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Book of Abstracts
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Kellie Ann Beall, Editor

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U.S. Department of Commerce
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Water Mist Suppression of Small Methanol Pool Flame

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Experimental observations have shown that small (less turbulent) flames are more difficult to extinguish with water mist than large turbulent flames[1]. This difficulty has highlighted the need to understand the mechanisms of interaction of water mist with small flames. Water mist suppresses fire through four key mechanisms, namely; gas phase cooling, oxygen dilution, fuel surface cooling and radiation attenuation. The purpose of this study is to examine the contributions of thermal cooling and oxygen dilution effects in the suppression of the flame sheet temperature of a small methanol pool flame.

The key component of the experimental setup is a modified Wolfhard - Parker burner where the fuel slot is 75mm long, 10mm wide and 150mm deep [2]. The methanol level in the fuel slot is kept constant using the Navy Research Laboratory's self-leveling mechanism described in [3].The burner has two identical oxidizer channels 82mm long, 35mm wide and 150mm deep on each side. Beside each oxidizer channel is the mist generation chamber, where mist is generated with commercial low flow Delavan ® nozzles. A fraction of the mist generated in this chamber is entrained into the air stream through a slot on the air channel. The characteristics of the droplets are measured as they exit from the burner. The flame temperature is mapped with a 50μm diameter fine platinum/platinum - 13%- rhodium thermocouple which can be moved around in the flame domain with a computer controlled Newport 3D positioning instrument. Thermal images of the flames were also obtained using Agema Thermovision ® 870.

A simple analysis was performed to provide estimates of the upper bound on the suppression in flame sheet temperature when small quantities of suppressants (far from extinction) are used. The results of both theory and experiments are summarized in figure 1 in terms of degree of suppression in flame sheet temperature. Experiments were conducted with nitrogen and with water mist as suppressants. Water mist absorbs latent heat from the flame as it evaporates to form steam. Steam dilutes oxygen concentration as well as absorbs sensible heat since its heat capacity is about twice that of air. Nitrogen, on the other hand, has only oxygen dilution effect since its heat capacity is about equal to that of air.

In Figure 1, the mist curve reveals the effects of latent heat, sensible heat and oxygen dilution while the nitrogen curve reveals the effects of oxygen dilution only. By considering the mist curve and the nitrogen curve in Figure 1, one can deduce (based on the suppression in flame sheet temperatures) that thermal cooling effects of water mist on small liquid pool flames are very significant. The results presented above are for small size water mist (sauter mean diameters between 30μm and 70μm).

References

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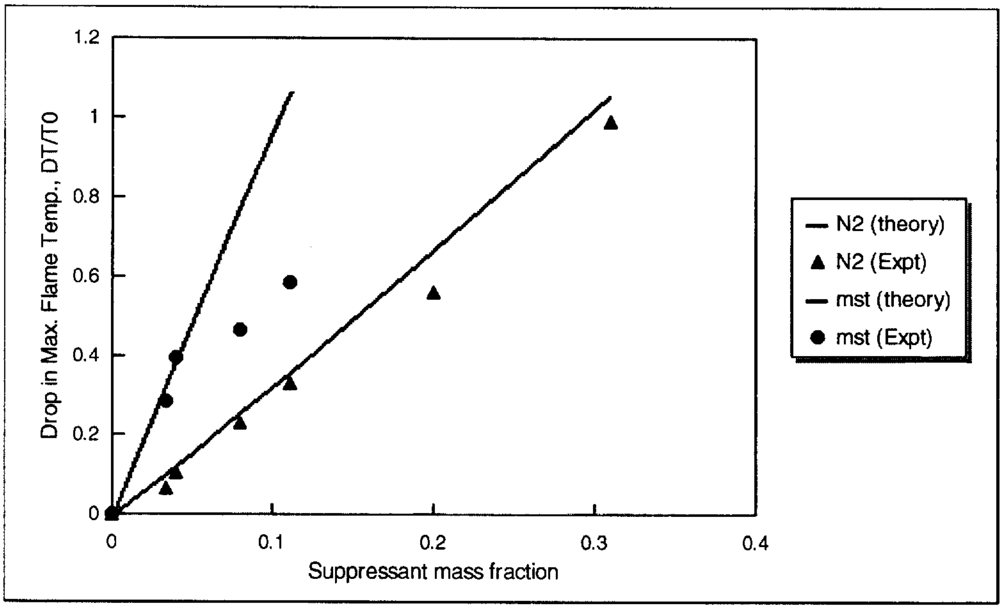

Figure 1: Degree of suppression in Maximum Flame temperature versus suppressant mass fraction, T_0 = 338 K