

Description

Background of the Invention

[0001] The present invention relates to an air-gas mixture burning appliance. The air-gas mixture burning appliance comprises a controller, a burning unit for burning a combustible air-gas mixture, an air-gas mixing unit that is arranged upstream of the burning unit and is adapted for mixing of air and gas to form the combustible air-gas mixture, and a gas valve that is arranged upstream of the air-gas mixing unit and is adapted for regulating a flow of the gas to the air-gas mixing unit. Furthermore, the present invention relates to a method of operating an air-gas mixture burning appliance that comprises a controller, a burning unit for burning a combustible air-gas mixture, a flame detector for sensing a presence of a flame in the burning unit, an air-gas mixing unit that is arranged upstream of the burning unit and is adapted for mixing of air and gas to form the combustible air-gas mixture, and a gas valve that is arranged upstream of the air-gas mixing unit and is adapted for regulating a flow of the gas to the air-gas mixing unit.

[0002] From the state of the art, an air-gas mixture burning appliance having a burning unit, an air-gas mixing unit, and a gas valve is known. More specifically, known air-gas mixture burning appliances usually mix 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. 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.

[0003] Therefore, during the ignition phase of the burning unit, the maximum allowed opening time of the gas valve without a flame being detected is limited to a short time period, which is sometimes also referred to as the ignition safety time. The ignition safety time is usually a fixed duration of time that is predetermined.

[0004] In the remainder of this description, the term "gas" refers to 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. Moreover, the term "air" refers to any suitable oxidizer that may be mixed with a fuel gas to form a combustible air-gas mixture.

Summary of the Invention

[0005] The present invention relates to an air-gas mixture burning appliance, comprising a burning unit for burning a combustible air-gas mixture, an air-gas mixing unit that is arranged upstream of the burning unit and is adapted for mixing of air and gas to form the combustible

air-gas mixture, a gas valve that is arranged upstream of the air-gas mixing unit and is adapted for regulating a flow of the gas to the air-gas mixing unit, and a controller that is adapted for determining a variable ignition safety time for an ignition phase of the burning unit by selecting from at least two different durations of time, wherein the controller determines the variable ignition safety time as an anticipated maximum duration of time that elapses between an opening of the gas valve and a closing of the gas valve for avoiding a hazardous accumulation of the combustible air-gas mixture in the burning unit.

[0006] Accordingly, the inventive air-gas mixture burning appliance may be able to adjust the ignition safety time and adapt to different modes of operation.

[0007] Optionally, the air-gas mixture burning appliance further comprises a secured gas pathway that is arranged between the gas valve and the air-gas mixing unit and is adapted for providing the gas from the gas valve to the air-gas mixing unit, and wherein the controller determines the variable ignition safety time based on an inferred concentration of the gas in the secured gas pathway.

[0008] Thus, the controller can select the variable ignition safety time based on whether the secured gas pathway is already filled with a gas or whether the secured gas pathway is filled with air at the beginning of the ignition phase.

[0009] Preferably, the controller determines the variable ignition safety time based at least on the type of the gas.

[0010] Accordingly, the inventive air-gas mixture burning appliance may be operated with different gas types.

[0011] Optionally, the controller determines the variable ignition safety time by selecting from a predetermined number of at least three different discrete durations of time, wherein all values of the at least three different discrete durations of time are smaller than or equal to a predetermined maximum ignition safety time.

[0012] Thus, the controller may have a simple design and be low cost.

[0013] According to one aspect, the controller determines the variable ignition safety time by selecting from a continuous range of values, wherein all values in the continuous range of values are smaller than or equal to a predetermined maximum ignition safety time.

[0014] Accordingly, the controller may fine-tune the ignition safety time and react to the combination of multiple parameters that may have an influence on the ignition safety time.

[0015] Preferably, the air-gas mixture burning appliance further comprises a flame detector for sensing a presence of a flame in the burning unit, wherein the controller determines the variable ignition safety time based at least on an elapsed time since the flame detector previously sensed a flame in the burning unit.

[0016] Thus, the inventive air-gas mixture burning appliance may reliably predict the concentration of the gas in the secured gas pathway at the beginning of the ignition

phase.

[0017] Optionally, the controller directs the gas valve to shut off if, during the ignition phase of the burning unit, the gas valve is open and the flame detector fails to sense a flame in the burning unit during the variable ignition safety time.

[0018] Accordingly, the controller ensures the prevention of a dangerous build-up of the combustible air-gas mixture after the burning unit and a related delayed ignition.

[0019] Preferably, the controller triggers a warning and/or puts the air-gas mixture burning appliance into one or more of a safe state, a restricted state, or a non-operational state, if during a predetermined number of consecutive ignition phases of the burning unit, the gas valve is open and the flame detector fails to sense a flame in the burning unit during the variable ignition safety time.

[0020] Accordingly, an operator may be alerted and/or the risks associated with a malfunction of the air-gas mixture burning appliance may be reduced.

[0021] Furthermore, a method of operating an air-gas mixture burning appliance that comprises a controller, a burning unit for burning a combustible air-gas mixture, a flame detector for sensing a presence of a flame in the burning unit, an air-gas mixing unit that is arranged upstream of the burning unit and is adapted for mixing of air and gas to form the combustible air-gas mixture, and a gas valve that is arranged upstream of the air-gas mixing unit and is adapted for regulating a flow of the gas to the air-gas mixing unit, comprises determining with the controller, a variable ignition safety time for an ignition phase of the burning unit by determining an anticipated maximum duration of time that can safely elapse between an opening of the gas valve and a closing of the gas valve for avoiding a hazardous accumulation of the combustible air-gas mixture in the burning unit.

[0022] Accordingly, the inventive method may operate an air-gas mixture burning appliance by adjusting the ignition safety time and adapt to different modes of operation.

[0023] Optionally, the method further comprises directing with the controller, the gas valve to shut off if, during the ignition phase of the burning unit, the gas valve is open and no flame is detected in the burning unit during the variable ignition safety time.

[0024] Thus, the inventive method may prevent a hazardous build-up of the combustible air-gas mixture in the burning unit of the air-gas mixture burning appliance.

[0025] Preferably, the air-gas mixture burning appliance further comprises a secured gas pathway that is arranged between the gas valve and the air-gas mixing unit and is adapted for providing the gas from the gas valve to the air-gas mixing unit, and determining the variable ignition safety time further comprises determining the variable ignition safety time based at least on the type of the gas, and/or on an inferred concentration of the gas in the secured gas pathway, and/or on an elapsed time since a flame detector previously sensed a flame in the

burning unit.

[0026] Thus, the inventive method may consider different parameters when determining the ignition safety time.

5 [0027] Optionally, the method further comprises triggering with the controller, a warning and/or putting, with the controller, the air-gas mixture burning appliance into one or more of a safe state, a restricted state or a non-operational state, if, during a pre-determined number of
10 consecutive ignition phases of the burning unit, the gas valve is open and no flame is detected in the burning unit during the variable ignition safety time.

[0028] Accordingly, an operator may be alerted and/or the risks associated with a malfunction of the air-gas mixture burning appliance may be reduced.
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Brief Description of the Drawings

[0029] 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.
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Fig. 1 shows a schematic view of an air-gas mixture burning appliance according to the present invention, during the ignition phase,
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Fig. 2 shows a schematic view of an air-gas mixture burning appliance having a fan downstream of an air-gas mixer and an air flow channel to a reference pressure port of a gas valve, and
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Fig. 3 shows a flowchart illustrating a method of operating an air-gas mixture burning appliance.

Detailed Description

40 [0030] Fig. 1 shows an exemplary air-gas mixture burning appliance 100 with a burning unit 120 for burning a combustible air-gas mixture 130, an air-gas mixing unit 110, a gas valve 194, a flame detector 150, and a controller 140. 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.

[0031] The air-gas mixing unit 110 is arranged upstream of the burning unit 120 and is adapted for mixing of air 111 and gas 119 to form the combustible air-gas mixture 130. Preferentially, the combustible air-gas mixture 130 is a homogenous mixture of the air 111 and the gas 119.
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[0032] By way of example, the air-gas mixing unit 110 includes an air supply unit and a gas supply unit. Illustratively, the air supply unit includes a fan 114 that may be operated with an adaptable fan speed and/or within predetermined ranges of fan speeds.
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[0033] As shown in Fig. 1, the fan 114 may push air 111 into the air-gas mixing unit 110. If desired, and as shown in Fig. 2, the fan 114 may draw the combustible air-gas mixture 130 from the air-gas mixing unit 110.

[0034] The gas supply unit may include the gas valve 194. The gas valve 194 is arranged upstream of the air-gas mixing unit 110 and is adapted for regulating a flow of the gas 119 to the air-gas mixing unit 110. A secured gas pathway 116 is arranged between the gas valve 194 and the air-gas mixing unit 110 and is adapted for providing the gas 119 from the gas valve 194 to the air-gas mixing unit 110.

[0035] The air supply unit and the gas supply unit may be interconnected via a mixer 118 which forms a corresponding discrete point of mixing. Preferably, the combustible air-gas mixture 130 is formed at the discrete point of mixing and guided via the mixer 118 and the combustible air-gas pathway 132 to the burning unit 120.

[0036] 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 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.

[0037] By way of example, during an ignition phase of the air-gas mixture burning appliance 100, the combustible air-gas mixture 130 from the air-gas mixing unit 110 may be ignited in the burning unit 120 at the burner surface 124. The resulting flame 122 is illustratively stabilised against the burner surface 124.

[0038] According to one aspect, the flame detector 150 is provided for sensing presence of a flame 122 in the burning unit 120. Thus, the flame detector 150 is suitable for determining whether a flame 122 is present at the burner surface 124 in the burning unit 120. 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.

[0039] Illustratively, the flame detector 150 may be connected to the controller 140. If desired, the flame detector 150 may generate and/or provide a flame detection signal 162 to the controller 140 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.

[0040] Alternatively, the controller 140 may determine whether a flame 122 is present in the burning unit 120 by comparing the detected flame signal 160 with a predetermined flame detection threshold.

[0041] As shown in Fig. 1, the controller 140 may be connected to the gas valve 194. Illustratively, the controller 140 may receive a control signal 182 from the gas valve 194. By way of example, the control signal 182 may

be indicative of the status of the gas valve 194. For example, the controller signal 182 may indicate whether the gas valve 194 is open or closed.

[0042] Illustratively, the controller 140 may send an actuator signal 183 to the gas valve 194. If desired, the actuator signal 183 may direct the gas valve 194 to open and/or to close. For example, at the beginning of an ignition phase, the controller 140 may direct the gas valve 194 to open.

[0043] During the ignition phase, the controller 140 tracks the duration of time between the opening of the gas valve 194 and the detection of a flame signal 160 at the burning unit 120. To avoid a delayed ignition, which refers to igniting a hazardous accumulation of the combustible air-gas mixture 130 and which usually leads to an explosion that may damage internal components of the air-gas mixture burning appliance 100 and endanger the surrounding environment, the maximum allowed opening time of the gas valve 194 without a flame 122 being detected is limited to a short period of time, which is sometimes also referred to as the ignition safety time.

[0044] In contrast thereto, the gas valve 194 needs to be open for a minimum opening time. The minimum opening time is defined as the time that is required for the gas 119 to flow from the gas valve 194 through the secured gas pathway 116 to the air-gas mixing unit 110 and from there, as a combustible air-gas mixture 130 to the burner surface 124, where a sufficient quantity of the combustible air-gas mixture 130 is required to accumulate such that a reliable ignition of the flame 122 is ensured.

[0045] However, the time between the opening of the gas valve 194 and the accumulation of a quantity of the combustible air-gas mixture 130 in the burning unit 120 that is sufficient for a sustained ignition may depend on the concentration of the gas 119 in the secured gas pathway 116 at the opening of the gas valve 194.

[0046] As an example, If the air-gas mixture burning appliance 100 were to stop burning gas 119, but after a short period of time be re-lit, then the secured gas pathway 116 would still be filled with gas 119, and the combustible air-gas pathway 132 would still be filled with the combustible air-gas mixture 130, and, as a result, a flame 122 could be established comparatively quickly at the burner surface 124.

[0047] As another example, in between periods of operation, the concentration of the gas 119 in the secured gas pathway 116 and in the combustible air-gas pathway 132 decays overtime. Thus, if the air-gas mixture burning appliance 100 is re-lit after a sufficient period of time, the secured gas pathway 116 and the combustible air-gas pathway 132 is nominally filled with air and contains a negligible concentration of the gas 119 at the start of the ignition sequence. In this case, the nominally air that is present in the secured gas pathway 116 and in the combustible air-gas pathway 132 must be displaced by gas 119 that is streaming through the opened gas valve 194.

[0048] This process of re-priming the secured gas pathway 116 and the combustible air-gas pathway 132

takes some time, which may depend, for example, on the flow rate of nominally air and the volume of the consecutive pathways 116, 132.

[0049] Consequently, a flame 122 appears at the burner surface 124 only after this priming process has sufficiently progressed, and takes more time in comparison to the ignition attempt made shortly after an end of a previous burn that was described in the previous example.

[0050] Thus, the controller 140 is adapted for determining a variable ignition safety time for an ignition phase of the burning unit 120 by selecting from at least two different durations of time. Thereby, the controller 140 determines the variable ignition safety time as an anticipated maximum duration of time that elapses between an opening of the gas valve 194 and a closing of the gas valve 194 for avoiding a hazardous accumulation of the combustible air-gas mixture 130 in the burning unit 120.

[0051] Since the decay of the concentration of the gas 119 in the secured gas pathway 116 over time is driven by a diffusion process that is relatively repeatable and predictable, the controller 140 may determine the variable ignition safety time based on an inferred concentration of the gas 119 in the secured gas pathway 116.

[0052] Moreover, the decay of the concentration of the gas 119 and/or the time to reprime the secured gas pathway 116 and the combustible air-gas pathway 132 may depend on the type of gas 119. For example, the difference in density of hydrogen or any other fuel gas that is less dense than air may result in an exacerbated delay in the appearance of a flame 122 at the burner surface 124. Therefore, the controller 140 may determine the variable ignition safety time based at least on the type of the gas 119.

[0053] Illustratively, the controller 140 may determine the variable ignition safety time based at least on an elapsed time since the flame detector 150 previously sensed a flame 122 in the burning unit 120.

[0054] By way of example, the controller 140 may determine the longest duration of time after the opening of the gas valve 194 that it is safe to wait for a flame 122 to appear in the burning unit 120 before the gas valve 194 must be closed to prevent an excessive accumulation of the combustible air-gas mixture 130 in the burning unit 120. This longest duration of time is sometimes also referred to as a predetermined maximum ignition safety time.

[0055] Illustratively, the controller 140 may determine the variable ignition safety time by selecting from a predetermined number of at least three different discrete durations of time wherein all values of the at least three different discrete durations of time are smaller than or equal to a predetermined maximum ignition safety time.

[0056] If desired, the controller 140 may determine the variable ignition safety time by selecting from a continuous range of values, wherein all values in the continuous range of values are smaller than or equal to a predetermined maximum ignition safety time.

[0057] Illustratively, the controller 140 may direct the gas valve 194 to shut off if, during the ignition phase of the burning unit 120, the gas valve 194 is open and the flame detector 150 fails to sense a flame 122 in the burning unit 120 during the variable ignition safety time. For example, the controller 140 may direct the gas valve 194 to close using actuator signal 183.

[0058] By way of example, the controller 140 may trigger a warning, if during a predetermined number of consecutive ignition phases of the burning unit 120, the gas valve 194 is open and the flame detector 150 fails to sense a flame 122 in the burning unit 120 during the variable ignition safety time.

[0059] The warning may be any signal that alerts an operator about the malfunction of the air-gas mixture burning appliance 100. For example, the warning may be a visual signal (e.g., a flashing display, a color coded display, a message, etc.), an audio signal (e.g., a warning message, a beeping signal, etc.), a tactile signal (e.g., a vibration), or any combination thereof.

[0060] Illustratively, the controller 140 may put the air-gas mixture burning appliance 100 into one or more of a safe state, a restricted state, or a non-operational state, if during a predetermined number of consecutive ignition phases of the burning unit 120, the gas valve 194 is open and the flame detector 150 fails to sense a flame 122 in the burning unit 120 during the variable ignition safety time.

[0061] If desired, the controller 140 may trigger a warning and put the air-gas mixture burning appliance 100 into one or more of a safe state, a restricted state, or a non-operational state, if during a predetermined number of consecutive ignition phases of the burning unit 120, the gas valve 194 is open and the flame detector 150 fails to sense a flame 122 in the burning unit 120 during the variable ignition safety time.

[0062] Fig. 2 shows a schematic view of an air-gas mixture burning appliance 100 having a fan 114 downstream of an air-gas mixer 118 and an air flow channel 250 to a reference pressure port 242 of a gas valve 194. As shown in Fig. 2, the air-gas mixture burning appliance 100 may include an air inlet for providing air 111, a gas inlet 117 for providing gas 119, and a flue outlet 155 for the evacuation of exhaust gas 152. Illustratively, the air-gas mixture burning appliance 100 may further include an air-gas mixing unit 110, a burning unit 120, and a heat exchanger 170.

[0063] The air-gas mixing unit 110 is preferably adapted for mixing of air 111 and gas 119 to form a combustible air-gas mixture 130. Preferentially, the combustible air-gas mixture 130 is a homogenous mixture of the air 111 and the gas 119.

[0064] 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 flows towards the burner surface 124. If desired, the fan 114 may drive the combustible air-gas mixture 130 through the combustible air-gas pathway

132 towards the burner surface 124.

[0065] The combustible air-gas mixture 130 is burned by the burning unit 120 and, more specifically, at the burner surface 124. The heat exchanger 170 may transfer the heat that is generated at the burner surface 124 to another medium. For example, the heat exchanger 170 may transfer the heat that is generated at the burner surface 124 to water in a water circuit. The flue outlet 155 may evacuate the exhaust gas 152 from the air-gas mixture burning appliance 100.

[0066] The gas valve 194 may include a reference pressure port 242. Preferably, the air flow channel 250 is adapted for providing the flow of the air 111 to the reference pressure port 242, and the gas valve 194 is adapted for regulating the flow of the gas 119 based on the pressure of the flow of the air 111 at the reference pressure port 242.

[0067] The controller 140 is adapted for determining a variable ignition safety time for an ignition phase of the burning unit 120 by selecting from at least two different durations of time. Thereby, the controller 140 determines the variable ignition safety time as an anticipated maximum duration of time that elapses between an opening of the gas valve 194 and a closing of the gas valve 194 for avoiding a hazardous accumulation of the combustible air-gas mixture 130 in the burning unit 120.

[0068] Illustratively, the controller 140 may send an actuator signal 183 to the gas valve 194. If desired, the actuator signal 183 may direct the gas valve 194 to open and/or to close. For example, at the beginning of an ignition phase, the controller 140 may direct the gas valve 194 to open.

[0069] By way of example, the controller 140 may direct the gas valve 194 to shut off if, during the ignition phase of the burning unit 120, the gas valve 194 is open and the flame detector 150 fails to sense a flame 122 in the burning unit 120 during the variable ignition safety time. For example, the controller 140 may direct the gas valve 194 to close using actuator signal 183.

[0070] Thus, actuator signal 183 may override the reference pressure port 242 of the gas valve 194.

[0071] Fig. 3 shows a flowchart illustrating a method 300 of operating an air-gas mixture burning appliance. The air-gas mixture burning appliance comprises a burning unit for burning a combustible air-gas mixture, a flame detector for sensing a presence of a flame in the burning unit, an air-gas mixing unit that is arranged upstream of the burning unit and is adapted for mixing of air and gas to form the combustible air-gas mixture, and a gas valve that is arranged upstream of the air-gas mixing unit and is adapted for regulating a flow of the gas to the air-gas mixing unit.

[0072] For example, the air-gas mixture burning appliance 100 of Fig. 1 or Fig. 2 comprises a burning unit 120 for burning a combustible air-gas mixture 130, a flame detector 150 for sensing a presence of a flame 122 in the burning unit 120, an air-gas mixing unit 110 that is arranged upstream of the burning unit 120 and is adapted

for mixing of air 111 and gas 119 to form the combustible air-gas mixture 130, and a gas valve 194 that is arranged upstream of the air-gas mixing unit 110 and is adapted for regulating a flow of the gas 119 to the air-gas mixing unit 110.

[0073] During operation 310, the air-gas mixture burning appliance determines, with a controller, a variable ignition safety time for an ignition phase of the burning unit by determining an anticipated maximum duration of time that can safely elapse between an opening of the gas valve and a closing of the gas valve for avoiding a hazardous accumulation of the combustible air-gas mixture in the burning unit.

[0074] For example, air-gas mixture burning appliance 100 of Fig. 1 or Fig. 2 may use controller 140 to determine a variable ignition safety time for an ignition phase of the burning unit 120 by determining an anticipated maximum duration of time that can safely elapse between an opening of the gas valve 194 and a closing of the gas valve 194 for avoiding a hazardous accumulation of the combustible air-gas mixture 130 in the burning unit 120.

[0075] During operation 320, the air-gas mixture burning appliance directs, with the controller, the gas valve to shut off if, during the ignition phase of the burning unit, the gas valve is open and no flame is detected in the burning unit during the variable ignition safety time.

[0076] For example, air-gas mixture burning appliance 100 of Fig. 1 or Fig. 2 may use controller 140 to direct the gas valve 194 to shut off if, during the ignition phase of the burning unit 120, the gas valve 194 is open and no flame 122 is detected in the burning unit 120 during the variable ignition safety time.

[0077] If desired, the air-gas mixture burning appliance may further comprise a secured gas pathway that is arranged between the gas valve and the air-gas mixing unit and is adapted for providing the gas from the gas valve to the air-gas mixing unit.

[0078] For example, the air-gas mixture burning appliance 100 of Fig. 1 or Fig. 2 may comprise a secured gas pathway 116 that is arranged between the gas valve 194 and the air-gas mixing unit 110 and is adapted for providing the gas 119 from the gas valve 194 to the air-gas mixing unit 110.

[0079] In such an air-gas mixture burning appliance, the operation of determining 310 the variable ignition safety time may further comprise the operation of determining the variable ignition safety time based at least on the type of the gas, and/or on an inferred concentration of the gas in the secured gas pathway, and/or on an elapsed time since a flame detector previously sensed a flame in the burning unit.

[0080] As an example, the air-gas mixture burning appliance 100 of Fig. 1 or Fig. 2 may determine the variable ignition safety time based at least on the type of the gas 119.

[0081] As another example, the air-gas mixture burning appliance 100 of Fig. 1 or Fig. 2 may determine the variable ignition safety time based at least on an inferred

concentration of the gas 119 in the secured gas pathway 116.

[0082] As yet another example, the air-gas mixture burning appliance 100 of Fig. 1 or Fig. 2 may determine the variable ignition safety time based at least on an elapsed time since a flame detector 150 previously sensed a flame 122 in the burning unit 120.

[0083] As yet another example, the air-gas mixture burning appliance 100 of Fig. 1 or Fig. 2 may determine the variable ignition safety time based at least on the type of the gas 119, and an inferred concentration of the gas 119 in the secured gas pathway 116.

[0084] As yet another example, the air-gas mixture burning appliance 100 of Fig. 1 or Fig. 2 may determine the variable ignition safety time based at least on the type of the gas 119 and an elapsed time since a flame detector 150 previously sensed a flame 122 in the burning unit 120.

[0085] As yet another example, the air-gas mixture burning appliance 100 of Fig. 1 or Fig. 2 may determine the variable ignition safety time based at least on an inferred concentration of the gas 119 in the secured gas pathway 116, and an elapsed time since a flame detector 150 previously sensed a flame 122 in the burning unit 120.

[0086] As yet another example, the air-gas mixture burning appliance 100 of Fig. 1 or Fig. 2 may determine the variable ignition safety time based at least on the type of the gas 119, and on an inferred concentration of the gas 119 in the secured gas pathway 116, and on an elapsed time since a flame detector 150 previously sensed a flame 122 in the burning unit 120.

[0087] Illustratively, the controller of the air-gas mixture burning appliance may further trigger a warning and/or put the air-gas mixture burning appliance into one or more of a safe state, a restricted state or a non-operational state, if, during a predetermined number of consecutive ignition phases of the burning unit, the gas valve is open and no flame is detected in the burning unit during the variable ignition safety time.

[0088] As an example, the controller 140 of the air-gas mixture burning appliance 100 of Fig. 1 or Fig. 2 may trigger a warning, if, during a predetermined number of consecutive ignition phases of the burning unit 120, the gas valve 194 is open and no flame 122 is detected in the burning unit 120 during the variable ignition safety time.

[0089] As another example, the controller 140 of the air-gas mixture burning appliance 100 of Fig. 1 or Fig. 2 may put, the air-gas mixture burning appliance 100 into one or more of a safe state, a restricted state or a non-operational state, if, during a predetermined number of consecutive ignition phases of the burning unit 120, the gas valve 194 is open and no flame 122 is detected in the burning unit 120 during the variable ignition safety time.

[0090] As yet another example, the controller 140 of the air-gas mixture burning appliance 100 of Fig. 1 or Fig.

2 may trigger a warning and put, the air-gas mixture burning appliance 100 into one or more of a safe state, a restricted state or a non-operational state, if, during a predetermined number of consecutive ignition phases of the burning unit 120, the gas valve 194 is open and no flame 122 is detected in the burning unit 120 during the variable ignition safety time.

10 Claims

1. An air-gas mixture burning appliance (100), comprising:

a burning unit (120) for burning a combustible air-gas mixture (130);
an air-gas mixing unit (110) that is arranged upstream of the burning unit (120) and is adapted for mixing of air (111) and gas (119) to form the combustible air-gas mixture (130);
a gas valve (194) that is arranged upstream of the air-gas mixing unit (110) and is adapted for regulating a flow of the gas (119) to the air-gas mixing unit (110); and
a controller (140) that is adapted for determining a variable ignition safety time for an ignition phase of the burning unit (120) by selecting from at least two different durations of time, wherein the controller (140) determines the variable ignition safety time as an anticipated maximum duration of time that elapses between an opening of the gas valve (194) and a closing of the gas valve (194) for avoiding a hazardous accumulation of the combustible air-gas mixture (130) in the burning unit (120).

2. The air-gas mixture burning appliance of claim 1, further comprising:

a secured gas pathway (116) that is arranged between the gas valve (194) and the air-gas mixing unit (110) and is adapted for providing the gas (119) from the gas valve (194) to the air-gas mixing unit (110), and wherein the controller (140) determines the variable ignition safety time based on an inferred concentration of the gas (119) in the secured gas pathway (116).

3. The air-gas mixture burning appliance of any one of the preceding claims, wherein the controller (140) determines the variable ignition safety time based at least on the type of the gas (119).

4. The air-gas mixture burning appliance of any one of the preceding claims, wherein the controller (140) determines the variable ignition safety time by selecting from a predetermined number of at least three different discrete durations of time, wherein all values of the at least three different discrete durations

of time are smaller than or equal to a predetermined maximum ignition safety time.

5. The air-gas mixture burning appliance of any one of claims 1 to 3, wherein the controller (140) determines the variable ignition safety time by selecting from a continuous range of values, wherein all values in the continuous range of values are smaller than or equal to a predetermined maximum ignition safety time.
6. The air-gas mixture burning appliance of any one of the preceding claims, further comprising:
a flame detector (150) for sensing a presence of a flame (122) in the burning unit (120), wherein the controller (140) determines the variable ignition safety time based at least on an elapsed time since the flame detector (150) previously sensed a flame (122) in the burning unit (120).
7. The air-gas mixture burning appliance of claim 6, wherein the controller (140) directs the gas valve (194) to shut off if, during the ignition phase of the burning unit (120), the gas valve (194) is open and the flame detector (150) fails to sense a flame (122) in the burning unit (120) during the variable ignition safety time.
8. The air-gas mixture burning appliance of claim 6 or 7, wherein the controller (140) triggers a warning and/or puts the air-gas mixture burning appliance (100) into one or more of a safe state, a restricted state, or a non-operational state, if during a predetermined number of consecutive ignition phases of the burning unit (120), the gas valve (194) is open and the flame detector (150) fails to sense a flame (122) in the burning unit (120) during the variable ignition safety time.
9. A method (300) of operating an air-gas mixture burning appliance (100) that comprises a controller (140), a burning unit (120) for burning a combustible air-gas mixture (130), a flame detector (150) for sensing a presence of a flame (122) in the burning unit (120), an air-gas mixing unit (110) that is arranged upstream of the burning unit (120) and is adapted for mixing of air (111) and gas (119) to form the combustible air-gas mixture (130), and a gas valve (194) that is arranged upstream of the air-gas mixing unit (110) and is adapted for regulating a flow of the gas (119) to the air-gas mixing unit (110), the method comprising:
determining (310) with the controller (140), a variable ignition safety time for an ignition phase of the burning unit (120) by determining an anticipated maximum duration of time that can safely elapse between an opening of the gas valve (194) and a closing of the gas valve (194) for avoiding a hazardous accumulation of the combustible air-gas mixture (130) in

the burning unit (120).

10. The method of claim 9, further comprising:
directing (320) with the controller (140), the gas valve (194) to shut off, if, during the ignition phase of the burning unit (120), the gas valve (194) is open and no flame (122) is detected in the burning unit (120) during the variable ignition safety time.
11. The method of any one of claims 9 or 10, wherein the air-gas mixture burning appliance (100) further comprises a secured gas pathway (116) that is arranged between the gas valve (194) and the air-gas mixing unit (110) and is adapted for providing the gas (119) from the gas valve (194) to the air-gas mixing unit (110), and wherein determining (310) the variable ignition safety time further comprises:
determining the variable ignition safety time based at least on the type of the gas (119), and/or on an inferred concentration of the gas (119) in the secured gas pathway (116), and/or on an elapsed time since a flame detector (150) previously sensed a flame (122) in the burning unit (120).
12. The method of any one of claims 10 or 11, further comprising:
triggering with the controller (140), a warning and/or putting, with the controller (140), the air-gas mixture burning appliance (100) into one or more of a safe state, a restricted state or a non-operational state, if, during a pre-determined number of consecutive ignition phases of the burning unit (120), the gas valve (194) is open and no flame (122) is detected in the burning unit (120) during the variable ignition safety time.

Fig. 1

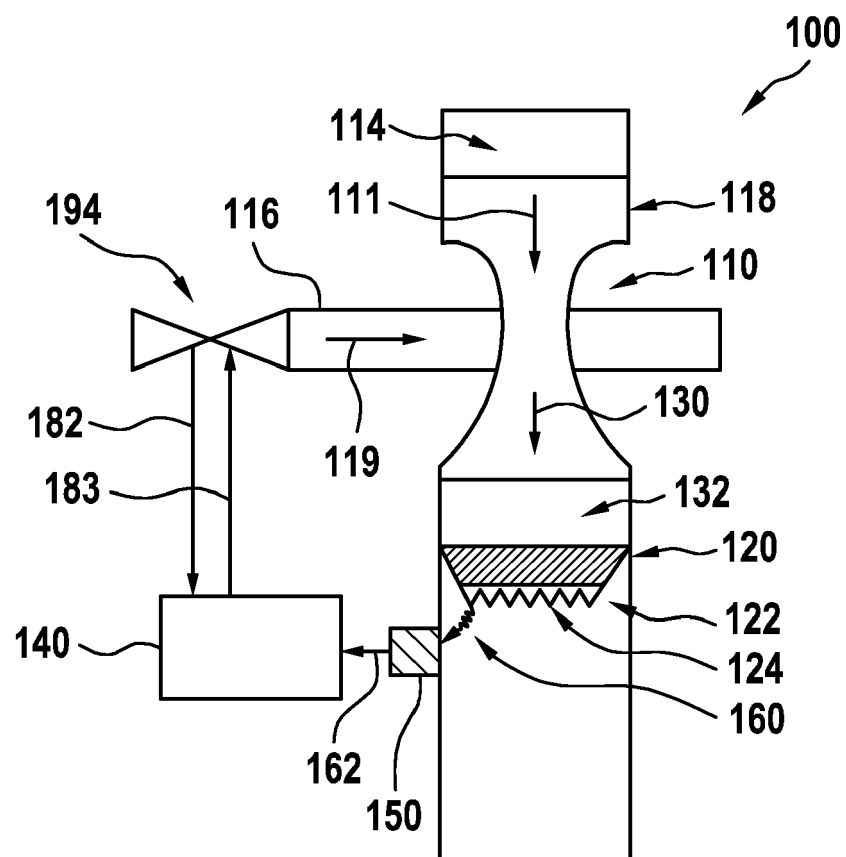


Fig. 2

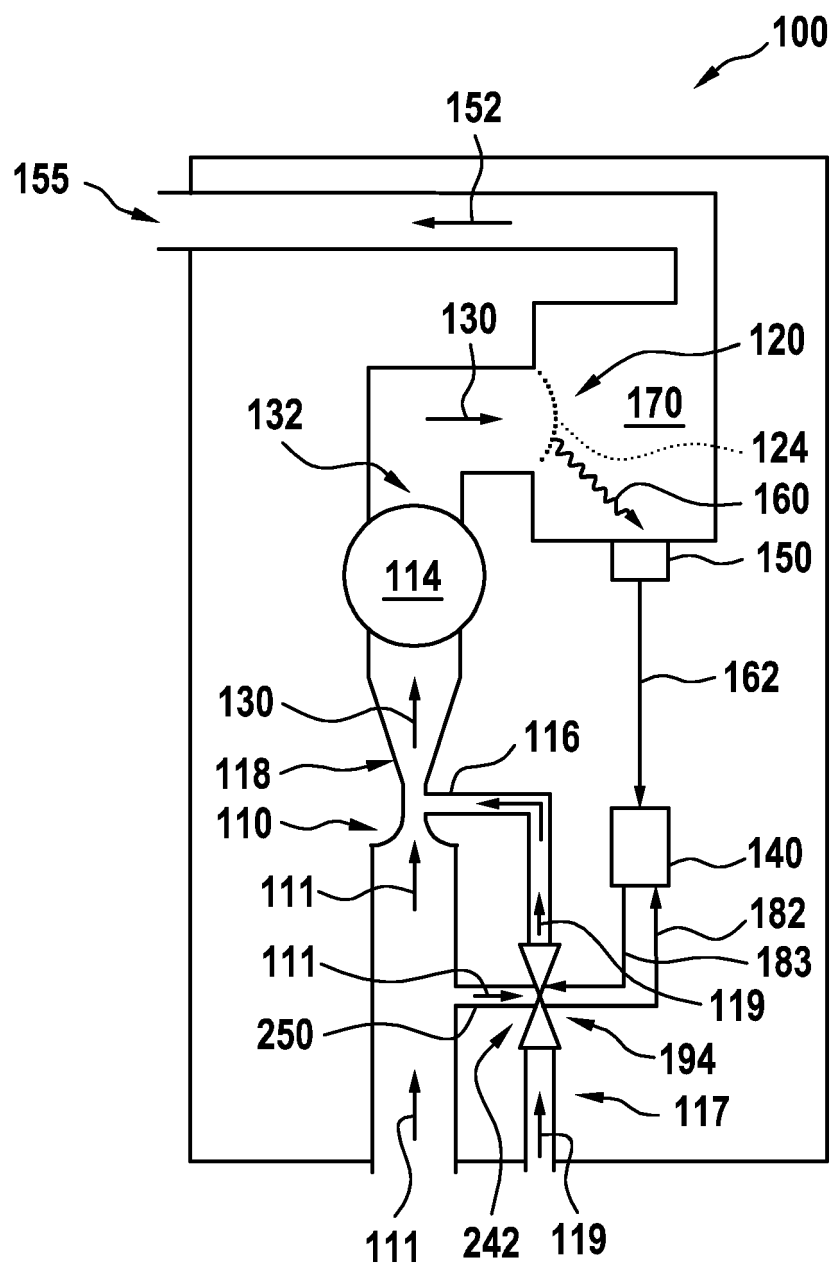
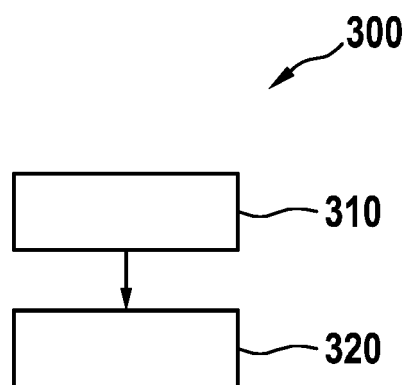


Fig. 3





EUROPEAN SEARCH REPORT

Application Number

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Place of search Munich		Date of completion of the search 6 April 2023	Examiner Vogl, Paul
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