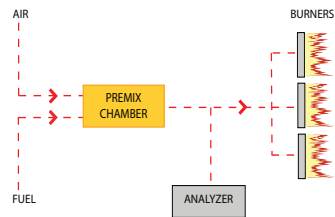


Monitoring Air/Fuel Mixtures in Glass and Glass Fiber Manufacturing

Oxygen measurement - an indispensable aid for controlling product quality.

Measurement of Premix Gas

To produce the desired flame in a glass forehearth or when making fiberglass (glass fiber) insulation, an air/fuel pre-mixer is used. The pre-mixer combines compressed natural gas or propane with air and this mixture is then piped to the process burners. At the burner, a fuel-rich or fuel-lean flame is produced depending on the air/fuel ratio selected. In many combustion applications, an oxygen analyzer measures the excess oxygen (fuel-lean) or excess fuel (fuel-rich) directly in the flue gas. In this application however, the flue gas cannot easily be reached or may not provide an accurate measurement due to air leakage. A pre-mix gas analyzer must therefore be used.

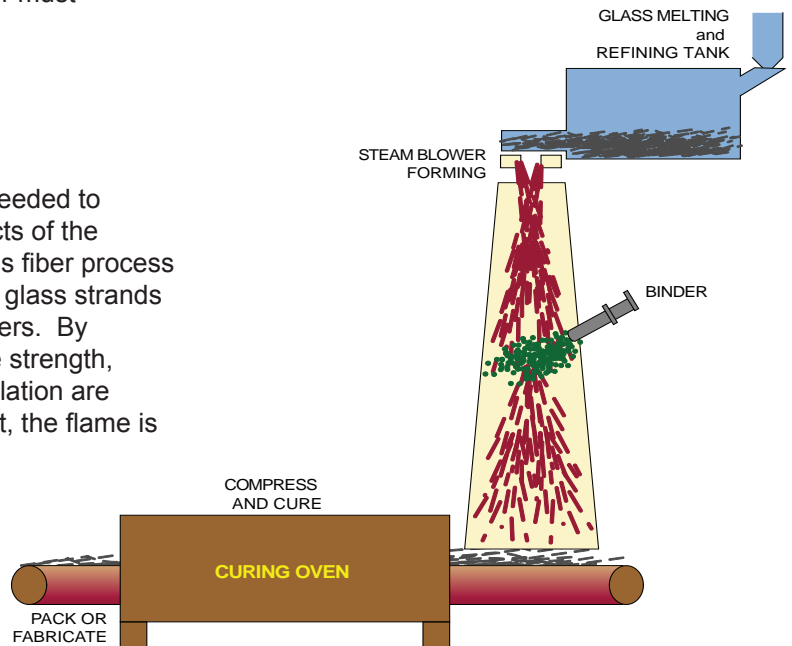


Analysis of Premix Gas

- || Control of air-to-fuel ratio is critical to the quality of glass or glass fiber products.
- || Processes using open flame burners cannot use traditional flue gas analysis.
- || The PreMix 2000 and CMFA-P2000 operate in fuel-rich or fuel-lean conditions.
- || The analyzer responds quickly to changes in the pre-mix gas by analyzing a small sample, paralleling actual burner conditions.

Glass Fiber Manufacturing

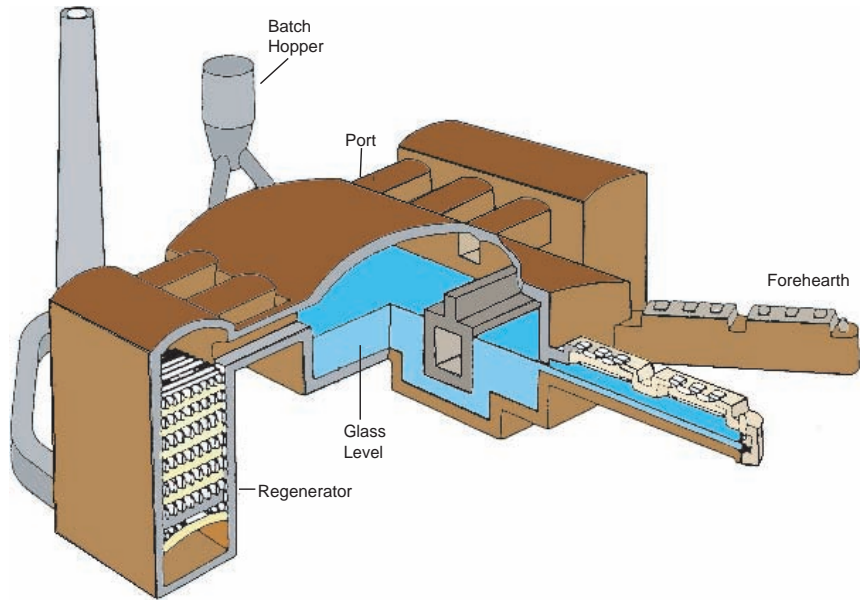
Similarly, precise combustion control is needed to manufacture glass fiber insulation products of the correct quality. The final stage of the glass fiber process uses a high velocity flame to melt coarse glass strands and draw them out into extremely fine fibers. By controlling the air/fuel mixture, the tensile strength, density, weight, and "R" factor of the insulation are controlled. Depending on the end product, the flame is kept slightly fuel-rich or slightly fuel-lean.



Glass Fiber Manufacture

Container Glass Forehearth

In the manufacture of bottles and other glass containers, open flame burners are used to control the atmosphere of the molten glass in the forehearth. Depending on the end product and desired process conditions, a slightly rich or a slightly lean combustion fuel mixture is needed in the different zones in the forehearth. Maintaining the correct air/fuel mixture both ensures the quality of the end product and also protects manufacturing equipment such as gobbing stirs.



Glass Melt Tank and Forehearth

Challenges to Maintaining Product Quality

Electrochemical, paramagnetic or laser oxygen analyzers can be used to monitor and control the fuel/air ratio in glass or glass fiber production. From time to time product defects still occur for no apparent reason.

Perhaps the problem lies with the measurement principle. Electrochemical, paramagnetic or laser oxygen analyzers measure the concentration by volume of the oxygen molecules in the unburned air/fuel mixture.

Let us assume the burners are operating on natural gas with a 9.6-to-1 air/fuel ratio. The analyzer will display a value around 19% O_2 , a normal and expected value. What happens if there is a change in heat content of the gas? Consider the following two examples:

1. In place of natural gas, mix and burn 1 cu. ft. Hydrogen with 9.6 cu. ft. air. According to the oxygen analyzer the air/fuel mixture is correct, yet the product quality has suddenly dropped off.
2. Now mix and burn 1 cu. ft. Nitrogen with 9.6 cu. ft. air. Even though the burners would now be trying to run with rarefied air, the analyzer still reads 19% O_2 .

Although the chosen examples are deliberately extreme, they show that this also applies to small variations in the calorific value of the fuel or humidity of the mixture. Hence product defects occur when using these types of analyzers.

The measuring principle used by electrochemical, paramagnetic or laser oxygen analyzers cannot recognize variations in the heat value or in the humidity of the mixture. They are therefore unsuitable for controlling the air/fuel ratio of these processes. This is particularly noticeable in sub-stoichiometric applications where even under steady conditions, a three decimal place resolution would be needed to maintain a specific air/fuel ratio.

Every change in the heat content or humidity of the air/fuel mixture directly corresponds to a change in the flue gas atmosphere, and affects the quality of the product.

The stationary PreMix 2000 and the portable CMFA-P2000 are oxygen analyzers designed specifically for analysis of premix gas.

Principle of Operation

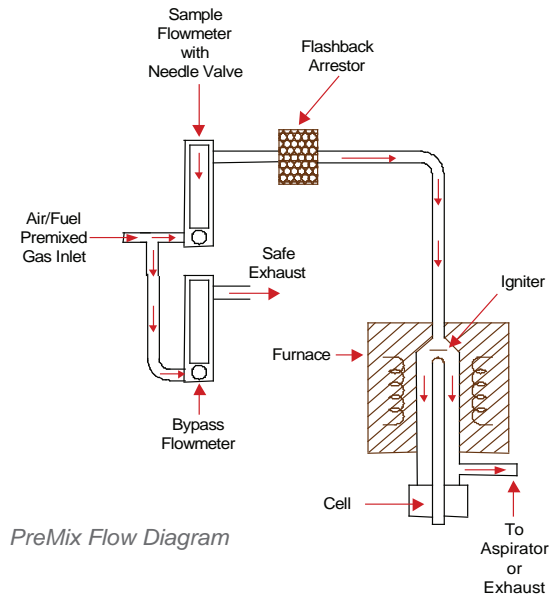
A small sample of the air/fuel mixture passes through the analyzer where it is ignited and completely burned. The newly created flue

gas is immediately analyzed on a zirconium oxide cell. The analyzer can handle oxidizing as well as sub-stoichiometric (reducing) premix gases, and provides a continuous measurement of the excess oxygen or excess fuel in the process flue gas. This approach ensures the optimum air/fuel ratio before the premix gas reaches the burner.

The unique concept of these analyzers simulates the combustion process in advance of the burners and thereby monitors the flue gas atmosphere which directly affects product quality. Both analyzers register every variation in the heat content of the fuel, every variation in humidity and, naturally, any changes in the air/fuel ratio control system.

PreMix 2000 Stationary Analyzer

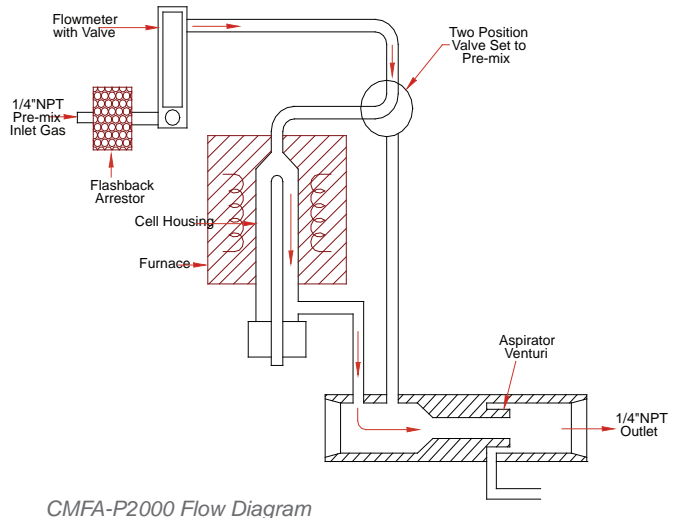
The PreMix 2000 analyzer uses the Series 2000 Control Unit. It enables the user to select the measurement to be displayed, as well as analog output ranges and alarm limits. This allows for easy system integration into the overall combustion control process. For details and specifications, refer to Bulletin F-0160.



CMFA-P2000 Portable Analyzer

The portable CMFA-P2000 houses both the sensor and the Series 2000 Control Unit in a luggage-style carrying case. It can be used as a premix analyzer or a flue gas oxygen analyzer. For details and specifications, refer to Bulletin F-0158.

For further information on the use of zirconium oxide in furnace atmosphere control, see the Application Note, "The Other Side of Zirconium Oxide".



Comparison with Other Types of Measurements

1. Flame Temperature

Unlike a measurement of flame temperature, the PreMix 2000 determines exactly how lean or rich the air/fuel mixture is. The analyzer provides an immediate response to changes in the air/fuel mixture versus the slow response of a temperature measurement. And the sample stream products of combustion measured by the analyzer match the actual process conditions, whereas a temperature measurement in a controlled atmosphere cannot duplicate process conditions.

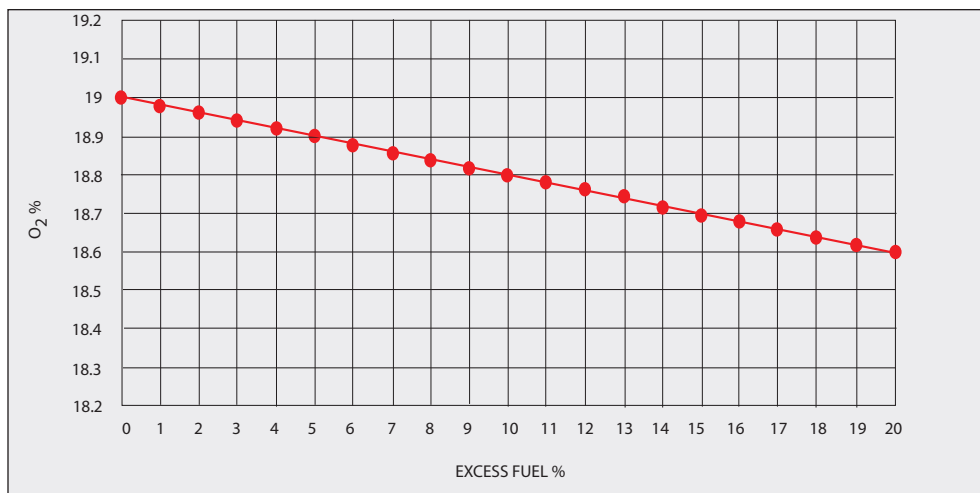
2. BTU Analyzer

Unlike BTU analyzers, the PreMix 2000 automatically corrects for air that may be trapped in the fuel. In this situation, a BTU analyzer will overestimate the amount of air required for desired combustion.

3. Air/Gas Meter (Oxygen Displacement)

In theory, it is possible to measure and control the air/fuel ratio by directly measuring the oxygen concentration of the premixed gas with a paramagnetic or fuel cell type of oxygen sensor. However, these types of sensors will not respond to changes in hydrogen-to-carbon ratio or to density changes, and are not sensitive enough to maintain specific excess fuel conditions.

The graph shows that a resolution of 0.001% oxygen in an 18% oxygen mixture would be required to maintain accurate control. Such a resolution is just not possible with any of these analyzers.



Oxygen in Premix vs. Excess Fuel



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F-0241 Rev. 6 (0216)

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