Electric-Discharge Control of Pre-Detonation Processes

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It has been demonstrated with the singing flame [1, 2] that a constant-current electric discharge localised in the flame zone will produce a variable Joulean heat release in anti-phase with the chemical heat release. This being so, the self-oscillatory combustion regime will be suppressed, for all harmonics at a time, when a constant-current electric discharge is applied to the singing flame. A constant-voltage electric discharge, on the contrary, will produce a variable heat release in phase with the chemical heat release, which will cause the self-oscillatory combustion processes to be intensified.

As is evident from [3-4], similar effects are observed for the case of a flame propagating in ducts. Constant-current electric discharges are expected to cause the flame front turbulisation to be reduced in intensity and the slow-combustion-to-detonation transition to be retarded. Alternatively, constant-voltage electric discharges are expected to cause the flame front turbulisation to be intensified and, hence, the slow-combustion-to-detonation transition time to be reduced.

The present article is concerned with further experimental investigation these effects.
As is evident from the experimental results, the effects of constant-current or constant-voltage electric discharges on the in-pipe propane-air or propane-oxygen flame zone are varied in nature, and they depend to a substantial degree on the chemical composition of the mixtures, their initial turbulence, the location and way of combustion initiation. In figures 1 and 2 are shown accordingly pressures signals , signals of photodetecting line, which was used for determining the flame propagation velocity, electrodes voltage and oscillogram of discharge current obtained for a stoichiometric propane-air mixture enriched with 25% (by volume) of oxygen for a constant-current (I = 10 mA) and constant-voltage (U = 1400 V) electric discharge, respectively. For comparison, oscillograms of pressure signal and signal photodetecting line for the same mixture without discharge are represented by dashed curves.

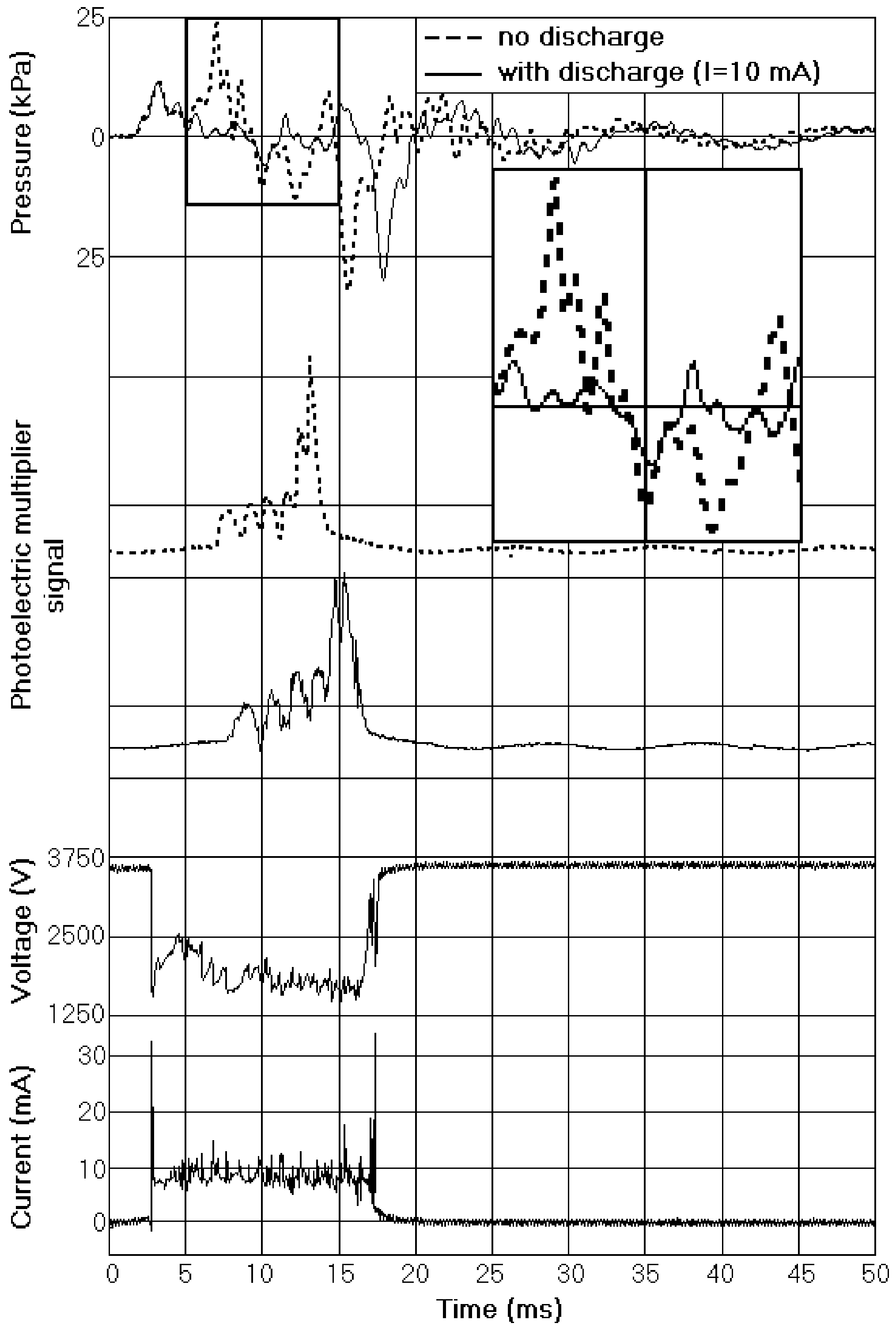

Figure 1. Oscillograms of pressure, photodetectors line signal, voltage of electrodes and discharge current. Discharge with constant electric current (I=10 ma). Stoichiometric propane-air mixture enriched with 25 per cent (bu volume) of oxygen.

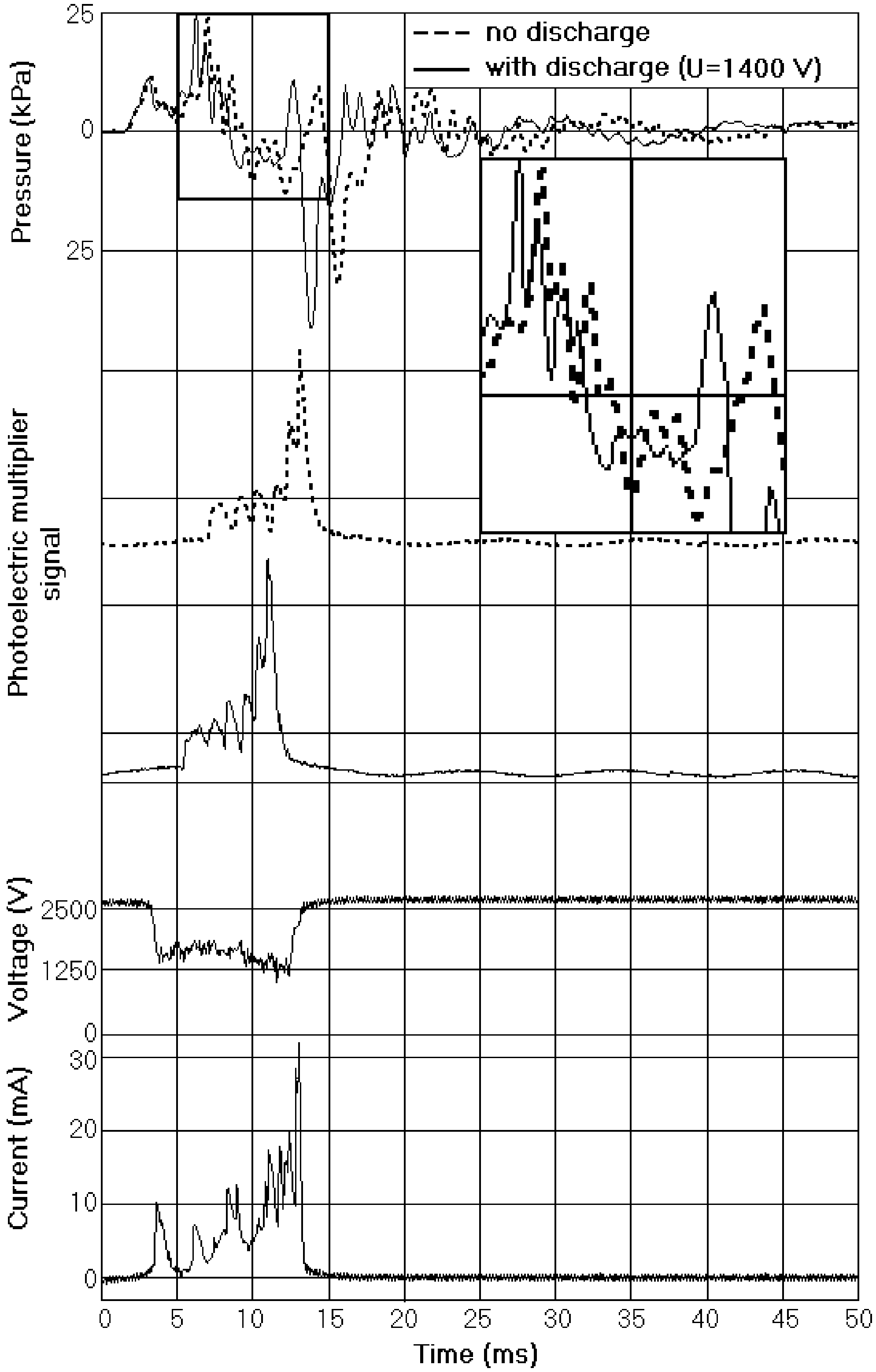

Figure 2. Oscillograms of pressure, photodetectors line signal, voltage of electrodes and discharge current. Discharge with constant voltage (U=1400 V). Stoichiometric propane-air mixture enriched with 25 per cent (bu volume) of oxygen.

As the above oscillograms suggest, the constant-current electric discharge does reduce the turbulent in-pipe burning velocity and the acoustic oscillation intensity, with the in-pipe combustion time increasing. However, the reversal of the trend will be observed when a constant-voltage electric discharge is applied to the flame zone. The in-pipe combustion time decreases and the pressure oscillations increase in amplitude. Also, it should be noted that strong current oscillations can be observed, which appears to be attributable to partial discharge filamentation .

The extent of the flame front turbulisation can be inferred, in qualitative terms, from the current and voltage oscillograms. The degree to which the flame zone electric resistance fluctuates is a function of the variable component of the flame surface area and the nonequilibrium concentration of the electrons in the chemical reaction zone, which, in turn, depends on the rate of the chemical reactions. This being so, an increase in the current fluctuations may be thought of as indicating the extent to which the flame zone turbulisation grows in intensity when a constant-voltage electric discharge occurs. Similarly, the same can be inferred from an increase in the voltage fluctuations when a constant-current electric discharge is applied to the flame zone. It may be therefore concluded that a constant-current electric discharge will reduce the extent to which the flame front is turbulised and a constant-voltage electric discharge will, on the contrary, intensify the flame front turbulisation. Thus, the turbulent combustion velocity can be controlled by electric discharges.

It has been established that the frequency characteristics of the power supply feedback chain exert an essential influence on the processes under investigation. When the power supply feedback chain passband is increased, the pre-detonation flame acceleration time will increase in the case of the constant-current discharge and decrease in the case of the constant-voltage discharge. Qualitatively it is possible to understand this from the analysis of currents oscillograms for event constant-voltage electric discharge. How experimental studies have shown, in this events, the characteristic frequencies of currents fluctuations should be determining by upper border frequency of passband of chain of feedback of power supply unit. With increasing this frequency, the fluctuations frequencies will be to enlarge and turbulence scale will be to decrease. This stimulating for increasing a turbulent rate of combustion and speedup of transition processes.

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