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# GLOBAL PROPERTIES OF GASEOUS POOL FIRES

A. HAMINS, K. KONISHI,* P. BORTHWICK AND T. KASHIWAGI
*Building and Fire Research Laboratory*
*National Institute of Standards and Technology*
*Gaithersburg, MD 20899 USA*

Global flame properties were measured as a function of fuel mass flux in a series of experiments conducted on gaseous pool fires burning in a quiescent environment. The measurements included radiative heat loss, heat transfer to the burner, and sensible enthalpy transfer to the surroundings by convection. A large number of fires was studied encompassing a wide range of pool fire parameters. Measurements were conducted using methane, propane, natural gas, and acetylene in burners varying from 0.1 to 1 m in diameter, producing flames from 0.1 to 2 m in height with total heat release rates from 0.4 to 200 kW. From these measurements, the combustion efficiency was calculated for smoky fires.

The measurements were used to test flame height correlations available in the literature for smoky fires. The correlations work well for nonsmoky fires but have not been proven for smoky fires. The measured flame heights conformed to the literature correlations for the nonsmoky flames burning methane, propane, and natural gas. When applied to high mass flux acetylene flames, however, the flame height measurements deviated from the literature flame height correlations. The correlations performed only slightly better when they were based on $\dot{Q}_c$, the sensible enthalpy heat loss. Caution is suggested when applying the standard literature flame-height correlations to smoky fires that may occur in realistic fire scenarios.

## Introduction

A key objective of this study was to test the flame-height correlations available in the literature on smoky fires. These correlations work well for nonsmoky flames but have not been proven for smoky fires. To accomplish this objective, a series of measurements were conducted on gaseous pool fires to determine the values of key parameters necessary for use of the flame height correlations. The measurements included radiative heat loss, heat transfer to the burner, and sensible enthalpy convected to the surroundings.

These global fire properties are of interest by themselves because they have important implications in terms of fire safety. In an enclosure, heat convected to a ceiling may have dramatic consequences in terms of time to flashover. The magnitude of the radiative transfer to targets external to the flame controls fire spread rates, which greatly affects the hazard posed by a particular fire. Radiative transfer from the flame to the fuel surface is the dominant heat feedback mechanism in large pool fires, governing the fuel evaporation rate.

### *Enthalpy Balance*

An overall enthalpy balance for a diffusion flame shows that the actual heat release from chemical reactions ($\dot{Q}_a$) is equal to the sum of the enthalpy convected from the buoyant plume to the surroundings ($\dot{Q}_c$), energy feedback to the burner surface ($\dot{Q}_1$), and energy radiated by high temperature soot particles and gas species ($\dot{Q}_r$):

$$\dot{Q}_a = \chi_a \cdot \dot{Q} = \dot{Q}_r + \dot{Q}_c + \dot{Q}_1 \tag{1}$$

where the actual heat release ($\dot{Q}_a$) is equal to the idealized or total heat release ($\dot{Q}$) modified by the combustion efficiency ($\chi_a$). The total heat release ($\dot{Q}$) is defined as

$$\dot{Q} = \dot{m} \cdot H_c \tag{2}$$

where $\dot{m}$ is the mass vaporization rate (kg/s) and $H_c$ is the heat of combustion (MJ/kg). Dividing by $\dot{Q}$, Eq. (1) can be rewritten as

$$\chi_a = \chi_r + \chi_c + \chi_1 \tag{3}$$

where the fractional enthalpy losses take on values less than unity, depending on a number of factors. The heat feedback to the burner, $\chi_1$, is defined as

$$\chi_1 = \dot{Q}_1/\dot{Q} \tag{4}$$

which represents the feedback via radiation, convection, and conduction. The fractional amount of en-

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*Permanent address: Department of Mechanical Engineering, Saitama Institute of Technology, Okabe, Japan 369-02.