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MKWS

PROJECT 2

Detonation velocity for different mixtures and initial parameters

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1 Introduction

In this project the detonations of 3 different gases: methane, ethane and propane were observed. For each gas 3 experiments were run - each one for different equivalence ratio. Calculated parameter was detonation velocity depending on initial parameters:

- temperature
- pressure

The results were presented on graphs: $v(T)$ and $v(p)$. For the experiment in which the temperature was variable the pressure was constant and equal to:
 $p=101325\text{Pa}$

For the experiment in which the pressure was variable the temperature was constant and equal to:
 $T=293\text{K}$

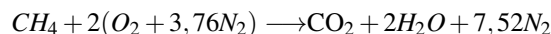
The aim of the experiment was to observe the differences in process of detonation depending on mixture's chemical composition. For this purpose the calculated parameter for different mixtures were compared to each other on graphs. Calculated parameter for different equivalence ratios of the same mixture were compared in Section 5.

An assumed simplifications were

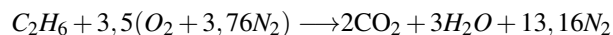
- the air consists of oxygen and nitrogen only and their ratio is 1:3,76.
- the flow is a 1-D flow
- the tube has a constant cross-sectional area
- the gas is ideal
- the detonation conditions are adiabatic

Taking into consideration assumed simplifications stoichiometric chemical reactions take the following forms:

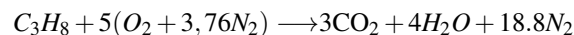
- methane



- ethane



- propane



assuming that combustion is complete and that nitrogen does not take part in combustion and does not convert into NO_x

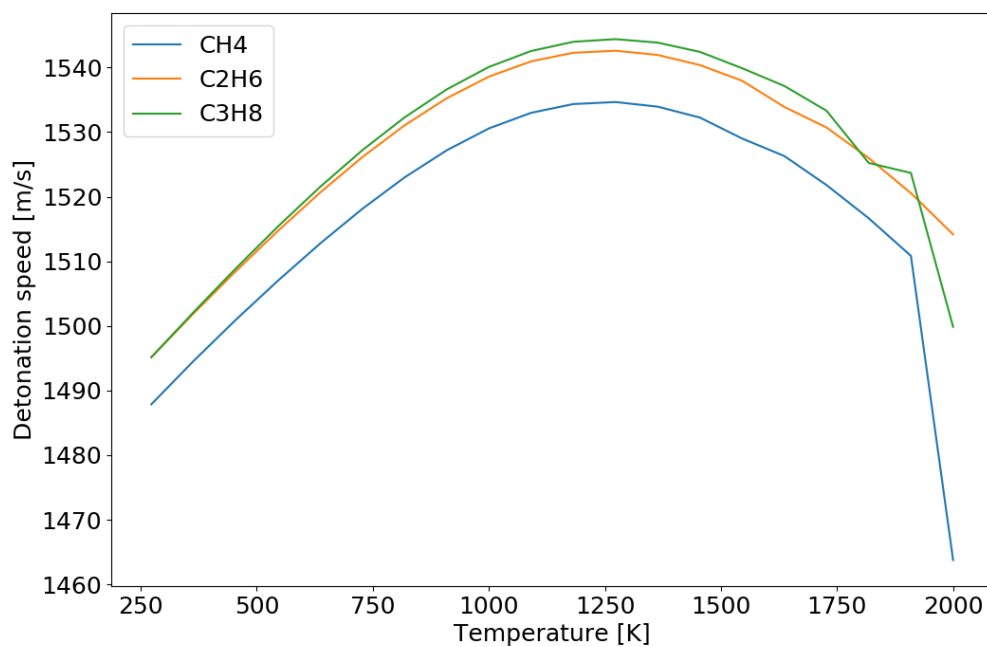
2 $\phi = 0.5$

In this section experiments for lean mixtures were run.

2.1 Variable temperature

The graph shows how detonation velocity depends on initial temperature of the process with constant initial pressure:

$p=101325\text{Pa}$

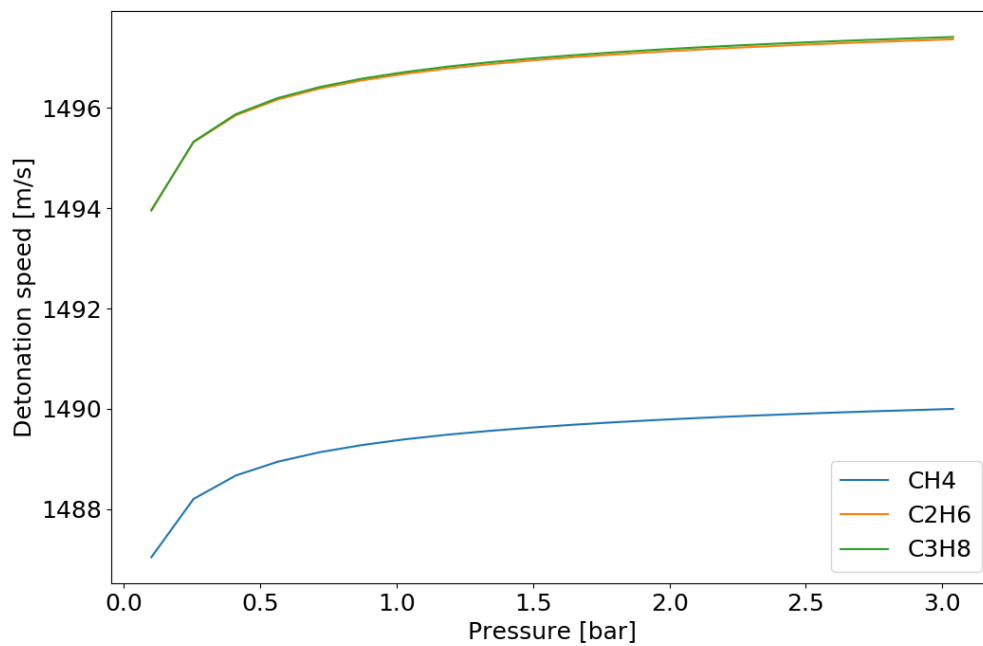


Ethane and propane have similar graphs especially for low temperatures which means that detonation velocity is similar for those gases when the initial temperature is the same. Methane has lower detonation velocities than other two gases. The shapes of 3 graphs are quite similar and for each of them the highest velocity is reached when the initial temperature is circa 1250K. The highest maximum velocity is for propane but the difference between propane and ethane max velocity is less than 3m/s. The difference between propane and methane maximum velocity is over 10m/s.

2.2 Variable pressure

The graph shows how detonation velocity depends on initial pressure of the process with constant initial temperature:

$T=293\text{K}$



As for the variable temperature, graphs for ethane and propane are similar and the graph for methane is below those two. The differences between ethane and propane are smaller than in 2.1 and neglectable. The velocity for methane is circa 10m/s smaller than for ethane or propane for every initial pressure for section 0 - 3bar. For this section the speed is increasing for rising pressure.

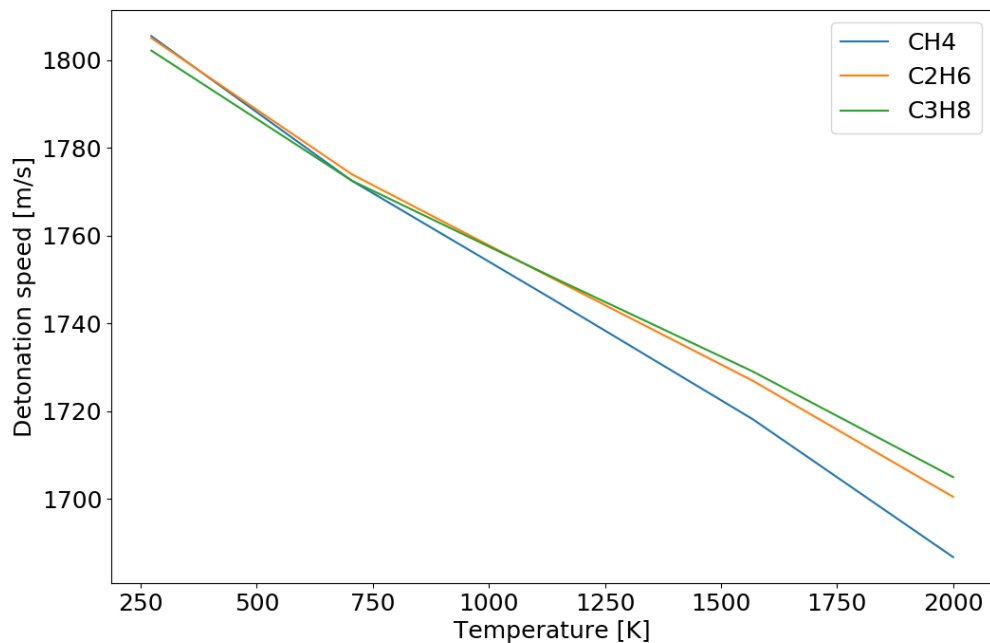
3 $\phi = 1$

In this sections detonation experiments were run for stoichiometric mixtures.

3.1 Variable temperature

The graph shows how detonation velocity depends on initial temperature of the process with constant initial pressure:

$p=101325\text{Pa}$

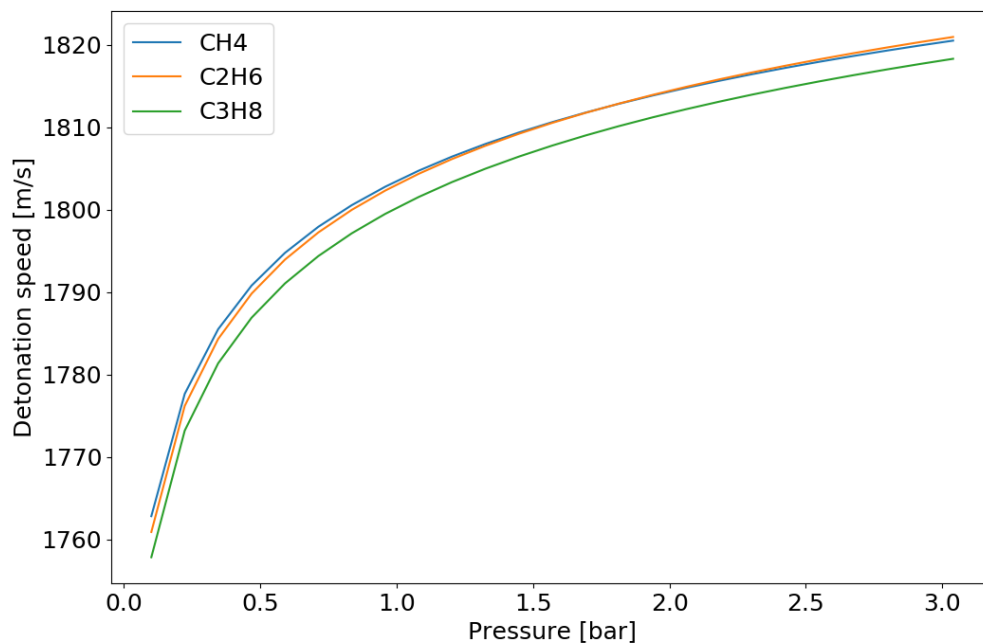


For stoichiometric mixtures velocity is decreasing when the temperature is rising. The graphs are similar and approximately linear especially for temperatures higher than 750K. For temperature circa 750K all velocities are almost equal. For higher temperatures the difference between velocities for propane and ethane are small and the difference between methane and the other two is quite significant as it is equal to circa 20m/s for 2000K.

3.2 Variable pressure

The graph shows how detonation velocity depends on initial pressure of the process with constant initial temperature:

$T=293\text{K}$



In this case graphs for methane and ethane are almost overlapping. Graph for propane is situated below those two graphs. It means that for the same initial pressure it is propane that will reach the lowest detonation velocity. The differences are smaller for lower initial pressures. For pressure higher than 0,5bar the difference is circa 4m/s. For each gas the velocity is constantly growing as the initial pressure is increased (between 0 and 3 bar).

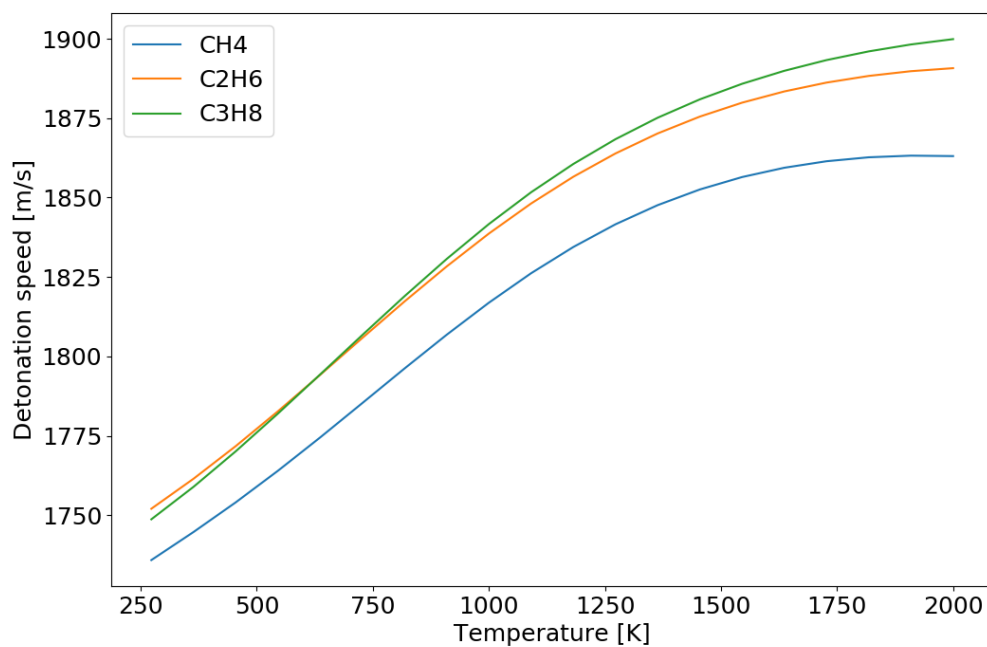
4 $\phi = 2$

In this section experiments were run for rich mixtures

4.1 Variable temperature

The graph shows how detonation velocity depends on initial temperature of the process with constant initial pressure:

$p=101325\text{Pa}$

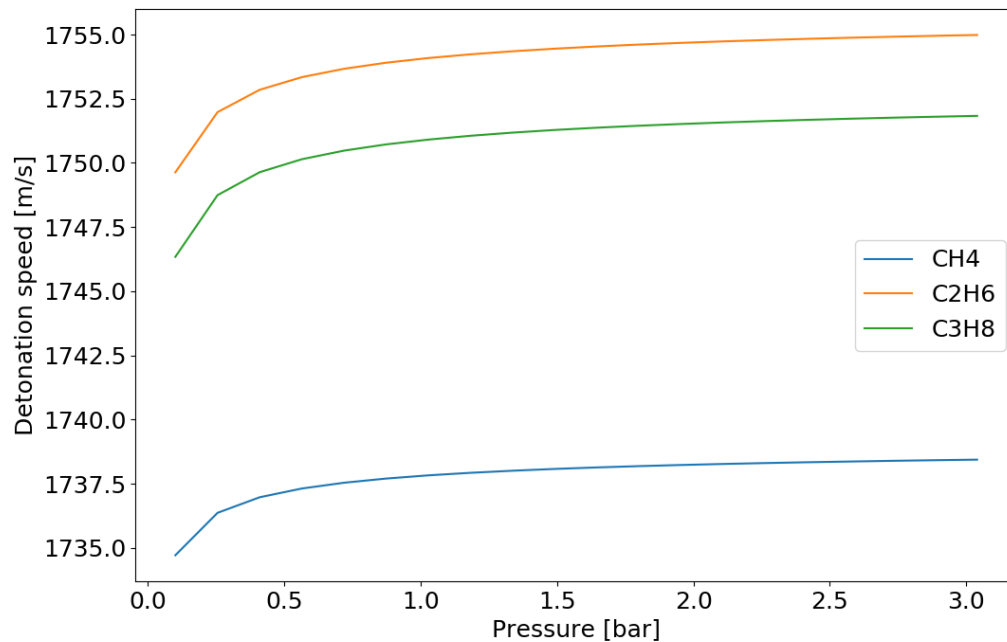


For rich mixtures propane and ethane have similar velocity dependencies on temperature especially for lower initial temperatures. The differences (more than 1m/s) are visible for T greater than 1000K. The velocity for methane is lower than for the other two gases for every initial temperature and the differences rise as the temperature increases (for 2000K it is circa 35m/s). The detonation velocity increases in the entire temperature section 250-2000K.

4.2 Variable pressure

The graph shows how detonation velocity depends on initial pressure of the process with constant initial temperature:

$T=293\text{K}$



The differences between ethane and propane are circa 3m/s, and between ethane and methane - 25m/s. The highest velocity is reached by ethane. For the entire section 0-3bar the velocity increases as the initial pressure rises, but the increase is significant only for pressures between 0-0,5bar. For higher pressures the graphs get flatter and become almost constant.

5 Equivalence ratio dependence

5.1 Variable temperature

For all equivalence ratios for higher temperatures (over 500K) propane has the highest velocities and methane - the lowest. For lower temperatures results vary depending on the equivalence ratio. The monotonicity is different for every ϕ . For lean mixture the velocity increases until it reaches its peak value and then decreases. For stoichiometric mixture

5.2 Variable pressure

For lean and rich mixtures the highest velocity is reached by propane and the lowest - by methane. For stoichiometric mixtures the lowest velocity is reached by propane and the highest - by methane and ethane (as the difference is neglectable). For each equivalence ratio the detonation velocity rises as the initial pressure rises. The graphs for lean and rich mixtures are similar as they turn to almost constant for higher pressures.

6 Summary

Conclusions

- Detonation parameters for ethane and propane are similar, in some cases even identical.
- The equivalence ratio has significant influence on $v(T)$ dependence.
- For rich and lean mixtures initial pressure does not influence detonation velocity significantly when the pressure is higher than 0,5bar.