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(54) AN AIR-GAS MIXTURE BURNING APPLIANCE WITH A VARIABLE EQUIVALENCE RATIO IGNITION SEQUENCE

LUFT-GAS-GEMISCHVERBRENNUNGSVORRICHTUNG MIT ZÜNDSEQUENZ MIT VARIABLEM ÄQUIVALENZVERHÄLTNIS

APPAREIL DE COMBUSTION DE MÉLANGE AIR-GAZ À SÉQUENCE D'ALLUMAGE À RAPPORT D'ÉQUIVALENCE VARIABLE

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(56) References cited:
GB-A- 2 016 138
JP-A- H10 300 077
JP-A- S62 284 122
US-A- 3 938 936
US-A- 5 035 607
US-A1- 2008 216 810
US-A1- 2016 047 547

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Description

Background of the Invention

[0001] The present invention relates to an air-gas mixture burning appliance that comprises a burning unit for burning a combustible air-gas mixture, a flame detector for sensing presence of a flame in the burning unit, an air-gas mixing unit that is arranged upstream of the burning unit for mixing of air and gas to form the combustible air-gas mixture, and a gas supply unit that is arranged upstream of the air-gas mixing unit. More specifically, the present invention relates to a method of operating such an air-gas mixture burning appliance.

[0002] From the state of the art, an air-gas mixture burning appliance with an air-gas mixing unit, a burning unit, a flame detector, and a gas supply unit is known. In this air-gas mixture burning appliance, hydrogen may be used as gas and mixed with air to form a combustible air-gas mixture.

[0003] More specifically, such an air-gas mixture burning appliance usually mixes air and gas directly before the burning unit. During the ignition phase, the combustible air-gas mixture enters the burning unit where it is ignited at a low heat input to assist with stability and acoustics upon start up. However, sometimes the combustible air-gas mixture is not ignited immediately, which can lead to a build-up of the combustible air-gas mixture after the burning unit. A delayed ignition, which refers to igniting the built-up combustible air-gas mixture, usually leads to an explosion that may damage internal components of the air-gas mixture burning appliance and endanger the surrounding environment.

[0004] Delayed ignition is unproblematic for current natural gas burning appliances. However, delayed ignition may have severe consequences for appliances that burn a combustible air-hydrogen mixture. For example, the explosion caused by a delayed ignition of a combustible air-hydrogen mixture may not only damage internal components of the appliance, but damaged internal components may be ejected from the boiler case of the appliance. Moreover, the high sound levels that such an explosion produces, could potentially lead to hearing damage of people who are in the vicinity of such an appliance.

[0005] Current appliances include a controller that activates a spark electrode and then opens the gas valve for a pre-set ignition safety time. The gas valve remains open If ignition and a stable flame is achieved during the pre-set ignition safety time. Current natural gas burning appliances light a combustible air-natural gas mixture that has a fixed concentration.

[0006] In the remainder of this description, the term "gas" refers as any fuel in gaseous form that when mixed with air forms a combustible air-gas mixture. Examples for such a gas include hydrogen, propane, butane, methane, liquefied petroleum gas, etc.

[0007] The concentration of the combustible air-gas mixture, which is sometimes also referred to as the air-gas ratio or the air to gas ratio, is the mass of air per mass of gas in the air-gas mixture. A complete combustion takes place when all the gas of the combustible air-gas mixture is burned. In other words, the exhaust gas is free of unburned gas. The air-gas ratio of a complete combustion is referred to as the stoichiometric air-gas ratio, and the ideal gas-air ratio is called stoichiometric gas-air ratio.

[0008] The equivalence ratio between gas and air is defined as the ratio of the actual gas-air ratio to the stoichiometric gas-air ratio. The equivalence ratio between gas and air is sometimes also referred to as the equivalence gas-air ratio and denoted by the symbol ϕ. The inverse of the equivalence gas-air ratio is sometimes referred to as the equivalence air-gas ratio, which is also denoted by the symbol λ. Thus, $\phi = 1/\lambda$. The equivalence air-gas ratio is also defined as the ratio of the actual air-gas ratio to the stoichiometric air-gas ratio.

[0009] Thus, the equivalence gas-air ratio is equal to the equivalence air-gas ratio and equal to one if the combustion is stoichiometric (i.e., $\phi = \lambda = 1$). If the combustion is lean with excess air, the equivalence gas-air ratio is smaller than one (i.e., $\phi < 1$). and the equivalence air-gas ratio greater than one (i.e., $\lambda>1$). Similarly, if the combustion is rich with incomplete combustion, the equivalence gas-air ratio is greater than one (i.e., $\phi > 1$) and the equivalence air-gas ratio smaller than one (i.e., $\lambda<1$).

[0010] Current natural gas burning appliances light a combustible air-natural gas mixture that has a fixed, rich concentration slightly below that of the stoichiometric air-gas ratio (i.e., $\lambda<1$). However, a delayed ignition of a combustible air-hydrogen mixture with an air-hydrogen ratio slightly below that of the stoichiometric air-hydrogen ratio would cause serious damage to the air-gas mixture burning appliance and to people who are in the vicinity of such an appliance during the occurrence of such a delayed ignition.

[0011] Document KR 100839523 B1 describes a burner for the combustion of hydrogen and oxygen gas. The connection between the burner and a hydrogen gas storage tank and an oxygen gas storage tank is provided with flow control valves to control the gas flow rate of hydrogen gas and oxygen gas such that 0.65 m^3 of oxygen gas are mixed with 1 m^3 of hydrogen gas for combustion, whereby 77% of the total volume percentage (%) of oxygen is supplied from the oxygen storage tank, and the remaining 23% of the total volume percentage of oxygen is supplied from the combustion air supplied by external combustion air suction means. Document KR 19980062747 U describes a burner pin structure of a gas boiler that is designed to improve ignition performance, reduce ignition noise, and reduce ignition failure due to delayed ignition by allowing a weak flame to be injected in a diagonal direction.

[0012] Document JP S62 284122 A describes a proportional control valve with a valve body, displaced by the spring load of a spring and an electromagnetic force depending on the amount of conduction for a coil, and controls the supplying amount of fuel in accordance with the amount of conduction for the coil. When thermal power is to be changed, the amount of power conduction for the coil is set once at a value A by a pulse generating circuit and the opening degree of the proportional control valve is set at the opening degree upon the maximum combustion, for example. Thereafter, the amount of power conduction, corresponding to the amount of combustion set by a thermal power regulating switch, is supplied to the coil through a thermal power regulation processing circuit, a proportional valve electric current switching circuit and a proportional valve driving circuit. According to this method, the opening degree of the proportional control valve is set in a predetermined opening degree in accordance with the setting condition of the thermal power regulating switch at all times regardless of the hysteresis characteristics. Further, when the opening degree of the proportional control valve is changed, an objective amount of conduction may be set after setting once the amount of conduction upon the minimum combustion.

[0013] Document JP H10 300077 A describes an electromagnetic type safety valve that is interposed in a gas supply path and an ignition plug connected to a piezoelectric element that is mounted near a burner. A microswitch is turned on in response to an operation of ignition and a controller detects the operation of ignition. A latch type solenoid valve is electrically energized in the direction of moving a plunger to the position of opening the valve. At the moment of electric energization, the latch type solenoid valve remains unchanged if opened. When made for ignition, the electric energization is continued for about two seconds. As a result, even when the piezoelectric element is struck by the hammer to generate vibration, the vibration occurs during the continuation of the electric energization. During the period, the plunger is attracted by a magnetic force of a permanent magnet or the like, thereby keeping the valve open.

Summary of the Invention

[0014] The present invention relates to a method of operating an air-gas mixture burning appliance that comprises an air-gas mixing unit, a burning unit that is arranged downstream of the air-gas mixing unit, a flame detector, and a gas supply unit that is arranged upstream of the air-gas mixing unit, the gas supply unit comprising a first gas flow channel with a gas flow restrictor, a second gas flow channel that is hydraulically parallel to the first gas flow channel and comprises a first gas valve, and a second gas valve that is arranged upstream of the first and second gas flow channels. The method comprises closing the first gas valve, opening the second gas valve, with the gas flow restrictor, restricting flow of gas through the first gas flow channel to the air-gas mixing unit, with the air-gas mixing unit, mixing air with the gas from the first gas flow channel to form a combustible air-gas mixture, igniting the combustible air-gas mixture in the burning unit, with the flame detector, sensing for presence of a flame in the burning unit, and in response to failing to sense the flame in the burning unit, maintaining the first gas valve in the closed position.

[0015] Advantageously, the inventive method may prevent the build-up of a damaging concentration of the combustible air-gas mixture in the burning unit of the air-gas mixture burning appliance, thereby eliminating the risks associated with a delayed ignition of such a damaging amount of the combustible air-gas mixture.

[0016] Preferably, the combustible air-gas mixture has a first equivalence ratio between gas and air.

[0017] Thus, the inventive method may adjust the equivalence ratio between gas and air to a first value for as long as no flame is detected in the burning unit.

[0018] Preferably, the first equivalence ratio between gas and air is smaller than 1.

[0019] Accordingly, the actual gas-air ratio is lean and below the stoichiometric gas-air ratio, which may prevent an explosion in case of a delayed ignition.

[0020] According to one aspect, the method may further comprise in response to sensing presence of the flame in the burning unit, opening the first gas valve.

[0021] Thus, the gas-air mixture burning unit may adjust the equivalence ratio between gas and air to a different value after ignition of the combustible air-gas mixture, thereby ensuring a clean and efficient combustion after the ignition of the combustible air-gas mixture.

[0022] Preferably, the method may further comprise waiting for a predetermined duration between sensing presence of the flame in the burning unit and opening the first gas valve.

[0023] Accordingly, the burning unit may ensure the establishment of a stable flame during the predetermined delay.

[0024] Preferably, the predetermined duration is between 0.5 seconds and 6 seconds.

[0025] Thus, the predetermined delay may allow for the establishment of a stable flame across the entire burner surface.

[0026] According to one aspect, the method may further comprise with the air-gas mixing unit, mixing air with the gas from the first and second gas flow channels to form another combustible air-gas mixture.

[0027] Thus, the air-gas mixing unit may vary the equivalence ratio between gas and air of the combustible gas-air mixture.

[0028] Preferably, the other combustible air-gas mixture has a second equivalence ratio between gas and air that is different than the first equivalence ratio.

[0029] Thus, the air-gas mixing unit may set the equivalence ratio between gas and air of the combustible gas-air mixture to a different value.

[0030] Preferably, the second equivalence ratio between gas and air is greater than the first equivalence ratio.

[0031] Thus, the air-gas mixture burning appliance may perform a more efficient combustion of the combustible air-gas mixture.

Brief Description of the Drawings

[0032] Exemplary embodiments of the present invention are described in detail hereinafter with reference to the attached drawings. In these attached drawings, identical or identically functioning components and elements are labelled with identical reference signs and they are generally only described once in the following description.

Fig. 1 shows a schematic view of an air-gas mixture burning appliance, during the ignition phase,

Fig. 2 shows a schematic view of the air-gas mixture burning appliance of Fig. 1, after establishment of a stable flame,

Fig. 3 shows a schematic view of a gas supply unit, and

Fig. 4 shows a functional diagram for illustrating operation of the air-gas mixture burning appliance of Fig. 1 to Fig. 3.

Detailed Description

[0033] Fig. 1 shows an exemplary air-gas mixture burning appliance 100 with an air-gas mixing unit 110, a burning unit 120, and a flame detector 150. By way of example, the air-gas mixture burning appliance 100 may be used in a boiler or, more generally, in a building heating system. Preferably, the gas used is hydrogen such that the air-gas mixture burning appliance 100 forms an air-hydrogen mixture burning appliance.

[0034] The air-gas mixing unit 110 is preferably adapted for mixing of air and gas to form a combustible air-gas mixture 130. Preferentially, the combustible air-gas mixture 130 is a homogenous mixture of the air and the gas.

[0035] By way of example, the air-gas mixing unit 110 includes an air supply unit 112 and a gas supply unit 116. Illustratively, the air supply unit 112 includes a fan 114 that may be operated with an adaptable fan speed and/or within predetermined ranges of fan speeds to draw air into the air-gas mixing unit 110.

[0036] The air supply unit 112 and the gas supply unit 116 may be interconnected via a mixer 118 which forms a corresponding discrete point of mixing 119. Preferably, the combustible air-gas mixture 130 is formed at the discrete point of mixing 119 and guided via the mixer 118 to the burning unit 120.

[0037] Illustratively, the burning unit 120 is provided with a burner surface 124 that is arranged downstream of the air-gas mixing unit 110 such that the combustible air-gas mixture 130 that is formed at the discrete point of mixing 119 flows towards the burner surface 124. The combustible air-gas mixture 130 is burned by the burning unit 120 and, more specifically, at the burner surface 124.

[0038] By way of example, the burner surface 124 is illustrated with a comparatively small flame 122 which occurs e.g. during an ignition phase of the air-gas mixture burning appliance 100. As an example, during such an ignition phase, the air-gas mixing unit 110 may have a low firing rate, i.e. a comparatively low rate at which feed of the combustible air-gas mixture 130 from the air-gas mixing unit 110 to the burning unit 120 occurs, in terms of volume, heat units, or weight per unit time. As another example, during such an ignition phase, the air-gas mixing unit 110 may provide a combustible air-gas mixture with a first equivalence rate between gas and air. If desired, the combustible air-gas mixture may be a lean combustible air-gas mixture with an equivalence ratio between gas and air that is below the stoichiometric ratio between gas and air. The comparatively small flame 122 is illustratively stabilised against the burner surface 124 and detected by means of the flame detector 150.

[0039] According to one aspect, the flame detector 150 is provided for sensing presence of a flame 122 in the burning unit 120. By way of example, the flame detector 150 detects a flame signal 160 in the burning unit 120. Thus, the flame detector 150 is suitable for determining whether a flame 122 is present in the burning unit 120, or not. However, it should be noted that suitable flame detection techniques that may be used with the flame detector 150 are well-known to the person skilled in the art and are, therefore, not described in more detail, for brevity and conciseness. For instance, the flame detector 150 may use any suitable sensing element for sensing presence of the flame 122 in the burning unit 120.

[0040] Illustratively, the flame detector 150 is connected to a controller 140. Preferably, the controller 140 is adapted to control supply of gas to the air-gas mixing unit 110, in particular to control the gas supply unit 116, on the basis of a detection signal 142 provided by the flame detector 150. If desired, the controller 140 may control a gas valve of the gas supply unit 116 on the basis of the detection signal 142.

[0041] The detection signal 142 may be created and/or provided by the flame detector 150, or alternatively by the controller 140, by comparing the detected flame signal 160 with a predetermined flame detection threshold. Thus, the controller 140 may create a control signal 182 on the basis of the detection signal 142. If desired, the gas supply unit 116 may use the detection signal 142 e.g. to regulate the flow of gas to the air-gas mixing unit 110 such that the combustible air-gas mixture 130 has a variable equivalence ratio between gas and air based on the detection signal 142, i.e., based on whether the flame detector 150 senses the presence of a flame 122 in the burning unit 120 or fails to sense the presence of a flame 122 in the burning unit 120.

[0042] As an example, the gas supply unit 116 may supply a first flow of gas to the air-gas mixing unit 120 such that the combustible air-gas mixture 130 has a first equivalence ratio between gas and air when the flame detector 150 fails to sense the presence of the flame 122. If desired, the first equivalence ratio between gas and air may be smaller than 1. In other words, the combustible air-gas mixture 130 may be lean.

[0043] As another example, the gas supply unit 116 may supply a second flow of gas to the air-gas mixing unit 120 such that the combustible air-gas mixture 130 has a second equivalence ratio between gas and air that is different than the first equivalence ratio between gas and air when the flame detector 150 senses the presence of the flame 122. If desired, the second equivalence ratio between gas and air may greater than the first equivalence ratio between gas and air. Thus, the gas supply unit 116 may regulate the equivalence ratio between gas and air by providing a richer combustible air-gas mixture 130 when the flame detector 150 senses the presence of the flame 122.

[0044] In some embodiments, the gas valve 184 may open with a predetermined delay after the flame detector 150 senses the presence of the flame 122. For example, the gas valve 184 may open with a predetermined delay that is between 0.1 seconds and 20 seconds. Preferably, the predetermined delay is between 0.5 seconds and 6 seconds.

[0045] Illustratively, the control circuit 140 may include a timer. Upon receipt of the detection signal 142 from the flame detector 150, the control circuit 140 may trigger the timer. When the timer has timed the predetermined delay, the control circuit 140 may send control signal 182 to the gas supply unit 116.

[0046] Fig. 2 shows the air-gas mixture burning appliance 100 of Fig. 1 with the air-gas mixing unit 110, the burning unit 120, the controller 140, and the flame detector 150. However, in contrast to Fig. 1, the air-gas mixture burning appliance 100 is shown with a greater flame 122 after the ignition phase. As an example, the air-gas mixing unit 110 may be operated at a high firing rate, i.e. a comparatively high rate at which feed of the combustible air-gas mixture 131 from the air-gas mixing unit 110 arrives at the burning unit 120, which may lead to the greater flame 122. The high firing rate may be associated with a normal operating range of the burning unit 120 compared to the low firing rate that is associated with the ignition phase of the air-gas mixture burning appliance 100, as described in Fig. 1.

[0047] As another example, after the ignition phase, the air-gas mixing unit 110 may provide a combustible air-gas mixture 131 with a second equivalence rate between gas and air. If desired, after the ignition phase, the combustible air-gas mixture 131 may be a rich combustible air-gas mixture with an equivalence ratio between gas and air that is above the stoichiometric ratio between gas and air. The comparatively great flame 122 may emit toward the flame detector 150 a flame signal 160 having a higher intensity than the flame signal 160 emitted by the flame 122 of Fig. 1.

[0048] Fig. 3 shows an illustrative gas supply unit 116. Gas supply unit 116 may be arranged upstream of an air-gas mixing unit (e.g., air-gas mixing unit 110 of Fig. 1 and Fig. 2), which is arranged upstream of a burning unit (e.g., burning unit 120 of Fig. 1 and Fig. 2).

[0049] Illustratively, gas supply unit 116 may be adapted to regulating the flow of gas to the air-gas mixing unit such that the combustible air-gas mixture produced by the air-gas mixing unit has a variable equivalence ratio. By way of example, the illustrative gas supply unit 116 may regulate the flow of gas depending on whether the presence of a flame or the absence of a flame is detected in the associated burning unit.

[0050] As an example, the gas supply unit 116 may supply a first flow of gas to the air-gas mixing unit such that the combustible air-gas mixture has a first equivalence ratio between gas and air when the absence of a flame is detected in the associated burning unit (e.g., using flame detector 150 of Fig. 1 and Fig. 2). If desired, the first equivalence ratio between gas and air may be smaller than one. In other words, the gas supply unit 116 may supply the first flow of gas to the air-gas mixing unit such that the air-gas mixing unit produces a lean mixture of air and gas as long as the absence of a flame is detected in the burning unit.

[0051] As another example, the gas supply unit 116 may supply a second flow of gas to the air-gas mixing unit such that the combustible air-gas mixture has a second equivalence ratio between gas and air when the presence of a flame is detected in the associated burning unit. The second equivalence ratio may be different than the first equivalence ratio between gas and air. If desired, the second equivalence ratio may be greater than the first equivalence ratio between gas and air. For example, the second equivalence ratio between gas and air may be greater than one. In other words, the gas supply unit 116 may supply the second flow of gas to the air-gas mixing unit such that the air-gas mixing unit produces a rich mixture of air and gas as long as the presence of a flame is detected in the burning unit.

[0052] If desired, the gas supply unit 116 may be adapted to supplying more than two discrete flows of gas to the air-gas mixing unit. For example, the gas supply unit 116 may be adapted to supplying any amount of gas to the air-gas mixing unit selected from a continuous range. The continuous range may be selected such that the variable equivalence ratio between gas and air is between 0.05 and 20. Preferably, the continuous range may be selected such that the variable equivalence ratio between gas and air is between 0.3 and 5.

[0053] Gas supply unit 116 may have at least two hydraulically parallel gas flow channels. For example, gas supply unit 116 may have two, three, four, or more hydraulically parallel gas flow channels. As shown in Fig. 3, gas supply unit 116 may have two hydraulically parallel gas flow channels 170, 180.

[0054] Each gas flow channel of the at least two hydraulically parallel gas flow channels may be adapted to supplying a flow of gas to the air-gas mixing unit. The flow of gas may be regulated in at least one gas flow channel of the at least two hydraulically parallel gas flow channels. If desired, the flow of gas may be interrupted in the at least one gas flow channel of the at least two hydraulically parallel gas flow channels.

[0055] A controller may control the at least two hydraulically parallel gas flow channels. Preferably, the controller may control and/or regulate the flow of gas in the at least two hydraulically parallel gas flow channels.

[0056] Illustratively, the controller may control only a subset of the at least two hydraulically parallel gas flow channels. In some embodiments, the controller may control each gas flow channel of the at least two hydraulically parallel gas flow channels independently of the other gas flow channels. If desired, the controller may control at least two gas flow channels of the at least two hydraulically parallel gas flow channels together.

[0057] By way of example, gas flow channel 170 of gas supply unit 116 may include a gas flow restrictor 172 that restricts flow of gas through gas flow channel 170 to the air-gas mixing unit. Gas flow channel 180 may be hydraulically parallel to gas flow channel 170.

[0058] Illustratively, gas flow channel 180 may include a gas flow restrictor 181 that restricts flow of gas through gas flow channel 180 to the air-gas mixing unit. If desired, gas flow channel 180 may include a gas valve 184. The gas valve 184 may be either closed and prevent the flow of gas through gas flow channel 180 or opened and allow the flow of gas through gas flow channel 180.

[0059] Gas valve 184 may be activated electrically or pneumatically. As shown in Fig. 3, a solenoid 186 may control gas valve 184. Thus, solenoid 186 may open or close gas valve 184. If desired, solenoid 186 may be controlled electrically. For example, an electrical control signal from a controller circuit (e.g., control signal 182 from controller 140 of Fig. 1 and Fig. 2) may control solenoid 186.

[0060] Illustratively, the control signal may be indicative of the presence or absence of a flame in the burning unit. As an example, consider the scenario in which the control signal is indicative of the absence of a flame in the burning unit. In this scenario, the solenoid 186 may control the gas valve 184 such that the gas valve 184 remains closed. Thus, only gas flow channel 170 may provide a flow of gas to the air-gas mixing unit such that the combustible air-gas mixture has a first equivalence ratio between gas and air when the control signal is indicative of the absence of a flame in the burning unit.

[0061] If desired, the gas flow restrictor 172 may be selected such that the first equivalence ratio between gas and air is smaller than one when only the gas flow channel 170 provides a flow of gas to the air-gas mixing unit. Thus, the combustible air-gas mixture may be lean. In case of a delayed ignition, the concentration of gas in the air-gas mixture may be low enough to prevent an explosion which may prevent damage to the air-gas mixture burning appliance.

[0062] As another example, consider the scenario in which the control signal is indicative of the presence of a flame in the burning unit. In this scenario, the solenoid 186 may control the gas valve 184 such that the gas valve 184 opens. If desired, the control signal may direct the solenoid 186 to open the gas valve 184 with a predetermined delay. For example, the predetermined delay may be selected to be between 0.5 and 6 seconds.

[0063] When the gas valve 184 is open, both gas flow channels 170, 180 may provide a flow of gas to the air-gas mixing unit such that the combustible air-gas mixture has a second equivalence ratio between gas and air when the control signal is indicative of the presence of a flame in the burning unit.

[0064] If desired, the gas flow restrictors 172, 181 may be selected such that the second equivalence ratio between gas and air is greater than the first equivalence ratio. For example, the second equivalence ratio between gas and air may be greater than one when both gas flow channels 170, 180 provide a flow of gas to the air-gas mixing unit. Thus, the combustible air-gas mixture may be rich and provide for an improved running efficiency of the air-gas mixture burning appliance once a stable flame has been established in the burning unit.

[0065] Illustratively, gas supply unit 116 may include an additional gas valve 194. The additional gas valve 194 may be arranged upstream of the first and second gas flow channels 170, 180. The additional gas valve 194 may be adapted to completely shutting off the flow of gas to the air-gas mixing unit.

[0066] Preferably, the additional gas valve 194 is a zero governor gas valve 196. If desired, the zero governor gas valve 196 may include at least one gas regulator 198. The at least one gas regulator 198 may be adapted to maintaining zero pressure at the outlet of the zero governor gas valve 196.

[0067] Illustratively, the additional gas valve 194 may include at least one of a pressure-controlled valve or an electronically-controlled valve. As shown in Fig. 3, the additional gas valve includes two electronically-controlled valves 198 that are controlled independently by solenoids 197, 199.

[0068] Fig. 4 shows a functional diagram for illustrating operation of the air-gas mixture burning appliance of Fig. 1 and Fig. 2. As shown in Fig. 1 and Fig. 2, the air-gas mixture burning appliance 100 may include an air-gas mixing unit 110, a burning unit 120 that is arranged downstream of the air-gas mixing unit 110, a flame detector 150, and a gas supply unit 116 that is arranged upstream of the air-gas mixing unit 110. The gas supply unit 116 may include a first gas flow channel 170 with a gas restrictor 172, a second gas flow channel 180 that is hydraulically parallel to the first gas flow channel 170 and comprises a first gas valve 184, and a second gas valve 194 that is arranged upstream of the first and second gas flow channels 170, 180.

[0069] During operation 210, the air-gas mixture burning appliance may close the first gas valve. For example, the air-gas mixture burning appliance 100 of Fig. 1 may close gas valve 184 during the ignition phase of the air-gas mixture burning appliance 100.

[0070] During operation 220, the air-gas mixture burning appliance may open the second gas valve. For example, the air-gas mixture burning appliance 100 of Fig. 1 may open the second gas valve 194, thereby enabling a flow of gas to the first and second gas flow channels 170, 180.

[0071] During operation 230, the air-gas mixture burning appliance may, with the gas restrictor, restrict flow of gas through the first gas flow channel to the air-gas mixing unit. For example, the air-gas mixture burning appliance 100 of Fig. 1 may, with the gas restrictor 172, restrict flow of gas through the first gas flow channel 170 to the air-gas mixing unit 110.

[0072] During operation 240, the air-gas mixture burning appliance may, with the air-gas mixing unit, mix air with the gas from the first gas flow channel to form a combustible air-gas mixture. For example, the air-gas mixture burning appliance 100 of Fig. 1 may, with the air-gas mixing unit 110, mix air with the gas from the first gas flow channel 170 to form a combustible air-gas mixture 130.

[0073] During operation 250, the air-gas mixture burning appliance may ignite the combustible air-gas mixture in the burning unit. For example, the air-gas mixture burning appliance 100 of Fig. 1 may ignite the combustible air-gas mixture 130 in the burning unit 120.

[0074] During operation 260, the air-gas mixture burning appliance may, with the flame detector, sense for presence of a flame in the burning unit. For example, the air-gas mixture burning appliance 100 of Fig. 1 may, with the flame detector 150, sense for presence of a flame 122 in the burning unit 120.

[0075] During operation 270, the air-gas mixture burning appliance may, in response to failing to sense the flame in the burning unit, maintain the first gas valve in the closed position. For example, the air-gas mixture burning appliance 100 of Fig. 1 may, in response to failing to sense the flame 122 in the burning unit 120, maintain the first gas valve 184 in the closed position.

[0076] During operation 280, the air-gas mixture burning appliance may, in response to sensing presence of the flame in the burning unit, open the first gas valve. For example, the air-gas mixture burning appliance 100 of Fig. 1 may, in response to sensing presence of the flame 122 in the burning unit 120, open the first gas valve 184.

[0077] If desired, the air-gas mixture burning appliance may wait for a predetermined duration between sensing presence of the flame in the burning unit and opening the first gas valve.

[0078] It should be noted that the first and second equivalence ratios between gas and air that the gas supply unit 116 supplies to the air-gas mixing unit 110 of the air-gas mixture burning appliance 100 of Fig. 1 to Fig. 2 during the ignition phase and after the ignition phase, are only cited by way of example, and not for limiting the invention accordingly. Instead, varying the equivalence ratios for other reasons are likewise contemplated, such as e.g. adjusting the equivalence ratio between gas and air depending on whether the air-gas mixture burning appliance 100 of Fig. 1 and Fig. 2 operates at low or high power.

Claims

1. A method (200) of operating an air-gas mixture burning appliance (100) that comprises an air-gas mixing unit (110), a burning unit (120) that is arranged downstream of the air-gas mixing unit (110), a flame detector (150), and a gas supply unit (116) that is arranged upstream of the air-gas mixing unit (110), the gas supply unit (116) comprising a first gas flow channel (170) with a gas flow restrictor (172), a second gas flow channel (180) that is hydraulically parallel to the first gas flow channel (170) and comprises a first gas valve (184), and a second gas valve (194) that is arranged upstream of the first and second gas flow channels (170, 180), the method comprising:

   closing (210) the first gas valve (184),
   opening (220) the second gas valve (194),
   with the gas flow restrictor (172), restricting (230) flow of gas through the first gas flow channel (170) to the air-gas mixing unit (110),
   with the air-gas mixing unit (110), mixing (240) air with the gas from the first gas flow channel (170) to form a combustible air-gas mixture (130),
   igniting (250) the combustible air-gas mixture (130) in the burning unit (120),
   with the flame detector (150), sensing (260) for presence of a flame (122) in the burning unit (120), and
   in response to failing to sense the flame (122) in the burning unit (120), maintaining (270) the first gas valve (184) in the closed position.

2. The method of claim 1, wherein the combustible air-gas mixture (130) has a first equivalence ratio between gas and air.

3. The method of claim 2, wherein the first equivalence ratio between gas and air is smaller than 1.

4. The method of claims 2 or 3, further comprising: in response to sensing presence the flame (122) in the burning unit (120), opening (280) the first gas valve (184).

5. The method of claim 4, further comprising: waiting for a predetermined duration between sensing presence of the flame (122) in the burning unit (120) and opening the first gas valve (184).

6. The method of claim 5, wherein the predetermined duration is between 0.5 seconds and 6 seconds.

7. The method of any one of claims 4 to 6, further com-

prising:
with the air-gas mixing unit (110), mixing air with the gas from the first and second gas flow channels (170, 180) to form another combustible air-gas mixture (131).

8. The method of claim 7, wherein the other combustible air-gas mixture (131) has a second equivalence ratio between gas and air that is different than the first equivalence ratio.

9. The method of claim 8, wherein the second equivalence ratio between gas and air is greater than the first equivalence ratio.

Patentansprüche

1. Verfahren (200) zum Betreiben einer Luft-Gas-Gemischverbrennungsvorrichtung (100), das eine Luft-Gas-Mischeinheit (110), eine stromabwärts der Luft-Gas-Mischeinheit (110) angeordnete Verbrennungseinheit (120), einen Flammendetektor (150) und eine stromaufwärts der Luft-Gas-Mischeinheit (110) angeordnete Gasversorgungseinheit (116) umfasst, wobei die Gasversorgungseinheit (116) einen ersten Gasströmungskanal (170) mit einem Gasströmungsbegrenzer (172), einen zweiten Gasströmungskanal (180), der hydraulisch parallel zum ersten Gasströmungskanal (170) ist und ein erstes Gasventil (184) umfasst, und ein zweites Gasventil (194), das stromaufwärts des ersten und des zweiten Gasströmungskanals (170, 180) angeordnet ist, umfasst, wobei das Verfahren umfasst:

Schließen (210) des ersten Gasventils (184),
Öffnen (220) des zweiten Gasventils (194),
mit dem Gasströmungsbegrenzer (172) Begrenzen (230) des Gasflusses durch den ersten Gasströmungskanal (170) zur Luft-Gas-Mischeinheit (110),
mit der Luft-Gas-Mischeinheit (110) Mischen (240) von Luft mit dem Gas aus dem ersten Gasströmungskanal (170) zur Bildung eines brennbaren Luft-Gas-Gemischs (130),
Zünden (250) des brennbaren Luft-Gas-Gemischs (130) in der Verbrennungseinheit (120),
mit dem Flammendetektor (150) Erfassen (260) des Vorhandenseins einer Flamme (122) in der Verbrennungseinheit (120), und
als Reaktion auf das Nichterfassen der Flamme (122) in der Verbrennungseinheit (120) Beibehalten (270) des ersten Gasventils (184) in der geschlossenen Stellung.

2. Verfahren nach Anspruch 1, wobei das brennbare Luft-Gas-Gemisch (130) ein erstes Äquivalenzverhältnis zwischen Gas und Luft aufweist.

3. Verfahren nach Anspruch 2, wobei das erste Äquivalenzverhältnis zwischen Gas und Luft kleiner als 1 ist.

4. Verfahren nach Anspruch 2 oder 3, ferner umfassend:
als Reaktion auf das Erfassen des Vorhandenseins der Flamme (122) in der Verbrennungseinheit (120) Öffnen (280) des ersten Gasventils (184).

5. Verfahren nach Anspruch 4, ferner umfassend:
Warten für eine vorbestimmte Dauer zwischen dem Erfassen des Vorhandenseins der Flamme (122) in der Verbrennungseinheit (120) und dem Öffnen des ersten Gasventils (184).

6. Verfahren nach Anspruch 5, wobei die vorbestimmte Dauer zwischen 0,5 Sekunden und 6 Sekunden beträgt.

7. Verfahren gemäß einem der Ansprüche 4 bis 6, ferner umfassend:
mit der Luft-Gas-Mischeinheit (110) Mischen von Luft mit dem Gas aus dem ersten und dem zweiten Gasströmungskanal (170, 180) zur Bildung eines weiteren brennbaren Luft-Gas-Gemischs (131).

8. Verfahren nach Anspruch 7, wobei das weitere brennbare Luft-Gas-Gemisch (131) ein zweites Äquivalenzverhältnis zwischen Gas und Luft aufweist, das von dem ersten Äquivalenzverhältnis verschieden ist.

9. Verfahren nach Anspruch 8, wobei das zweite Äquivalenzverhältnis zwischen Gas und Luft größer als das erste Äquivalenzverhältnis ist.

Revendications

1. Procédé (200) de mise en fonctionnement d'un appareil de brûlage de mélange air-gaz (100) qui comprend une unité de mélangeage air-gaz (110), une unité de brûlage (120) qui est agencée en aval de l'unité de mélangeage air-gaz (110), un détecteur de flamme (150), et une unité d'alimentation en gaz (116) qui est agencée en amont de l'unité de mélangeage air-gaz (110), l'unité d'alimentation en gaz (116) comprenant un premier canal d'écoulement de gaz (170) avec un limiteur d'écoulement de gaz (172), un second canal d'écoulement de gaz (180) qui est hydrauliquement parallèle au premier canal d'écoulement de gaz (170) et comprend une première soupape à gaz (184), et une seconde soupape à gaz (194) qui est agencée en amont des premier et second canaux d'écoulement de gaz (170, 180), le procédé comprenant :

la fermeture (210) de la première soupape à gaz (184),
l'ouverture (220) de la seconde soupape à gaz (194),
avec le limiteur d'écoulement de gaz (172), la limitation (230) d'un écoulement de gaz à travers le premier canal d'écoulement de gaz (170) jusqu'à l'unité de mélangeage air-gaz (110),
avec l'unité de mélangeage air-gaz (110), le mélangeage (240) d'air avec le gaz provenant du premier canal d'écoulement de gaz (170) pour former un mélange air-gaz combustible (130),
l'allumage (250) du mélange air-gaz combustible (130) dans l'unité de brûlage (120),
avec le détecteur de flamme (150), la détection (260) pour déterminer si une flamme (122) est présente dans l'unité de brûlage (120), et
en réponse à l'échec de la détection de la flamme (122) dans l'unité de brûlage (120), le maintien (270) de la première soupape à gaz (184) dans la position fermée.

2. Procédé de la revendication 1, dans lequel le mélange air-gaz combustible (130) a un premier rapport d'équivalence entre gaz et air.

3. Procédé de la revendication 2, dans lequel le premier rapport d'équivalence entre le gaz et l'air est inférieur à 1.

4. Procédé de la revendication 2 ou 3, comprenant en outre :
en réponse à la détection de la présence de la flamme (122) dans l'unité de brûlage (120), l'ouverture (280) de la première soupape à gaz (184).

5. Procédé de la revendication 4, comprenant en outre :
l'attente pendant une durée prédéterminée entre la détection de la présence de la flamme (122) dans l'unité de brûlage (120) et l'ouverture de la première soupape à gaz (184).

6. Procédé de la revendication 5, dans lequel la durée prédéterminée est entre 0,5 seconde et 6 secondes.

7. Procédé de l'une quelconque des revendications 4 à 6, comprenant en outre :
avec l'unité de mélangeage air-gaz (110), le mélangeage d'air avec le gaz provenant des premier et second canaux d'écoulement de gaz (170, 180) pour former un autre mélange air-gaz combustible (131).

8. Procédé de la revendication 7, dans lequel l'autre mélange air-gaz combustible (131) a un second rapport d'équivalence entre le gaz et l'air qui est différent du premier rapport d'équivalence.

9. Procédé de la revendication 8, dans lequel le second rapport d'équivalence entre le gaz et l'air est supérieur au premier rapport d'équivalence.

Fig. 1

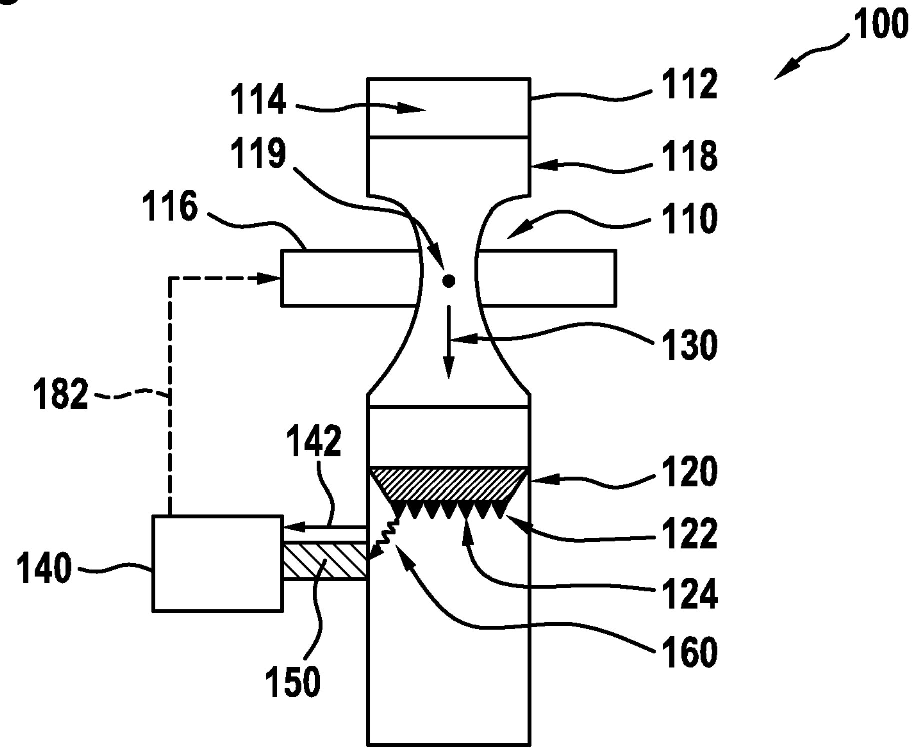
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Fig. 2

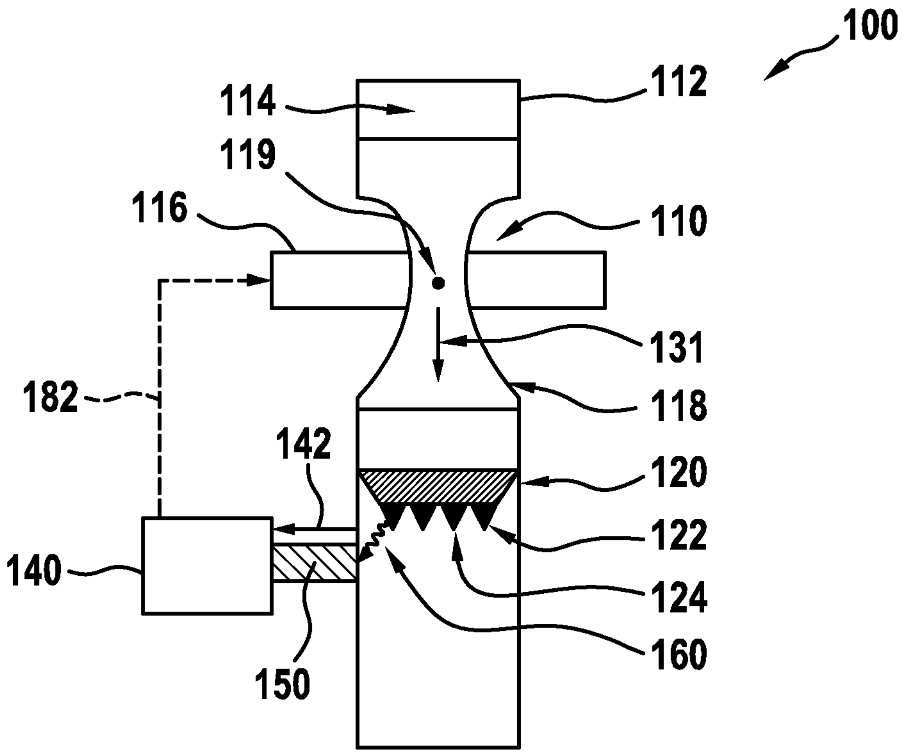
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Fig. 3

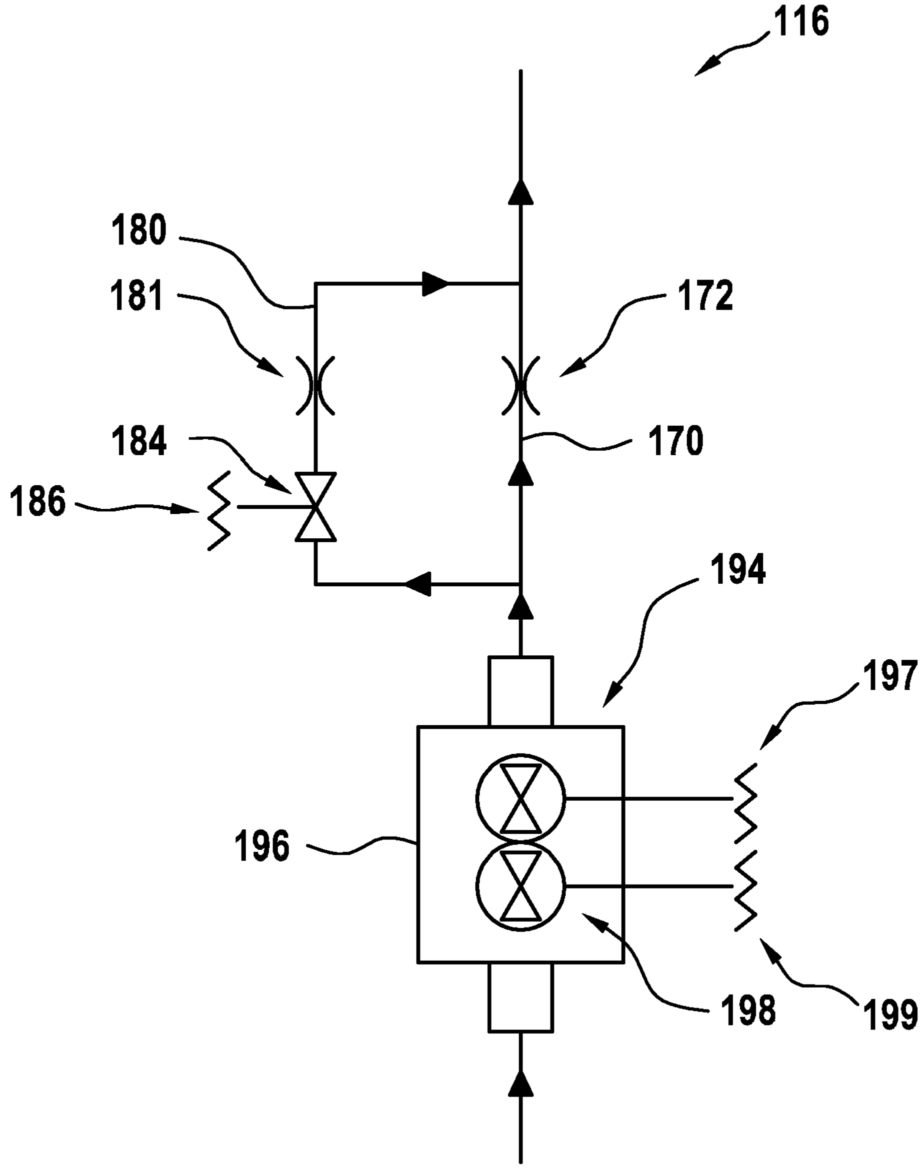
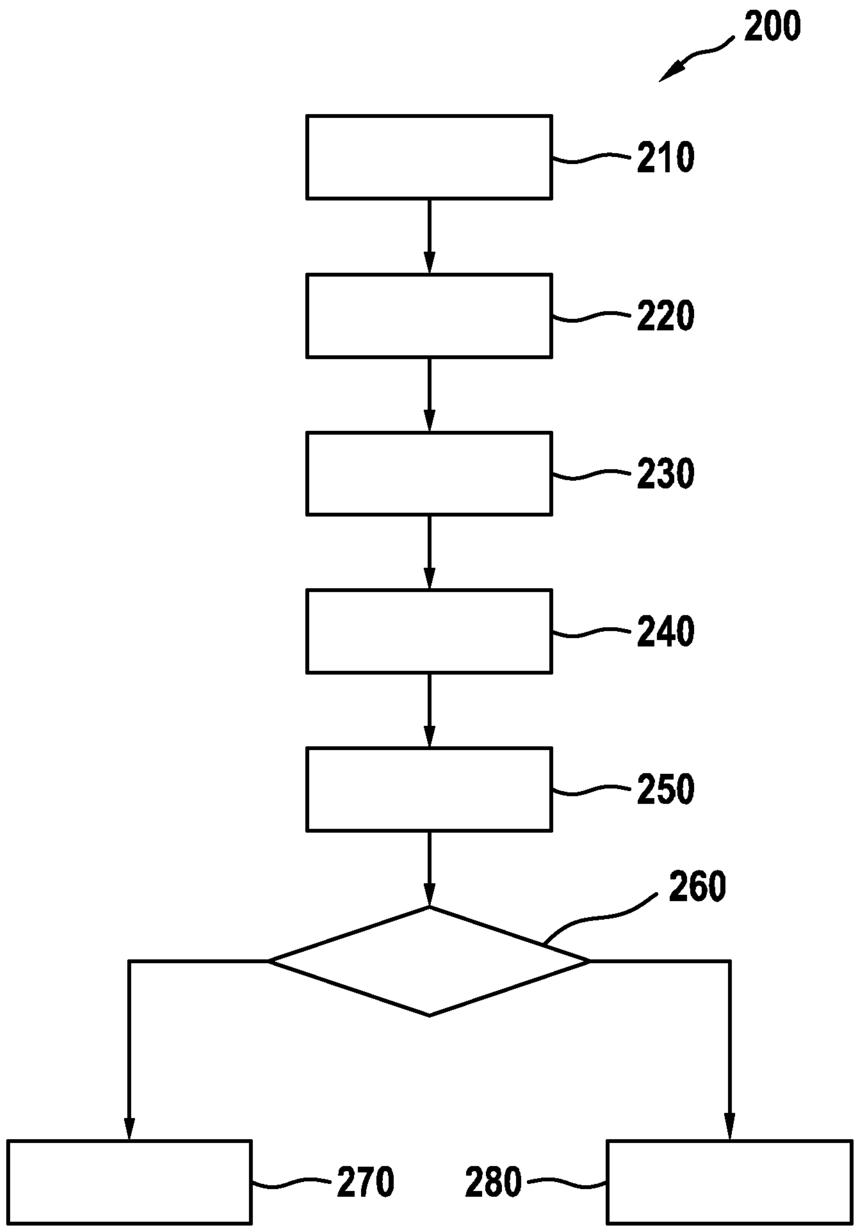


Fig. 4



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- KR 100839523 B1 **[0011]**
- KR 19980062747 U **[0011]**
- JP S62284122 A **[0012]**
- JP H10300077 A **[0013]**