

Method for the Combustion Management in Firing Installations and Firing Installation

[01] The invention pertains to a method for the combustion management in firing installations, in which a primary combustion gas quantity is conveyed through the fuel into a primary combustion area, wherein part of the waste gas flow is extracted in the rear grate area and returned to the combustion process in the form of internal recirculation gas.

[02] The invention furthermore pertains to a firing installation, particularly for carrying out such a method, with a firing grate and a device that is arranged underneath the firing grate and serves for supplying primary combustion air through the firing grate, wherein at least one suction pipe for waste gas is provided in the combustion chamber above the firing grate, and wherein the suction side of a fan is connected to the suction pipe and the pressure side of said fan is connected to nozzles via a conduit.

[03] A corresponding method and a corresponding firing installation are known from EP 1 901 003 A1. In this case, recirculation gas is used in order to reduce the volume of the waste gas flow and the polluting emissions.

[04] The present invention is based on the objective of optimizing a method of this type in such a way that a particularly sound burn-out of solid fuels and a minimal nitrogen oxide formation are achieved.

[05] With respect to the process technology, this objective is attained with the characteristics of the method disclosed in claim 1. With respect to the system technology, the above-defined objective is attained with a firing installation with the characteristics disclosed in claim 13.

[06] The inventive method makes it possible to achieve an optimal burn-out of the waste gases with low nitrogen oxide formation, wherein a stable operation can be

realized with a minimal waste gas volume at low excess air coefficients of about $\lambda = 1,1$ to $\lambda = 1,5$.

[07] According to an enhanced method, it is proposed that no secondary combustion gas is supplied in a first waste gas flue.

[08] With respect to the process technology, it is advantageous if stoichiometric to highly substoichiometric reaction conditions with $\lambda = 1$ to $\lambda = 0,5$ are adjusted in the primary combustion area, and if the internal recirculation gas is supplied in a burn-out area that lies downstream of the primary combustion area referred to the flow direction.

[09] In this case, it is attempted to realize a dwell time of the waste gases of at least 2 seconds at a temperature in excess of 850°C after the last supply of the internal recirculation gas.

[10] An improved burn-out can be achieved by supplying a turbulence gas downstream of the primary combustion area referred to the flow direction in order to generate turbulence. This turbulence gas preferably consists of steam or inert gas.

[11] It is furthermore proposed to supply an external recirculation gas downstream of the turbulence gas supply referred to the flow direction, wherein said recirculation gas has passed through a steam generator and, if applicable, a waste gas cleaning system.

[12] In this case, internal recirculation gas may be supplied upstream of the turbulence gas supply.

[13] In order to cool the internal recirculation gas and to also lower the oxygen content, it is proposed to admix external recirculation gas, which has passed through a steam generator and, if applicable, a waste gas cleaning system, to the internal recirculation gas. This also positively affects the control of the gas burn-out.

[14] In order to influence the air ratio λ in the primary combustion or the gasification, it is proposed to admix air to the internal recirculation gas. This also makes it possible to cool the internal recirculation gas.

[15] The primary combustion can be substoichiometrically managed over a broad range such that air ratios λ far below 1, namely as low as $\lambda = 0,5$, can be achieved. As a result, syngas heating values up to $4000 \text{ kJ} / \text{Nm}^3$ can be measured in the gasification area of the combustion chamber such that a gasification process is carried out. In practical applications, a syngas heating value in excess of $2000 \text{ kJ} / \text{Nm}^3$, preferably in excess of $3000 \text{ kJ} / \text{Nm}^3$, is adjusted in the primary combustion area upstream of the internal recirculation gas supply referred to the flow direction.

[16] According to a special process management, it is proposed that the fuel gasifies on a gasification grate, that the cinder burn-out is ensured in the downstream burn-out grate, and that the gas burn-out is achieved in a burn-out chamber by supplying the internal recirculation gas to the waste gas flow at this location in order to burn out the gases and to achieve excess air coefficients of $\lambda = 1,1$ to $\lambda = 1,5$. The combustion management therefore can be controlled in such a way that the primary fuel conversion on the grate takes place under substoichiometric conditions, i.e. the fuel gasifies and the combustion does not take place until the internal recirculation gas is once again added.

[17] Due to the defined addition of primary air and the extraction of internal recirculation gas, it is possible to gasify the fuel on the gasification grate, to control the cinder burn-out in the downstream burn-out grate and to control the gas burn-out in a burn-out chamber in a compact hybrid process. In this case, the gasification grate and the burn-out grate may consist of downstream grates or also be realized in the form of a grate. Downstream air zones on a single and, if applicable, longer grate may be assigned to the gasification grate and the burn-out grate. These air zones may be realized in the form of areas or chambers. The post-combustion air zone or post-combustion chamber corresponds to the segment of the process, in which the internal recirculation gas is

supplied to the waste gas flow in order to burn out the gases and to achieve excess air coefficients of $\lambda = 1,1$ to $\lambda = 1,5$.

[18] In order to carry out the inventive method, it is proposed to arrange the nozzles downstream of the firing grate referred to the flow direction in the form of first gas supply nozzles.

[19] It is advantageous if the design of the gas flue and the arrangement of the nozzles are realized in such a way that the waste gases reach a dwell time of at least 2 seconds at a temperature in excess of 850°C after the last supply of the internal recirculation gas.

[20] It is furthermore proposed to arrange turbulence nozzles with an inert gas connection or a steam connection between the firing grate and the nozzles.

[21] Nozzles for waste gases of an external waste gas circulation may be arranged between the firing grate and the nozzles.

[22] Other control options are realized if the suction pipe features an inlet for admixing ambient air.

[23] According to a simple constructive design, it is proposed that the gasification grate and the burn-out grate represent serially arranged air zones on a single grate.

[24] The invention is described in greater detail below with reference to the drawings. In these drawings,

Figure 1 shows a schematic longitudinal section through a firing installation,

Figure 2 schematically shows an air conduction according to EP 1 901 003 A1,

Figure 3 schematically shows an inventive air conduction without secondary air,

- Figure 4 schematically shows the air conduction illustrated in Figure 3 with additional nozzles for introducing steam or inert gas,
- Figure 5 schematically shows an air conduction according to Figure 4 with an additional supply of external waste gas,
- Figure 6 schematically shows an air conduction with an additional supply of internal recirculation gas underneath the steam injection,
- Figure 7 schematically shows a combustion management with an external gas recirculation in the form of a gas mixture of internal and external gas recirculation,
- Figure 8 schematically shows a process management according to Figure 7, in which ambient air is admixed to the internal gas recirculation,
- Figure 9 shows an exemplary indication of air ratios in different areas of the schematically illustrated installation,
- Figure 10 schematically shows the gasification and burn-out sequence,
- Figure 11 schematically shows the gasification and combustion of the solid fuel and the burn-out of the waste gases,
- Figure 12 schematically shows a process sequence with internal recirculation, gasification, combustion and burn-out, and
- Figure 13 shows a longitudinal section through a firing installation with a combustion air conduction according to Figure 6.

[25] The firing installation illustrated in Figure 1 features a feeding hopper 1 with a downstream feeding chute 2 for delivering the fuel onto an infeed table 3, on which charging pistons 4 are provided in a reciprocating fashion in order to deliver the fuel arriving from the feeding chute 2 onto a firing grate 5, on which the combustion of the

fuel takes place, wherein it is irrelevant whether the grate consists of an inclined or horizontal grate regardless of its operating principle.

[26] A device for supplying primary combustion air, which is altogether identified by the reference symbol 6, is arranged underneath the firing grate 5 and may comprise several chambers 7 to 11, to which primary combustion air can be supplied by means of a fan 12 via a conduit 13. Due to the arrangement of the chambers 7 to 11, the firing grate is divided into several underblast zones such that the primary combustion air can be adjusted differently on the firing grate in accordance with the respective requirements.

[27] A firing chamber 14 is located above the firing grate 5, wherein the front segment of said firing chamber transforms into a waste gas flue, to which not-shown downstream units such as, for example, a waste heat recovery boiler and a waste gas cleaning system are connected.

[28] In its rear area, the firing chamber 14 is defined by a ceiling 16, a rear wall 17 and sidewalls 18. Gasification of the fuel identified by the reference symbol 19 takes place on the front segment of the firing grate 5, above which the waste gas flue 15 is located. Most of the primary combustion air is supplied through the chambers 7, 8 and 9 in this area.

[29] Only fuel that has been largely burnt out, i.e. cinder, is located on the rear segment of the firing grate 5 and primary combustion air essentially is in this area only supplied via the chambers 10 and 11 in order to cool and to realize the residual burn-out of this cinder.

[30] The burnt-out fractions of the fuel then drop into a cinder discharge 20 at the end of the firing grate 5. The nozzles 21 and 22 are provided in the lower area of the waste gas flue 15 and supply internal recirculation gas from the rear area of the firing chamber 14 to the ascending waste gas in order to thoroughly mix the waste gas flow and to cause a post-combustion of the combustible fractions in the waste gas.

[31] For this purpose, waste gas referred to as internal recirculation gas is extracted from the rear segment of the combustion chamber, which is defined by the ceiling 16, the rear wall 17 and the sidewalls 18. In the exemplary embodiment shown, a suction opening 23 is provided in the rear wall 17. This suction opening 23 is connected to the suction side of a fan 25 such that waste gas can be extracted. The pressure side of the fan is connected to a conduit 26 that supplies the extracted waste gas quantity to nozzles 27 in the upper area of the waste gas flue 15, namely the burn-out area 28. Part of the recirculation gas is conveyed onward from this location to the nozzles 21 and 22.

[32] The waste gas flue 15 is significantly constricted in the burn-out area 28 or above this burn-out area in order to intensify the turbulence and the mixing effect of the waste gas flow, wherein the nozzles 27 are located in this constricted area. However, it would also be possible to provide baffles or elements 29 that interfere with the gas flow and thereby generate turbulence.

[33] Nozzles 30 and 31 are provided on one or more levels in the waste gas flue 15 in order to supply steam and/or inert gas to the waste gas on one or more levels. In addition, nozzles 32 and 33 are provided in order to supply external recirculation waste gas to the waste gas on one or more levels of the waste gas flue 15. This external recirculation waste gas, which has already passed through a steam generator and, if applicable, a (not-shown) waste gas cleaning system, not only can be supplied to the nozzles 32 and 33, but also to the internal recirculation waste gas, preferably upstream of the fan 25, via the conduit 34. In addition, ambient air can be admixed to the internal recirculation gas via the conduit 35.

[34] Based on the known method for supplying combustion gas according to EP 1 901 003 A1, which is illustrated in Figure 2, Figures 3-8 show different variations of the inventive method, in which the reference symbol 51 respectively identifies the primary air, the reference symbol 52 identifies the internal gas recirculation, the reference symbol 53 identifies the waste gas, the reference symbol 54 identifies the secondary air,

the reference symbol 55 identifies the steam or inert gas, the reference symbol 56 identifies external waste gas and the reference symbol 57 identifies ambient air.

[35] Figure 3 shows that it is possible to completely forgo the secondary air illustrated in Figure 2. In Figure 4, steam or inert gas 55 is added underneath the recirculation gas 52. Figure 5 shows the external waste gas circulation 56 and Figure 6 shows an additional supply of internal recirculation gas 52 underneath the steam injection 55. In the design according to Figure 7, a gas mixture of internal gas recirculation 52 and external gas recirculation 56 is supplied to the waste gas as internal recirculation gas 52.

[36] Figure 8 shows the admixing of ambient air 57 to the internal gas recirculation 52.

[37] Figure 9 shows that a constriction 61 may be provided in the waste gas flue 60 underneath the addition of the recirculation gas 52, wherein steam or inert gas 55 can be injected in the area of this constriction. In this case, for example, lambda values of 1,15 can be adjusted above the firing grate, lambda values of 0,5 can be adjusted in the area of the constriction and lambda values of 1,3 can be adjusted above the supply of the gas of the internal recirculation 52, wherein gases with a lambda value of 0,65 can be extracted in the rear area of the grate and added with a lambda value of 0,15 during the addition of air. The area underneath the addition of the internal recirculation gas 52 therefore is substoichiometric and forms the gasification area 62 whereas the area above the addition of the internal recirculation gas is hyperstoichiometric and serves as burn-out area 63.

[38] Gasification process flowcharts are illustrated in Figures 10-12. Garbage 70 is respectively supplied in a gasification area 71, in which the garbage gasifies into cinder 73 together with primary air 72 at a lambda value far below 1.

[39] A syngas 74 with a heating value up to $4 \text{ MJ} / \text{m}^3$ is created during the gasification and burnt out into waste gas 77 in a burn-out area 76 with a lambda value of 1,1 to 1,5 after the addition of external recirculation gas 75. In this case, the addition of air 78 should be completely eliminated, if possible.

[40] In case the cinder 73 is not completely burnt out during the gasification 71, a combustion area 79 for the cinder is arranged directly downstream, wherein the cinder 73 combusts into a well burnt-out cinder 81 in said combustion area together with primary air 80 at a lambda values above 1. This combustion area produces a waste gas 82 with a lambda value >1 , which is supplied to the burn-of area 76 in the form of internal recirculation gas.

[41] Figure 13 shows a firing installation with a combustion air conduction according to the design illustrated in Figure 6. This firing installation is designed similar to the firing installation illustrated in Figure 1 and suitable for the process managements schematically illustrated in Figures 2 to 12 just as the firing installation illustrated in Figure 1. This figure shows an additional supply of internal recirculation gas 52 underneath the schematically indicated injection 55 of steam or inert gas. An injection of external recirculation gas 56 is provided above the steam or inert gas injection 55.

Claims:

1. A method for the combustion management in firing installations, in which a primary combustion gas quantity (72) is conveyed through the fuel (70) into a primary combustion area (71), wherein part of the waste gas flow is extracted in the rear grate area and returned to the combustion process in the form of internal recirculation gas (52, 82), **characterized in that** no secondary combustion air (54) is supplied between the grate (5) and the supply of the internal recirculation gas (52, 82).
2. The method according to claim 1, **characterized in that** no secondary combustion gas (54, 78) is supplied in a first waste gas flue (15).
3. The method according to one of the preceding claims, **characterized in that** stoichiometric to highly substoichiometric reaction conditions with $\lambda = 1$ to $\lambda = 0,5$ are adjusted in the primary combustion area (71), and in that the internal recirculation gas (82) is supplied in a burn-out area (76) that lies downstream of the primary combustion area (71) referred to the flow direction.
4. The method according to one of the preceding claims, **characterized in that** the waste gases have a dwell time of at least 2 seconds at a temperature in excess of 850°C after the last supply (27) of the internal recirculation gas (52, 82).
5. The method according to one of the preceding claims, **characterized in that** a turbulence gas (55) is supplied downstream of the primary combustion area (71) referred to the flow direction in order to generate a turbulence.
6. The method according to claim 5, **characterized in that** the turbulence gas (55) consists of steam or inert gas.
7. The method according to claim 5, **characterized in that** an external recirculation gas (56) is supplied downstream of the supply of turbulence gas (55) referred to

the flow direction, wherein said recirculation gas has passed through a steam generator and, if applicable, a waste gas cleaning system.

8. The method according to claim 5 or 6, ***characterized in that*** internal recirculation gas (52, 82) is supplied upstream of the supply of turbulence gas (55) referred to the flow direction.
9. The method according to one of the preceding claims, ***characterized in that*** external recirculation gas (56), which has passed through a steam generator and, if applicable, a waste gas cleaning system, is admixed to the internal recirculation gas (52, 82).
10. The method according to one of the preceding claims, ***characterized in that*** air (57) is admixed to the internal recirculation gas (52, 82).
11. The method according to one of the preceding claims, ***characterized in that*** a syngas heating value in excess of 2000 kJ/Nm^3 , preferably in excess of 3000 kJ/Nm^3 , is adjusted in the primary combustion area (71) upstream of the addition of the internal recirculation gas (52, 82) referred to the flow direction.
12. The method according to one of the preceding claims, ***characterized in that*** the fuel (70) gasifies on a gasification grate, in that the cinder burn-out is ensured in the downstream burn-out grate, and in that the gas burn-out is achieved in a burn-out chamber by supplying the internal recirculation gas (52, 82) to the waste gas flow at this location in order to burn out the gases and to achieve excess air coefficients of $\lambda = 1,1$ to $\lambda = 1,5$.
13. A firing installation, particularly for carrying out a method according to one of the preceding claims, with a firing grate (5) and a device (7-11) that is arranged underneath the firing grate (5) and serves for supplying primary combustion air through the firing grate (5), wherein at least one suction pipe (24) for waste gas is provided in the combustion chamber (14) above the firing grate (5), and

wherein the suction side of a fan (25) is connected to the suction pipe (24) and the pressure side of said fan is connected to nozzles (27) via a conduit (26), ***characterized in that*** the nozzles (27) are arranged above the firing grate (5) in such a way that no air supply is arranged between the firing grate (5) and the nozzles (27).

14. The firing installation according to claim 12, ***characterized in that*** the nozzles (27) are arranged downstream of the firing grate (5) referred to the flow direction in the form of first gas supply nozzles.
15. The firing installation according to claim 12 or 13, ***characterized in that*** the design of the waste gas flue (15) and the arrangement of the nozzles (27) are realized in such a way that the waste gases reach a dwell time of at least 2 seconds at a temperature in excess of 850°C after the last supply of the internal recirculation gas (52, 82).
16. The firing installation according to one of the preceding device claims, ***characterized in that*** turbulence nozzles (30, 31) with an inert gas connection or a steam connection are arranged between the firing grate (5) and the nozzles (27).
17. The firing installation according to one of the preceding device claims, ***characterized in that*** nozzles (32, 33) for waste gases of an external waste gas recirculation are arranged between the firing grate (5) and the nozzles (27).
18. The firing installation according to one of the preceding device claims, ***characterized in that*** the suction pipe (24) features an inlet for admixing ambient air (57).
19. The firing installation according to one of the preceding device claims, ***characterized in that*** the gasification grate and the burn-out grate represent serially arranged air zones on a single grate (5).