visualization of the flame development around the ignition point reveals that the flame grows as a "finger" until the sides extinguish when in contact with the outer walls. The pressure increase is closely linked with the expansion of the burned gases producing the measured pressure wave (piston effect). This phenomenon was modeled theoretically (Bychkov and al., 2007). In small tubes, the wall effects might be more pronounced. The typical duration of this phase is typically 50 ms for methane and 5 ms for hydrogen, roughly in proportion with the expansion velocities. Note that the one dimensional material velocity in the pipe produced during this expansion (ration between the pressure and the specific mass of the reactants times the sound velocity) is about for methane 30 m/s and 150 m/s for hydrogen. This is about 10 times the expansion velocity suggesting an increase of the flame area amounting 10 times the cross section of the pipe. This is in full agreement with the existing data. Obviously, the mode of ignition should influence this phase (see below).

Table 3: Amplitude of the first pressure pulse in bar (stoichiometry only)

Fuel	**σ. S_{lad} (m/s)**	**Pipe 100mm-26m**	**Pipe 100mm-14m**	**Pipe 250mm-30m**	**Pipe 22mm-1.2m**	**Pipe 40mm-6m**
methane	2.8	0.12	0.12	0.12	N.D.	N.D.
Propane	3.4	0.25	0.2	0.2	N.D.	0.15
Ethylene	5.7	0.50	0.35*	0.35*	0.25	N.D.
Hydrogen	16.1	0.75	0.7*	0.7*	N.D.	N.D.

*leaner than stoichiometry

This initial phase is also visible on figure 9 and 10 giving the evolution of the flame trajectories as function of the time. A flame speed "plateau" is visible especially for methane and propane for which the initial flame development is slower. Note the values of the flame speed are in good agreement with the above estimations. A detonation regime was clearly triggered for hydrogen and ethylene. The transition happens when the flame speed is on the order of 500 m/s and lasts about 2 m. For propane-air mixtures the DDT seems to occur close to the exit. The description of this phase is still a matter of debate (Oran and Gamezo, 2007). For our purpose, it is sufficient to realize that whenever the flame can accelerate above 500 m/s, DDT will spontaneously occur (Table 4).

Table 4: Transition to detonation (stoichiometric conditions), L_{DD} is the run up distance at which DDT occurs and V_{DDT} is the last deflagration speed measured before DDT

Tube	**ID 100 mm**		**ID 250 mm**	
	L_{DDT} (m)	V_{DDT} (m/s)	L_{DDT} (m)	V_{DDT} (m/s)
methane	N.O.	N.O.	N.O.	N.O.
Propane	18	>350	18	650
Ethylene	6	550	18*	600*
Hydrogen	5	550	9*	600*

*leaner than stoichiometry

It is thus of importance to focus of the acceleration phase from the initial flame development ("finger") to this threshold velocity (figure 9 and 10). To a reasonable degree of certainty, during this phase, the flame is uniformly accelerated since the flame velocity seems to increase linearly with time. Note there is a transient phenomenon for methane around time 0.15 s. Considering the pressure traces (figure 5 test 65), it appears that after time 0.15 s, a set of pressure oscillations is triggered. 0.15 s is exactly the time required for a pressure wave to travel way and back inside the pipe[1]. This pressure wave is certainly produced by the initial flame development. It can be verified that its amplitude is about 100-200 mbar and, following, the corresponding material velocity should be about 50 m/s[2]. This value is in line with the observed velocity fluctuations on figure 10. It can be further noted that, in many cases, the duration of the explosion is smaller than 0.15 s so that the flame trajectory is not influenced by the resonance of the pipe. For shorter pipes, the pressure oscillations superpose with the acceleration process (Kerampran, 2000).

The coefficient of acceleration of the flame between this initial phase and the onset of the detonation regime were calculated plotting a linear regression curve in the graph time-flame velocity. The values are listed in table 5 for the experimental situations under concern. On the basis of the accuracy of the experiments, the acceleration coefficient seems to be mainly mixture dependent. Although some geometrical effects may intervene for the smallest experimental setups, they might remain of second order.

[1] Two times the length of the pipe (2 x 26 m) divided by the sound velocity of the mixture (340 m/s).
[2] The material velocity induced by the wave is the ratio between the overpressure (15000 to 20000 Pa) and the product of the specific mass (1.1 kg/m^3) and sound velocity of the mixture (340 m/s)

Table 5: Flame acceleration coefficient for the various fuels-air mixtures used and various geometries (stoichiometry only)

Fuel	**σ. S_{lad} (m/s)**	**Acc (m/s^2) ID=100 mm L = 26 m**	**Acc (m/s^2) ID=100 mm L = 14 m**	**Acc (m/s^2) ID=250 mm L = 30 m**	**Acc (m/s^2) ID=22 mm L = 1.7 m**	**Acc (m/s^2) ID=40 mm L = 6 m**
methane	2.8	1000	N.D	1500	N.D.	N.D.
Propane	3.4	4300	5000	3500	1000	2000
Ethylene	5.7	16000	18000	7000*	6000	N.D.
Hydrogen	16.1	45000	50000	20000*	N.D.	N.D.

*leaner than stoichiometry

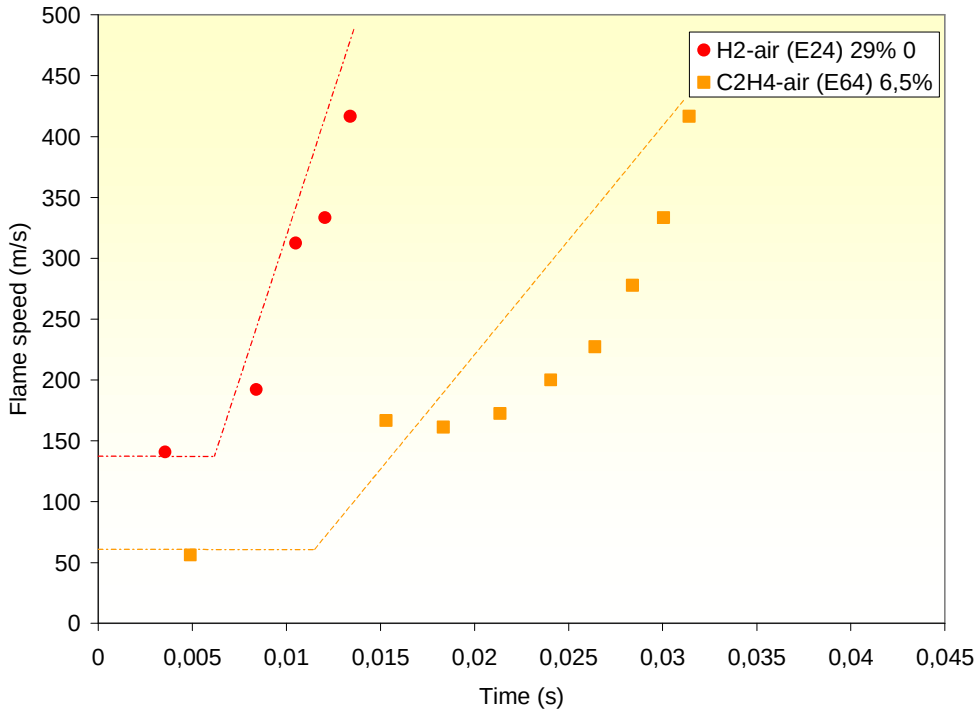

Figure 9 : Acceleration phase of the flame trajectory in the 100 mm ID pipe, 26 m (H_2-air and C_2H_4-air stoichiometric mixtures)

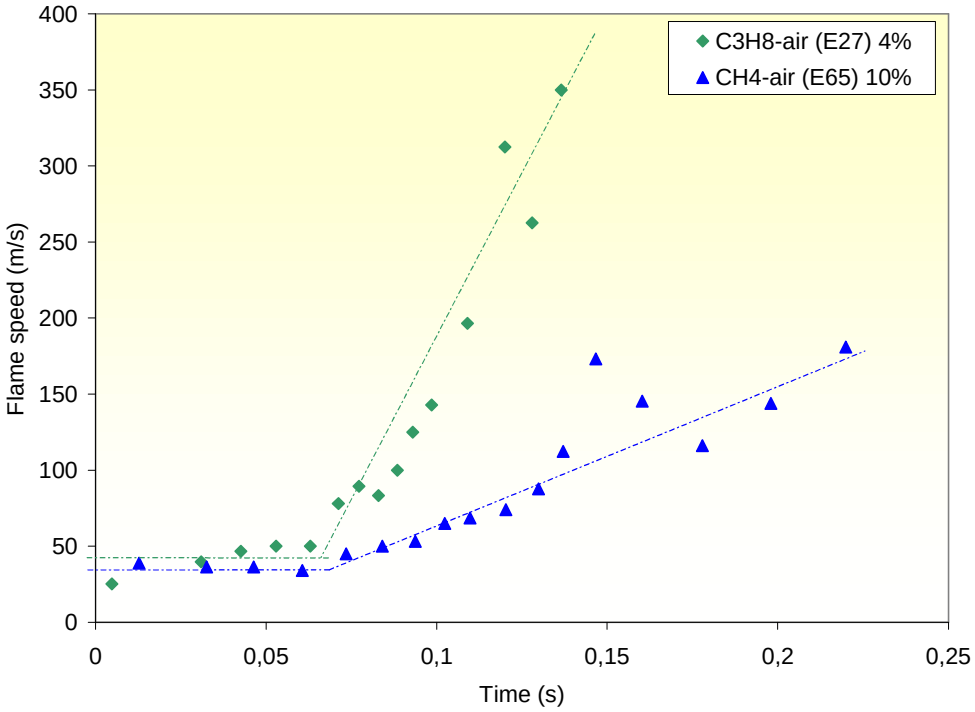

Figure 10 : Acceleration phase of the flame trajectory in the 100 mm ID pipe, 26 m (C_3H_8-air and CH_4-air stoichiometric mixtures)

To conclude, the present experimental data suggest that the flame acceleration process leading eventually to a DDT, may not depend strongly on the geometry of the pipe but, to a considerable extent on the nature and composition of the fuel. This finding, if confirmed, might suggest that other parameters than the turbulence of the flow might intervene.

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