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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.

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Abstract of the Disclosure

The method for burning fuels, particularly garbage, in incinerators with a grate firing, for which the primary air is supplied below the grate firing into the fuel layer and the secondary air is supplied above the fuel layer, is controlled in such a way that the intensity of the combustion of the fuel on the furnace grate is increased by increasing the oxygen content of the primary air and the intensity of the combustion in the secondary combustion zone is choked by decreasing the oxygen content in the secondary air, and that waste gas, preferably from the combustion process, is recycled in order to reduce the oxygen content of the secondary air.

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Key for Figure 2:

- 1 =Reducing the amount of waste gas by a combination of increasing the oxygen content and recycling the waste gas**
- 2 =oxygen concentration in the primary air**
- 3 =relative volume of waste gases**
- 4 =recirculated gas, as a percentage of the secondary air**

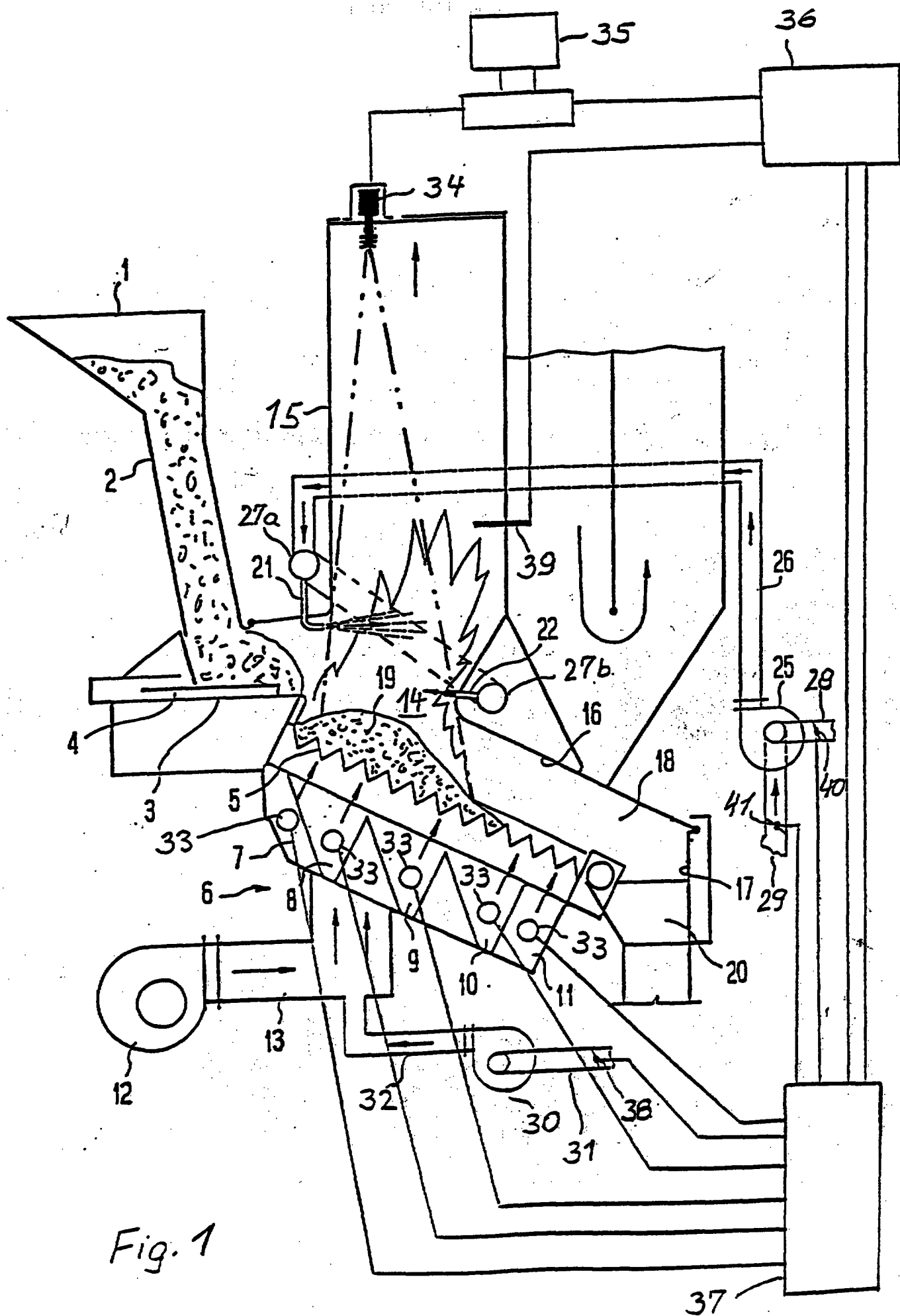
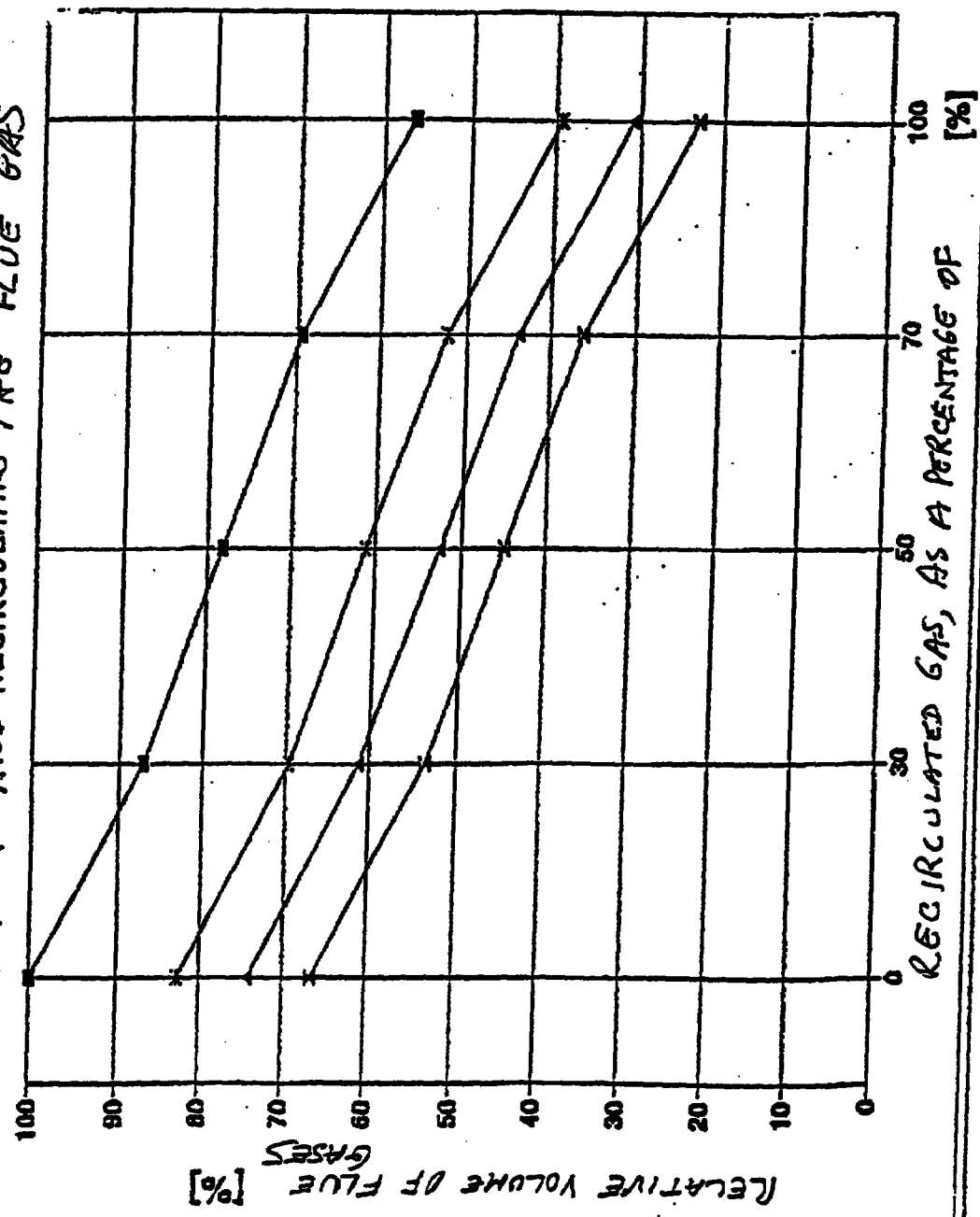


Fig. 1

REDUCING THE AMOUNT OF FLUE GAS BY A
COMBINATION OF INCREASING THE OXYGEN
CONTENT AND RECIRCULATING THE FLUE GAS



O₂ - CONCENTRATION
IN THE PRIMARY
AIR:

- 21,0 % vol O₂
- *— 30,0 Vol.-% O₂
- ▲— 38,0 Vol.-% O₂
- x— 50,0 Vol.-% O₂

Fig.2

SECONDARY AIR

BALANCE SHEET OF GARBAGE INCINERATION

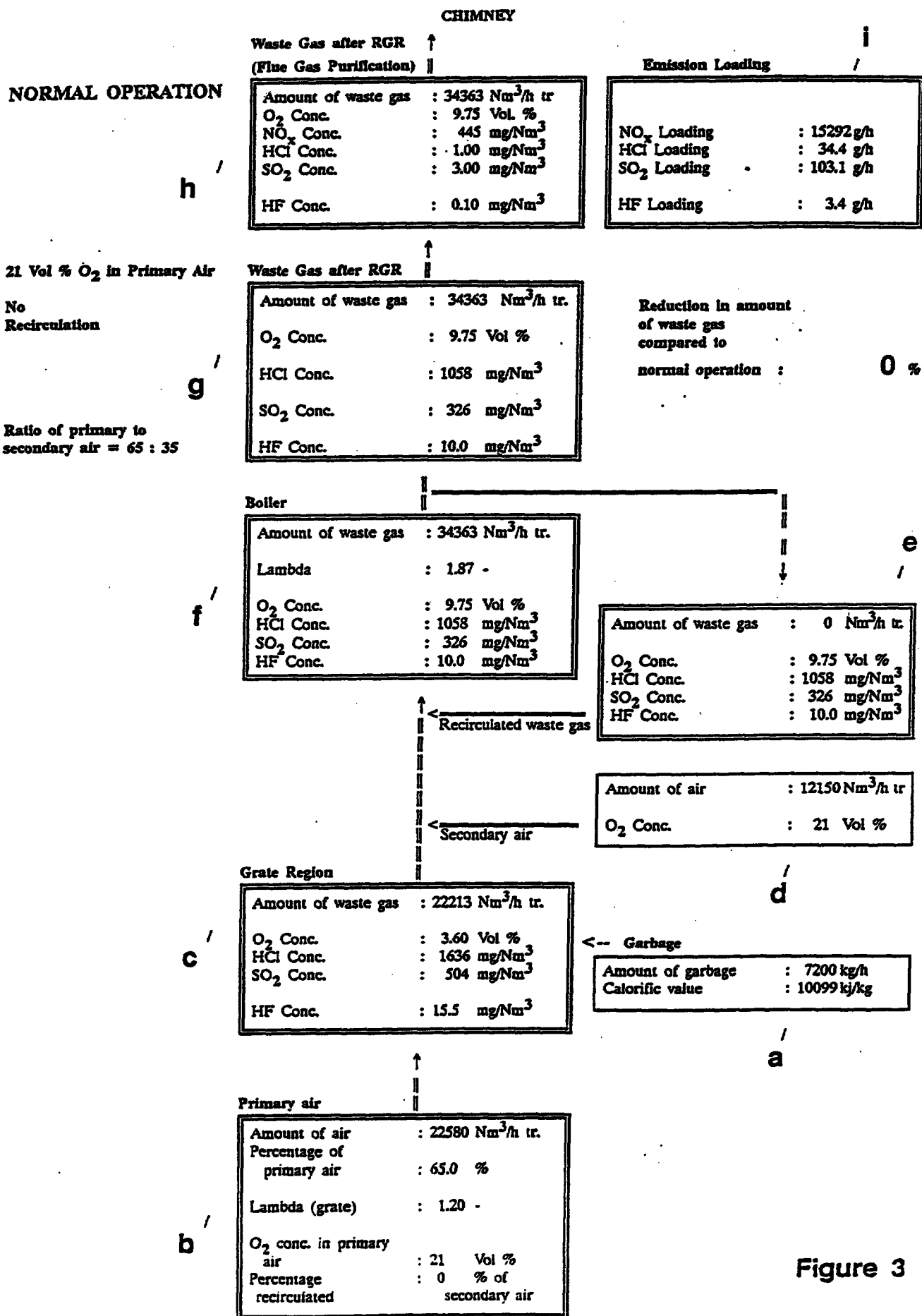


Figure 3

BALANCE SHEET OF GARBAGE INCINERATION

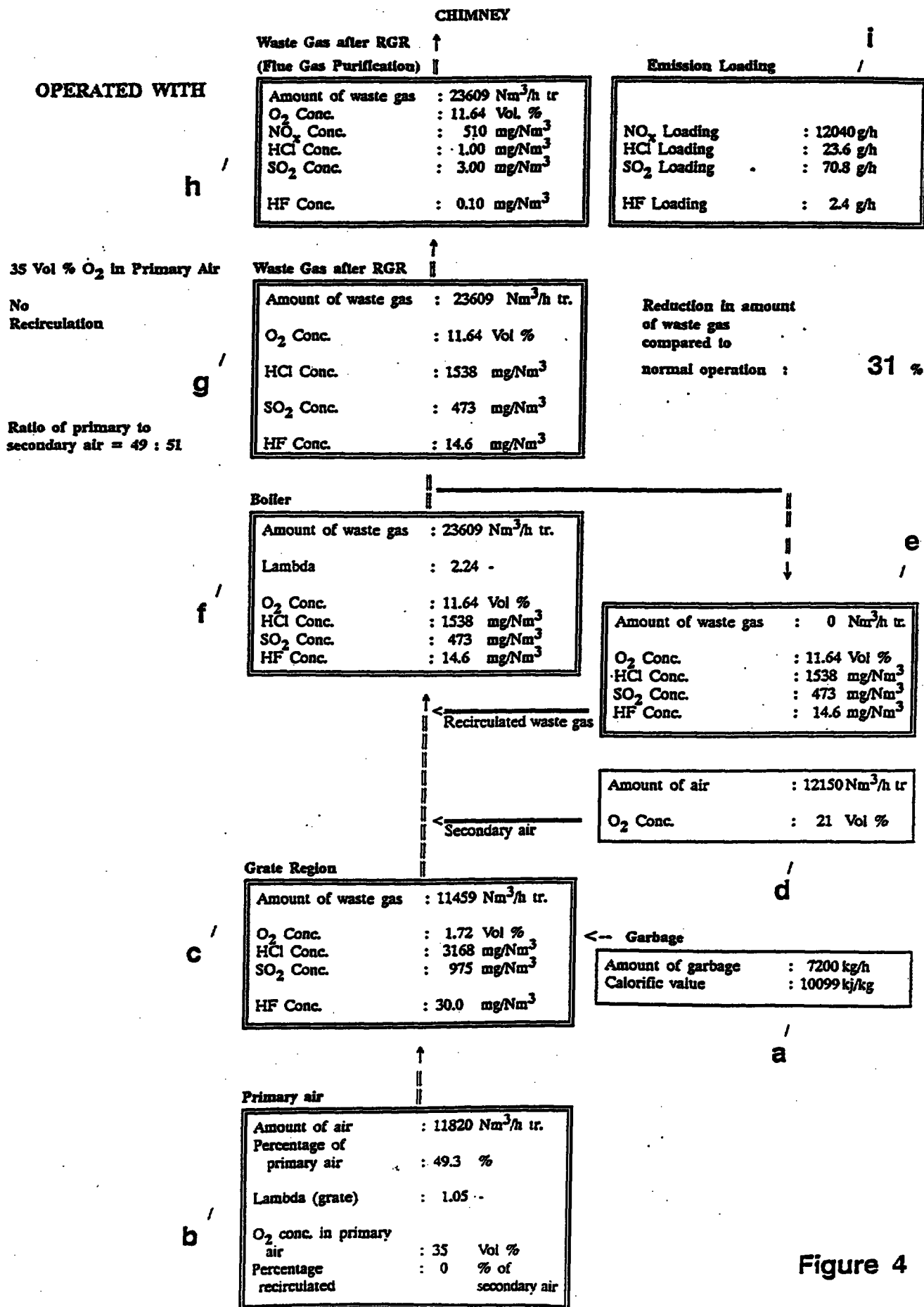


Figure 4

BALANCE SHEET OF GARBAGE INCINERATION

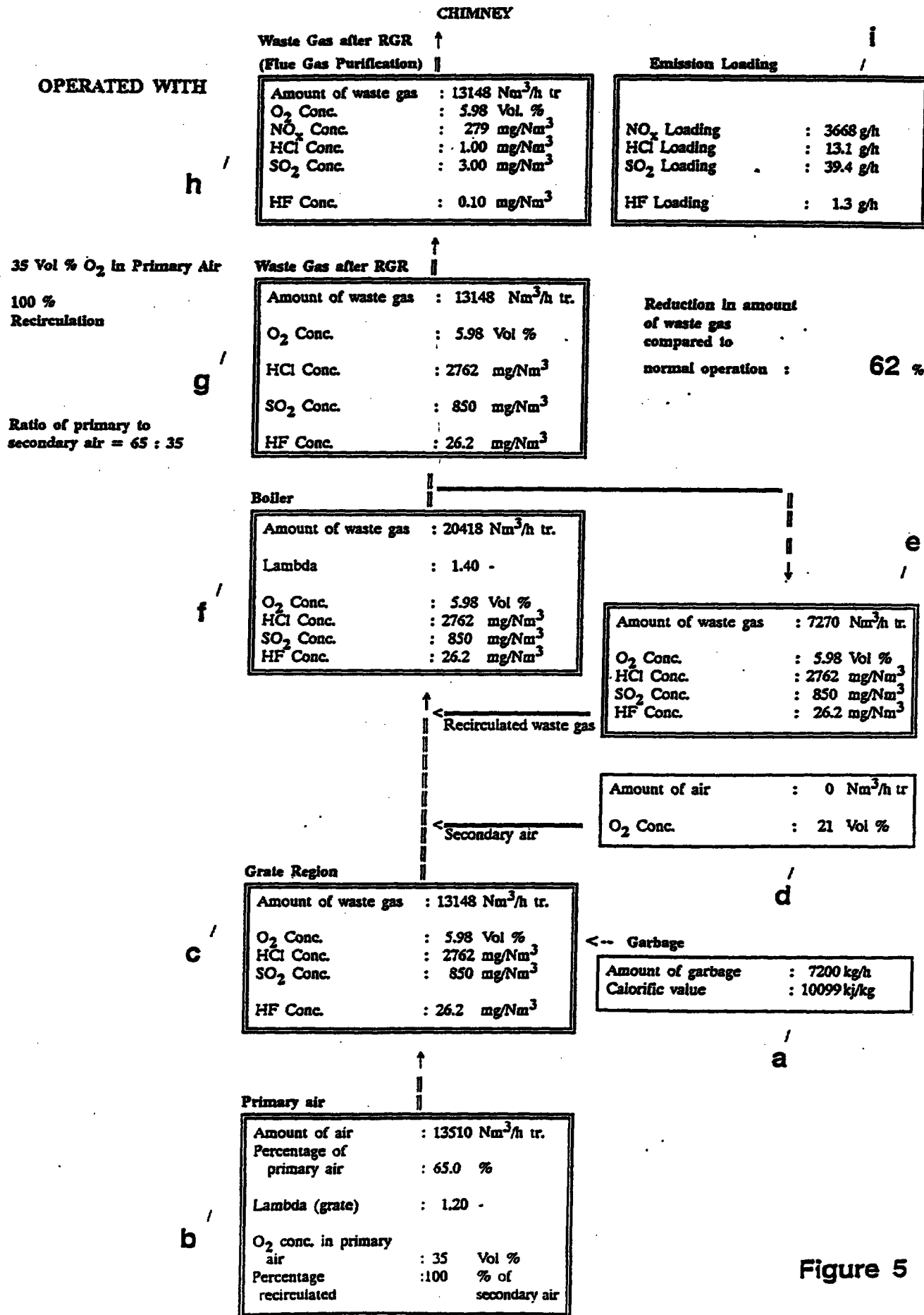


Figure 5

BALANCE SHEET OF GARBAGE INCINERATION

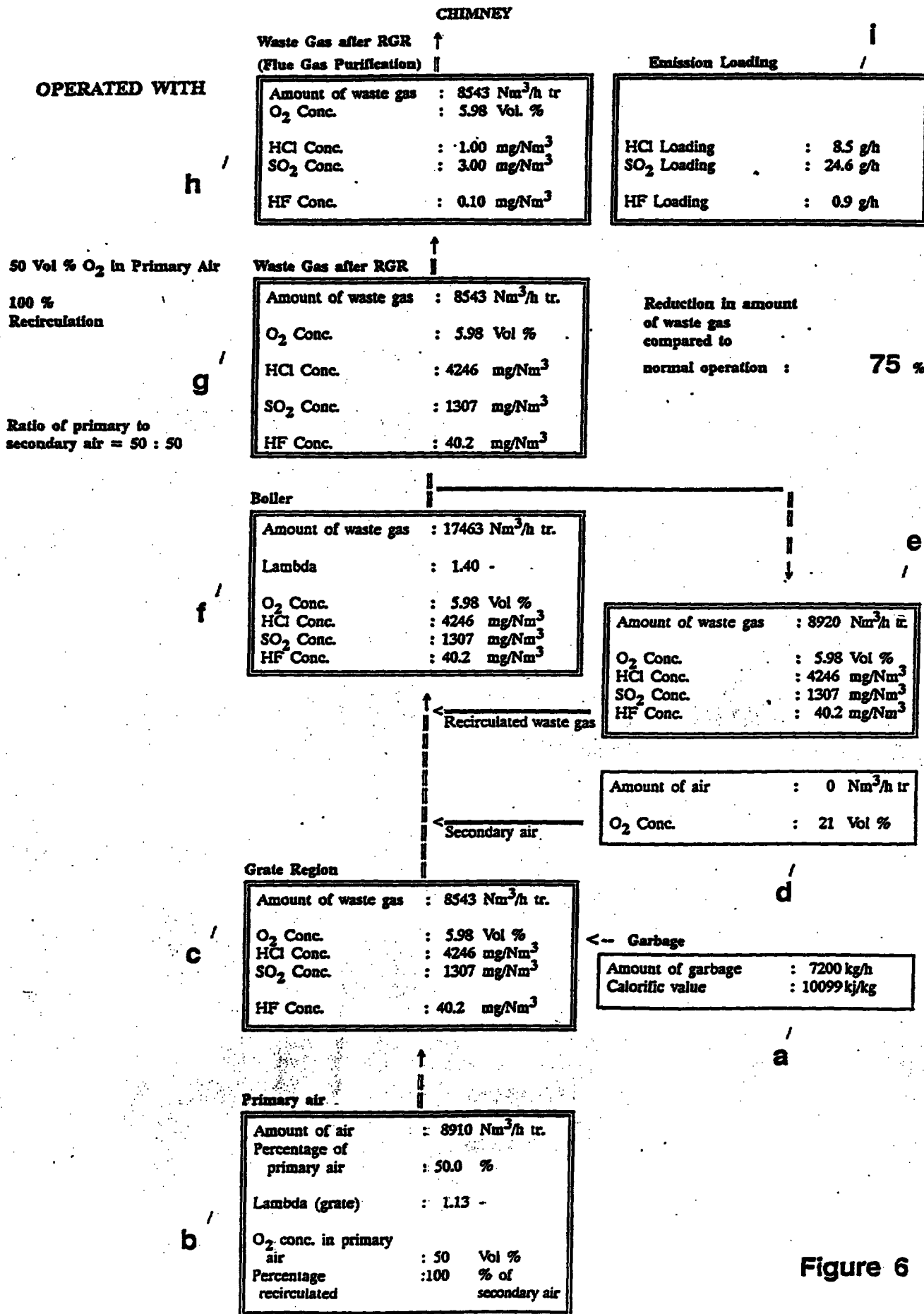


Figure 6

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REPLACEMENT SHEETS	SG
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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.

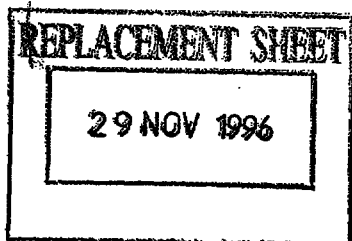
Methods of this general type have been known for a long time.

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

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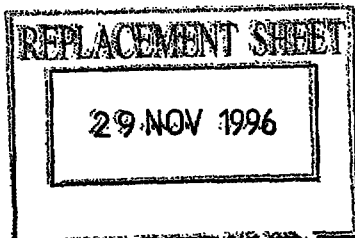


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performance, so that technical exertion no longer is justifiable for increasing the purification efficiency further. With the presently known measures, the technically justifiable limit of purifying waste gases has been reached. Particularly in recent 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



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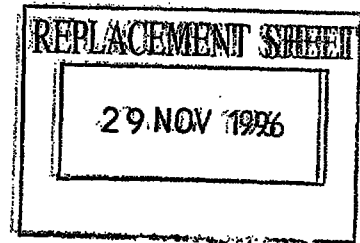


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varied, this variation extending from an increase in the proportion of oxygen above that of the surrounding air to a decrease in the proportion of oxygen below that of the surrounding air. For this purpose, the oxygen, obtained in an air fractionation 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

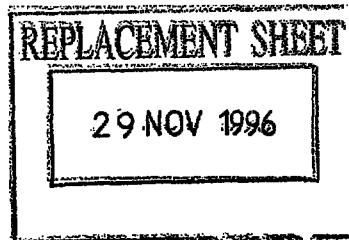


relationship, already alluded to above, between the degree of deposition and the expenditure for or the dimensioning of aggregates to be used.

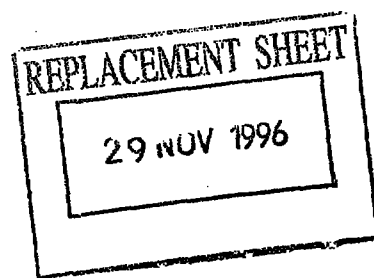
It is therefore an object of the invention to achieve a significant decrease, beyond the previously obtained findings with respect to the attainable purification efficiencies, in the pollutant loading emitted to the environment, with a higher technical efficiency and smaller dimensioning of the aggregates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

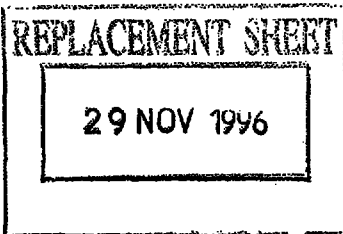


induced-draft blower and the chimney. The appreciable increase in the intensity of the primary combustion usually leads to an increase in the temperature of the combustion bed on the combustion grate and of the flame in the secondary combustion zone. The higher combustion bed temperatures have the advantageous 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



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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.

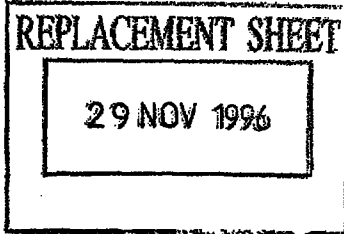
Starting out from the general, basic teachings explained above, a special further development of the invention consists therein that the oxygen content of the primary air is increased locally, above the oxygen content of the surrounding air, as a function of the combustion behavior or the burning intensity 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.

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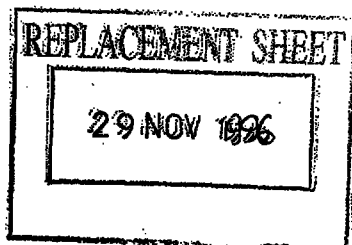


Depending on the type of material to be combusted, it may be advantageous to increase the oxygen content of the primary air only in the main combustion zone of the grate firing, because the fuel in other regions initially is preheated or already has too low a calorific value, as is the case, for example,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



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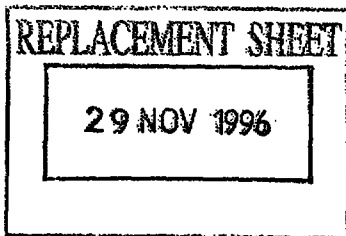
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air combustion zone or the length of the flame in the vertical direction in the combustion chamber.

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



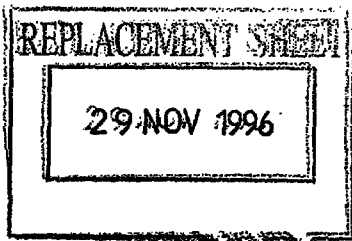
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past, reduced the thermal efficiency considerably. This effect of reducing the thermal efficiency decreases correspondingly due to the decrease in the percentage of nitrogen, so that the thermal efficiency is improved. The increase in the percentage 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



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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;

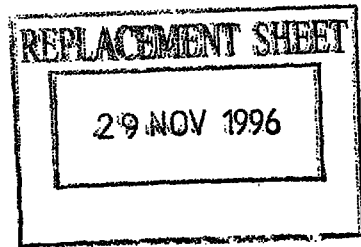


Figure 3 shows an experimental result from the operation of a furnace using outside air as primary air and without any recycling of the waste gases into the secondary air;

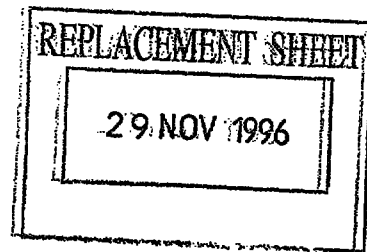
Figure 4 shows an experimental result from the operation of a furnace with an oxygen concentration of 35% by volume without any recycling of the waste gases;

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.

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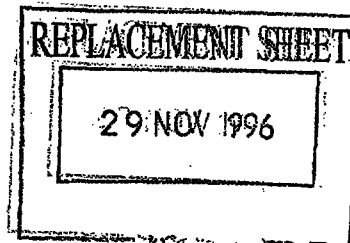
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From an air fractionation plant, which is not shown, either pure oxygen or oxygen-enriched air from the environment is taken by a blower 30 over pipeline 31 and supplied over pipeline 32 to pipeline 13 for the primary combustion air. The amounts of 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.

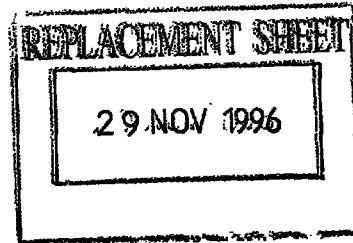
For controlling the combustion process, a video camera or a thermographic camera 34, a monitor 35, a freely programmable computer 36 and a controller unit 37 are provided. The video camera or thermographic camera 34 is aligned, so that it can view the material 19 burning on the furnace grate 15 from 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

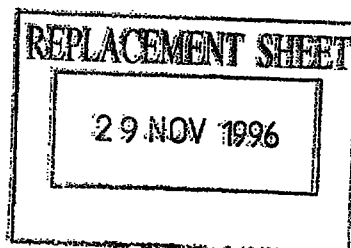
In all the experiments described below, the installation is charged with fuel consisting of garbage, the hourly amount charged and the calorific value being kept constant in all experiments, so that the effects of the inventive measures become clear under constant starting conditions with respect to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

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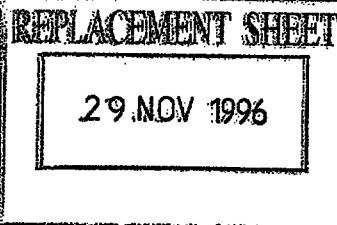


given in field b. The amount of waste gas arising in the grate region, the oxygen concentration and the concentration of the important pollutants are listed in field c. The amount of and the oxygen concentration in the secondary air are given in field d. The amount of waste gas, the oxygen concentration 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



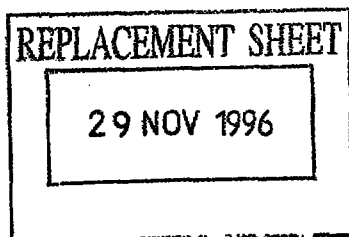
air being used for the secondary air. Compared to the normal operation of Figure 3, it was possible to achieve a reduction of 31% in the amount of waste gas. Compared to the normal operation, it was possible to reduce already appreciably the pollutant loading of oxidizable pollutants leaving the chimney 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.



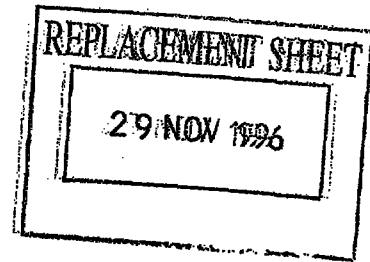
If the pollutant concentrations in the waste gas after the purification of the flue gas, for example in the case of the experiment of Figure 3, that is, of a normal operation, and the pollutant concentration in the experiment of Figure 6 are considered, these values in each case being given in field 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.





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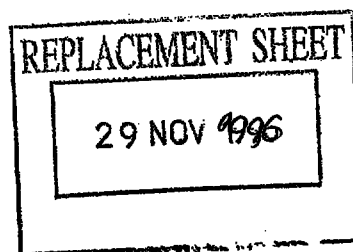
Claims



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.

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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.

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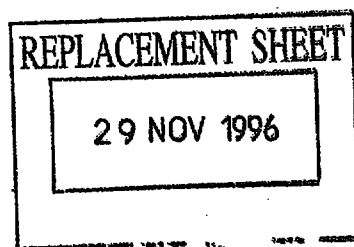


**METHOD FOR BURNING FUELS, PARTICULARLY
FOR INCINERATING GARBAGE**

Abstract of the Disclosure

The method for burning fuels, particularly garbage, in incinerators with a grate firing, for which the primary air is supplied below the grate firing into the fuel layer and the secondary air is supplied above the fuel layer, is controlled in such a way that the intensity of the combustion of the fuel on the furnace grate is increased by increasing the oxygen content of the primary air and the intensity of the combustion in the secondary combustion zone is choked by decreasing the oxygen content in the secondary air, and that waste gas, preferably from the combustion process, is recycled in order to reduce the oxygen content of the secondary air.

FIGURE 1.



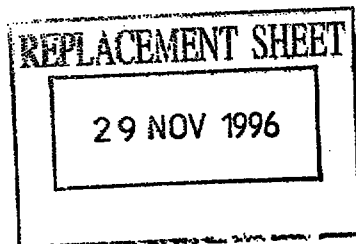
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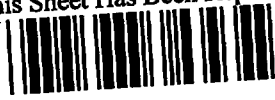


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Key for Figure 2:

- 1 =Reducing the amount of waste gas by a combination of increasing the oxygen content and recycling the waste gas
- 2 =oxygen concentration in the primary air
- 3 =relative volume of waste gases
- 4 =recirculated gas, as a percentage of the secondary air





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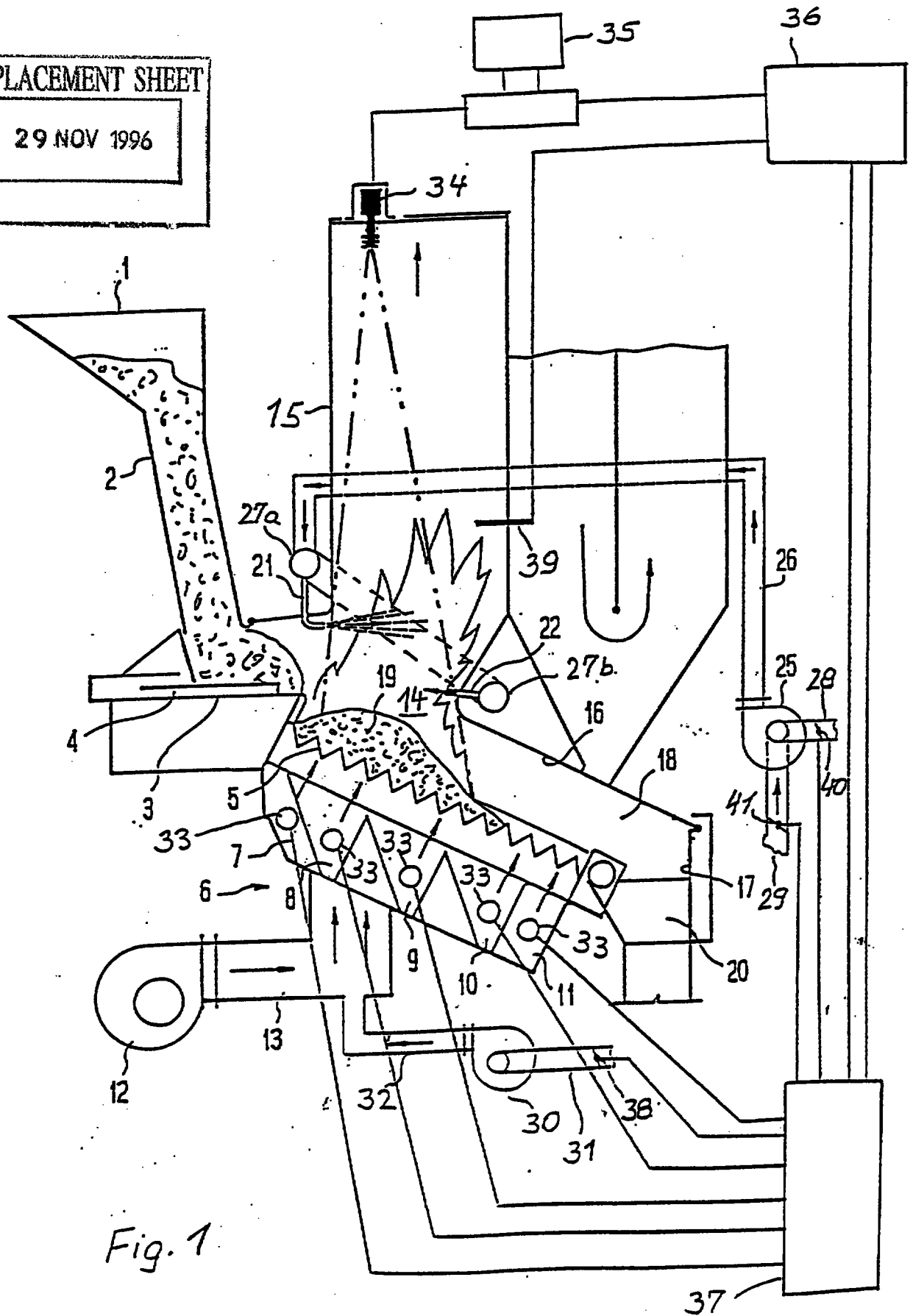
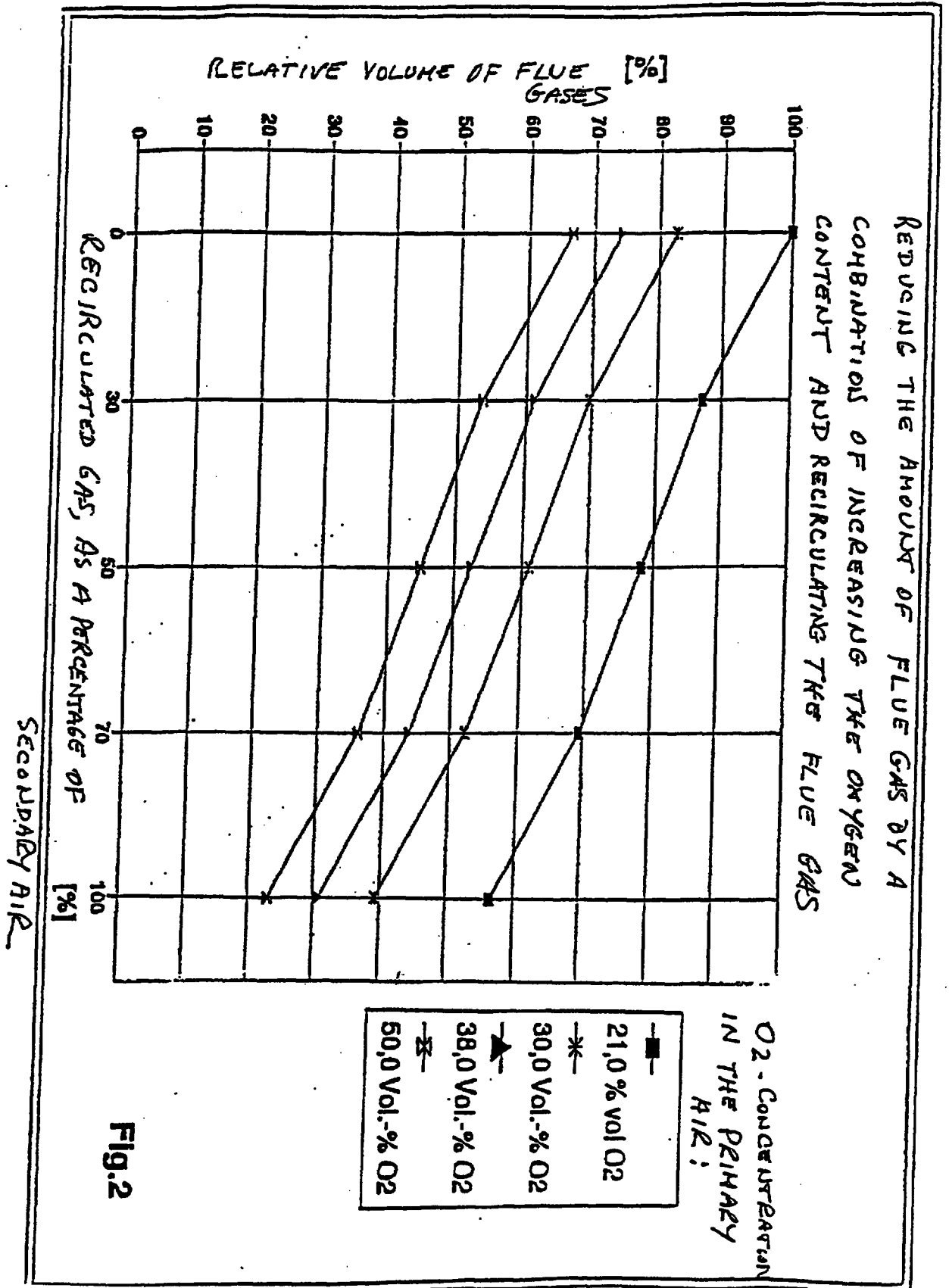
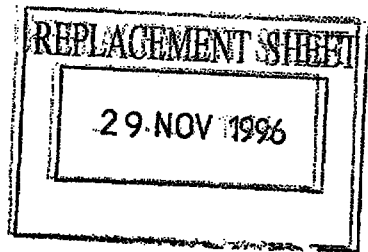


Fig. 1

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- 3 -

REPLACEMENT SHEET

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CHIMNEY

NORMAL OPERATION

Waste Gas after RGR
(Flue Gas Purification)

Amount of waste gas	: 34363 Nm ³ /h tr
O ₂ Conc.	: 9.75 Vol. %
NO _x Conc.	: 445 mg/Nm ³
HCl Conc.	: 1.00 mg/Nm ³
SO ₂ Conc.	: 3.00 mg/Nm ³
HF Conc.	: 0.10 mg/Nm ³

Emission Loading

NO _x Loading	: 15292 g/h
HCl Loading	: 34.4 g/h
SO ₂ Loading	: 103.1 g/h
HF Loading	: 3.4 g/h

21 Vol % O₂ in Primary Air

No
Recirculation

Ratio of primary to
secondary air = 65 : 35

Waste Gas after RGR

Amount of waste gas	: 34363 Nm ³ /h tr.
O ₂ Conc.	: 9.75 Vol %
HCl Conc.	: 1058 mg/Nm ³
SO ₂ Conc.	: 326 mg/Nm ³
HF Conc.	: 10.0 mg/Nm ³

Reduction in amount
of waste gas
compared to
normal operation : 0 %

Boiler

Amount of waste gas	: 34363 Nm ³ /h tr.
Lambda	: 1.87
O ₂ Conc.	: 9.75 Vol %
HCl Conc.	: 1058 mg/Nm ³
SO ₂ Conc.	: 326 mg/Nm ³
HF Conc.	: 10.0 mg/Nm ³

Amount of waste gas	: 0 Nm ³ /h tr.
O ₂ Conc.	: 9.75 Vol %
HCl Conc.	: 1058 mg/Nm ³
SO ₂ Conc.	: 326 mg/Nm ³
HF Conc.	: 10.0 mg/Nm ³

Recirculated waste gas

Secondary air

Amount of air	: 12150 Nm ³ /h tr
O ₂ Conc.	: 21 Vol %

Grate Region

Amount of waste gas	: 22213 Nm ³ /h tr.
O ₂ Conc.	: 3.60 Vol %
HCl Conc.	: 1636 mg/Nm ³
SO ₂ Conc.	: 504 mg/Nm ³
HF Conc.	: 15.5 mg/Nm ³

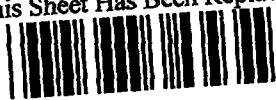
Garbage

Amount of garbage	: 7200 kg/h
Calorific value	: 10099 kJ/kg

Primary air

Amount of air	: 22580 Nm ³ /h tr.
Percentage of primary air	: 65.0 %
Lambda (grate)	: 1.20
O ₂ conc. in primary air	: 21 Vol %
Percentage recirculated	: 0 % of secondary air

Figure 3



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- 4 -

CHIMNEY

Waste Gas after RGR ↑
(Flue Gas Purification) ||

Emission Loading /

OPERATED WITH

Amount of waste gas	: 23609 Nm ³ /h tr
O ₂ Conc.	: 11.64 Vol %
NO _x Conc.	: 510 mg/Nm ³
HCl Conc.	: 1.00 mg/Nm ³
SO ₂ Conc.	: 3.00 mg/Nm ³
HF Conc.	: 0.10 mg/Nm ³

NO _x Loading	: 12040 g/h
HCl Loading	: 23.6 g/h
SO ₂ Loading	: 70.8 g/h
HF Loading	: 2.4 g/h

35 Vol % O₂ in Primary Air

No
Recirculation

Waste Gas after RGR ↑

Amount of waste gas	: 23609 Nm ³ /h tr.
O ₂ Conc.	: 11.64 Vol %
HCl Conc.	: 1538 mg/Nm ³
SO ₂ Conc.	: 473 mg/Nm ³
HF Conc.	: 14.6 mg/Nm ³

Reduction in amount
of waste gas
compared to
normal operation : 31 %

Ratio of primary to
secondary air = 49 : 51

Boiler

Amount of waste gas	: 23609 Nm ³ /h tr.
Lambda	: 2.24 -
O ₂ Conc.	: 11.64 Vol %
HCl Conc.	: 1538 mg/Nm ³
SO ₂ Conc.	: 473 mg/Nm ³
HF Conc.	: 14.6 mg/Nm ³

Amount of waste gas	: 0 Nm ³ /h tr.
O ₂ Conc.	: 11.64 Vol %
HCl Conc.	: 1538 mg/Nm ³
SO ₂ Conc.	: 473 mg/Nm ³
HF Conc.	: 14.6 mg/Nm ³

Recirculated waste gas

Secondary air

Amount of air	: 12150 Nm ³ /h tr
O ₂ Conc.	: 21 Vol %

Grate Region

Amount of waste gas	: 11459 Nm ³ /h tr.
O ₂ Conc.	: 1.72 Vol %
HCl Conc.	: 3168 mg/Nm ³
SO ₂ Conc.	: 975 mg/Nm ³
HF Conc.	: 30.0 mg/Nm ³

← Garbage

Amount of garbage	: 7200 kg/h
Calorific value	: 10099 kJ/kg

Primary air

Amount of air	: 11820 Nm ³ /h tr.
Percentage of primary air	: 49.3 %
Lambda (grate)	: 1.05 -
O ₂ conc. in primary air	: 35 Vol %
Percentage recirculated	: 0 % of secondary air

Figure 4



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CHIMNEY

Waste Gas after RGR
(Flue Gas Purification)

Amount of waste gas	: 13148 Nm ³ /h tr
O ₂ Conc.	: 5.98 Vol. %
NO _x Conc.	: 279 mg/Nm ³
HCl Conc.	: 1.00 mg/Nm ³
SO ₂ Conc.	: 3.00 mg/Nm ³
HF Conc.	: 0.10 mg/Nm ³

Emission Loading

NO _x Loading	: 3668 g/h
HCl Loading	: 13.1 g/h
SO ₂ Loading	: 39.4 g/h
HF Loading	: 1.3 g/h

OPERATED WITH

35 Vol % O₂ in Primary Air100 %
RecirculationRatio of primary to
secondary air = 65 : 35

Waste Gas after RGR

Amount of waste gas	: 13148 Nm ³ /h tr.
O ₂ Conc.	: 5.98 Vol %
HCl Conc.	: 2762 mg/Nm ³
SO ₂ Conc.	: 850 mg/Nm ³
HF Conc.	: 26.2 mg/Nm ³

Reduction in amount
of waste gas
compared to
normal operation : 62 %

Boiler

Amount of waste gas	: 20418 Nm ³ /h tr.
Lambda	: 1.40 -
O ₂ Conc.	: 5.98 Vol %
HCl Conc.	: 2762 mg/Nm ³
SO ₂ Conc.	: 850 mg/Nm ³
HF Conc.	: 26.2 mg/Nm ³

Amount of waste gas	: 7270 Nm ³ /h tr.
O ₂ Conc.	: 5.98 Vol %
HCl Conc.	: 2762 mg/Nm ³
SO ₂ Conc.	: 850 mg/Nm ³
HF Conc.	: 26.2 mg/Nm ³

Recirculated waste gas

Secondary air

Amount of air	: 0 Nm ³ /h tr
O ₂ Conc.	: 21 Vol %

Grate Region

Amount of waste gas	: 13148 Nm ³ /h tr.
O ₂ Conc.	: 5.98 Vol %
HCl Conc.	: 2762 mg/Nm ³
SO ₂ Conc.	: 850 mg/Nm ³
HF Conc.	: 26.2 mg/Nm ³

Garbage

Amount of garbage	: 7200 kg/h
Calorific value	: 10099 kJ/kg

Primary air

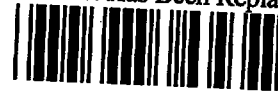
Amount of air	: 13510 Nm ³ /h tr.
Percentage of primary air	: 65.0 %
Lambda (grate)	: 1.20 -
O ₂ conc. in primary air	: 35 Vol %
Percentage recirculated	: 100 % of secondary air

Figure 5

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CHIMNEY

Waste Gas after RGR ↑
(Flue Gas Purification) ↓

Amount of waste gas : 8543 Nm³/h tr
O₂ Conc. : 5.98 Vol. %
HCl Conc. : 1.00 mg/Nm³
SO₂ Conc. : 3.00 mg/Nm³
HF Conc. : 0.10 mg/Nm³

Emission Loading

HCl Loading : 8.5 g/h
SO₂ Loading : 24.6 g/h
HF Loading : 0.9 g/h

OPERATED WITH

h

50 Vol % O₂ in Primary Air

100 %
Recirculation

Ratio of primary to
secondary air = 50 : 50

Waste Gas after RGR ↑

Amount of waste gas : 8543 Nm³/h tr.
O₂ Conc. : 5.98 Vol %
HCl Conc. : 4246 mg/Nm³
SO₂ Conc. : 1307 mg/Nm³
HF Conc. : 40.2 mg/Nm³

Reduction in amount
of waste gas
compared to
normal operation : 75 %

g

Boiler

Amount of waste gas : 17463 Nm³/h tr.
Lambda : 1.40 -
O₂ Conc. : 5.98 Vol %
HCl Conc. : 4246 mg/Nm³
SO₂ Conc. : 1307 mg/Nm³
HF Conc. : 40.2 mg/Nm³

e

Amount of waste gas : 8920 Nm³/h tr.
O₂ Conc. : 5.98 Vol %
HCl Conc. : 4246 mg/Nm³
SO₂ Conc. : 1307 mg/Nm³
HF Conc. : 40.2 mg/Nm³

Recirculated waste gas

Secondary air

Amount of air : 0 Nm³/h tr
O₂ Conc. : 21 Vol %

Grate Region

Amount of waste gas : 8543 Nm³/h tr.
O₂ Conc. : 5.98 Vol %
HCl Conc. : 4246 mg/Nm³
SO₂ Conc. : 1307 mg/Nm³
HF Conc. : 40.2 mg/Nm³

c

← Garbage

Amount of garbage : 7200 kg/h
Calorific value : 10099 kJ/kg

a

Primary air

Amount of air : 8910 Nm³/h tr.
Percentage of
primary air : 50.0 %
Lambda (grate) : 1.13 -
O₂ conc. in primary
air : 50 Vol %
Percentage
recirculated : 100 % of
secondary air

b

Figure 6

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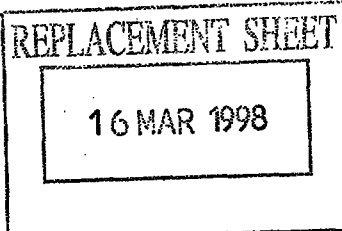
TEXT OF THE ABSTRACT

METHOD FOR BURNING FUELS, PARTICULARLY FOR
INCINERATING GARBAGE

The method for burning fuels, particularly garbage (19), in incinerators with a grate firing (5), for which the primary air (23) is supplied below the grate firing into the fuel layer and the secondary air (21,22) is supplied above the fuel layer, is controlled in such a way that the intensity of the combustion of the fuel on the furnace grate is increased by increasing the oxygen content of the primary air and the intensity of the combustion in the secondary combustion zone is choked by decreasing the oxygen content in the secondary air, and that waste gas, preferably from the combustion process, is recycled in order to reduce the oxygen content of the secondary air.

Fig. 1

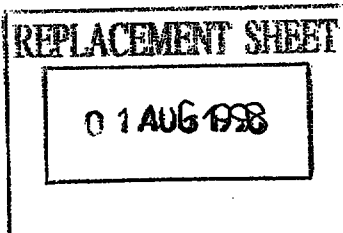
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✓ Drawing(s) : paged 13... to paged 14..
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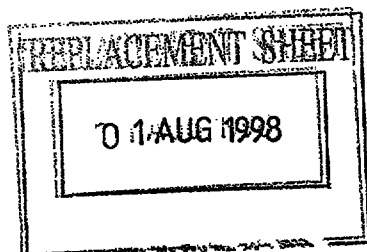
METHOD FOR THE COMBUSTION OF FUELS, PARTICULARLY WASTE

The invention relates to a method for the combustion of fuels, particularly waste, in combustion plants with grate firing, in which primary air is fed under the grate into the fuel bed and secondary air is fed above the fuel bed.

Methods of this general type have been known for some time.

On account of political objectives, the combustion of waste must be effected in such a manner that environmental pollution is substantially avoided. The hitherto conventional method of procedure for achieving this aim is to optimise the combustion process on the grate by controlling the quantity and distribution of the combustion air fed in along the grate and also in the region of the secondary combustion zone and to use increasingly extensive and complicated apparatus for the subsequent gas purification. Although this has already led to a drastic reduction in the emissions from plants of this kind, it has also meant a sharp increase in the waste disposal costs associated with the operation of these plants and highly superproportional expansion of the waste-gas purification apparatus relative to the conventional part of the plant consisting of firing and energy recovery, e.g. steam generation. In the meantime, such a standard has been achieved in waste-gas purification plants that a further improvement in separation efficiency can be expected only at very high additional costs, as purification efficiency of 99 % has been achieved. Experience has shown that there is an exponential relationship between expenditure and purification efficiency, so that the technical input required to achieve a further increase in purification efficiency is no longer justifiable. The technically justifiable boundary for the purification of waste gases has been reached with the measures known at present. Above all in recent years, attempts have additionally been made to achieve further improvements by influencing the combustion process.

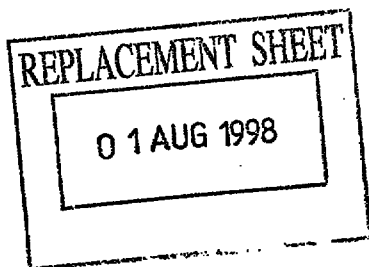
DE 39 15 992 A1 discloses how to prevent the production of nitrogen oxides in order to allow for savings in the subsequent purification plants. The basic principle of this known method consists principally in varying the oxygen content of the primary air by admixing recycled waste gases from the combustion process in such a manner that the combustion on the grate is damped so that the maximum temperature achieved in the centre of the flame is 1300°C, as it is known that the intensive formation of nitrogen



oxides begins above this temperature. In this known method, the secondary air is introduced in two superimposed stages, substantially recycled waste gas being introduced in the lower stage in order to generate turbulence, whereas ambient air is fed in in the second stage in order to obtain the necessary combustion of the waste gases. However, in this controlled slowing down of the combustion reactions, there is a marked deterioration in the ignition of solid waste constituents on the combustion grate. The proportion of unburnt substances in the combustion residue increases as a direct consequence of this and there is less chance of harmful substances being integrated into the residue, i.e. into the slag, as a result of the lower fuel bed temperatures. In this method, therefore, although the proportion of nitrogen oxides is reduced, the proportion of combustible harmful substances is increased as a result of the reduction in the oxidation potential.

In another known method according to DE 40 27 908 A1, the oxygen content of both the primary combustion air and the secondary combustion air is varied, this variation ranging from an increase in the oxygen content relative to the ambient air to a reduction in the oxygen content relative to the ambient air. This sole purpose of this variation of the oxygen content of both the primary combustion air and the secondary combustion air is to adjust the quantity of oxygen required for combustion at the individual points of the combustion plant as precisely as possible. This should result in good burn-out and the residual oxygen quantity should not fall below the prescribed value. The oxygen recovered in an air-separation plant and the nitrogen also recovered there are used in order to increase the oxygen content by feeding in oxygen and to reduce the oxygen content in the combustion air by feeding in nitrogen. This method of procedure can improve the course of the combustion process in essential regions of the furnace or furnace chamber, although it does not lead to a reduction in the volumetric flow rate of the waste gas through the entire plant, nor above all in the waste-gas purification plant.

The recycling of waste gas via secondary air nozzles is known from Patent Abstracts of Japan, Vol. 8, No. 148 (M-308) (1585), July 11, 1984. However, in this known combustion process, the primary combustion air is throttled in order to accelerate



gasification of the waste on the grate and thereby to suppress the formation of nitrogen oxides.

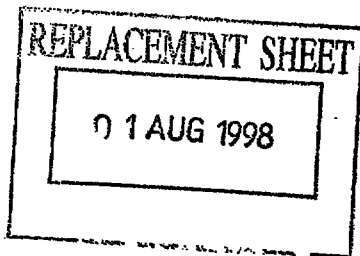
DE-A-1 751 133 describes a combustion method in which the combustion air as a whole is enriched with oxygen, over the entire length of the grate, in order to burn all of the odorous substances. No secondary combustion zone is provided in this method.

It is known from DE-B-1 019 788 to draw off the waste gas from a region in which there is still a very high proportion of unconsumed oxygen, this waste gas drawn off being fed to the secondary air nozzles. This results in a large mixing penetrative effect in association with specific air feeding in order to obtain complete combustion in the secondary combustion zone at high temperatures with little excess air.

The environmental importance of waste incineration plants has hitherto usually been evaluated on basis of the concentration of harmful substances in the waste gas. The current emission guidelines, i.e. the 17th Federal Anti-Pollution Act or the EC Directive on the combustion of waste, like the previous acts in this connection, regulate plants of this kind by means of concentration limits. However, this approach gives an incomplete picture of the harmful substances discharged into the environment as only relative, but not actual quantities leaving an emission source can be identified. More comprehensively, on the other hand, the evaluation of the harmful substance load describes the ecological importance of an emission source.

Practical experience from modern waste-gas purification plants has shown that the harmful substance/clean gas concentrations that can be achieved are virtually no longer dependent on the harmful substance concentrations prior to waste-gas purification, but the concentration values remain constant at the end of the waste-gas purification. This is explained by the exponential relationship between separation efficiency and the cost or dimensions of the units to be used already described hereinabove.

The aim of the invention is to go beyond the knowledge obtained hitherto with respect to the purification efficiency that can be achieved and to achieve a considerable reduction in the harmful substance load discharged into the environment with higher



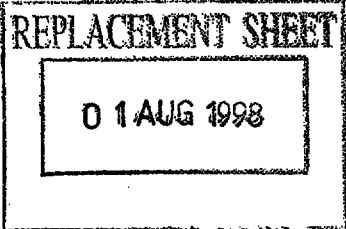
technical efficiency and smaller dimensions of the units subsequent to the combustion apparatus.

This problem is solved according to the invention departing from a method for the combustion of fuels of the type mentioned at the outset in that the combustion intensity of the fuel on the grate is increased at least in parts thereof by increasing the oxygen content of the primary air to 25 to 50 % by volume with a simultaneous reduction in the nitrogen content of the primary air relative to the ambient air and that above the fuel bed, once the removal of oxidisable harmful constituents has been substantially completed, the combustion intensity in the secondary combustion zone is throttled by reducing the oxygen content in the secondary air relative to the ambient air by means of recycled waste gas, the recycled waste gas making up 20 to 65 % of the total quantity of air and gas fed into the combustion process.

The nitrogen content is necessarily reduced as a result of the sometimes considerable increase in the oxygen content of the primary combustion air dependent on the reaction zones, e.g. the pre-heating zone, the main combustion zone or the burn-out zone, leading in the case of a considerably increased combustion intensity to a sharp reduction in the required air volume as the nitrogen acting only as a diluent is reduced. This already results in a considerable saving in volume in the combustion air, allowing not only for a reduction in the dimensions of the primary air fan and ducts, but also, in particular, for a reduction in the size of the subsequent units, such as steam generator, waste-gas purification apparatus, underblast fan and chimney. The considerable increase in the intensity of the primary combustion usually leads to an increase in the fuel bed temperature on the combustion grate and the flame temperature in the secondary combustion zone. Whereas higher fuel bed temperatures have the advantageous effect of improved burn-out of the solid fuel particles and improved integration of harmful substances into the combustion ash as a result of sintering, the increased secondary combustion temperature results in the intensified formation of nitrogen oxides (thermal NO_x). In one known method mentioned at the outset, the combustion process is already substantially throttled on the grate for this reason. The invention therefore firstly follows a course which would be regarded as erroneous in

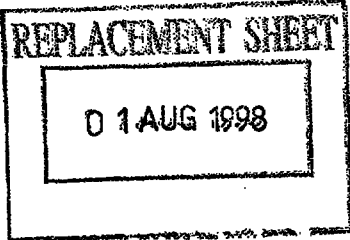
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accordance with previous knowledge, in that combustion is initially effected on the grate beyond the hitherto usual extent in order thereby to achieve a considerable reduction in the quantity of primary air, an improvement in the slag quality and a reduction in the combustible, i.e. oxidisable harmful substances, but then corrects this course in the secondary combustion zone in order to prevent the increased formation of nitrogen oxides, the removal of which would involve considerable expense. It is at this point therefore that the further measure according to the invention comes into operation, consisting in throttling the combustion process above the fuel bed at the beginning of the secondary combustion zone in such a manner that the nitrogen oxide formation usually occurring is prevented or sharply reduced. This damping measure therefore begins at a time when the removal of the oxidisable harmful substances by means of the intensive combustion process has already been substantially completed. As a result of the sharp increase in the oxygen content in the primary air, there is still sufficient oxygen present once this primary air has passed through the fuel bed to allow for the desired throttled combustion in the secondary combustion region, wherein this should be controlled in such a manner that the temperatures leading to the formation of nitrogen oxides are not reached. In order to achieve this throttling, waste gas with a considerably reduced oxygen content is used in the method for damping subsequent combustion according to the invention. Using waste gas means that it is no longer necessary to feed in additional low-oxygen gas or inert gas, as a result of which the gas quantity no longer has to be increased in spite of sufficient combustion in the secondary combustion region, as was the case in the methods known hitherto, in which additional combustion air in the form of ambient air was fed in via secondary air nozzles in the region of the secondary combustion zone. Even in the methods in which no pure combustion air was fed in, the gas quantity was still increased as a mixture of ambient air and waste gas or inert gas, e.g. nitrogen, was fed in, thereby increasing the total quantity. In this invention, therefore, the damping measures in the secondary combustion zone are produced with the aid of waste gases produced during the primary combustion, i.e. during the combustion of the fuel bed on the grate, so that additional quantities of gas are no longer necessary.

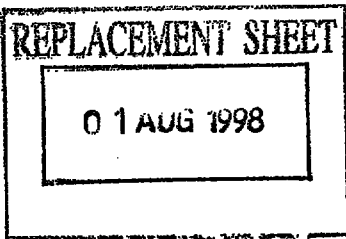


As the combustion intensity on the grate is increased particularly sharply within the primary combustion zone according to this invention, there is still sufficient oxygen for secondary combustion in the air passing through the fuel bed so that, according to a further embodiment of the invention, the waste gases recycled in the secondary combustion zone can make up 20 to 65 %, preferably 35 % of the total quantity of air and gas fed into the combustion process. E.g. the entire quantity of gas introduced through the secondary air nozzles can therefore consist of recycled waste gas if it is assumed that preferably 35 % of the total quantity of gas and air is used in the form of recycled waste gases and the secondary air makes up 35 % of the total gas quantity. As this is recycled gas, this measure results in a saving of more than a third of the total gas quantity, assuming that modern waste incineration plants are generally operated with the combustion air divided into 65 % primary air and 35 % secondary air. Together with the measure of increasing the oxygen content in the primary air, the total quantity of gases flowing through the subsequent units can thus be reduced by two thirds. If, however, as established hereinabove, the concentration values of the harmful substances at the end of waste-gas purification are independent of the harmful substances concentrations prior to the waste-gas purification, the harmful substance load, i.e. the quantity of harmful substances discharged from an emission source, can be reduced relative to previously operated plants by reducing the overall gas volume by up to two thirds in a manner not possible in the traditional method of operation of waste incineration plants as a result of the exponential increase in expenditure described at the outset.

Departing from the essential instructions described hereinabove, one special development of the invention consists in that the oxygen content of the primary air is increased locally as a function of the combustion behaviour or the combustion intensity of the fuel bed situated on the grate departing from the oxygen content of the ambient air and that the secondary air is adjusted locally with respect to composition, quantity, feed point and high turbulence in the secondary combustion zone so as to substantially prevent the formation of nitrogen oxides above the fuel bed. By adapting the method to the local conditions, i.e. by taking account of the different states of the fuel along



the grate, the primary air can be adapted to the prevailing conditions and can be adjusted in such a manner that the desired increased combustion effect, and thus the combustion of oxidisable harmful substances, is achieved. To this end, use is made, e.g. of known thermocouples for measuring temperatures or of infrared cameras for detecting the solid-state radiation emanating directly from the fuel bed, indicating the fuel bed temperature, i.e. the temperature of the burnt-out fuel mass, in order to adjust the oxygen content required for increased combustion intensity at the relevant point of the combustion grate, this being possible, e.g. by dividing the underblast guide for the combustion grate in a corresponding manner. A relevant proposal has already been made to this end in DE 38 25 931 C2. What is crucial here is not the known fact that the oxygen content can in principle be controlled, but the fact that, in this invention, the oxygen content is increased so sharply that the combustion intensity, and thus the associated reduction in the oxidisable harmful substances, achieved was not attempted hitherto in view of the disadvantages to be expected. However, these disadvantages, consisting, e.g. of the thermal formation of nitrogen oxides and overheating of the protective lining of the furnace chamber, are avoided in this invention in that controlled damping measures with respect to temperature development and the adjustment of other conditions are introduced above the fuel bed, so that the expected disadvantages do not occur. These damping measures in principle include the reduction of the oxygen content, as already described hereinabove. The quantities of secondary air, the point at which relative to the fuel bed or the furnace chamber and the turbulence with which the quantity of gas referred to as secondary air is fed in via the secondary air nozzles are of great importance in this connection. The generation of high turbulence is particularly advantageous as it is thus possible to compensate for an often irregular oxygen distribution and better use can therefore be made of the oxygen present, as a result of which the desired course of the combustion process can be obtained in the secondary combustion region at relatively low temperatures. The conditions in the secondary combustion region can be adjusted in such a manner with the aid of temperature measurements and observations by means of infrared cameras or flame monitors that temperatures harmful to the lining of the furnace chamber and promoting



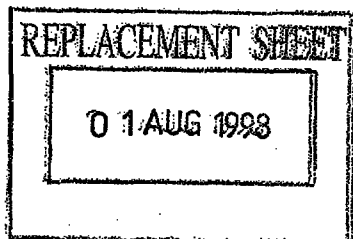
the formation of nitrogen oxides are prevented, in accordance with which it is known, e.g. that the temperature of 1300°C represents a limit above which the increased formation of nitrogen oxides has to be expected.

Depending on the nature of the substances to be burnt, it may be advantageous for the oxygen content of the primary air only to be increased in the main combustion zone of the primary combustion zone of the grate, as in the other regions the fuel is first preheated or already has too low a calorific value, as is the case, e.g. in the burn-out zone.

Preferred parameters for controlling the oxygen content with respect to the primary combustion air are the surface temperature of the fuel and with respect to the secondary air the temperature prevailing in the secondary combustion zone or the length of the flames in the vertical extent in the furnace chamber.

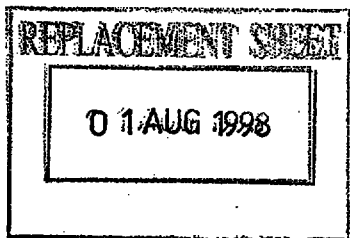
The waste gas to be recycled is preferably exhausted after flowing through the boiler, as a result of which the reduction in the gas volume as a result of the waste-gas recycling first becomes noticeable in the waste-gas purification plant. In special cases, it may also be possible to exhaust the waste gas to be recycled immediately above the fuel bed.

The adjustment of the oxygen content in the primary air, and thus the intentional increase in the combustion intensity in the primary combustion zone on the grate, can be accelerated without regard to the subsequent consequences prevented by the damping measures according to the invention to such an extent that the combustion process on the grate is substantially limited by conditions resulting from the operational reliability of the combustion grate. A temperature increase in the fuel bed of up to 300°C relative to conventional combustion processes is therefore possible. As the fuel bed temperature can be up to 300°C higher than in the case of combustion with normal external air, there is a higher degree of integration of harmful substances into the slag. The resulting reduced leachability of the harmful substances improves the possibility of the slag being used as building material or reduces the requirements imposed with respect to the dumping of residue.



In principle, enriching the oxygen in the primary combustion air results in various considerable advantages. It has already been emphasised in detail that the total gas volume can be reduced by up to two thirds, resulting in smaller dimensions for the entire plant and thus in a considerable reduction in costs. The increase in the oxygen content in the primary air necessarily results in a drastic reduction in the proportion of nitrogen fed in, only to be regarded as a diluent and hitherto considerably reducing thermal efficiency. This reduction in thermal efficiency decreases accordingly as a result of the reduction in the nitrogen content, thereby improving thermal efficiency. The increase in the oxygen content has its limits where there could be thermal overload of the individual elements of the grate. It has been found in practice that the oxygen content can make up to 50 % by volume of the quantity of primary air fed in without leading to damage of the grate elements. The reduction in the volumetric flow rate of the gas reduces the entrainment effect to small and light waste particles so that these burn on or immediately above the grate and do not arrive in the purification plant as unburnt components. Dust separators can therefore be made even smaller, in addition to the possible reduction in size as a result of the smaller waste gas volume. The considerably more intensive combustion begun as a result of the invention not only leads to higher temperatures of the fuel particles on the grate itself, but also increases the gas temperatures immediately above the fuel bed, leading to a reduction in the carbon monoxide and residual hydrocarbon concentrations. The concentration of what are referred to as precursor compounds, which could lead to the formation of dioxins and furans in the region of the subsequent cooling of the combustion gases, is furthermore reduced.

The drastic throttling of the combustion process in the secondary combustion region, preferably by recycling waste gas, prevents the disadvantages occurring as a result of the previous oxygen enrichment above the grate. It has been found that the secondary combustion region is subject to overheating when ambient air is fed into this region. This results in a higher content of thermally formed nitrogen oxides and long-term, unavoidable destruction of the ceramic protective lining of the combustion chamber region. These disadvantages are prevented by the drastic throttling of the course of the



combustion process above the fuel bed, i.e. in the secondary combustion region. The mixing required in the secondary combustion region in order to prevent a gradient in the O_2 concentration between the recycled gas and the combustion gas from the primary combustion zone is achieved by feeding the recycled gas into the secondary combustion zone, the quantity of gas fed in being sufficient to ensure the necessary turbulence. The lower raising of dust in and above the fuel bed leads additionally to the lower leachability of dust filters already mentioned, as well as to lower contamination of the heating surfaces in the boiler and thus also to more advantageous operating conditions with respect to boiler availability, the interval between the purification of two heating surfaces and boiler efficiency. The sharp reduction in the gas quantity necessarily results in a proportional increase in the concentration of the different harmful substances to be separated by the waste-gas purification plant with a constant quantity of fuel, as will be clear from the diagrams shown in Figures 3 to 6. If material recovery is provided for during the waste-gas purification, e.g. in the recovery of hydrochloric acid and gypsum from separated harmful substances, the efficiency and complexity of this process are considerably improved.

The invention will now be described by way of example with reference to a combustion plant for carrying out the method in association with diagrams showing various test results. In the figures illustrated in the accompanying drawings:

Figure 1 is a longitudinal section through a combustion plant;

Figure 2 is a diagram illustrating the reduction in the quantity of waste gas for different oxygen concentrations in the primary air and different recycled fractions relative to the secondary air quantity;

Figure 3 shows a test result for the operation of a combustion plant using external air as the primary air and without waste-gas recycling of the secondary air;

Figure 4 shows a test results for the operation of a combustion plant with an oxygen content of 35 % by volume without waste-gas recycling;

Figure 5 shows a test result for the operation of a combustion plant with 35 % by volume oxygen in the primary air and complete waste-gas recycling, and

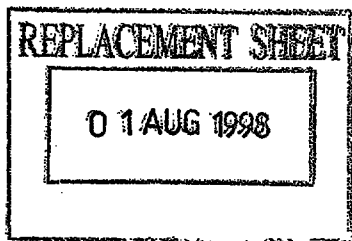


Figure 6 shows a test result for the operation of a combustion plant with 50 % by volume oxygen in the primary air and 100 % waste-gas recycling.

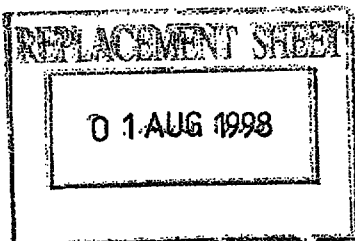
As will be clear from the drawings, a combustion plant for carrying out the method described has a feed hopper 1 with an adjacent feed chute 2 for feeding the fuel on to a feed table 3 on which reciprocating feed pistons 4 are provided in order to feed the fuel emerging from the feed chute on to a grate 5 on which combustion of the fuel takes place. It does not matter whether the grate is inclined or horizontal or how it operates.

A means for feeding in primary combustion air designated in general by the reference numeral 6 is arranged below the grate 5 and may include a plurality of chambers 7 to 11 fed with primary combustion air by means of a ventilator 12 via a line 13. The grate is divided into a plurality of underblast zones by means of the arrangement of the chambers 7 to 11 so that the primary combustion air can be adjusted differently in accordance with the requirements on the grate. These underblast zones can also be divided in the transverse direction depending on the width of the grate, so that the feeding of the primary air can be controlled in accordance with the local conditions.

The furnace chamber 14 is situated above the grate 5 and passes over in its upper part into a waste-gas offtake 15 to which units (not shown), e.g. a waste-heat boiler and a waste-gas purification plant, are connected. The furnace chamber 14 is delimited in its rear region by a roof 16, a rear wall 17 and side walls 18.

The combustion of the fuel designated by the reference numeral 19 is effected on the front part of the grate 5, above which the waste-gas offtake 15 is situated. The most primary combustion air is fed in in this region through the chambers 7, 8 and 9. Only burnt-out fuel, i.e. slag, is situated on the rear part of the grate 5 and primary combustion air is fed into this region via the chambers 10 and 11 essentially only for cooling this slag.

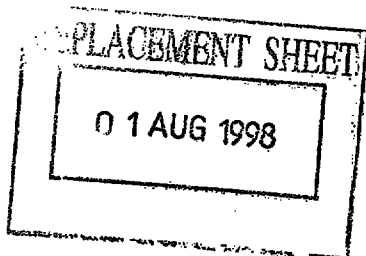
The burnt-out particles then drop into a slag discharge point 20 at the end of the grate 5. Rows of secondary air nozzles 21 and 22 are provided in the lower region of the waste-gas offtake 15 and feed secondary combustion air to the ascending waste gas in order to effect subsequent combustion of the combustible fractions in the waste gas.



The rows of secondary air nozzles 21 and 22 are connected to air collectors 27a and 27b supplied via a line 26 by a fan 25 which in turn exhausts waste gas from a part of the combustion plant situated further back via a line 28 and optionally ambient air via a line 29.

Either pure oxygen or oxygen-enriched ambient air is exhausted from an air-separation plant (not shown) by a fan 30 via a line 31 and is fed via the line 32 to the line 13 for the primary combustion air. The respective quantities of air in the chambers 7 to 11 are adjusted by means of control means 33 which control the feeding of the air/oxygen mixture to the individual chambers 7 to 11. Each chamber 7 to 11 can of course have a separate oxygen line so that the oxygen content of the primary air can be adjusted differently in individual chambers.

A video camera or thermographic camera 34, a monitor 35, a freely programmable computer 36 and a control unit 37 are provided to control the combustion method. The video camera or thermographic camera 34 is aligned in such a manner that it can observe the fuel 19 on the grate 5 from above through the furnace chamber 14. The video camera is connected to the monitor 35 and the freely programmable computer 36, which resolves the image received in a corresponding manner and compares the digital values obtained, which represent a measure of the brightness on the respective combustion zone, with predetermined guide values and, in the event of deviation, triggers an appropriate control process via the control unit 37 which adjusts the control means 33 in the form of valves or slides in the individual chambers 7 to 11. The video camera 34 therefore delivers values indicating the temperature of the fuel bed 19 as a result of the solid-state radiation emanating from the fuel bed 19. The primary air quantity is adjusted by adjusting the control means 33 and the oxygen content of the primary air is adjusted via the control unit 37 by adjusting the control means 38 in the line 31. The primary air quantity and the oxygen content are adjusted as a function of the combustion behaviour of the fuel bed 19 on the grate 5 in the respective zones of the grate monitored. Thermocouples are provided in the region of the secondary combustion zone, only one of these thermocouples 39 being shown in the drawings. The thermocouple 39 serves to monitor the temperature in the secondary combustion



zone and is connected to the freely programmable computer 36 which is in turn connected to the control unit 37. The latter adjusts the quantity of the waste gas to be fed to the secondary air nozzles 21 and 22 via control means 40 and 41 and optionally the quantity of ambient air, adjusted via the control means 41. Instead of thermocouples 39, the temperature can also be measured by means of sonic pyrometers (pyrosonics) or by the laser Doppler method.

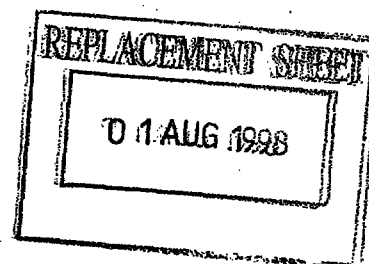
With the aid of this control means and the corresponding monitoring means, the intensive combustion on the grate can be controlled by controlling the primary air quantity and the oxygen content in the combustion air and the behaviour in the secondary combustion zone can be controlled by adjusting the secondary air, consisting for the greater part of recycled waste gas. This prevents an excessive increase in temperature in the secondary combustion region and reduces the quantity of gas led through the entire plant. The reduction in the gas quantity is greatest if no additional ambient air is exhausted. The quantity of primary air is therefore reduced relative to hitherto known combustion plants in that the oxygen content of the primary air relative to the ambient air is increased and the nitrogen acting as a diluent is therefore reduced.

Figure 2 is a diagram showing the reduction in the waste gas quantity that can be obtained as a function of, on the one hand, the oxygen concentration of the primary air and, on the other hand, the recycled fraction of the secondary air. The relative waste gas volume from 0 to 100 % is plotted on the y-axis and the x-axis shows the recycled fraction of the secondary air from 0 to 100 %. The four curves plotted show the reduction in the waste gas quantity as a function of the oxygen concentration of the primary air.

Figures 3 to 6 show various test results. The following formulae and abbreviations are used:

O ₂ -Konz	=	oxygen concentration
NO _x -Konz	=	nitrogen oxide concentration
HCL-Konz	=	hydrogen chloride concentration
SO ₂ -Konz	=	sulphur dioxide concentration

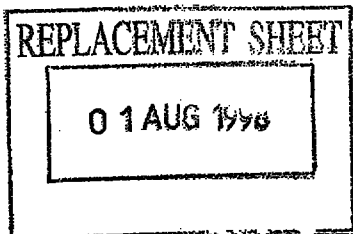
HF-Konz	=	hydrogen fluoride concentration
RGR	=	waste-gas purification
PL	=	primary air
SKL	=	secondary air
Rezi-Anteil	=	recycled fraction of the secondary air
Lambda	=	air excess factor



In all of the tests described hereinafter, the installation is loaded with fuel consisting of waste, the hourly feed rate and the calorific value being kept constant in all of the tests so as to clearly illustrate the effects of the measures according to the invention with the same starting conditions with respect to the fuel.

In all of the test diagrams, the quantity of waste fed in per hour and the calorific value are given in box a, and the primary air quantity, the primary air content of the total combustion air, the lambda value, the oxygen concentration in the primary air and the recycled fraction are given in box b. The quantity of waste gas in the grate region, the oxygen concentration and the concentration of the essential harmful substances are given in box c. Box d gives the quantity and the oxygen concentration of the secondary air. Box e gives the waste gas quantity, the oxygen concentration in the waste gas and the quantities of the various harmful substances. Box f gives the quantity of waste gas flowing through the boiler, the air excess factor measured in the boiler, the oxygen concentration and the concentrations of the various harmful substances in mg/Nm^3 . Boxes g and h give the waste gas quantity, the oxygen concentration and the concentrations of the various harmful substances before and after waste-gas purification. Box i gives the harmful substance loads leaving the chimney after waste-gas purification in g/h. The percentage reduction in the waste gas quantity is given under box i.

Figure 3 gives the test results for normal operation of a combustion plant. In this normal operation, the plant is operated with normal external air as the primary air and with normal external air as the secondary air. The ratio of primary air to secondary air is 65 : 35. As normal external air is used for the secondary air there is no waste-gas recycling.



Whereas normal operation is shown in the first test shown in Figure 3, the percentage reductions in the waste gas quantity that can be obtained relative to normal operation and the harmful substance loads occurring will be clear from the diagrams of Figures 4 to 6 as the essential results of the combustion method according to the invention.

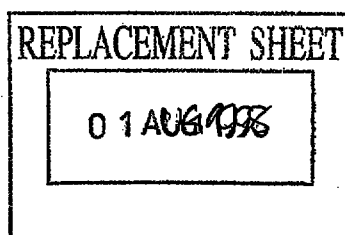
In the test result shown in Figure 4, the plant was operated with an oxygen content of 35 % by volume in the primary air, a ratio of primary air to secondary air of 49.3 : 50.7 without waste-gas recycling, normal external air being used for the secondary air. In this case, it was possible to achieve a 31 % reduction in the waste gas quantity relative to normal operation according to Figure 3. It was already possible to considerably reduce the hourly harmful substance load of oxidisable harmful substances leaving the chimney relative to normal operation, as will be clear from the comparison of the figures given in box i. On the other hand, the NO_x content was increased slightly relative to Figure 3, this being due to the increased oxygen content in the primary air. However, the NO_x load is lower as a result of the reduced waste gas quantity.

A 62 % reduction in the waste gas quantity relative to normal operation and a further drastic reduction in the harmful substance load leaving the chimney will be clear from a further test result given in Figure 5. The plant 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 with 100 % recycling. The sharp reduction in the NO_x content in spite of the high oxygen content in the primary air is due to the damping measures as a result of the waste-gas recycling.

In the test given in Figure 6, the plant was operated with an oxygen content of 50 % by volume in the primary air, a ratio of primary air to secondary air of 50 : 50 with 100 % recycling. A 75 % reduction in the waste gas quantity relative to normal operation was obtained here. Comparing the harmful substance loads of this test given in box i with the normal operation according to Figure 3, it will be established that the HCL load of 34.4 g/h has been reduced to 8.5 g/h, corresponding to a reduction of approximately 75 % relative to normal operation. In the case of the other harmful substance loads, the reduction is also approximately 75 % relative to normal operation. Not only was there therefore a 75 % reduction in the waste gas quantity relative to normal operation

in the test according to Figure 6, but a correspondingly high reduction in the harmful substance load was also obtained.

Looking at the harmful substance concentrations in the waste gas after waste-gas purification, e.g. in the case of the test according to Figure 3, i.e. in normal operation, and the harmful substance concentrations in the test according to Figure 6, these values each being given in box h, it will be clear that the values are identical, whereas the corresponding values before waste-gas purification in relation to the standard cubic metre of waste gas are approximately four times as high in the test according to Figure 6 as in the test according to Figure 3, i.e. during normal operation. It will be clear from this that there is a substantially higher, i.e. approximately four times as high a harmful substance concentration in the waste gas before waste-gas purification as a result of the reduction in the waste gas quantity in relation to the standard cubic metre of waste gas, as a result of which this waste gas offers substantially better conditions for the recovery, e.g. of hydrochloric acid and gypsum than the waste gas during normal operation, as during normal operation the plant has to be operated with very complex equipment in order to allow for the recovery of hydrochloric acid and gypsum departing from the relatively low harmful substance concentrations.





CLAIMS

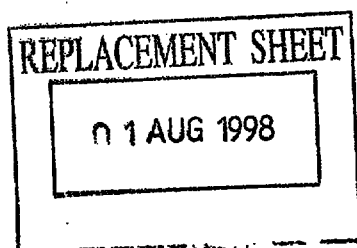
1. Method for the combustion of fuels, particularly waste, in combustion plants with grate firing, in which primary air is fed under the grate into the fuel bed and secondary air is fed above the fuel bed, characterised in that the combustion intensity of the fuel on the grate is increased at least in parts thereof by increasing the oxygen content of the primary air to 25 to 50 % by volume with a resulting percentage reduction in the nitrogen content of the primary air relative to the ambient air and that above the fuel bed, once the removal of oxidisable harmful substances has been substantially completed, the combustion intensity in the secondary combustion zone is throttled by reducing the oxygen content in the secondary air relative to the ambient air by means of recycled waste gas, the recycled waste gas making up 20 to 65 % of the total quantity of air and gas fed into the combustion process.
2. Method according to claim 1, characterised in that the oxygen content of the primary air is increased locally as a function of the combustion behaviour or the combustion intensity of the fuel bed situated on the grate departing from the oxygen content of the ambient air and that the secondary air is adjusted locally with respect to composition, quantity, feed point and high turbulence in the secondary combustion zone so as to substantially prevent the formation of nitrogen oxides above the fuel bed.
3. Method according to claim 1 or claim 2, characterised in that the oxygen content of the primary air is only increased in the main combustion zone of the primary combustion zone of the grate.
4. Method according to one of claims 1 to 3, characterised in that the oxygen content of the primary combustion air is adjusted as a function of the surface temperature of the fuel.

REPLACEMENT SHEET

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5. Method according to one of claims 1 to 4, characterised in that the oxygen content in the secondary air is adjusted as a function of the temperature in the secondary combustion zone.
6. Method according to one of claims 1 to 5, characterised in that the oxygen content in the secondary air is adjusted as a function of the length of the flames in the vertical extent in the combustion chamber.
7. Method according to one of claims 1 to 6, characterised in that the waste gas to be recycled is exhausted after flowing through the boiler.
8. Method according to one of claims 1 to 6, characterised in that the waste gas to be recycled is exhausted immediately above the fuel bed.



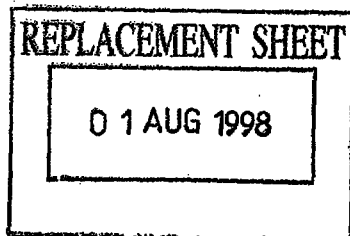
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METHOD FOR BURNING FUELS, PARTICULARLY
FOR INCINERATING GARBAGE

Abstract of the Disclosure

The method for burning fuels, particularly garbage, in incinerators with a grate firing, for which the primary air is supplied below the grate firing into the fuel layer and the secondary air is supplied above the fuel layer, is controlled in such a way that the intensity of the combustion of the fuel on the furnace grate is increased by increasing the oxygen content of the primary air and the intensity of the combustion in the secondary combustion zone is choked by decreasing the oxygen content in the secondary air, and that waste gas, preferably from the combustion process, is recycled in order to reduce the oxygen content of the secondary air.

FIGURE 1.



1

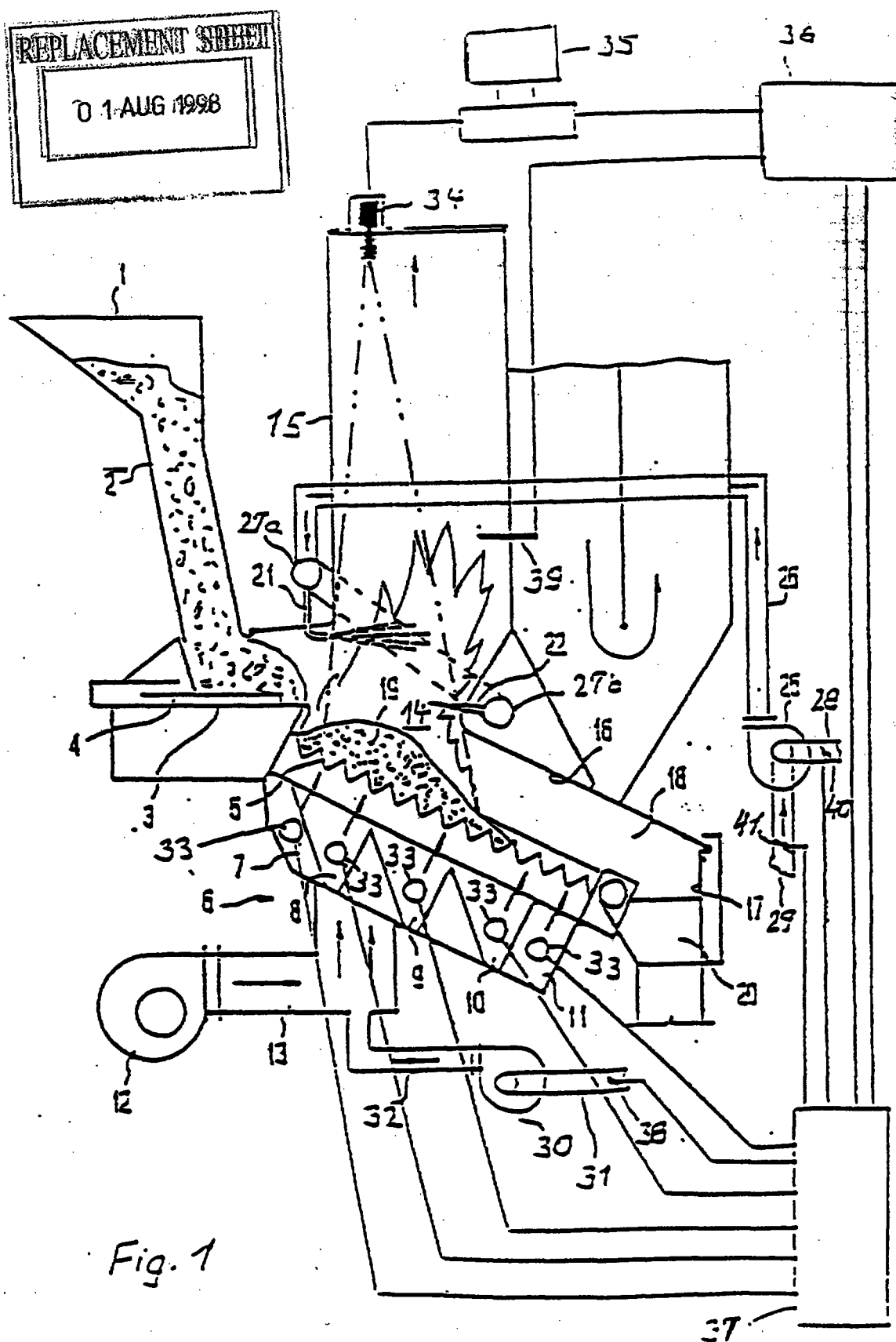


Fig. 1

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REDUCTION IN THE WASTE GAS QUANTITY
by a combination of O₂ enrichment and waste-gas recycling

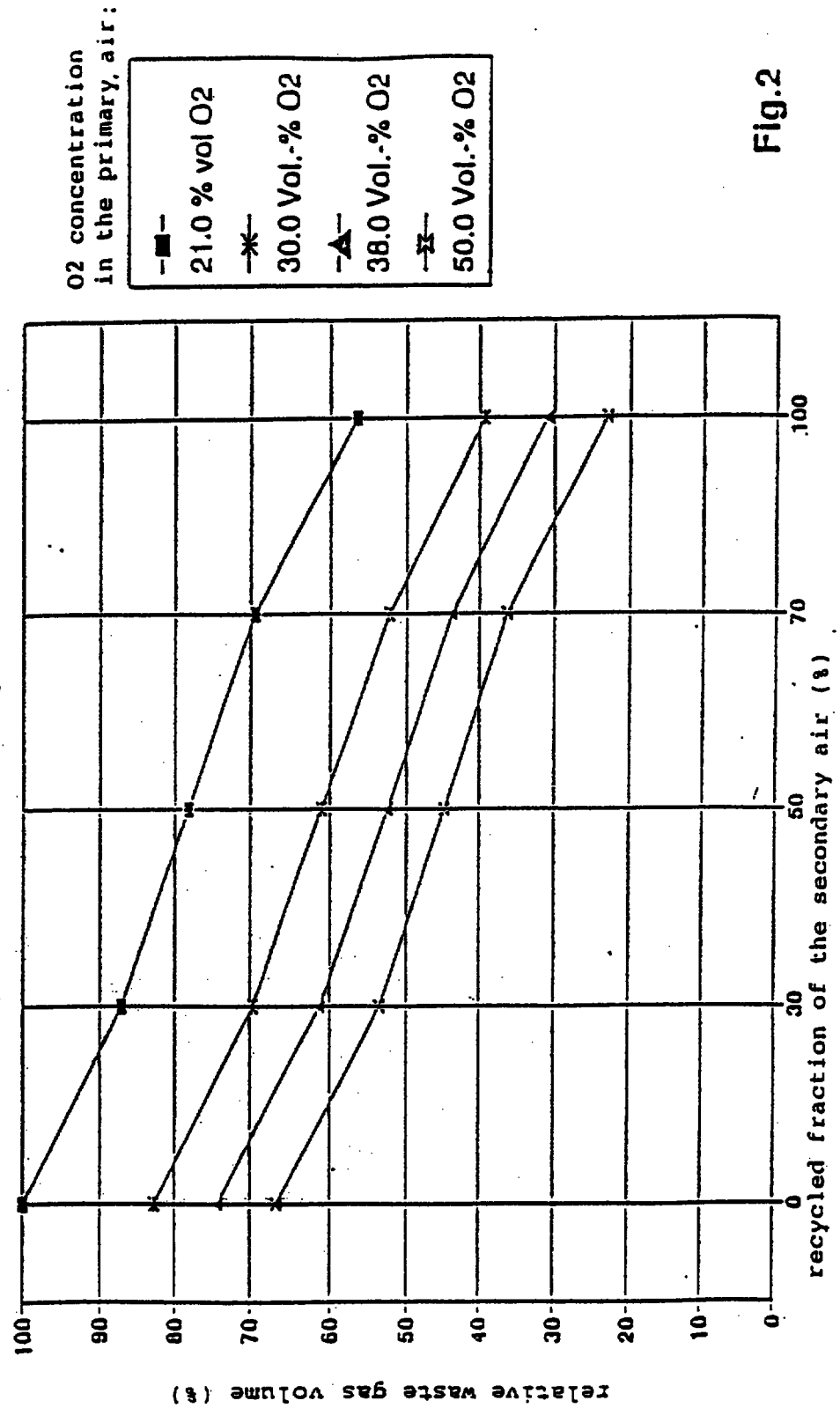


Fig.2

REPLACEMENT SHEET

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3

REPLACEMENT SHEET

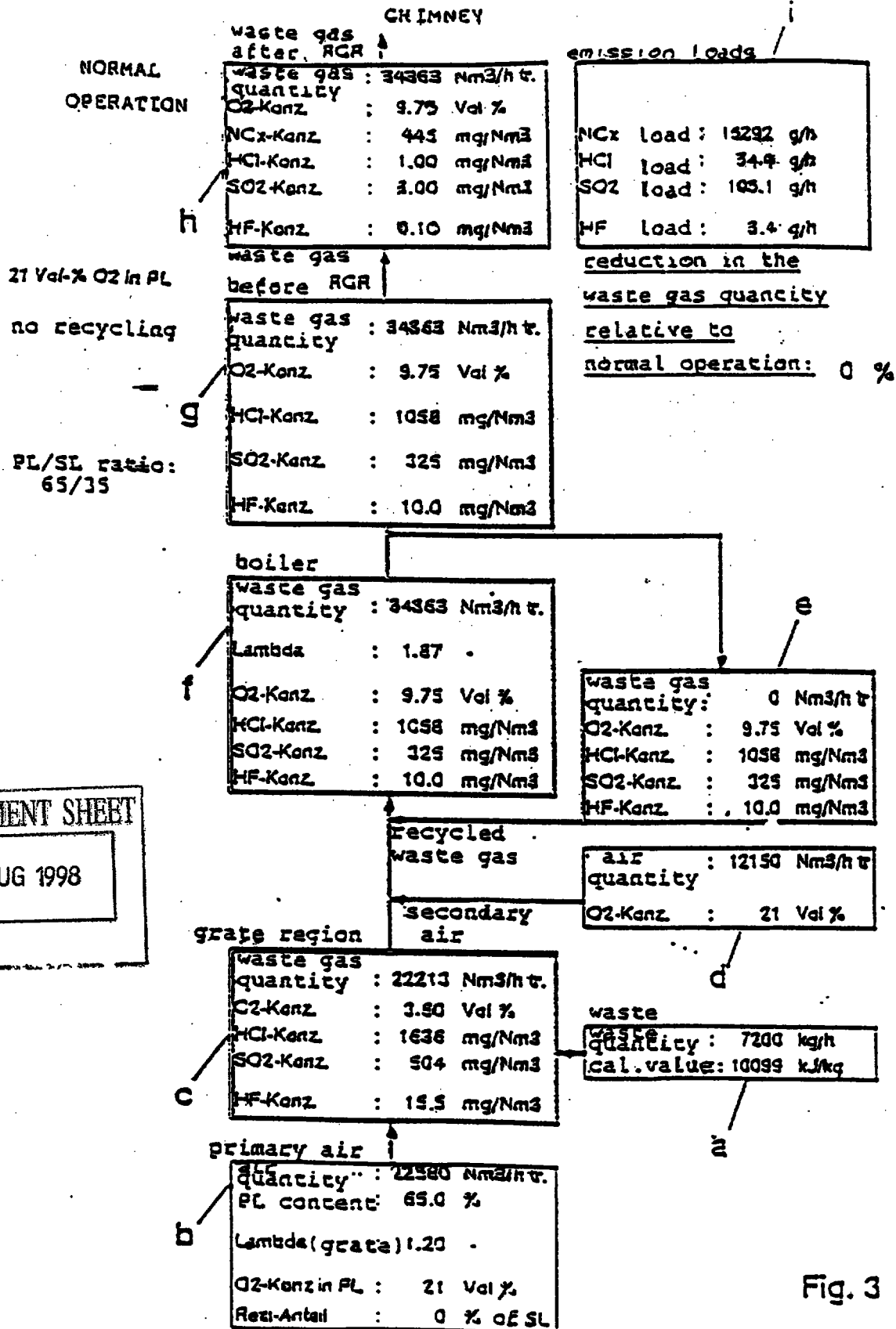


Fig. 3

4

CHIMNEY

waste gas

after RGR

waste gas : 23609 Nm³/h r.
 quantity
 C₂-Konz. : 11.54 Vol %
 HCl-Konz. : 510 mg/Nm³
 HCl-Konz. : 100 mg/Nm³
 SO₂-Konz. : 3.00 mg/Nm³
 HF-Konz. : 0.10 mg/Nm³

emission loads

NO_x load : 12040 g/h
 HCl load : 23.6 g/h
 SO₂ load : 70.3 g/h
 HF load : 2.4 g/h

OPERATION WITH

35 Vol-% O₂ in PL

no recycling

PL/SL ratio:

49/51

49/51

waste gas
before RGR

waste gas : 23609 Nm³/h r.
 quantity
 O₂-Konz. : 11.54 Vol %
 HCl-Konz. : 1538 mg/Nm³
 SO₂-Konz. : 473 mg/Nm³
 HF-Konz. : 14.5 mg/Nm³

reduction in the
 waste gas quantity
 relative to
 normal operation: 31 %

boiler

waste gas : 23609 Nm³/h r.
 quantity
 Lambda : 2.24
 C₂-Konz. : 11.54 Vol %
 HCl-Konz. : 1538 mg/Nm³
 SO₂-Konz. : 473 mg/Nm³
 HF-Konz. : 14.5 mg/Nm³

waste gas : 0 Nm³/h r.
 quantity
 O₂-Konz. : 11.54 Vol %
 HCl-Konz. : 1538 mg/Nm³
 SO₂-Konz. : 473 mg/Nm³
 HF-Konz. : 14.5 mg/Nm³

recycled
waste gassecondary
air

grate region

waste gas : 11459 Nm³/h r.
 quantity
 C₂-Konz. : 1.72 Vol %
 HCl-Konz. : 3188 mg/Nm³
 SO₂-Konz. : 975 mg/Nm³
 HF-Konz. : 30.0 mg/Nm³

air : 12150 Nm³/h r.
 quantity
 C₂-Konz. : 21 Vol %

waste : 7200 kg/h
 quantity
 cal. value: 10099 kJ/kg

primary air

air : 11820 Nm³/h r.
 quantity
 PL content : 49.3 %
 Lambda (grate) : 1.05
 C₂-Konz in PL : 35 Vol %
 Rezi-Anteil : 0 % of SL

REPLACEMENT SHEET

01 AUG 1998

Fig. 4

REPLACEMENT SHEET

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OPERATION WITH

35 Vol-% O₂ in PL

100 %

recycling

PL/SL ratio 65/35

CHIMNEY

waste gas
after RGA

waste gas quantity	: 13148 Nm ³ /hr.
O ₂ -Konz.	: 5.98 Vol %
NCx-Konz.	: 279 mg/Nm ³
HCl-Konz.	: 1.00 mg/Nm ³
SO ₂ -Konz.	: 3.00 mg/Nm ³
HF-Konz.	: 0.10 mg/Nm ³

emission loads

NCx load	: 3668 g/h
HCl load	: 12.1 g/h
SO ₂ load	: 99.4 g/h
HF load	: 1.3 g/h

waste gas
before RGA

waste gas quantity	: 13148 Nm ³ /hr.
O ₂ -Konz.	: 5.98 Vol %
HCl-Konz.	: 2762 mg/Nm ³
SO ₂ -Konz.	: 850 mg/Nm ³
HF-Konz.	: 26.2 mg/Nm ³

reduction in the
waste gas quantity
relative to
normal operation: 62 %

boiler

waste gas quantity	: 20413 Nm ³ /hr.
Lambda	: 1.40
O ₂ -Konz.	: 5.98 Vol %
HCl-Konz.	: 2762 mg/Nm ³
SO ₂ -Konz.	: 850 mg/Nm ³
HF-Konz.	: 26.2 mg/Nm ³

waste gas quantity	: 7270 Nm ³ /hr.
O ₂ -Konz.	: 5.98 Vol %
HCl-Konz.	: 2762 mg/Nm ³
SO ₂ -Konz.	: 850 mg/Nm ³
HF-Konz.	: 26.2 mg/Nm ³

recycled
waste gas

air quantity	: 0 Nm ³ /hr.
O ₂ -Konz.	: 21 Vol %

grate region

secondary
air

waste gas quantity	: 13143 Nm ³ /hr.
O ₂ -Konz.	: 5.98 Vol %
HCl-Konz.	: 2762 mg/Nm ³
SO ₂ -Konz.	: 850 mg/Nm ³
HF-Konz.	: 26.2 mg/Nm ³

waste quantity	: 7200 kg/h
cal. value	: 10099 kJ/kg

primary air

air quantity	: 13510 Nm ³ /hr.
PL content	: 65.0 %
Lambda(grate)	: 1.20
O ₂ -Konz in PL	: 35 Vol %
Regr-Antal	: 100 % of SL

Fig. 5

6

OPERATION WITH

50 Vol-% O₂ in PL

100 %

recycling

PL/SL ratio 50/50

CHIMNEY

waste gas
after RGR

waste gas quantity	: 8543 Nm ³ /h r.
O ₂ -Konz.	: 5.98 Vol %
HCl-Konz.	: 1.00 mg/Nm ³
SO ₂ -Konz.	: 3.00 mg/Nm ³
HF-Konz.	: 0.10 mg/Nm ³

emission loads

HCl load	: 8.5 g/h
SO ₂ load	: 25.6 g/h
HF load	: 0.3 g/h

waste gas
before RGR

waste gas quantity	: 8543 Nm ³ /h r.
O ₂ -Konz.	: 5.98 Vol %
HCl-Konz.	: 4246 mg/Nm ³
SO ₂ -Konz.	: 1307 mg/Nm ³
HF-Konz.	: 40.2 mg/Nm ³

reduction in the
waste gas quantity
relative to
normal operation: 75 %

boiler

waste gas quantity	: 17463 Nm ³ /h r.
Lambda	: 1.40
O ₂ -Konz.	: 5.98 Vol %
HCl-Konz.	: 4246 mg/Nm ³
SO ₂ -Konz.	: 1307 mg/Nm ³
HF-Konz.	: 40.2 mg/Nm ³

waste gas quantity	: 8920 Nm ³ /h r.
O ₂ -Konz.	: 5.98 Vol %
HCl-Konz.	: 4246 mg/Nm ³
SO ₂ -Konz.	: 1307 mg/Nm ³
HF-Konz.	: 40.2 mg/Nm ³

recycled
waste gas

air quantity	: 0 Nm ³ /h r.
O ₂ -Konz.	: 21 Vol %

grate region

waste gas quantity	: 8543 Nm ³ /h r.
O ₂ -Konz.	: 5.98 Vol %
HCl-Konz.	: 4246 mg/Nm ³
SO ₂ -Konz.	: 1307 mg/Nm ³
HF-Konz.	: 40.2 mg/Nm ³

waste quantity	: 7200 kg/h
cal. value	: 10099 kJ/kg

primary air

air quantity	: 8910 Nm ³ /h r.
PL content	: 50.0 %
Lambda (grate)	: 1.13
O ₂ -Konz in PL	: 30 Vol %
Rezi-Anteil	: 100 % of SL

Fig. 6