combustion chamber as well as for the formation of nitrogen oxides are prevented, since it is known, for example, that a temperature of 1,300°C represents a limiting value, above which increased formation of nitrogen oxides must be expected.



Depending on the type of material to be combusted, it may be advantageous to increase the oxygen content of the primary air only in the main combustion zone of the grate firing, because the fuel in other regions initially is preheated or already has too low a calorific value, as is the case, for example, in the final combustion zone.

The oxygen content of the primary air, which can be adjusted locally differently in relation to the length of the combustion segment on the furnace grate, can be adjusted to a value of 25 to 50% by volume and preferably of 35% by volume. By these means, the amount of primary air can be reduced in accordance with the diagram, which is explained in greater detail below and is referred to as Figure 2.

Since the combustion intensity on the furnace grate within the primary combustion zone can be increased particularly greatly pursuant to the present invention, sufficient oxygen for the secondary combustion still remains in the air that has passed through the combustion layer, so that, pursuant to a further development of the invention, the waste gases, in the secondary combustion zone, constitute 20% to 65% and preferably 35% of the total amount of air and gas supplied to the combustion process. For example, the total amount of gas, which is introduced through the secondary air nozzles, may consist of recycled waste gas if it is assumed the preferably 35% of the total amount of air and gas is used as recycled waste gas and that the secondary air constitutes 35% of the total amount of gas. Since it is a question of recycled gas, more than a third of the total amount of gas is saved by this method.

Preferred parameters for controlling the oxygen content are, in relation to the primary combustion air, the surface temperature of the material being combusted and, in relation to the secondary air, the temperature existing in the secondary

air combustion zone or the length of the flame in the vertical direction in the combustion chamber.

The recycled waste gas is preferably exhausted after it has passed through the boiler. As a result, the decrease in the volume of gas, arising out of the recycling of the waste gas, becomes noticeable only in the waste gas purification installation. In particularly placed cases, it may also be possible to exhaust the recycled waste gas directly above the combustion layer.

The adjustment of the oxygen content of the primary air and, with that, the deliberate increase in the combustion intensity in the primary combustion zone can be advanced so far without regard to the later consequences, which are eliminated by the inventive damping measures, that the combustion process on the furnace grate is limited essentially by conditions, which arise out of the operating ability of the combustion grate. An increase in the temperature of the combustion layer by up to 300°C above that of conventional combustion processes is possible. Since the combustion bed temperature can be up to 300°C higher than in the case of a combustion with normal outside air, the pollutants are bound into the slag to a higher degree. The hereby decreased leachability of the pollutants improves the possibility of using the slag as a building material or lowers the requirements that a residue garbage dump must meet.

Basically, various important advantages arise out of enriching the oxygen content of the primary combustion air. It has already been emphasized in detail that the total amount of gas volume can be reduced up to two thirds, as a result of which a smaller dimensioning of the installation as a whole and, with that, a considerable reduction in costs arise. Due to the increase in the oxygen content in the primary air, there necessarily is a drastic reduction in the percentage of nitrogen supplied. This nitrogen is to be regarded merely as ballast and, in the



past, reduced the thermal efficiency considerably. This effect of reducing the thermal efficiency decreases correspondingly due to the decrease in the percentage of nitrogen, so that the thermal efficiency is improved. The increase in the percentage of oxygen has its limits where a thermal overloading of the individual grate elements could occur. In practice, it has turned out that the percentage of oxygen can constitute up to 50% by volume of the primary air supplied without damage to the grate elements. By decreasing the volume flow of gas, the entraining effect on light and small garbage particles is reduced, so that these burn on or immediately above the grate and do not reach the purification installation as uncombusted parts. Dust precipitators, in addition to the possible reduction in size due to the lower volume of waste gas, can therefore also be dimensioned smaller. The clearly more intensive combustion resulting from the invention does not lead only to higher temperatures of the fuel particles on the grate itself, but also brings about an increase in the gas temperatures immediately above fuel layer, which leads to a decrease in the concentrations of carbon monoxide and residual hydrocarbons. Furthermore, the concentration of the so-called precursor compounds is lowered, which in the region of the later cooling of the combustion gases can lead to the formation of dioxins and furans.

Due to the drastic choking of the combustion process in the secondary combustion region preferably by recycling waste gas, disadvantages are avoided, which have arisen above the grate due to the previous oxygen enrichment. By supplying air from the environment to the secondary combustion region, overheating has been detected in this region. The result is expressed in a higher percentage of thermally formed nitrogen oxides and a long-term, unavoidable destruction of the protective ceramic lining of the combustion chamber region. These disadvantages are avoided by drastically choking the course of the combustion above the combustion layer, that is, in the secondary combustion



region. The thorough mixing, required in the secondary combustion region in order to avoid an oxygen concentration gradient between recirculation gas and combustion gas from the primary combustion zone, is achieved by supplying the recirculation gas to the secondary combustion zone, the amount of gas supplied here being sufficient for ensuring the required turbulence. The lesser swirling up of dust in and above the combustion layer leads, in addition to the already mentioned smaller design of the dust filters, also to less contamination of the heating surfaces in the boiler and thus also to more favorable operating conditions with respect to boiler availability, elapsed time between two heating-surface cleanings and boiler efficiency. Due to the greatly reduced amount of gas while the amount of fuel is kept constant, there is necessarily a proportional increase in the concentration of the different pollutants, which are to be deposited by the waste gas purification installation. This is evident from the diagrams in Figures 3 to 6. In the event that valuable materials are to be recovered in the waste gas purification process, the effectiveness and costs of this process are distinctly improved, for example, for the recovery of hydrochloric acid and gypsum from precipitated pollutants.

The invention is explained in the following by way of example by means of a furnace for carrying out the method in conjunction with diagrams, which show various experimental results. In the enclosed drawing,

Figure 1 shows a longitudinal section through a furnace;

Figure 2 shows a diagram relating to the reduction in the amount of waste gas at different oxygen concentrations in the primary air and different percentages of recirculation gas based on the amount of secondary air;



Figure 3 shows an experimental result from the operation of a furnace using outside air as primary air and without any recycling of the waste gases into the secondary air;

Figure 4 shows an experimental result from the operation of a furnace with an oxygen concentration of 35% by volume without any recycling of the waste gases;

Figure 5 shows an experimental result from the operation of a furnace with an oxygen concentration of 35% by volume in the primary air and complete recycling of the waste gases and

Figure 6 shows an experimental result from the operation of a furnace with an oxygen concentration of 50% by volume in the primary air and 100% recycling of the waste gases.

As is evident from the drawing, a furnace for carrying out the method described has a charging hopper 1 with connecting charging chute 2 for charging the material to be burned on a charging table 3, on which charging rams 4, which can be moved back and forth, are provided, in order to feed the material to be burned and coming from the charging chute to a firing grate 5, on which the combustion of the material takes place. It is immaterial here whether grate is inclined or horizontal, no matter what principle is involved.

Below the firing grate 5, facilities for supplying primary combustion air are disposed. Said facilities, as a whole, are labeled 6 and can comprise several chambers 7 to 11, to which primary combustion air is supplied over a pipeline 13 by means of a fan 12. Due to the arrangement of the chambers 7 to 11, the firing grate is divided into several underblast zones, so that the primary



combustion air can be adjusted differently depending on the requirements on the furnace grate. Depending on the width of the furnace grate, the underblast zones can also be divided in the transverse direction, so that the supply of primary air can be controlled depending on local circumstances.

Above the furnace grate 5, there is the combustion chamber 14, which in the upper part goes over into a waste gas flue 15, adjoining which there are aggregates that are not shown, such as a waste-heat boiler and a waste gas purifying plant. In the rear region, the combustion space 14 is bounded by a cover 16, a rear wall 17 and side walls 18.

The combustion of the material labeled 19 takes place on the front part of the furnace grate 5, over which there is the waste gas flue 15. In this region, most of the primary combustion air is supplied through the chambers 7, 8 and 9. On the rear part of the furnace grate 5, there is only completely burned material, that is, the slag and primary combustion air is supplied to this region over chambers 10 and 11 essentially for the purpose of cooling this slag.

The combusted parts then fall onto a slag discharging unit 20 at the end of the furnace grate 5. In the lower region of the waste gas flue 15, rows of secondary air nozzles 21 and 22 are provided, which supply the secondary combustion air to the rising waste gas, in order to bring about afterburning of the combustible parts in the waste gas.

The rows 21 and 22 of secondary air nozzles are connected to air collectors 27a and 27b, which are supplied over a pipeline 26 by a blower 25, which takes in, on the one hand, waste gas over a pipeline 28 from a part of the incinerator lying further to the rear and, on the other, if necessary, air from the environment over a pipeline 29.



From an air fractionation plant, which is not shown, either pure oxygen or oxygen-enriched air from the environment is taken by a blower 30 over pipeline 31 and supplied over pipeline 32 to pipeline 13 for the primary combustion air. The amounts of air in chambers 7 to 11 are adjusted by control facilities 33, which control the supply of the air-oxygen mixture to the individual chambers 7 to 11. Of course, each chamber 7 to 11 can have a separate oxygen pipeline, in order to be able to adjust the oxygen content of the primary air differently in the individual chambers.

For controlling the combustion process, a video camera or a thermographic camera 34, a monitor 35, a freely programmable computer 36 and a controller unit 37 are provided. The video camera or thermographic camera 34 is aligned, so that it can view the material 19 burning on the furnace grate 15 from above through the combustion chamber 14. The video camera is connected to the monitor 35 and the freely programmable computer 36, which resolves the image received appropriately and compares the digital values obtained, which are a measure of the brightness on the respective combustion zone, with specified standard values and, in the event of a deviation, initiates an appropriate control process over the controller unit 37, which adjusts the control facilities 33, which are constructed as shutters or slides, in the individual chambers 7 to 11. On the basis of solid body radiation received and emanating from the combustion layer 19, the video camera 34 supplies values, which permit conclusions to be drawn concerning the temperature of the combustion layer 19. The amount of primary air can be adjusted by adjusting the control devices 33 and the oxygen content of the primary air is adjusted over the controller unit 37 by adjusting the control device 38 in the pipeline 31. The amount of primary air and the oxygen content are adjusted as a function of the burning behavior of the combustion layer 19 on the furnace grate 5 in the respectively monitored zone of the furnace grate. In the region of the secondary combustion zone, thermocouple elements are



provided, of which only one thermocouple element 39 is shown in the drawing. The thermocouple element 39 serves to monitor the temperature in the secondary combustion zone and is connected with the freely programmable computer 36, which, in turn, is connected with the controller unit 37. Over the control devices 40 and 41, this controller unit 37 adjusts the amount of waste gas, which is to be supplied to the secondary air nozzles 21 and 22 and optionally the amount of air from the surroundings, which is adjusted over the controlling device 41. Instead of with thermocouple elements 39, the temperature can also be measured by means of a sound pyrometer (pyrosonic) or by the laser Doppler method.

With the help of this control device and the corresponding monitors, it is possible to control on the one hand, the intensive burning on the furnace grate by controlling the amount of primary air and the percentage of oxygen in the combustion air and, on the other, the behavior in the secondary combustion zone by adjusting the secondary air, which consists largely of recycled waste gas. By these means, an excessive increase in the temperature in the secondary combustion region is avoided and the amount of gas, passed through the installation as a whole, is reduced. In this connection, the reduction in the amount of gas is at a maximum, when no additional air is taken in from the surroundings. Compared to previously known incinerators, the amount of primary air is reduced owing to the fact that the oxygen content of the primary air is increased over that of the surrounding air and, with that, the percentage of nitrogen, which acts as a ballast, is decreased.

The diagram of Figure 2 shows the achievable reduction in the amount of waste gas as a function of the oxygen concentration of the primary air on the one hand and the recirculated amount, as a percentage of the secondary air, on the other. The relative volume of waste gas is plotted from 0% to 100% on the



abscissa and the recirculated amount, as a percentage of the secondary air, is plotted from 0% to 100% on the ordinate. The four curves drawn reproduce the reduction in the amount of waste gases as a function of the oxygen concentration of the primary air.

Various experimental results are assembled in Figures 3 to 6. To help with understanding these results, the formulas and abbreviations used there are explained below:

O ₂ -Konz.	= oxygen concentration
NO _x -Konz.	= nitrogen oxide concentration
HCL-Konz.	= hydrogen chloride concentration
SO ₂ -Konz.	= sulfur dioxide concentration
HF-Konz.	= hydrogen fluoride concentration
RGR	= waste gas purification
PL	= primary air
SKL	= secondary air
Rezi-Anteil	= recirculated amount, as a percentage of the secondary air
Lambda	= air excess factor

In all the experiments described below, the installation is charged with fuel consisting of garbage, the hourly amount charged and the calorific value being kept constant in all experiments, so that the effects of the inventive measures become clear under constant starting conditions with respect to the fuel.

In all the experiment diagrams, the amounts of garbage charged hourly and the calorific value are given in field a and the amount of primary air, the primary air as a percentage of the total combustion air, the lambda value, the oxygen concentration in the primary air and the percentage of waste gas recirculated are

given in field b. The amount of waste gas arising in the grate region, the oxygen concentration and the concentration of the important pollutants are listed in field c. The amount of and the oxygen concentration in the secondary air are given in field d. The amount of waste gas, the oxygen concentration in the waste gas, as well as the amounts of the different pollutants are given in field e. The amount of waste gas flowing through the boiler, the air excess factor measured in the boiler, the oxygen concentration as well as the concentrations of the different pollutants in mg/Nm^3 are assembled in field f. The amount of waste gas, the oxygen concentration as well as the concentrations of the different pollutants, in each case before and after the flue gas purification, are assembled in fields g and h. The pollutant loadings in g/h, which leave the chimney after the purification of the flue gas, are given in field i. Below field i, the reduction in the amount of waste gases is given as a percentage.

The experimental results during the normal operation of an incinerator are given in Figure 3. During this normal operation, the incinerator is operated with normal outside air as primary air and with normal outside air as secondary air. The ratio of primary air to secondary air is 65 : 35. Since normal outside air is used for the secondary air, there is no recycling of waste gas.

In the first experiment, which is summarized in Figure 3, the normal operation is reproduced. The achievable reductions in the amounts of waste gas as a percentage compared to normal operation and the pollutant loads arising as important results of the inventive combustion process are given in Figures 3 and 4.

For the experimental results given in Figure 4, the installation was operated with an oxygen content of 35% by volume in the primary air, a ratio of primary air to secondary air of 49.3 : 50.7 without recycling of the waste gas, normal outside



air being used for the secondary air. Compared to the normal operation of Figure 3, it was possible to achieve a reduction of 31% in the amount of waste gas. Compared to the normal operation, it was possible to reduce already appreciably the pollutant loading of oxidizable pollutants leaving the chimney every hour, as is evident from a comparison of the numbers given in field i. On the other hand, the proportion of NO_x increased slightly in comparison to Figure 3. This can be attributed to the increased oxygen content in the primary air. However, the NO_x loading is less because of the decreased amount of waste gas.

From a further experimental result assembled in Figure 5, a decrease in the amount of waste gas of 62% compared to the normal operation and a further drastic reduction of the pollutant loading leaving the chimney can be observed. For this, the installation was operated with an oxygen content of 35% by volume in the primary air, a ratio of primary air to secondary air of 65 : 35 and a recirculation of 100%. The great reduction in the portion of NO_x despite the high oxygen percentage in the primary air can be attributed to the damping measures achieved by recirculating the waste gas.

For the experiment recorded in Figure 6, the installation was operated with an oxygen concentration of 50% by volume in the primary air, a ratio of primary air to secondary air of 50 : 50 and with 100% recirculation. A reduction in the amount of waste gas of 75% compared to normal operation was achieved. If the pollutant loading of this experiment, given in field i, is compared with that of the normal operation given in Figure 3, it is observed that the HCl loading has decreased from 34.4 g/h to 8.5 g/h; this corresponds to a decrease of about 75% compared to the normal operation. For the other pollutant loadings, the reduction is also around 75% compared to the normal operation. In other words, not only is the amount of waste gas in the experiment of Figure 6 reduced by 75% compared to that of a normal operation, but a correspondingly high reduction in the pollutant loading has also been achieved.



If the pollutant concentrations in the waste gas after the purification of the flue gas, for example in the case of the experiment of Figure 3, that is, of a normal operation, and the pollutant concentration in the experiment of Figure 6 are considered, these values in each case being given in field h, it is noted that the values are identical, whereas the corresponding values before the purification of the flue gas, based on the standard cubic meter of waste gas, are almost four times as high in the experiment of Figure 6 than in the experiment of Figure 3, that is, during normal operation. From this it can be seen that, due to the reduction in the amount of waste gas and based on the standard cubic meter of waste gas, there is a significantly higher, that is, about four times as high a concentration of pollutants in the waste gas before the purification of the flue gas. As a result, this waste gases offers significantly better preconditions, for example, for the recovery of hydrochloric acid and gypsum than does the waste gas from normal operations. For normal operations, the expenditure for equipment is very high if hydrochloric acid and gypsum are to be recovered starting out from the relatively low concentrations of these pollutants.

This Sheet Has Been Replaced





Claims

1. A method for burning fuels, particularly garbage, in incinerators with a grate firing, for which the primary air is supplied into the fuel layer below the grate firing and the secondary air is supplied above the fuel layer, characterized in that the intensity of the combustion of the fuels on the furnace grate is increased at least partly by increasing the percentage of oxygen in the primary air and that the intensity of the combustion in the secondary combustion zone is choked by decreasing the percentage of oxygen in the secondary air.
2. The method of claim 1, characterized in that waste gas recycled from the combustion process is used to decrease the percentage of oxygen in the secondary air.
3. The method of claims 1 or 2, characterized in that the oxygen content of the primary air is increased locally, beyond the oxygen content of the air of the surroundings, as a function of the burning behavior or the combustion intensity of the fuel layer on the furnace grate, that the oxygen content of the secondary air is decreased below the oxygen content of the air of the surroundings by admixing recycled waste gas and that the secondary air is adjusted locally with respect to the composition, the amount, the place at which it is supplied and with respect to a high turbulence in the secondary combustion zone in such a way, that the formation of nitrogen oxides above the fuel layer is largely prevented.
4. The method of one of the claims 1 to 3, characterized in that the oxygen content of the primary air is increased only in the main combustion zone of the grate firing.





5. The method of one of the claims 1 to 4, characterized in that the oxygen content of the primary air is adjusted to 25% to 50% by volume and preferably to 35% by volume of oxygen.
6. The method of one of the claims 1 to 5, characterized in that the waste gases, recycled in the secondary combustion zone, constitute 20% to 65% and preferably 35% of the total amount of air and gas recycled to the combustion process.
7. The method of one of the claims 1 to 6, characterized in that the oxygen content of the primary combustion air is adjusted as a function of the surface temperature of the material being burned.
8. The method of one of the claims 1 to 7, characterized in that the oxygen content of the secondary air is adjusted as a function of the temperature in the secondary combustion zone.
9. The method of one of the claims 1 to 8, characterized in that the oxygen content in the secondary air is adjusted as a function of the length of the flame in the vertical direction in the combustion chamber.
10. The method of one of the claims 1 to 9, characterized in that the recycled waste gas is drawn off after it has passed through the boiler.
11. The method of one of the claims 1 to 9, characterized in that the recycled waste gas is drawn off immediately above the fuel layer.

This Sheet Has Been Replaced

