DYNAMICS OF FAST FLAMES, DETONATIONS AND THEIR SUPPRESSION IN C_2H_4/AIR AND C_3H_8/AIR PREMIXED SYSTEMS[1]

Grzegorz Gmurczyk and William Grosshandler

National Institute of Standards and Technology
Building and Fire Research Laboratory
Gaithersburg, MD 20899, USA

Experimental investigations of the effect of the fuel type, composition of the combustible mixture, geometry of the combustion system and concentration of the suppressing agent were investigated in a two-sectional 50 mm i.d. detonation tube (see Figure 1). Depending on the initial and boundary conditions, fast flames, quasi-detonations, Chapman-Jouguet detonations, and over-driven detonations were obtainable as possible modes of combustion. Each of such combustion modes constituted a reference state for further determination of the dynamic characteristics of the suppression processes. The 5 m long driver section of the tube was the auxiliary part of the set-up, serving as a flame generator. The essential part of the facility was the 2.5 m long test section separated from the driver part by a high-vacuum gate valve. A 44% blockage ratio spiral obstruction inserted into the tube was used optionally as a turbulence generator to broaden the gas dynamic conditions attainable by the flame. To produce the premixed flames, lean, stoichiometric, and rich C_2H_4/Air and C_3H_8/Air mixtures were employed as the combustible media. In all the cases, the initial pressure in the system was 100 kPa and the initial temperature was 295 K. The reference states were obtained when no suppressing agent was present in the test section. The suppression characteristics were taken in the presence of an extinguishant premixed with the combustible mixture in the test section of the tube. The composition of the mixtures in the two sections were prepared with the method of partial pressures. The combustible mixture was ignited due to a microexplosion of a tin droplet on the tips of an AC spark plug located at the end of the driver section.

A primary objective of the work has been to determine the suppression efficiencies of different agents under highly dynamic situations, without the undue influence of either the ignition event or the mixing of the agent into the flame front. The dynamic characteristics of the combustion and inhibition processes were determined by measurements of the velocity and pressure ratio as the shock/flame system entered the test section of the tube, which contained optionally a suppressant premixed with a fuel/air combination. Flame and shock wave velocities ranging from 300 m/s to 2200 m/s, pressure ratios across the shock fronts ranging from 18:1 to 45:1, and shock wave/flame spacings ranging from 1 mm to 100 mm were measured with piezo-electric pressure transducers and fast photodiodes. The experimental facility was successfully employed [1] to clearly discriminate among the dynamic characteristics of the extinguishing compounds, revealing behavior distinct from what was observed in companion studies using atmospheric non-premixed flames. It has been found that the dynamics of the

[1] The work sponsored by the U.S. Air Force, Navy, Army, and FAA.

combustion and suppression processes is strongly influenced by the concentration of an agent, the structure and composition of an agent molecule, the composition of the combustible mixture itself, the type of fuel used and the geometry of the combustion system.

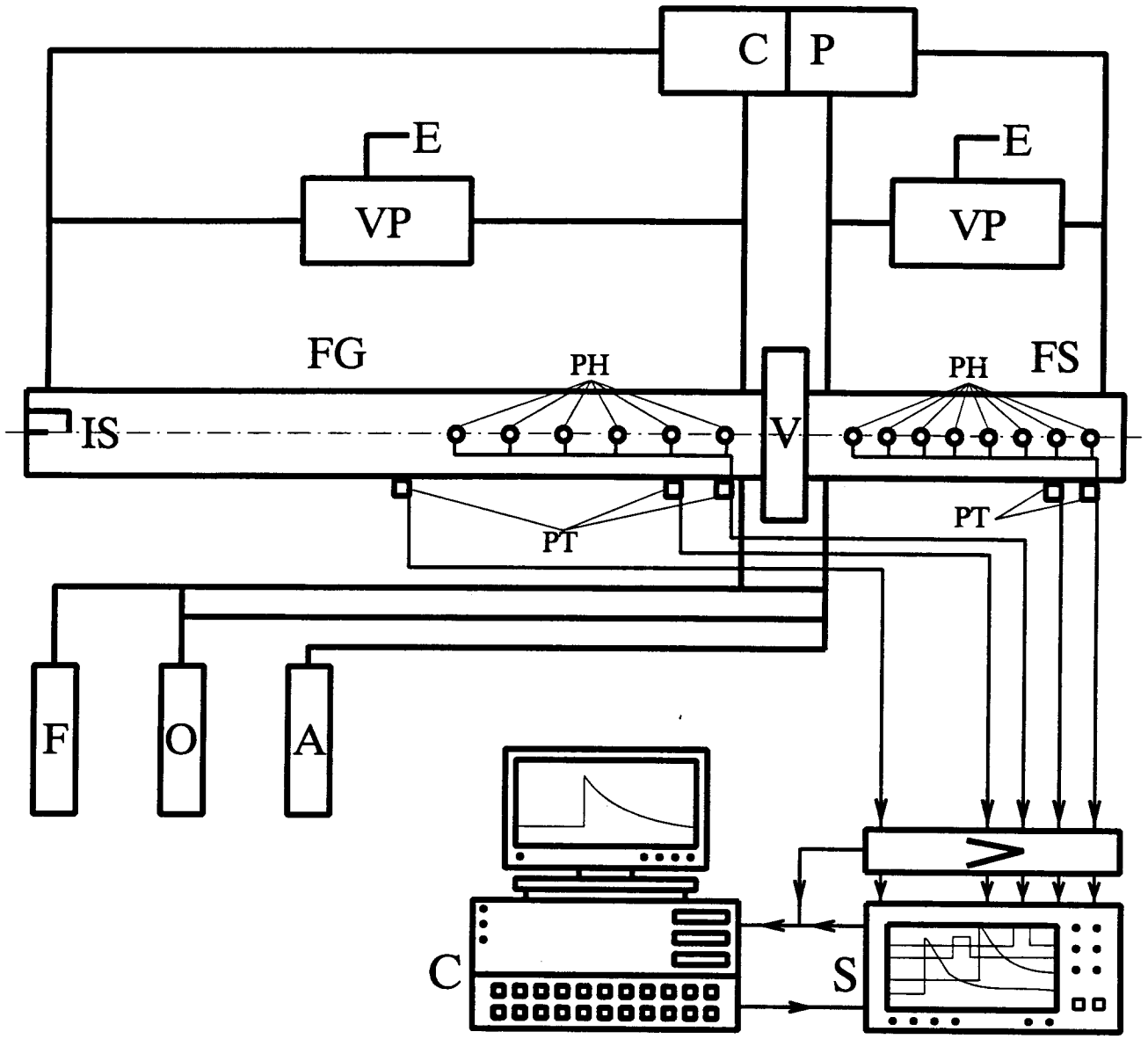

Figure 1. Schematic of the detonation tube facility: FG - flame generation section, FS - flame suppression section, V - high-vacuum gate valve, IS - ignition system, CP - dual circulation pump, VP - vacuum pump, E - exhaust, PH - fast photodiode, PT - piezoelectric pressure transducer, F - fuel, O - oxidizer, A - agent, C - computer, S - digital scope.

References

[1] Gmurczyk, G.W., Grosshandler, W.L. and Lowe D.L.: Suppression Effectiveness of Extinguishing Agents under Highly Dynamic Conditions. Fourth International Symposium on Fire Safety Science, Ottawa, Canada, 1994.