Analysis of the adiabatic temperature in methane-air mixture combustion with different concentrations.

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Contents

1 Introduction

Methane is a chemical compound represented by the chemical formula CH_4. It is commonly used in many laboratories as very useful in the LBV[1] studies and in the flame structure analysis whatsoever. Methane is very explosive with the air as the oxidizer. Explosion of methane-air mixture can be reached, when the methane concentration is 5 to 15 percents.
The goal of this study is to plot adiabatic temperature of combustion connections depending on the initial temperature and pressure and concentration of methane in air. In order to complete the calculations Cantera[2] was used.

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

$$CH_4 + 2(O_2 + 3.76N_2) -> CO_2 + 2H_2O + 7.52N_2$$

As presented above, the combustion is complete.

In this study initial parameters represented as temperature, pressure and equivalence ratio[3] will change in order to plot the characteristics of adiabatic temperature of combustion as a function.

The values of initial parameters are presented below:

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

$$T_0 = 273[K] \tag{2}$$

The equivalence ratios were given as:

$$\phi_1 = 0.5[-] \tag{3}$$

$$\phi_2 = 1[-] \tag{4}$$

$$\phi_3 = 2[-] \tag{5}$$

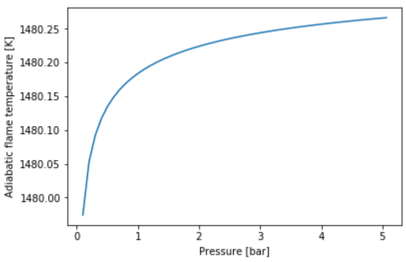
$$\phi_4 = 3[-] \tag{6}$$

[1] LBV in an abbreviation of Laminar Burning Velocity
[2] Cantera is an open-source suite of tools for problems involving chemical kinetics, thermodynamics, and transport processes.
[3] Equivalence ratio (ϕ) is the real fuel-to-oxidizer ratio to stoichiometric fuel-to-oxidizer ratio.

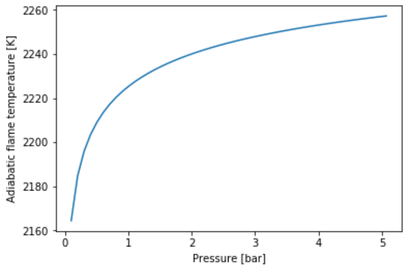
2 Model

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 (e.g. the gas model is ideal, the combustion chamber is determined by the program conditions etc.).

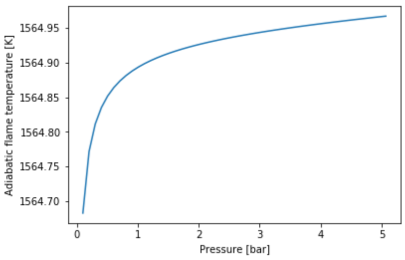
3 Results



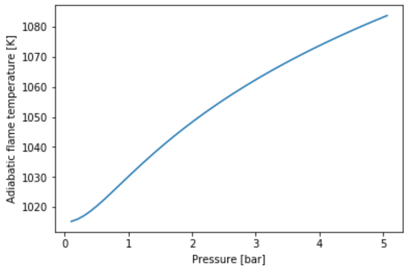
Adiabatic temperature as function of pressure for ϕ=0.5



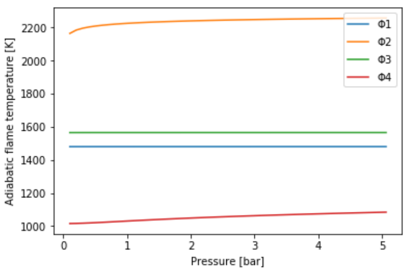
Adiabatic temperature as function of pressure for ϕ=1



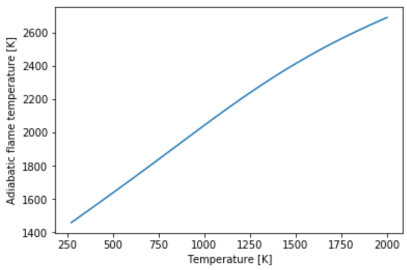
Adiabatic temperature as function of pressure for ϕ=2



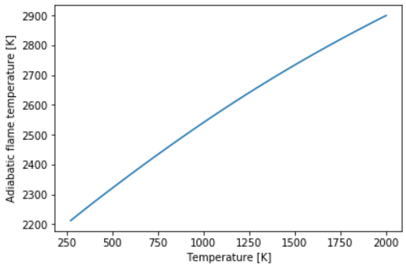
Adiabatic temperature as function of pressure for ϕ=3



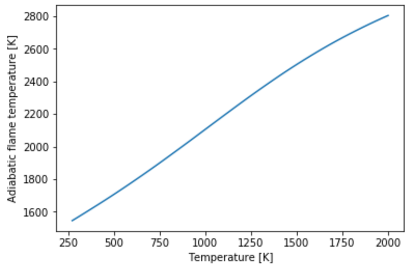
Adiabatic temperature as function of pressure - comparison of all cases.



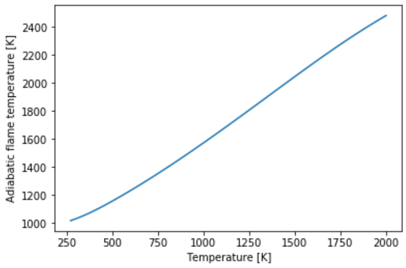
Adiabatic temperature as function of temperature for ϕ=0.5



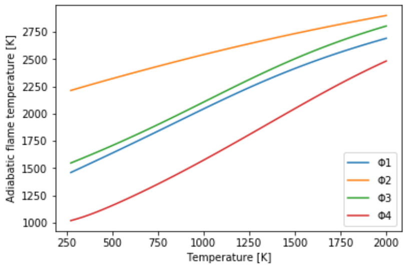
Adiabatic temperature as function of temperature for ϕ=1



Adiabatic temperature as function of temperature for ϕ=2



Adiabatic temperature as function of temperature for ϕ=3



Adiabatic temperature as function of temperature - comparison of all cases.

4 Summary

A consistent fact for all graphs is that the adiabatic combustion temperatures increase with the reaction temperatures and pressures. However, while the pressure increase is not high, the temperature jump is a big significance.

The above charts do not seem to present other real and meaningful conclusions. However, after thorough consideration, it is possible to link the adiabatic combustion temperature values to the limits of methane flammability. It can be seen that the best combustion conditions occur at ϕ equals 1. Further study and analysis as well as calculations would give a response which concentration is most advantageous from the point of view of combustion. However, this is not the subject of this work.

5 References

[1] https://en.wikipedia.org/wiki/Flammability$_{l}imit$

[2] https://en.wikipedia.org/wiki/Methane

[3] https://www.coursehero.com/file/36378839/CANTERA-HandsOnpdf/

[4] https://en.wikipedia.org/wiki/Air

[5] 2011, M. Gieras - "Spalanie - wybrane zagadnienia w zadaniach."