

## Measuring the Air/Fuel Ratio for Pre-Mix Burners Used for Heating and Surface Treatment

When hydrocarbon fuels burn in air they do so according to a precise chemical equation. An example of such an equation is shown below.

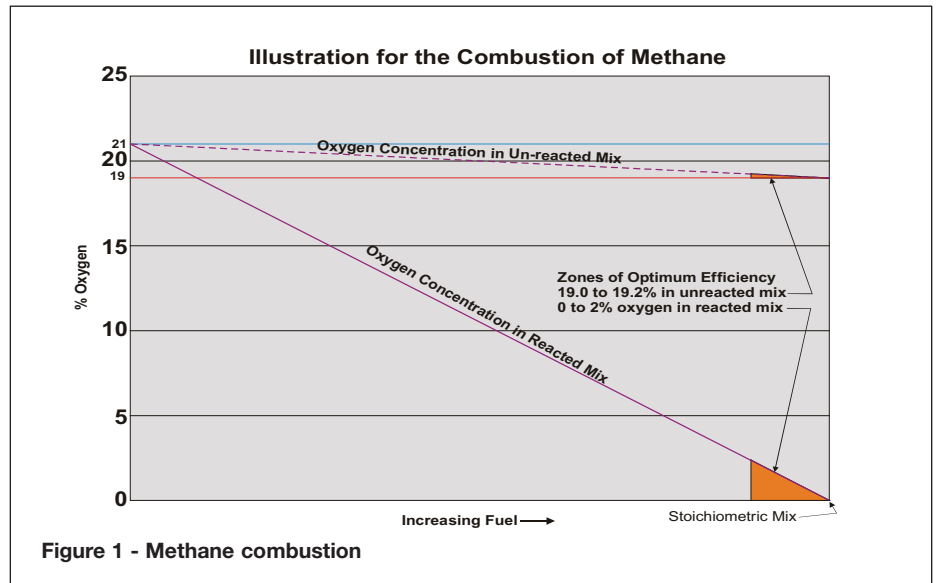
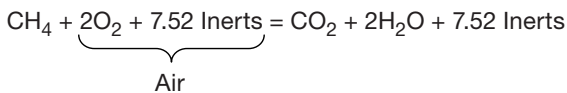


Figure 1 - Methane combustion

This equation illustrates the combustion of methane (CH<sub>4</sub>) in air (approximately 21% oxygen + 79% inerts).



This equation shows amounts (volumes) of each component required to perform a complete reaction of the methane and air. A mix of reactants where each is in a proportion to react completely is called a 'stoichiometric' mixture. Similar equations can be written for other fuels.

Typically mixtures of air and gas burnt for heating etc. contain a small amount of excess air for optimum efficiency.

Measuring and controlling the air/fuel ratio is crucial to maintaining an efficient combustion and to create the correct surface tension in flame treatment processes.

One way of measuring the ratio is to measure the oxygen in the unreacted fuel air mix. For methane the oxygen concentration in the unreacted mixture at stoichiometry would be:

$$\frac{2 \times 100}{1+2+7.52} = 19.01\%$$

So the change in oxygen concentration from air to a stoichiometric mixture is only 2% (21-19). Although oxygen

analysers exist to measure these concentrations, to get any appreciable accuracy ( $\pm 0.01\%$  at least) requires a very expensive device.

An alternative way of determining the air fuel ratio is to pre-burn a small amount of the mixture and measure the oxygen remaining. In this way, the difference in oxygen from air to a stoichiometric mix is 21% - i.e. more than ten times the shift in the in-reacted mixture. The graph above illustrates the difference.

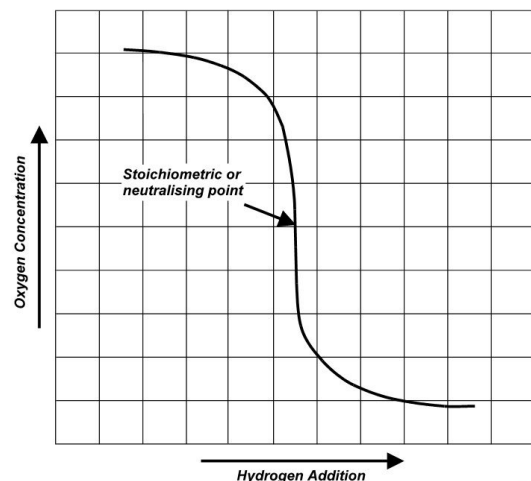


Figure 2 - Neutralisation curve

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Zirconia oxygen analysers are ideal for measuring oxygen in these combusted mixtures for two main reasons. Firstly, they operate at elevated temperatures (600+°C/1100+°F) and so it is not necessary to cool or otherwise condition the sample. Secondly, they can measure the low levels of oxygen present at stoichiometry (and beyond into the reducing zone if necessary) with high accuracy. This equates to an accuracy in the unreacted mixture of about  $\pm 0.002\%$  - significantly better than any alternative.

They measure oxygen concentration in a way analogous to pH electrodes measuring acidity. And in a similar way to a pH electrode being used to monitor the neutralising of an acid by an alkali so a zirconia oxygen sensor can be used to monitor a “neutralisation” of oxygen with the fuel. The graph in Figure 2 shows the classic 'neutralisation' curve for such a process. The “neutralisation” point is where the reactants are in exactly the correct proportions to produce no excess of either.

**Note:** Hitech analyser models Z1915C and Z3000 are used in this type of application.

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