

Temperature evolution during first millisecond after ignition in a gas stove

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Abstract

We use an IR camera to record and describe the ignition process during the first few milliseconds after the electrical spark has initiated the combustions. The measurement of the temperature distribution process resulted in improved thermomechanical ignition chamber design.

Key Words: calibration, small temperature changes, high frequency

1. Summary

Temperature distribution over a burner surface may be effectively measured as a function of time with an IR camera, as described previously. Figure 1 shows a photo (left) and a schematic diagram (right) of a gas burner to be used in home applications in the USA. The combustion is an exothermic chemical reaction where a rapid oxidation of one substance (the fuel) liberates thermal and luminous energy. The ignition energy is the minimum energy required to initiate the combustion process. It may be provided with a pilot light, an electric arc, or any other external source of energy. Figure 2 presents Infrared images of the ignition process of a gas stove initiated with an electrical spark. The Bunsen burners employ a fraction of air (between 40% and 60%) with the flux of fuel to decrease the formation of soot (carbon) particles. Additionally, they may burn LPG (propane to butane in a fraction of 60% to 40%) or natural gas (methane > 90%).

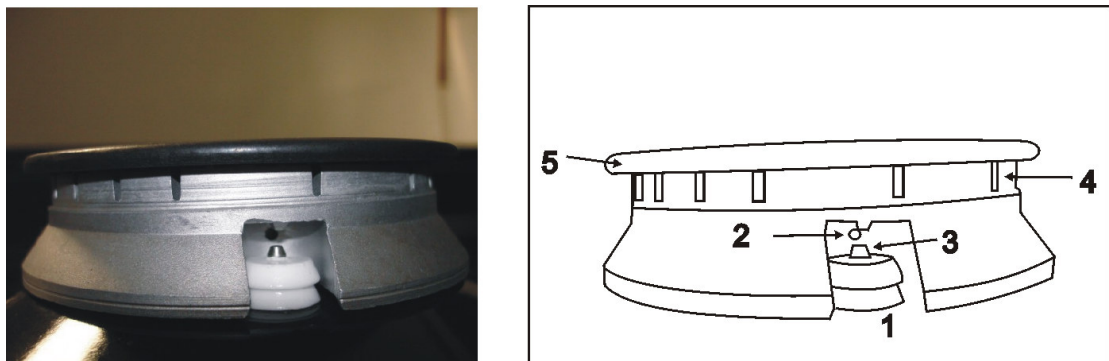


Fig. 1. A photo (left) and a schematic diagram (right) of a gas burner to be used in home applications in the USA: (1) the ignition chamber; (2) start-up gas-feeder; (3) electric ignition; (4) ring of gas feeders; (5) cover of the burner.

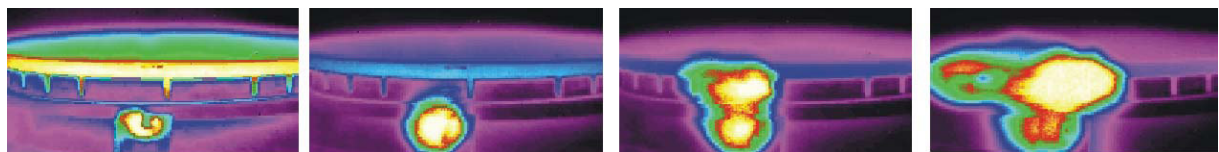
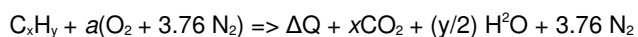


Fig. 2. Infrared images of the ignition process of a gas stove initiated with an electrical spark.

A flame is a mixture of gases at high temperature that arise in a combustion process. The ideal or stoichiometric combustion of oxygen and hydrocarbons produces only water (H₂O) and carbon dioxide (CO₂). The process becomes more complex and incomplete when combustion of hydrocarbons takes place in normal air. Here, the constant a represents a fuel mixture ratio, $a = x + (y/4)$.



Δq

Currently, there does not exist an efficient and precise model that describes the combustion processes adequately. The reaction is basically exothermic, even though some small amount of heat is required to initiate the reaction. After the reaction has been started, the heat that is produced by fuel burning earlier facilitates the subsequent reactions. The surface of highest temperature is localized at those positions in space where the

mixture meets the prescribed stoichiometric proportions. The fuel to oxygen ratio is too high in the inner cone, and too low outside the hottest surface.

Figure 3 exhibits a schematic diagram (left) and a photo (right) of a flame generated in a Bunsen gas burner. The size of the flame is defined by its length L and the mouth diameter $2R$. Temperature distribution in the absence of air turbulence is elliptical in shape. It is governed by the mixture of fuel and oxygen, and their flow. The flame zones are classified according to their meeting, exceeding or not reaching the proper stoichiometric proportions.

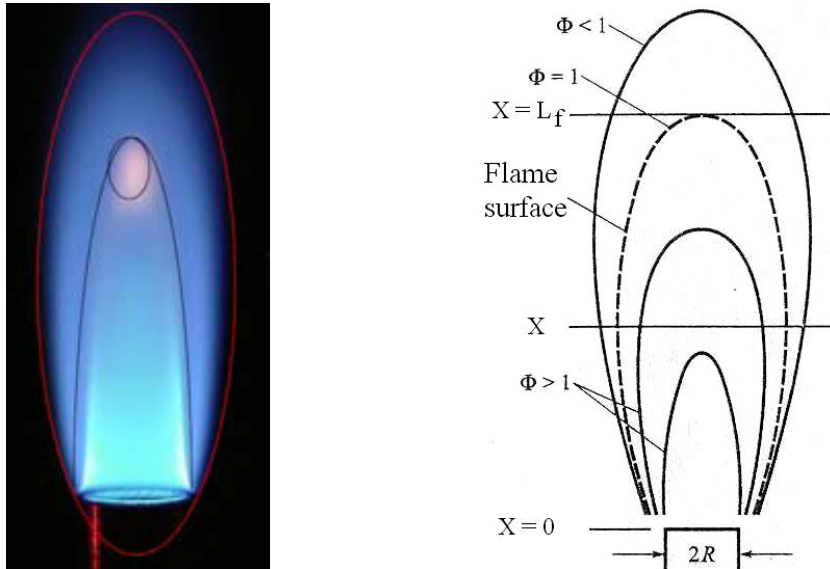


Fig. 3. A schematic diagram (left) and a photo (right) of a flame generated in a Benson gas burner. The size of the flame is defined by the mouth diameter $2R$. We denote by Φ the fraction of oxygen and fuel: (a) $\Phi < 1$ – the mixture has too much air; (b) $\Phi = 1$ – stoichiometric mixture; (c) $\Phi > 1$ – the mixture has too much fuel.

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