Abstract: A burner flame detection and monitoring system for a pilot burner for combustion of wastes gases and waste materials. The system includes a pilot burner assembly. A gas premix burner assembly includes a fuel gas delivery conduit, a fuel metering orifice, a fuel and air mixing device, a pilot tube and a pilot burner tip assembly. A primary sensor is in communication with the pilot burner assembly downstream of the fuel metering orifice. A secondary sensor is in communication with pilot burner assembly at or upstream of the fuel metering orifice. A processor receives input from both the primary sensor and the secondary sensor. A mechanism integrates the input from the primary sensor and the input from the secondary sensor to deduce the presence, absence or quality of a pilot flame.
BURNER FLAME DETECTION AND MONITORING SYSTEM

STATEMENT OF PRIORITY

This application claims priority to U.S. Application No. 13/482,575 which was filed on May 29, 2012.

BACKGROUND OF THE INVENTION

1. Field of the Invention.

The present invention is directed to a sensing system for detecting the existence, absence or quality of a pilot burner flame. In particular, the present invention is directed to a sensing system utilizing multiple sensors operating in conjunction with each other to detect the existence, absence or quality of a pilot burner flame.

2. Prior Art.

In commercial, industrial, power generation and petrochemical processing applications, waste gases and waste materials are often combusted in large, tall flare stacks. The flare is typically ignited with a pilot burner flame, which may be located in a remote location, such as at the top of a flare stack. Depending on the configuration, the top of the flare stack may be from 20 to several hundred feet from ground level. Accordingly, direct visual monitoring of the pilot flame may be inconvenient or difficult. In some applications, the waste gases and waste materials are delivered intermittently while the pilot burner flame remains constantly lit.

It is desirable to be able to monitor the pilot burner flame. The pilot burner flame ignites the waste gases and waste materials emitted from the flare stack in order to initiate the combustion reaction at the flare main burner. Flame detection and monitoring assists in establishing and maintaining safe and reliable pilot burner performance thereby insuring safe and reliable flame main burner performance.

In the event that the pilot burner flame is not operational, waste gases may be released directly into the atmosphere due to failure of the flare main burner, causing combustion inefficiency and possible release of pollutants. Increasingly, regulations prohibit release of pollutants directly to the atmosphere.

Possible causes of pilot burner flame failure include natural gas supply interruptions, clogging of delivery lines and extreme ambient conditions, such as high wind and heavy rain.
Various devices have been proposed in the past for monitoring the presence of a pilot burner flame. Acoustic monitoring of the pilot burner flame has been proposed. Other sensing mechanisms proposed in the past include pressure sensors, optical sensor systems, thermocouples, video systems including visible and infrared monitoring, flame ionization rods, and gas detection systems. For example, Palmer (U.S. Patent No. 4,959,638) discloses an acoustic sensor. Puster et al (U.S. Patent No. 5,665,916) discloses a pressure transducer in a fuel line. Waters et al (U.S. Patent No. 6,164,957) discloses an electromagnetic transducer in the form of a geophone responsive to acoustic energy.

While each of the foregoing systems could be employed, each has its own relative strengths and weaknesses. For example, optical systems must be kept clean to operate. Optical and UV systems might also suffer interference from direct sunlight at certain times of the day or suffer interference from fog or other weather-related issues. Thermocouples provide slow response to the presence or absence of flame. Flame ionization rods can become short circuited by environmental exposure.

Unnecessary false alarms from the sensing and monitoring system should be minimized as these could lead to unnecessary shutdown of an entire operation.

There remains a need for a pilot burner flame detection and monitoring system which increases the speed and the probability of accurate detection significantly and decreases the incidence of false readings or false alarms.

Accordingly, it is a principal object and purpose of the present invention to provide a pilot burner flame detection and monitoring system utilizing multiple sensors operating in conjunction with each other.

It is a further object and purpose of the present invention to provide a pilot burner flame detection and monitoring system with multiple sensors of different types measuring different parameters wherein the sensors operate in conjunction with each other.

It is a further object and purpose of the present invention to fuse data from multiple sensors into a single parameter to indicate the presence or absence of a pilot burner flame, to detect the condition of the pilot burner flame and to issue commands to modulate input parameters such as fuel pressure to enhance and control pilot burner flame quality.
SUMMARY OF THE INVENTION

The present invention is directed to a pilot burner flame detection and monitoring system for a pilot burner. A pilot burner assembly is connected to a pilot tube or pipe which is in fluid communication with a gas premix burner assembly.

In one preferred embodiment of the present invention, the pilot burner assembly includes a fuel gas delivery conduit and a fuel metering orifice connected to a fuel and air mixing device. Atmospheric air and fuel are introduced into the air mixing device.

A primary sensor is in communication with the fuel and air mixing device. The primary sensor detects a sound or pressure signal of the fuel gas jet through the fuel metering orifice and the pilot burner flame.

A secondary sensor is in communication with the fuel metering orifice on, within or near the fuel delivery conduit. The secondary sensor primarily detects a sound or pressure signal of the fuel gas jet.

Each of the sensors converts sound or pressure to an electric signal. The primary sensor and the secondary sensor are each independently wired to a signal amplifier and conditioning processor. The amplifier and conditioner detects and recognizes the pilot flame signal and provides an output signal for further processing by other control devices or systems.

In another preferred embodiment, a primary sensor such as a pressure transducer is in fluid communication via interconnecting tubing with the pilot burner assembly downstream of the fuel metering orifice. A secondary sensor, such as a pressure transducer, is in communication with the fuel metering orifice. Each sensor provides an output signal which is integrated to deduce the presence, absence or quality of a pilot flame.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram of a flare stack with pilot burner in the prior art prior to introduction of the present invention;

Figure 2 illustrates a schematic diagram of a first preferred embodiment of a burner flame detection and monitoring system constructed in accordance with the present invention; and

Figure 3 illustrates a schematic diagram of a second preferred embodiment of a burner flame detection and monitoring system of the present invention.
DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiments discussed herein are merely illustrative of specific manners in which to make and use the invention and are not to be interpreted as limiting the scope of the instant invention.

While the invention has been described with a certain degree of particularity, it is to be noted that many modifications may be made in the details of the invention's construction and the arrangement of its components without departing from the spirit and scope of this disclosure. It is understood that the invention is not limited to the embodiments set forth herein for purposes of exemplification.

Figure 1 illustrates an example of a known flare stack burner 10 for combustion of waste gases and waste materials prior to introduction of the present invention. The flare stack burner 10 may be employed in a wide variety of applications including commercial, industrial, power generation and petrochemical processing. The present invention may also be utilized on a pilot burner assembly or a process burner, boiler burner, or other burner types.

A pilot burner tip assembly 14 includes a pilot ignition system for igniting combustible waste gases. The pilot burner tip assembly 14 is connected to a pilot hollow tube or pipe 16 which is in fluid communication with a fuel and air mixing device 36. The device 36 is in fluid communication with a fuel gas supply, such as a natural gas line. Other types of fuel may be used within the spirit and scope of the present invention.

A hollow tube or pipe 22 (known as a flame front generator tube) terminates at an open end adjacent the pilot burner tip assembly 14. The pipe 22 extends to a fuel and air mixing chamber and an igniter assembly 24 (represented by a box) that may be located remotely such as at ground level. The igniter assembly 24 may operate in conjunction with other or alternate ignition mechanisms.

The igniter assembly 24 and the tube or pipe 22 together constitute an example of a flame front generator ignition system.

The pilot burner tube 16 and the igniter tube 22 may be secured to the flare stack 10 by one or more brackets 30.

The fuel metering orifice 34, mixing device 36, pilot tube 22 and the pilot burner tip assembly 14 together constitute the pilot burner assembly 18. The assembly 18 might be other types of gas premix burner assemblies.
Figure 2 illustrates a first preferred embodiment of the present invention. The pilot tube 16 is in fluid communication with a fuel and air mixing device 36. The device 36 includes a fuel gas delivery conduit 32, and a fuel metering orifice 34 connected to a fuel and air mixing device 36. Atmospheric air is introduced into the mixing device 36 through an integral venturi. The device 36 is in fluid communication with the pilot burner tip assembly 14 through the pilot tube 16.

The fuel metering orifice 34, mixing device 36, pilot tube 22 and the pilot burner tip assembly 14 together constitute the pilot burner assembly 18. The assembly 18 might be other types of gas premix burner assemblies.

A primary sensor 40 is in communication with the burner assembly 18 downstream of the metering orifice 34. In a non-limiting present embodiment, the primary sensor 40 is an acoustic microphone or pressure transducer. In one preferred arrangement, the primary sensor 40 is attached to or within the mix chamber. The primary sensor detects the sound signal emitted by the pilot flame and the jet noise emitted from the orifice 34. The highest amplitude sound signal present in the mix chamber 36 is that of the fuel gas jet emitted through the fuel metering orifice.

A secondary sensor 42, an acoustic microphone or pressure transducer, is in communication with the fuel metering orifice 34. In one preferred arrangement, the secondary sensor is on, within, near or in fluid communication with the fuel metering orifice 34. The secondary sensor will primarily detect the signal of the fuel gas jet and will not respond significantly to the sound of the flame at the pilot burner flame tip 14.

Each of the sensors 40 and 42 converts sound or pressure to an electric signal. The primary sensor 40 and the secondary sensor 42 are each independently connected via wires, 44 and 46 respectively, to a signal amplifier and conditioning processor 48. The electric signal is processed by the amplifier and its circuitry and programming. In one non-limiting example, the amount of energy of various frequencies is determined. An acoustic signature may be generated from the data from each sensor. The acoustic signature may be compared to nominal operating conditions. The amplifier and conditioner 48 detect and recognize the pilot flame signal and provide an output signal for further processing by other control devices or systems (not seen).

The output signal could indicate the presence, absence or quality of the pilot burner flame. The quality signal may be further processed to modulate pilot burner input
parameters such as fuel pressure.

In addition to determining the presence or absence of a pilot flame, the present invention may utilize the data gathered by the sensors 40 and 42 and other sensors to infer data concerning combustion efficiency, pollutant (NO\textsubscript{x}, CO) emissions, and flame stability.

Figure 3 illustrates a schematic diagram of a second preferred embodiment of the present invention.

A primary sensor, for example a pressure transducer 60, is attached to and in fluid communication via interconnecting tubing 62 with the pilot burner assembly 18 downstream of the fuel metering orifice 34.

As in the previous embodiment, the pilot burner assembly 18 includes a fuel gas delivery conduit 32 and a fuel metering orifice 34 connected to the fuel and air mixing device 36. The pressure transducer 60 detects a characteristic pressure signal emitted by the pilot flame and jet noise when the flame is present and burning. The highest amplitude pressure signal present in the mixing chamber is that induced by the fuel gas jet emitted from the fuel metering orifice 34. The primary sensor 60 is in turn connected to a signal amplifier and conditioning processor 64 by wire 66.

A secondary sensor 70, for example a pressure transducer or acoustic microphone, is in communication with the fuel metering orifice. The secondary sensor will primarily detect the signal of the fuel gas jet.

The processor 64 detects the flame signal and provides an output signal for further processing by other control devices or systems. The output signal will indicate the presence, absence or quality of the pilot flame. Separate output signals may provide further indication of condition or nature of the pilot flame. For example, the amplitude or intensity of the flame signal detected by the pressure transducer may provide an indication of the quality of the pilot flame. Information deduced from the pressure signal may be of a quality and nature such that the processor 64 may provide a signal that acts to modulate input parameters such as the fuel pressure and flow to the pilot burner assembly 1. For example, the amount of fuel directed to and consumed by the pilot burner may be minimized while maintaining a sufficiently robust flame.

Whereas, the present invention has been described in relation to the drawings attached hereto, it should be understood that other and further modifications, apart from those shown or suggested herein, may be made within the spirit and scope of this invention.
CLAIMS:

1. A burner flame detection and monitoring system for a pilot burner for combustion of gases, which system comprises:
   a pilot burner assembly;
   a gas premix burner assembly having a fuel gas delivery conduit, a fuel metering orifice, and a fuel and air mix chamber in communication with said pilot burner assembly;
   a primary sensor in communication with said fuel and air mix chamber;
   a secondary sensor in communication with said fuel metering orifice;
   a processor receiving input from both said primary sensor and said secondary sensor; and
   a mechanism to integrate said input from said primary sensor and from said secondary sensor to deduce the presence, absence, or quality of a pilot flame.

2. A burner flame detection and monitoring system as set forth in Claim 1 wherein said primary sensor is an acoustic microphone.

3. A burner flame detection and monitoring system as set forth in Claim 1 wherein said primary sensor is a pressure transducer.

4. A burner flame detection and monitoring system as set forth in Claim 1 wherein said secondary sensor is an acoustic microphone.

5. A burner flame detection and monitoring system as set forth in Claim 1 wherein said secondary sensor is a pressure transducer.

6. A burner flame detection and monitoring system as set forth in Claim 1 wherein said mechanism to integrate said input from said primary sensor and said secondary sensor subtracts said input from said secondary sensor from said input from said primary sensor.
7. A multi-sensor, multi-parameter flame monitoring system, which comprises:
   a first flame monitor measuring a first parameter chosen from a group consisting of an acoustic monitor, a thermocouple monitor, an optical monitor, a video monitor, a pressure monitor, and a gas detection monitor;
   a second flame monitor measuring a second parameter different from said first parameter wherein said second flame monitor is chosen from the group consisting of an acoustic monitor, a thermocouple monitor, an optical monitor, a video monitor, a pressure monitor, and a gas detection monitor; and
   a mechanism to combine and integrate data from said first flame monitor and data from said second flame monitor in order to deduce the presence, absence or quality of a flame.

8. A multi-sensor, multi-parameter flame monitoring system as set forth in Claim 7 wherein said mechanism to combine and integrate data subtracts input from one of said monitors from another said monitor to deduce the presence, absence or quality of a pilot flame.

9. A multi-sensor, multi-parameter flame monitoring system as set forth in Claim 7 wherein said first pilot flame monitor is in communication with a pilot burner assembly downstream of a fuel metering orifice.

10. A multi-sensor, multi-parameter flame monitoring system as set forth in Claim 7 wherein said second flame monitor is in communication with a pilot burner assembly at or upstream of a fuel metering orifice.
INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 2013/041502

A. CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) or to both national classification and IPC.

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F23N 5/00-5/26, F23Q 9/00-9/14, G01H 17/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, Information Retrieval System of FIPS (http://www.fips.ru)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
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<td>A</td>
<td>RU 242 1662 C2 (SIEMENS AKTIENGESELLSCHAFT) 20.06.201 1</td>
<td>1-10</td>
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☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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