Comparison of the detonation velocity and the width of the detonation cells for the combustion of hydrogen in oxygen and air.

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1 Introduction

The goal of this study is to plot detonation velocity and the width of the detonation cells for the combustion connections depending on the initial temperatures and pressures. In order to complete the calculations Cantera[1] and SD Toolbox were used.

Stoichiometric equation representing hydrogen-air combustion is given as followed:

$$2H_2 + (O_2 + 3.76N_2) -> 2H_2O + 3.76N_2$$

As presented above, the combustion is complete.

Stoichiometric equation representing hydrogen-oxygen combustion is given as followed:

$$2H_2 + O_2 -> 2H_2O$$

This combustion is also complete.

In this study initial parameters represented as temperature and pressure will change in order to plot the characteristics of detonation velocity and width of the detonation cells.

The values of initial parameters are presented below:

$$p_0 = 1[bar] \tag{1}$$

$$p_1 = 2[bar] \tag{2}$$

$$p_2 = 5[bar] \tag{3}$$

$$T_0 = 300[K] \tag{4}$$

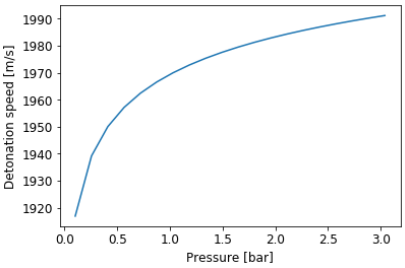
$$T_1 = 400[K] \tag{5}$$

$$T_2 = 500[K] \tag{6}$$

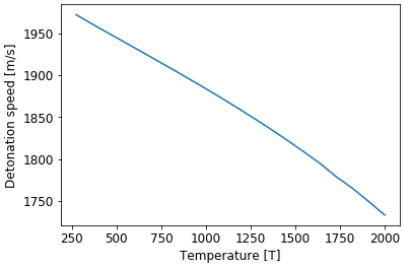
Using Cantera the basic reactor and gas models were prepared. Spyder was used to obtain the necessary characteristics. All the simplifications and assumptions of the model are in line with those adopted in Cantera and SD Toolbox (e.g. the gas model is ideal, the combustion chamber is determined by the program conditions etc.).

[1] Cantera is an open-source suite of tools for problems involving chemical kinetics, thermodynamics, and transport processes.

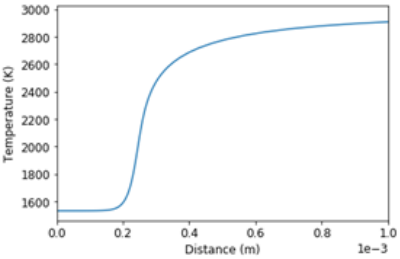
2 Results for H2-Air



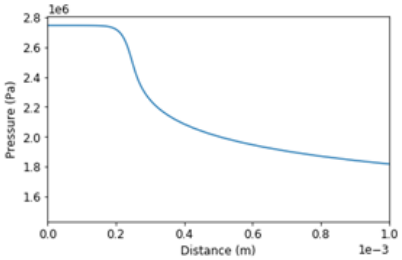
Detonation velocity as function of pressure for hydrogen-air mixture.



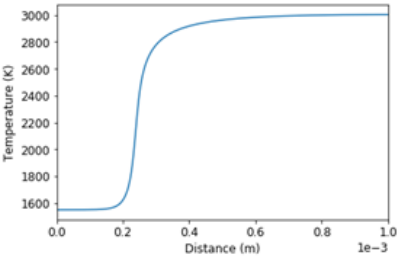
Detonation velocity as function of temperature for hydrogen-air mixture.



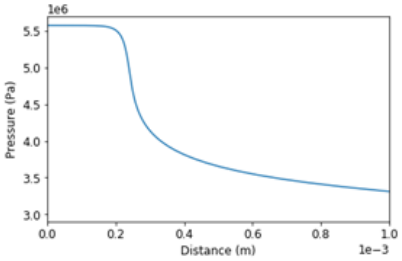
P0, T0, cell size predictions according to Gavrikov correlation: 6.935 e-02 [m]



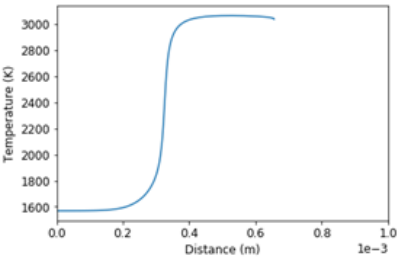
P0, T0, cell size predictions according to Gavrikov correlation: 6.935 e-02 [m]



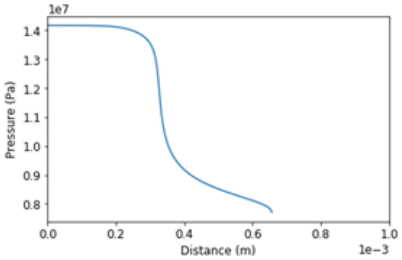
P1, T0, cell size predictions according to Gavrikov correlation: 5.749 e-01 [m]



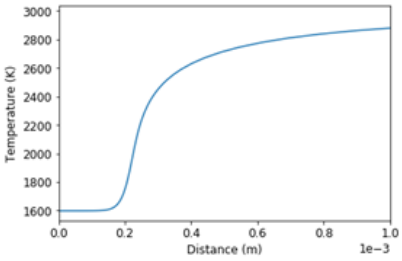
P1, T0, cell size predictions according to Gavrikov correlation: 5.749 e-01 [m]



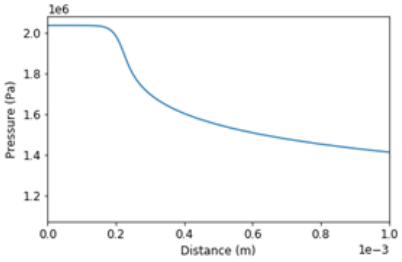
P2, T0, cell size predictions according to Gavrikov correlation: 1.809 e-01 [m]



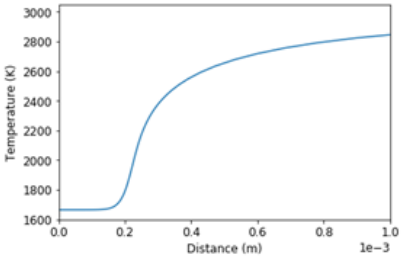
P2, T0, cell size predictions according to Gavrikov correlation: 1.809 e-01 [m]



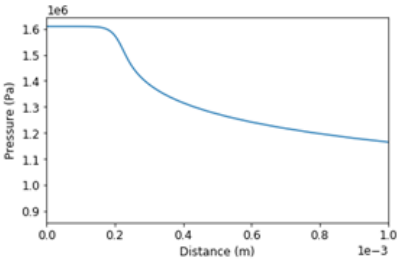
P0, T1, cell size predictions according to Gavrikov correlation: 2.759 e-02 [m]



P0, T1, cell size predictions according to Gavrikov correlation: 2.759 e-02 [m]

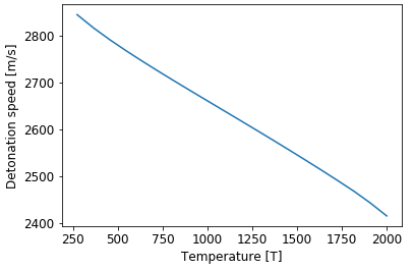


P0, T2, cell size predictions according to Gavrikov correlation: 9.013 e-03 [m]

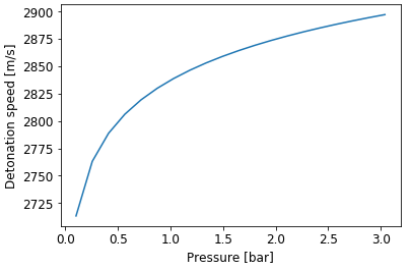


P0, T2, cell size predictions according to Gavrikov correlation: 9.013 e-03 [m]

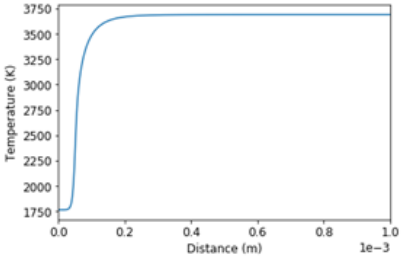
3 Results for H2-Oxygen



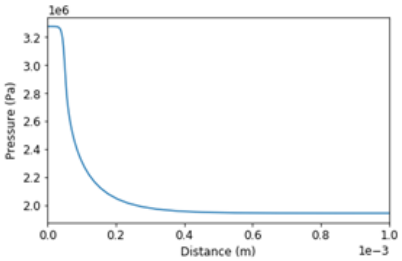
Detonation velocity as function of temperature for hydrogen-oxygen mixture.



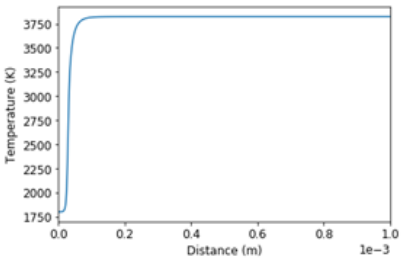
Detonation velocity as function of pressure for hydrogen-oxygen mixture.



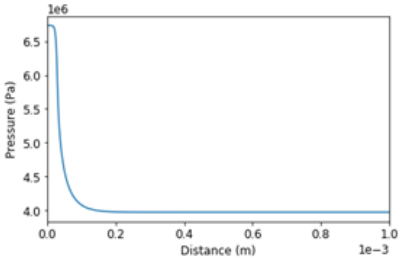
P0, T0, cell size predictions according to Gavrikov correlation: 3.677 e-03 [m]



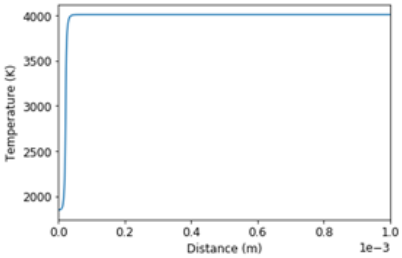
P0, T0, cell size predictions according to Gavrikov correlation: 3.677 e-03 [m]



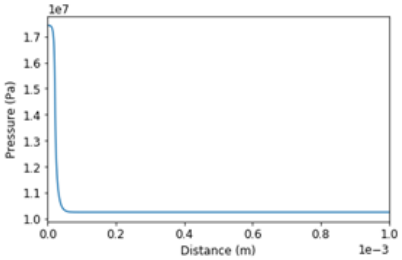
P1, T0, cell size predictions according to Gavrikov correlation: 3.101 e-03 [m]



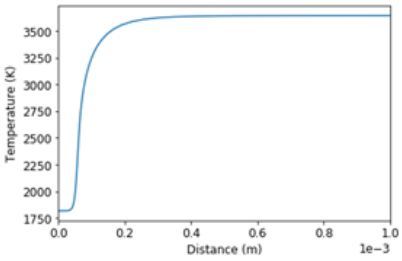
P1, T0, cell size predictions according to Gavrikov correlation: 3.101 e-03 [m]



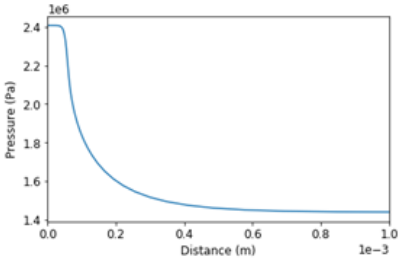
P2, T0, cell size predictions according to Gavrikov correlation: 2.680 e-03 [m]



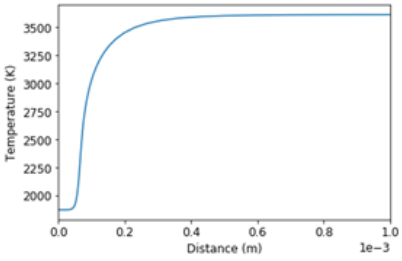
P2, T0, cell size predictions according to Gavrikov correlation: 2.680 e-03 [m]



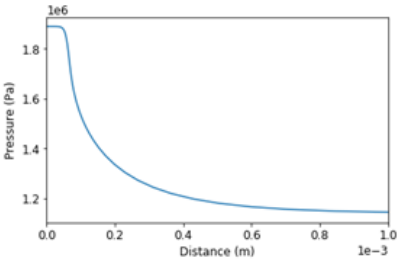
P0, T1, cell size predictions according to Gavrikov correlation: 3.104 e-03 [m]



P0, T1, cell size predictions according to Gavrikov correlation: 3.104 e-03 [m]



P0, T2, cell size predictions according to Gavrikov correlation: 1.940 e-03 [m]



P0, T2, cell size predictions according to Gavrikov correlation: 1.940 e-03 [m]

4 Summary

Analysis of the detonation velocity characteristics allows the conclusion that it increases proportionally to the increase in pressure and inversely proportionally to the temperature increase. For the combustion of the hydrogen-air mixture it also takes lower values then the hydrogen-oxygen mixture.
The above charts presents also the other conclusion. The width of the detonation cells highly depends on the initial parameters. The higher the initial pressure, the faster the cells reach a larger size. The higher the temperature, the lower the cell width values.
The cell sizes of detonation in both mixtures assume similar values.

5 References

[1] https://en.wikipedia.org/wiki/Detonation*velocity*
[2] https://en.wikipedia.org/wiki/Hydrogen
[3] https://www.coursehero.com/file/36378839/CANTERA-HandsOnpdf/
[4] 2011, M. Gieras - "Spalanie - wybrane zagadnienia w zadaniach."