Induction time vs detonation cell size. Investigation using ZND model

Pawel Krason

Computational methods in combustion
Warsaw University of Technology

Contents

1 Introduction

This project explores relation between detonation cell size and induction time for hydrogen - air mixture. It uses code for python based on Zeldovich-von Neumann-Doring theory acquired from
http://shepherd.caltech.edu/EDL/public/cantera/html/SD_Toolbox/ZND

2 Mathematical model

ZND theory is one-dimensional detonation theory proposed by Zeldovich, von Neumann and Doring in 1940-42. According to it, the detonation front consists of two phases: compression by shockwave and a finite combustion zone.

Important parameter of a mixture is its detonation cell size. The smaller the value, the more susceptible the mixture is for detonation. Many experiments have shown that size of detonation cell is linearly dependent on induction time.

$$\lambda = at_i \tag{1}$$

Where:
λ - detonation cell width
a - linear coefficient
t_i - induction time

3 Results

Figure 1, acquired from an experiment shows detonation cell size for hydrogen for varying fuel concentration values. Looking both at it and figure 2 we see a very similar graph shape, which confirms the idea, that the relation between these two parameters, induction time and detonation cell size, is indeed linear.

Using data obtained from the graphs, one can write:

$$\lambda = 0.014m, \quad t_i = 0.4\mu s \tag{2}$$

$$a = \frac{\lambda}{t_i} = 0.035 \left[\frac{m}{\mu s}\right] \tag{3}$$

which is a proportional constant between these two parameters for hydrogen.

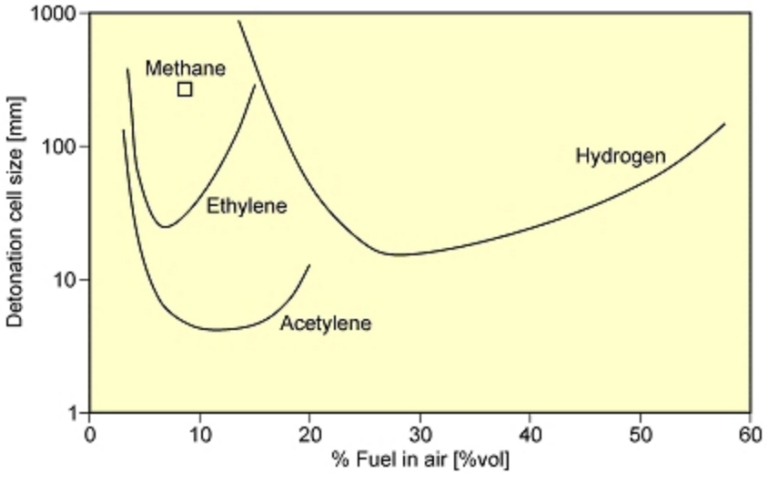

Figure 1: Detonation cell size for various mixtures

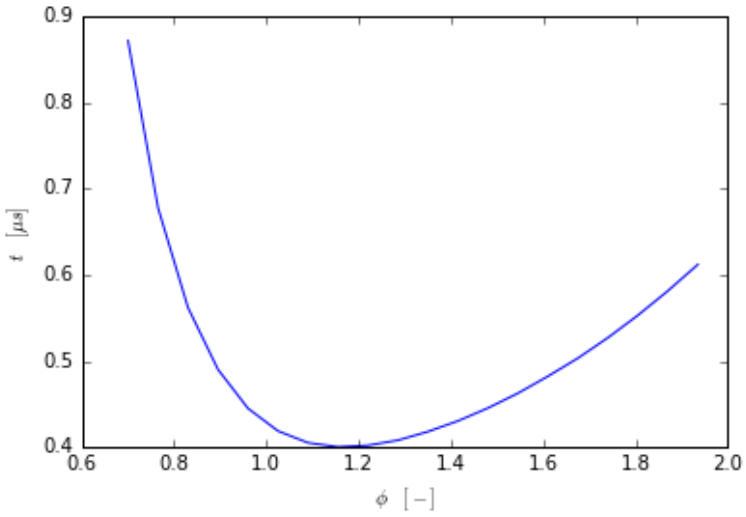

Figure 2: Induction time acquired from calculations

4 Summary

This project proved that induction time is a linear function of detonation cell size.

5 References

[1] Kordylewski Wlodzimierz, Spalanie i paliwa, Oficyna Wydawnicza Politechniki Wroclawskiej, 2005