Analysis of the adiabatic temperature and the temperature with constant volume in hydrogen air mixture combustion with different initial conditions

Kamil Maciejczyk

Warsaw University of Technology

Faculty of Power and Aeronautical Engineering

Computational Methods in Combustion

June 2021

Contents

1 Introduction

Hydrogen is a chemical compound represented by the chemical formula H2. It is commonly used in many laboratories as very useful in the Laminar Burning Velocity studies and in the flame structure analysis whatsoever. Hydrogen is very explosive with the air as the oxidizer. Explosion of hydrogen-air mixture can be reached, when the hydrogen concentration is 4 to 75 percents.The goal of this study is to plot adiabatic temperature and temperature with constant volume of combustion connections depending on the initial temperature and pressure and concentration of hydrogen in air. In order to complete the calculations Cantera was used.

1.1 Stoichiometric equation

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

$$H_2 + 0.5(O_2 + 3.76N_2) = H_2O + 1.88N_2$$

1.2 Initial parameters

Initial temperature and pressure vary between:

$$T_0 = 273 - 2000\ [K]$$

$$p_0 = 0.1 - 5\ [MPa]$$

Assumed initial concentrations:

$$\phi_0 = 0.5$$

$$\phi_1 = 1$$

$$\phi_2 = 2$$

$$\phi_3 = 3$$

$$\phi_4 = 4$$

2 Model

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

3 Results

3.1 Temperature as function of initial pressure at constrained initial temperature

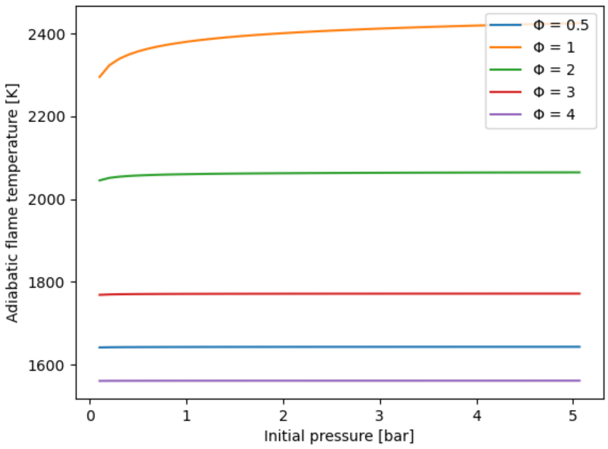

Figure 3.1.1: Adiabatic flame temperature for $T_0 = 273$ $[K]$

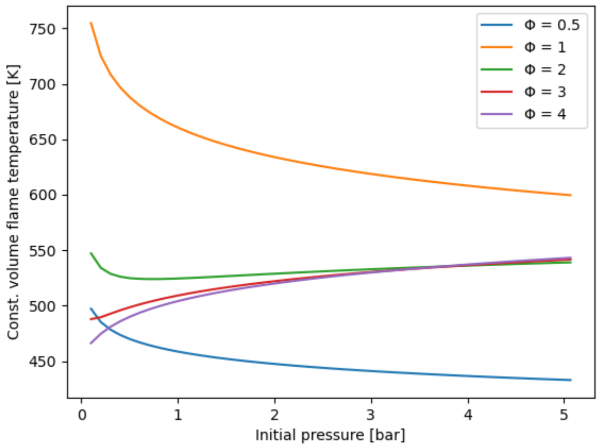

Figure 3.1.2: Flame temperature with constant volume $T_0 = 273$ $[K]$

3.2 Temperature as function of initial temperature at constrained initial pressure

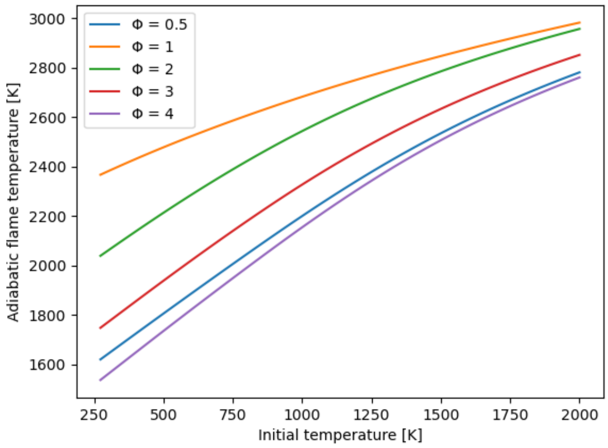

Figure 3.2.1: Adiabatic flame temperature for $T_0 = 273$ $[K]$

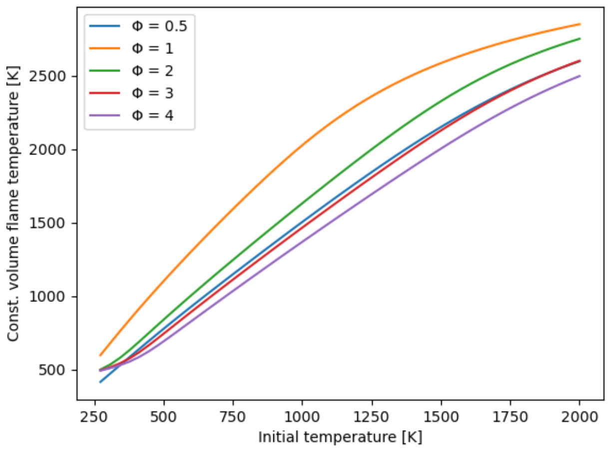

Figure 3.2.2: Flame temperature with constant volume $T_0 = 273$ $[K]$

3.3 Adiabatic flame temperature as function of initial temperature and initial pressure for constrained concentration

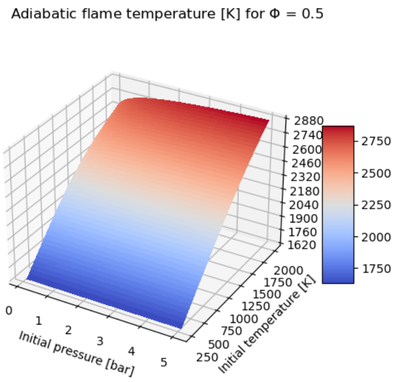

Figure 3.3.1: For $\phi = 0.5$

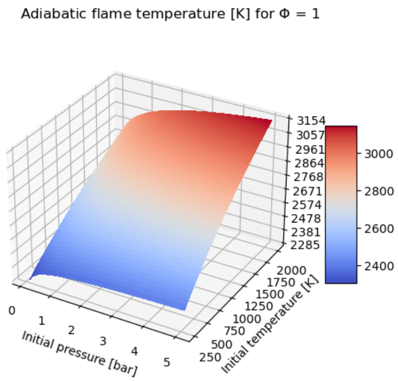

Figure 3.3.2: For $\phi = 1$

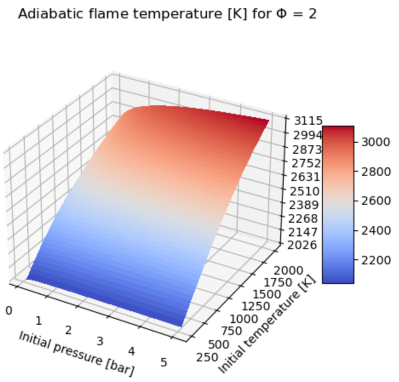

Figure 3.3.3: For $\phi = 2$

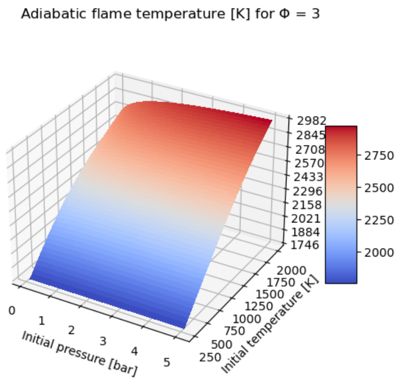

Figure 3.3.4: For $\phi = 3$

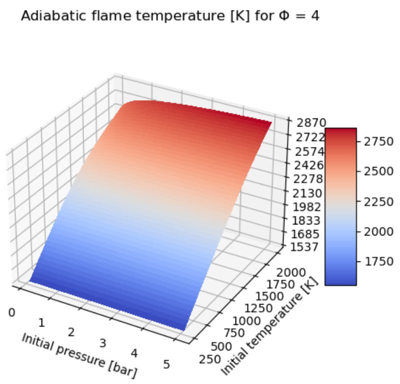

Figure 3.3.5: For $\phi = 4$

3.4 Flame temperature with constant volume as function of initial temperature and initial pressure for constrained concentration

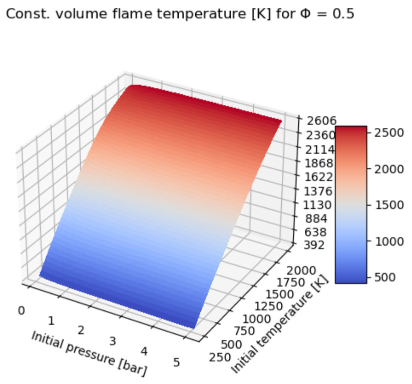

Figure 3.4.1: For $\phi = 0.5$

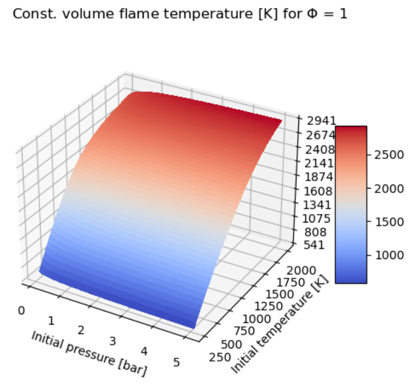

Figure 3.4.2: For $\phi = 1$

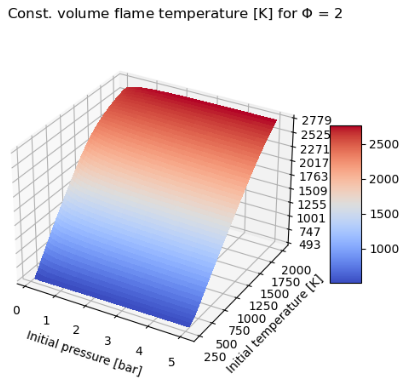

Figure 3.4.3: For $\phi = 2$

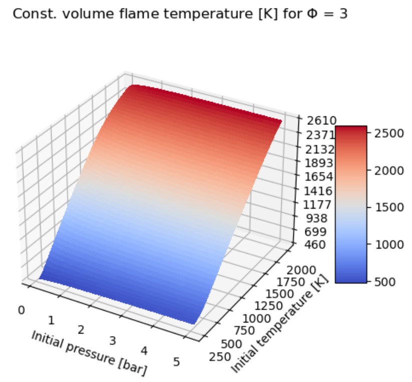

Figure 3.4.4: For $\phi = 3$

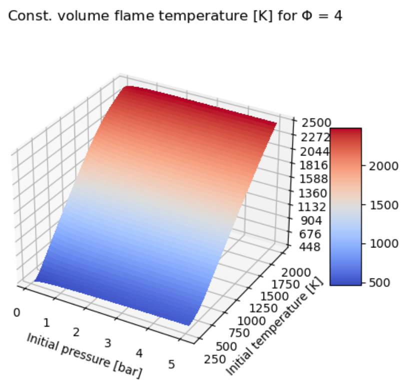

Figure 3.4.5: For $\phi = 4$

4 Summary

The purpose of this report was to examine the influence of the initial pressure, initial temperature and mixture concentration on adiabatic flame temperature and flame temperature with constant volume.

Considering all figures, It seems that both adiabatic flame temperature and temperature with constant volume have the greatest value for stoichometric mixture, $\phi = 1$.

Fig. 3.1.1 shows that adiabatic flame temperature for $T_0 = 273[K]$ is pressure independent (independent means, has less impact on combustion temperature), It can be noticed also on 3.3.1 - 3.3.5, for all condensations temperature is pressure independent, except $\phi = 1$.

Fig. 3.1.2 depicts that flame temperature with constant volume also is pressure independent.

Fig. 3.2.1 - 3.2.2 shows influence of initial temperature on both kind of combustion. Explicitly It has grater impact on combustion temperature than initial pressure.

To sum up, in both kinds of combustion i.e. adiabatic and with constant volume, temperature increases along with increase of initial conditions.

5 References

1. Andrzej Furmański, *Analysis of the adiabatic temperature in methane-air mixture combustion with different concentrations.*, March 2019
   `https://github.com/AndrzejFurmanski/-MKWS2019---Cantera`
2. Marian Gieras, *Spalanie - wybrane zagadnienia w zadaniach*, 2011
3. `https://en.wikipedia.org/wiki/Air`
4. `https://en.wikipedia.org/wiki/Hydrogen`