Metody Komputerowe w Spalaniu

Project 1

Ignition delay in three mixtures: hydrogen - air, methane - air and ethane - air

Prowadzący: dr inż. Mateusz Żbikowski

Anne Klecha

21 maja 2018

Theoretical introduction

Autoignition theory

A vessel of volume V and of a constant wall temperature T_0 contains a mixture of a flammable gas and air. In the vessel a chemical reaction occurs at speed W measured by how many moles of the product of the oxidation X appear in a second in the volume unit.

$$W = \frac{dX}{dt} = k_0 exp(\frac{-E}{RT})p^n$$

where:

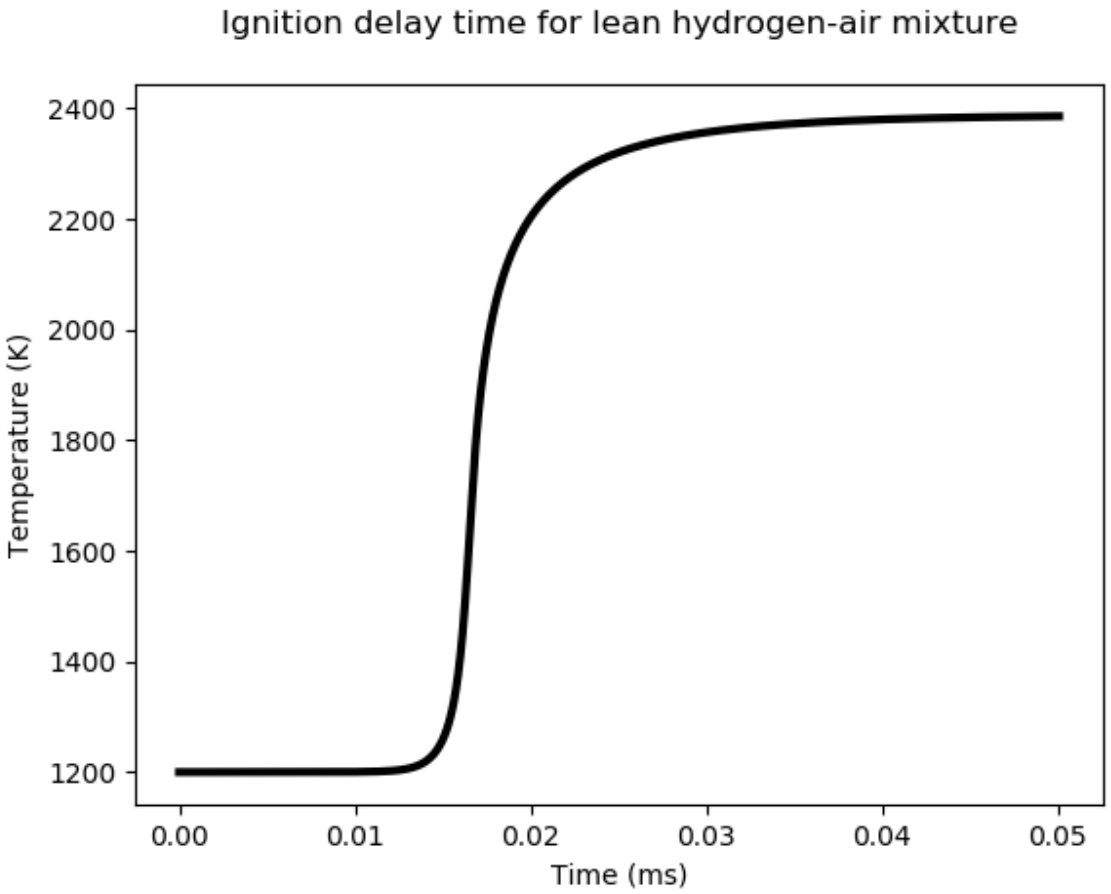
1. k_0 - reaction rate constant
2. p - partial pressure of the combustible gas
3. n - order of the chemical reaction
4. $exp(\frac{-E}{RT})$ - Arrhenius function, which expresses the effect of temperature on the reaction speed
5. R - gas constant
6. E - activation energy
7. t - time
8. T - temperature of the mixture

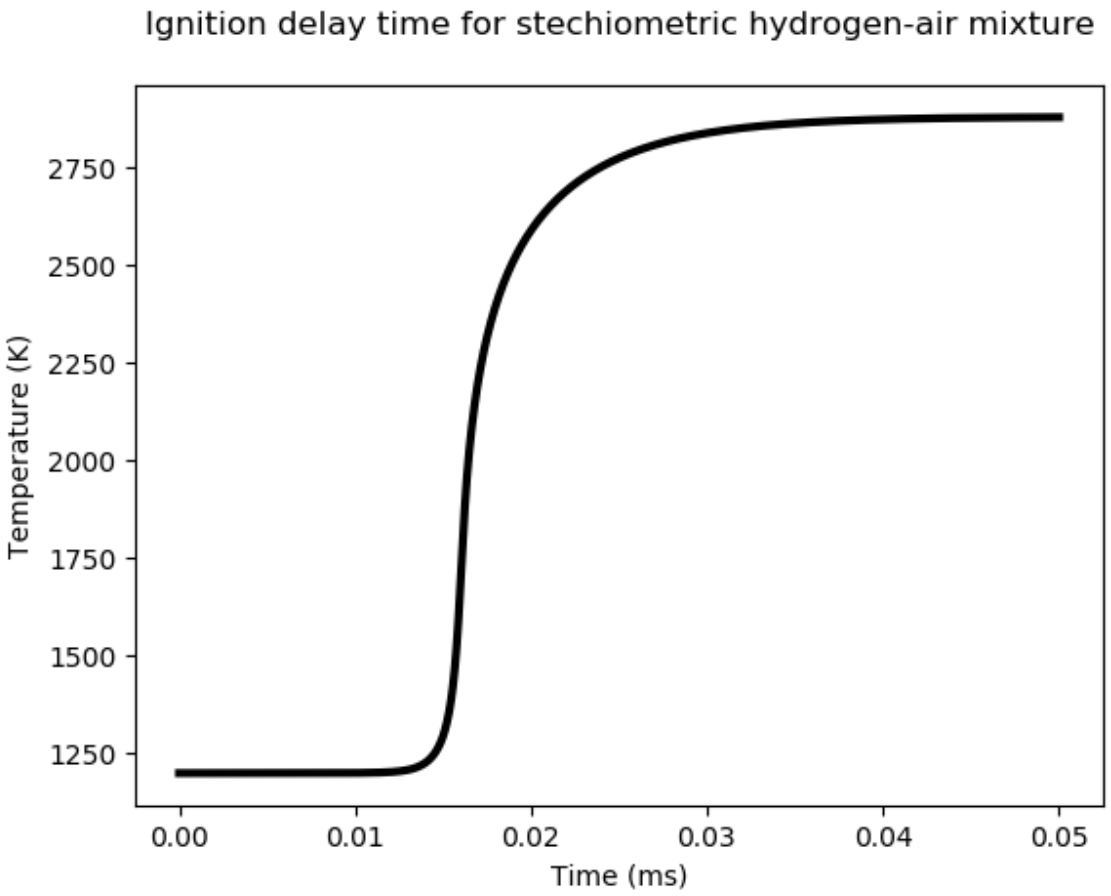
Description of the code

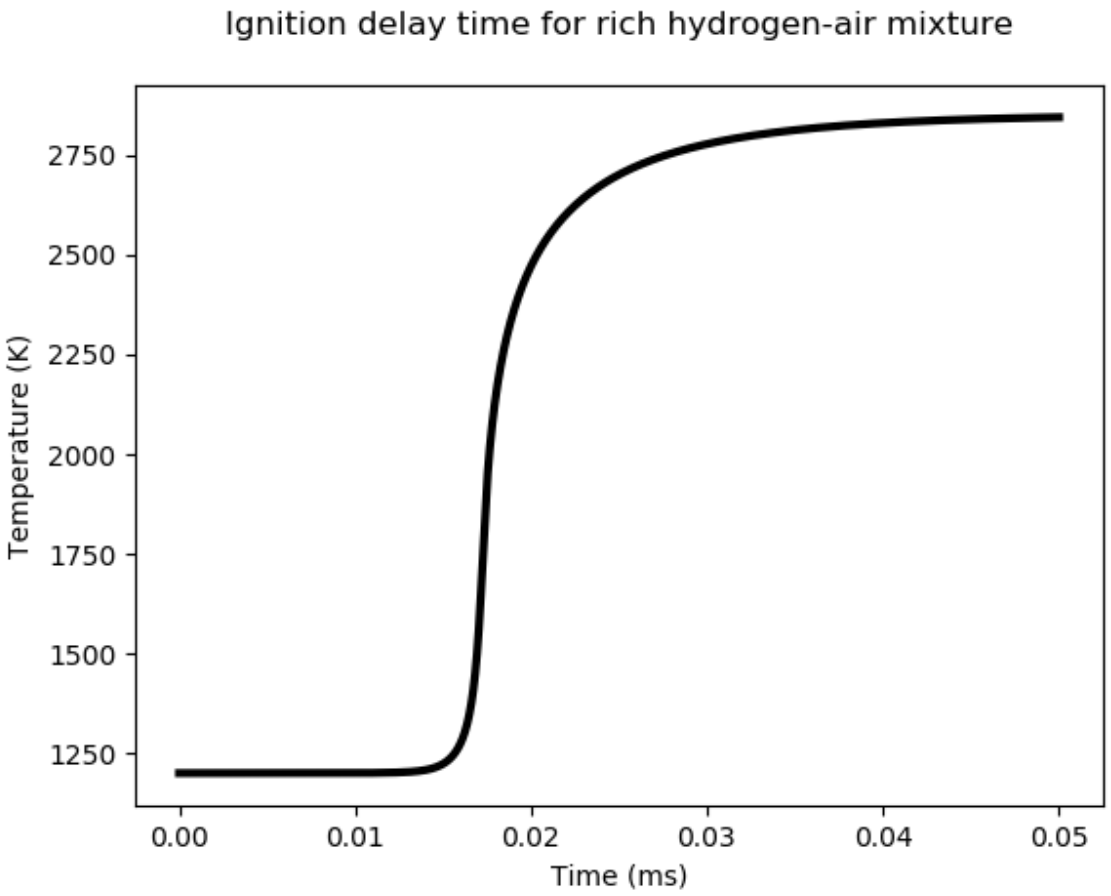
The project consists in making a comparison of the ignition delay time of three different gaseous mixtures that have three different concentrations of the flammable gas in air. The table beneath represents mole ratios of the gas in mixtures, considering that oxygen is 1.0 and nitrogen 3.76.

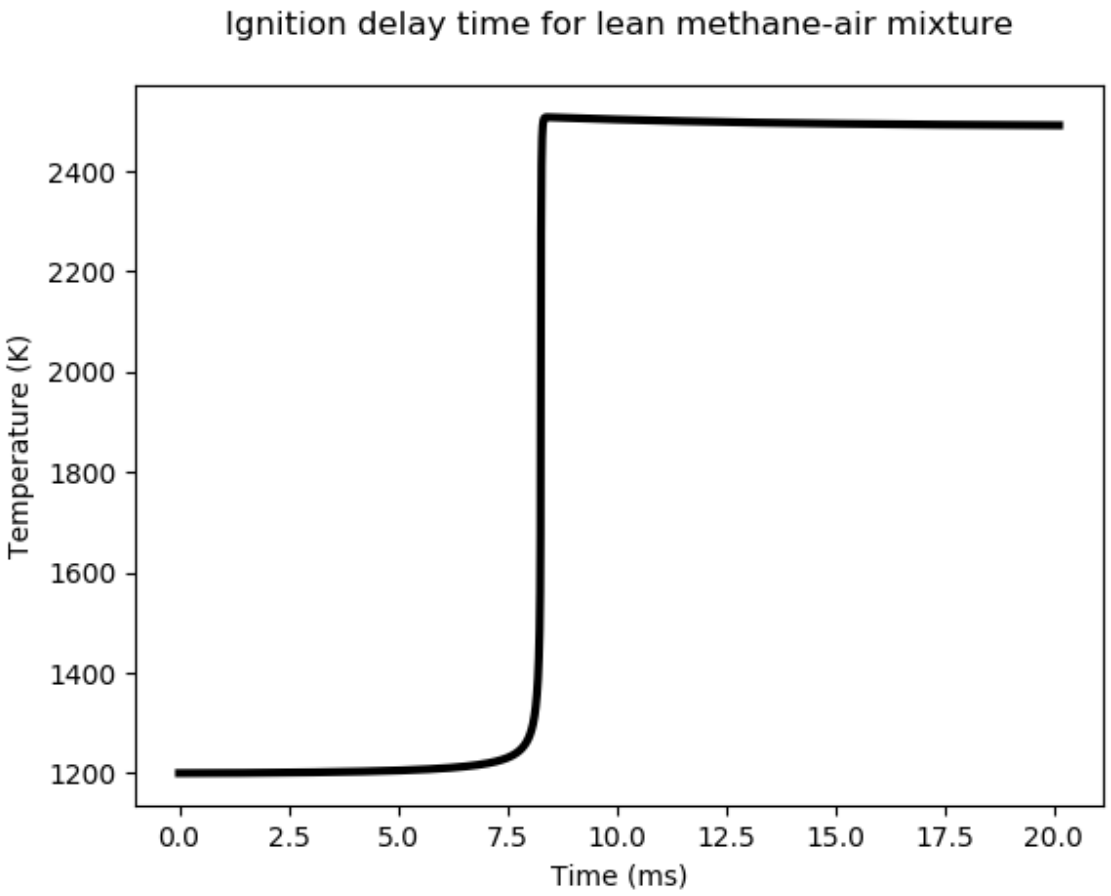
	$Hydrogen$	$Methane$	$Ethane$
$lean$	1	0.35	0.15
$close-to-stechiometric$	2	0.5	0.28
$rich$	3	0.65	0.41

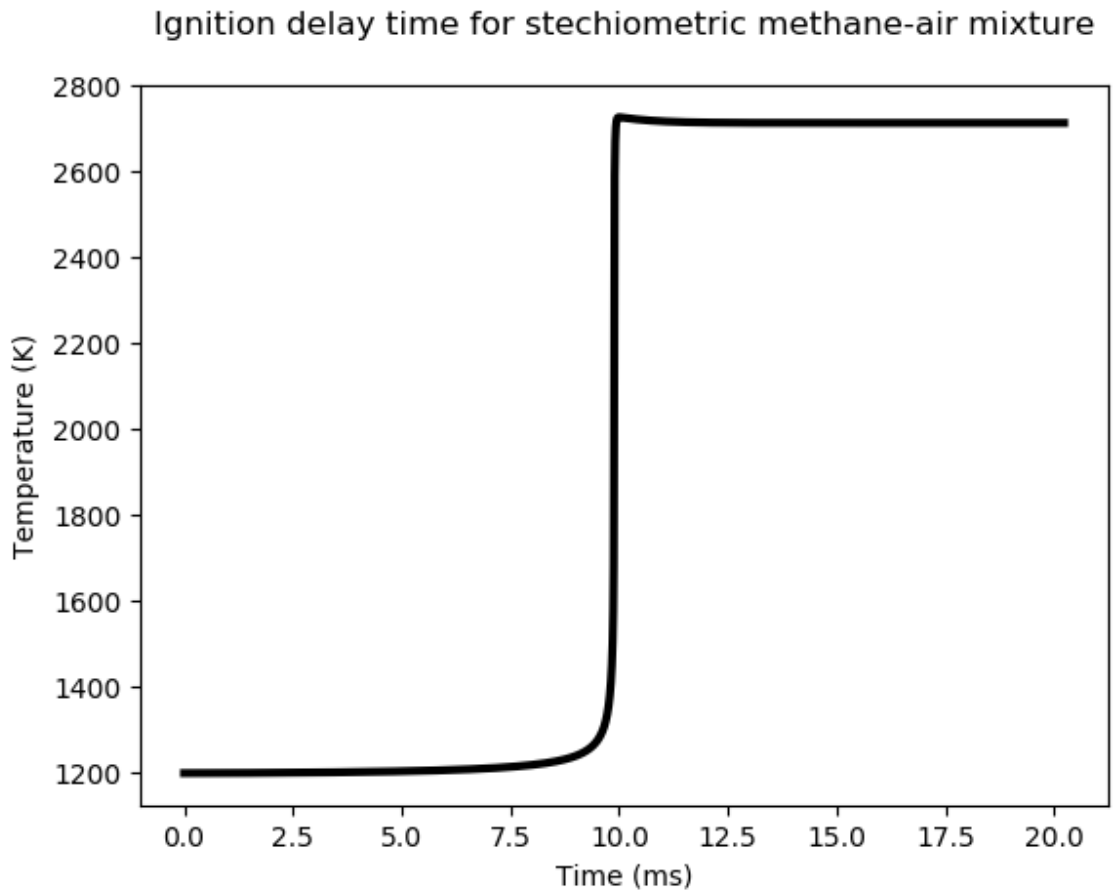
Results

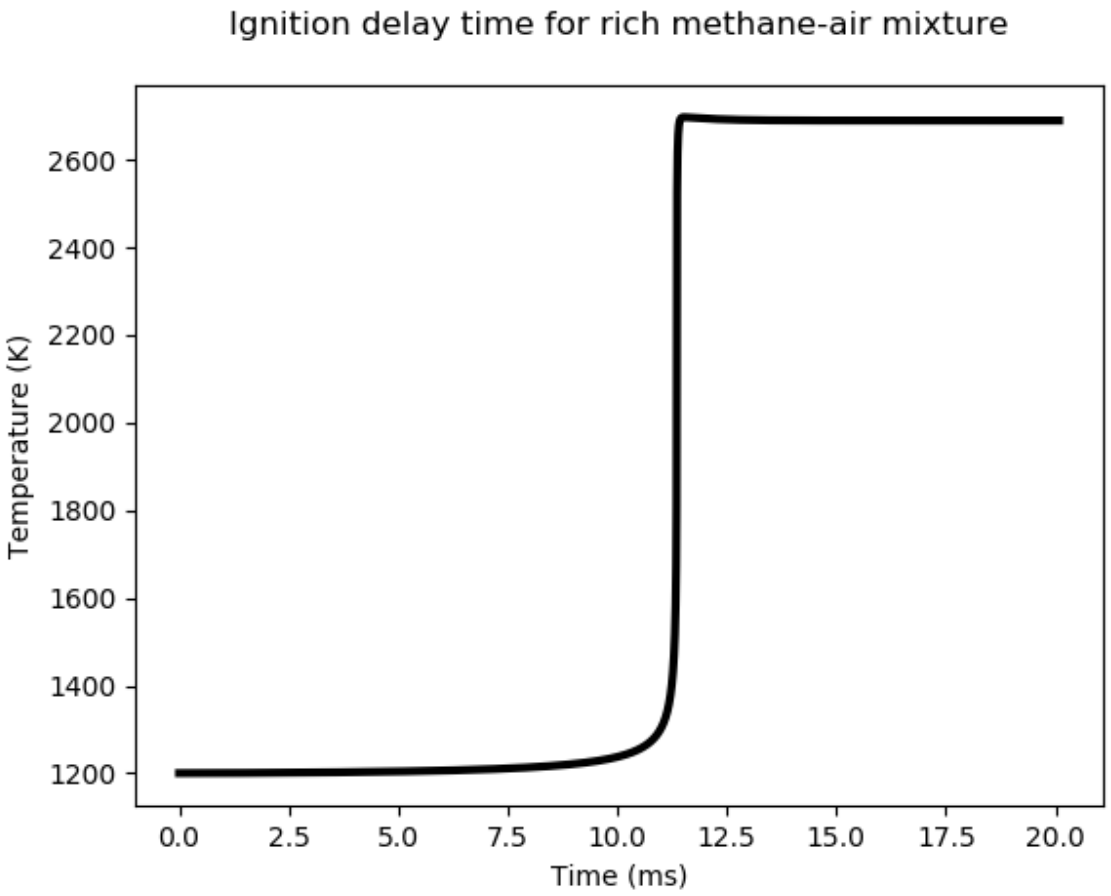

Ignition delay time for lean hydrogen-air mixture
Temperature (K)
2400
2200
2000
1800
1600
1400
1200
0.00
0.01
0.02
0.03
0.04
0.05
Time (ms)

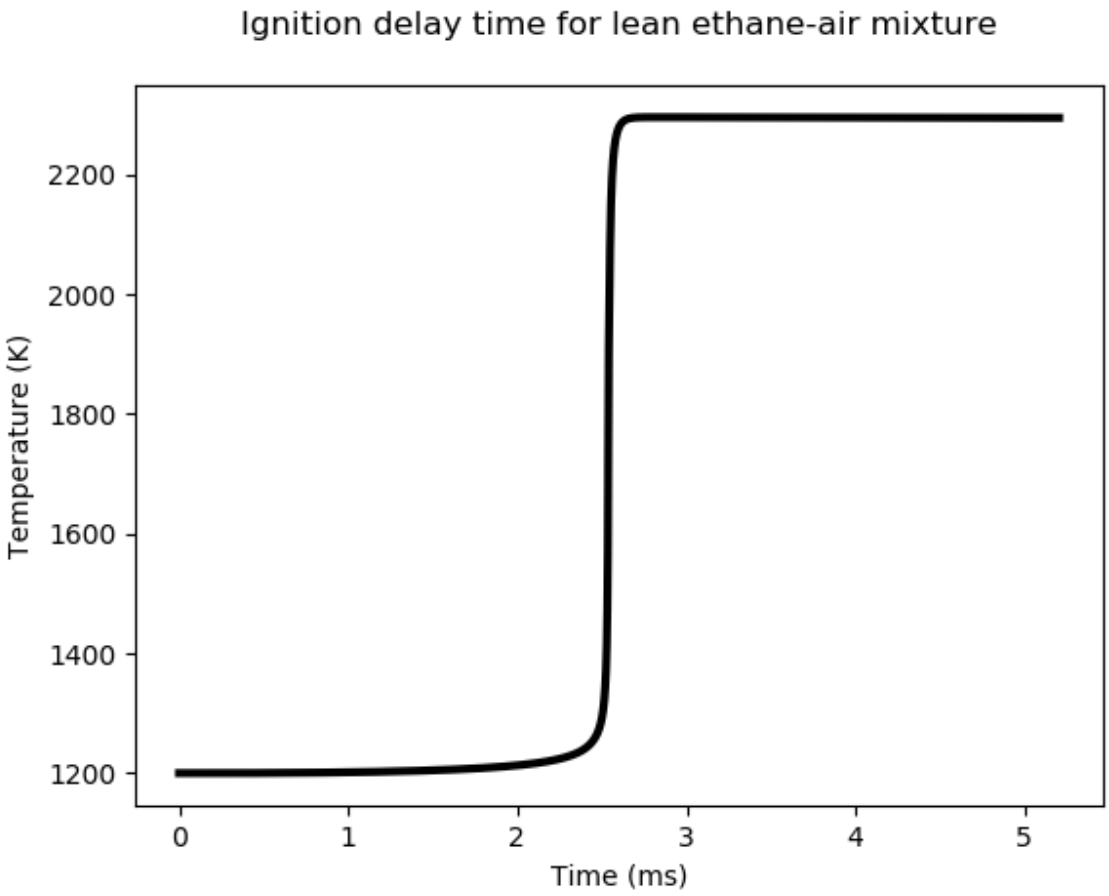

Ignition delay time for stechiometric hydrogen-air mixture
Temperature (K)
2750
2500
2250
2000
1750
1500
1250
0.00
0.01
0.02
0.03
0.04
0.05
Time (ms)

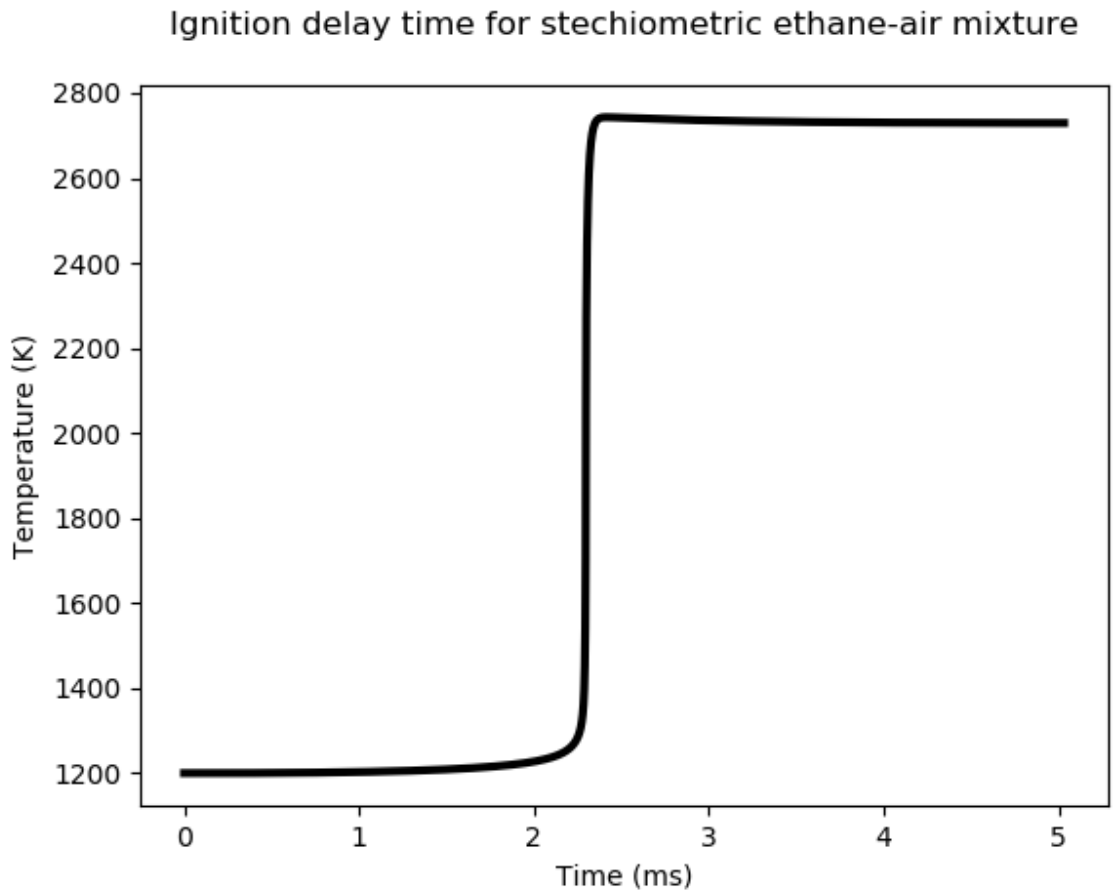

Ignition delay time for rich hydrogen-air mixture
Temperature (K)
2750
2500
2250
2000
1750
1500
1250
0.00
0.01
0.02
0.03
0.04
0.05
Time (ms)

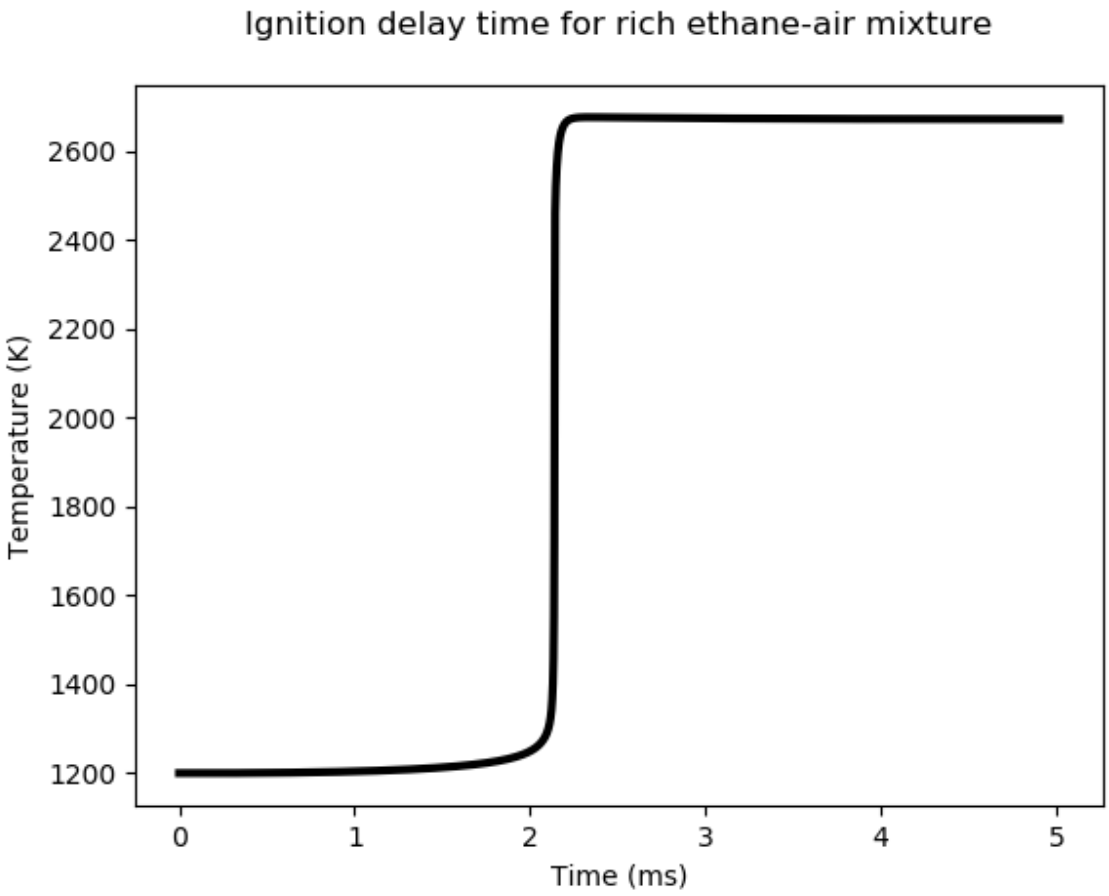

Ignition delay time for lean methane-air mixture
Temperature (K)
2400
2200
2000
1800
1600
1400
1200
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
Time (ms)


Ignition delay time for stechiometric methane-air mixture
Temperature (K)
2800
2600
2400
2200
2000
1800
1600
1400
1200
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
Time (ms)


Ignition delay time for rich methane-air mixture
Temperature (K)
2600
2400
2200
2000
1800
1600
1400
1200
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
Time (ms)


Ignition delay time for lean ethane-air mixture
Temperature (K)
2200
2000
1800
1600
1400
1200
0
1
2
3
4
5
Time (ms)


Ignition delay time for stechiometric ethane-air mixture
Temperature (K)
2800
2600
2400
2200
2000
1800
1600
1400
1200
0
1
2
3
4
5
Time (ms)


Ignition delay time for rich ethane-air mixture
Temperature (K)
2600
2400
2200
2000
1800
1600
1400
1200
0
1
2
3
4
5
Time (ms)

Bibliography

- Marian Gieras - "Spalanie - wybrane zagadnienia w zadaniach"
- www.cantera.org