METODY KOMPUTEROWE W SPALANIU

Combustion of ethane - oxygen mixture for different initial temperature, pressure and equivalence ratio

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1 Abstract.

The purpose of the project was to conduct a study of Chapman-Jouget detonation of a ethane oxygen mixture for different initial temperature, pressure and equivalent ratio, using Cantera and SDToolbox software. The results of the study are several plots, showing influence of these parameters on C-J detonation speed, temperature, pressure and density.

2 Mathematic model.

There are several mechanisms that can be used for C-J detonation parameters. For the needs of the study, we used the one called 'gir30 highT Mechanism'. It uses conservation of energy rules:

1. $\rho_1 w_1 = \rho_2 w_2$
2. $P_1 + \rho_1 (w_1)^2 = P_2 + \rho_2 (w_2)^2$
3. $h_1 + w_1^2/2 = h_2 + w_2^2/2$

The calculations were held for 10 different temperatures, pressures and $\phi(10x10x10)$. The more accurate we want the calculations to be, the more iterations we have to make and the more time it takes. For the purpose of this project, 10x10x10 is more than enough.

3 Results and plots.

3.1 Results for $P = 1013,25hPa$, $\phi = 1$ and different initial temperatures.

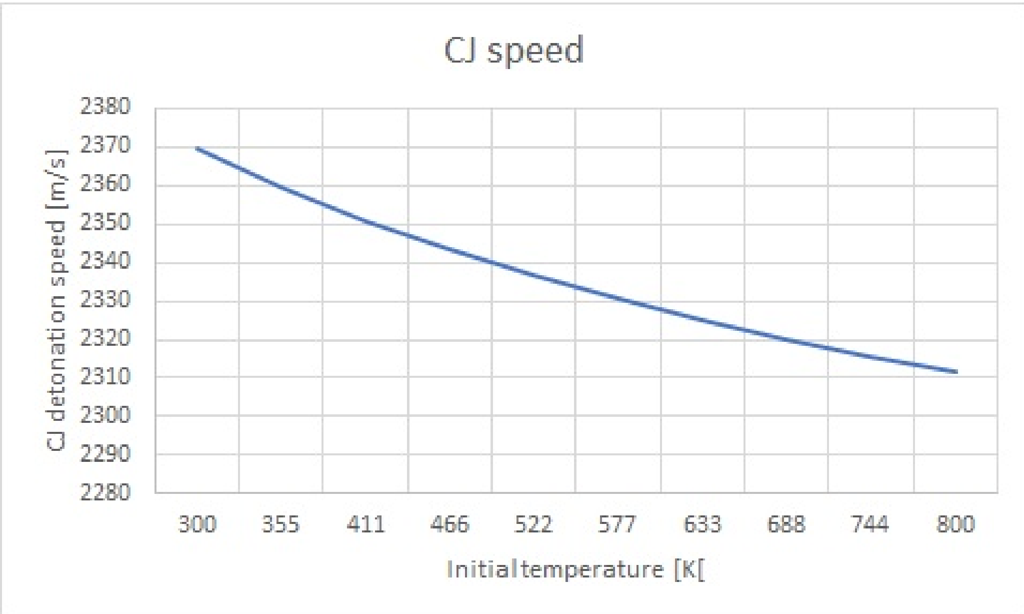

Figure 1: Influence of initial temperature on C-J detonation speed.

We observe a severe drop of the C-J detonation speed with a rise of the temperature.

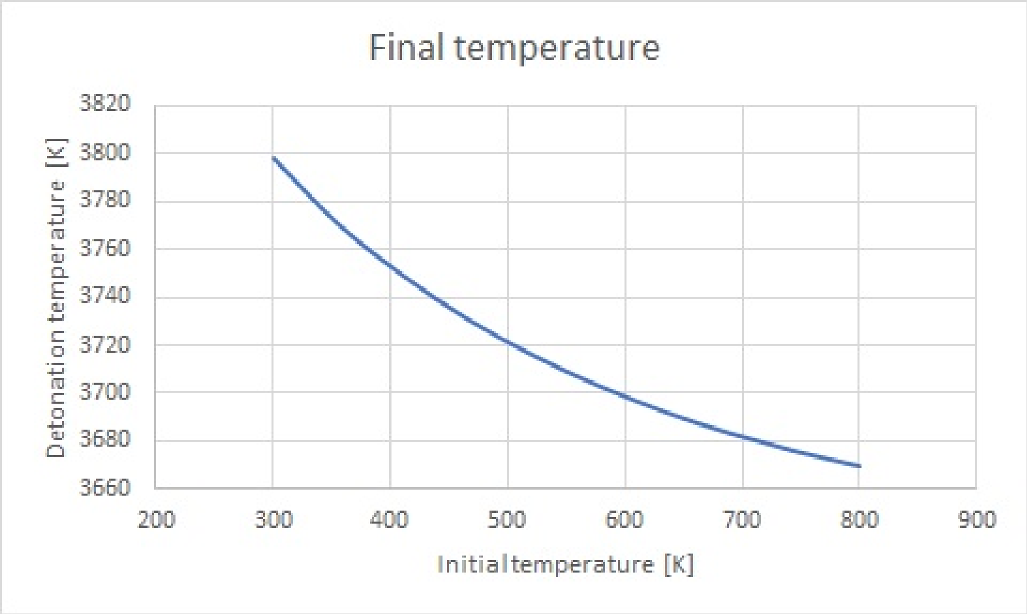

Figure 2: Influence of initial temperature on detonation temperature.

Influence of initial temperature on final temperature. Starting with 300K, a decrease of a final temperature is noticed. For initial temperature of 300K detonation temperature is 3798K and for initial temperature of 800K detonation temperature is 3670K.

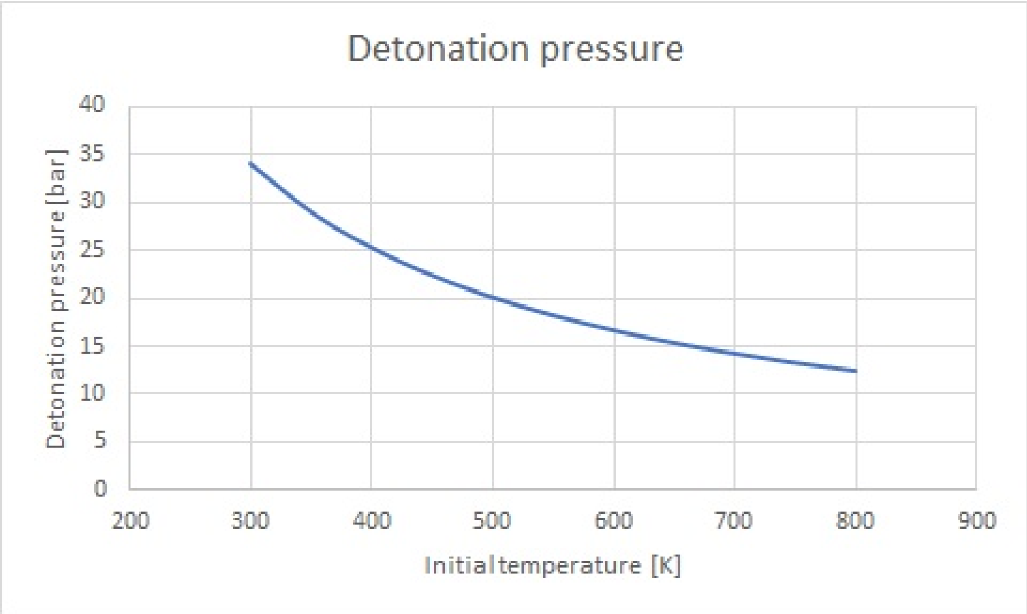

Figure 3: Influence of initial temperature on detonation pressure.

Influence of initial temperature on detonation pressure. Starting with 300K, a decrease of detonation pressure is noticed.

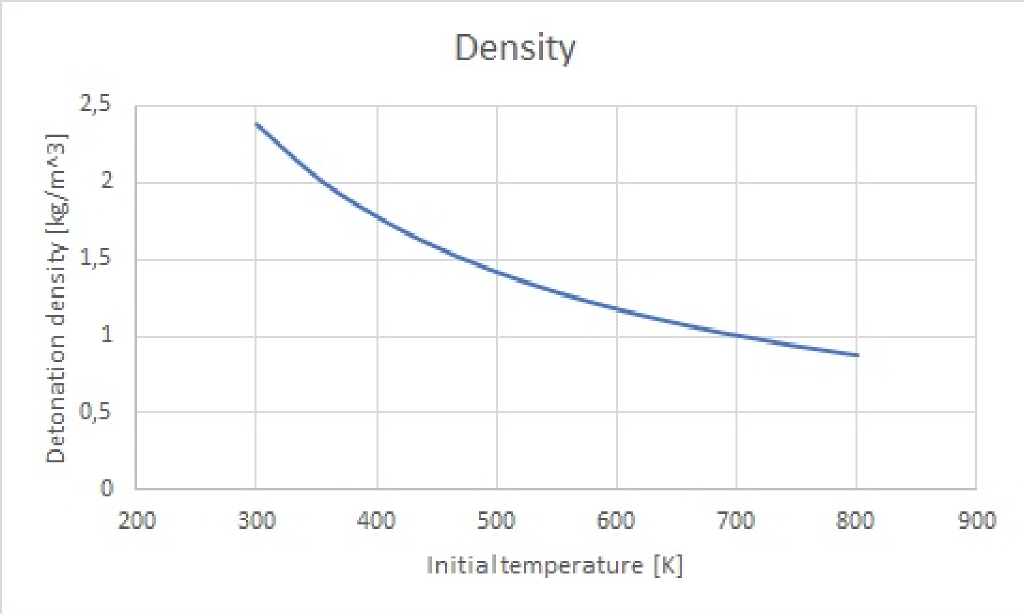

Figure 4: Influence of initial temperature on detonation density.

Influence of initial temperature on detonation density. Starting with 300K, a decrease of detonation density is noticed.

3.2 Results for $T = 300K$, $\phi = 1$ and different initial pressure.

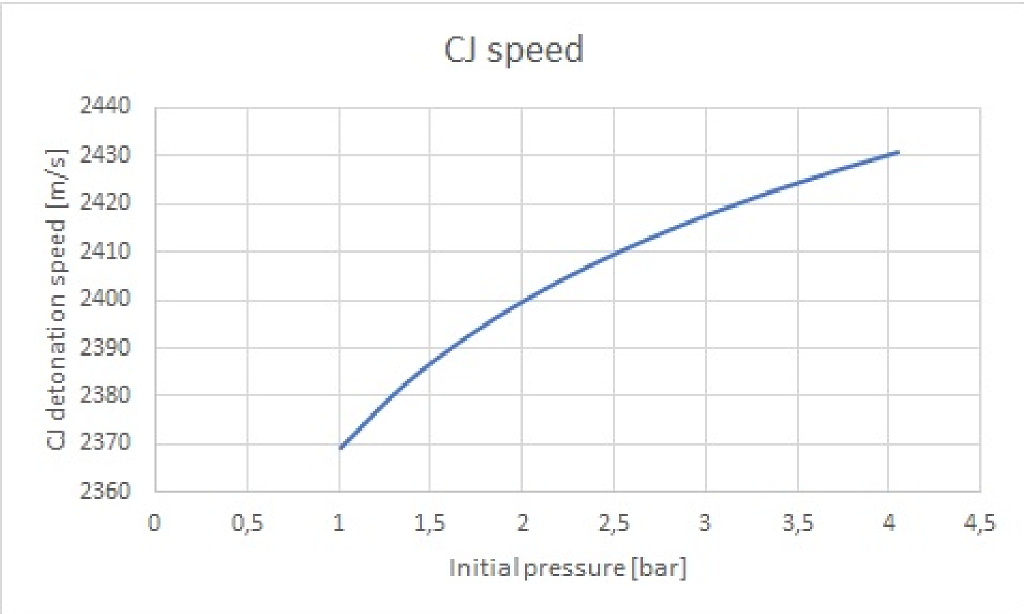

Figure 5: Influence of initial pressure on C-J detonation speed.

We observe an increase of the C-J detonation speed with a rise of the pressure.

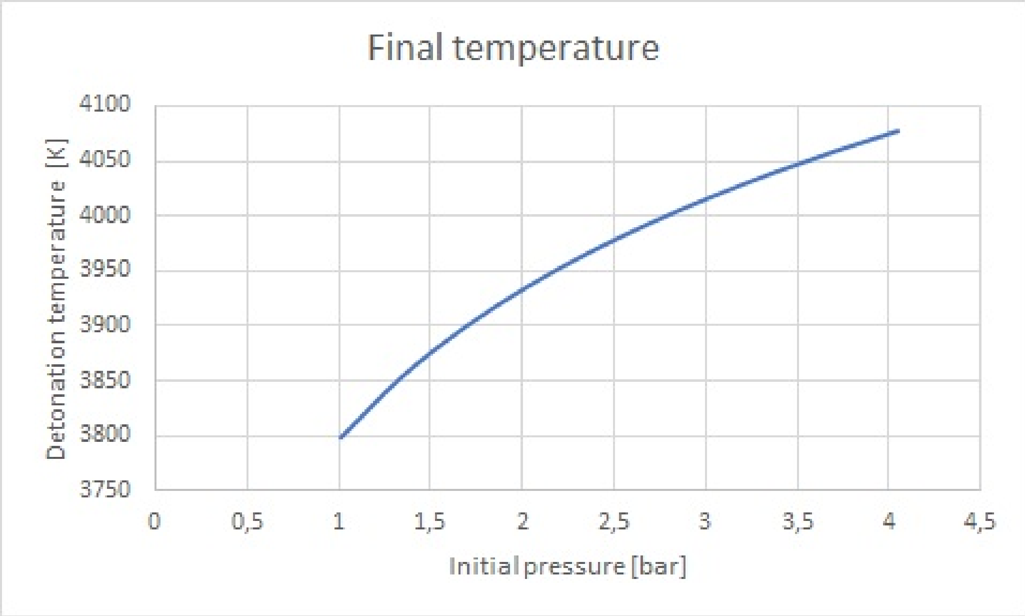

Figure 6: Influence of initial pressure on detonation temperature.

Influence of initial pressure on final temperature. An increase of a final temperature is noticed.

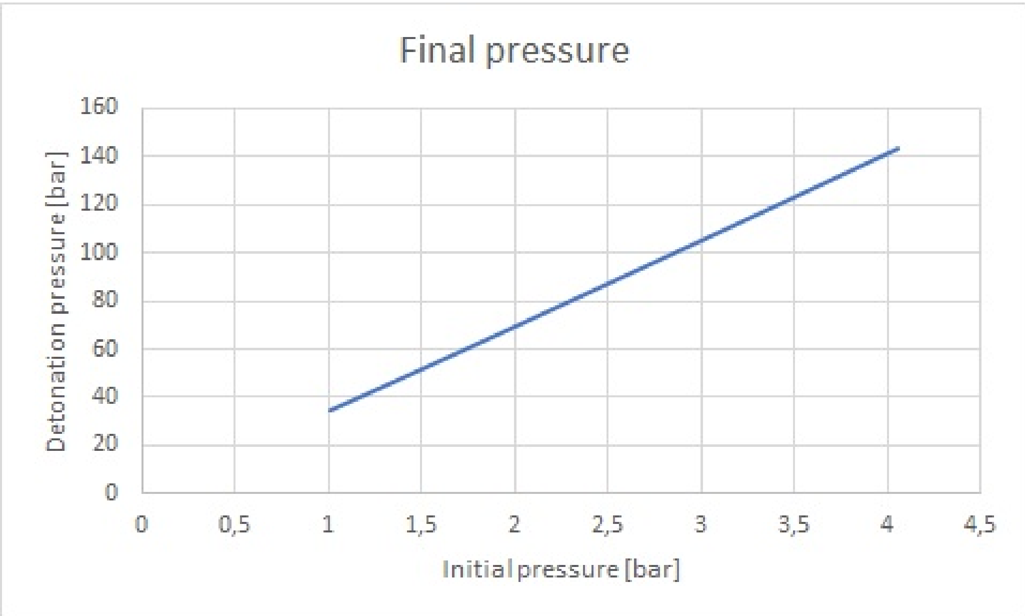

Figure 7: Influence of initial pressure on detonation pressure.

Influence of initial pressure on detonation pressure. An increase of detonation pressure is noticed.

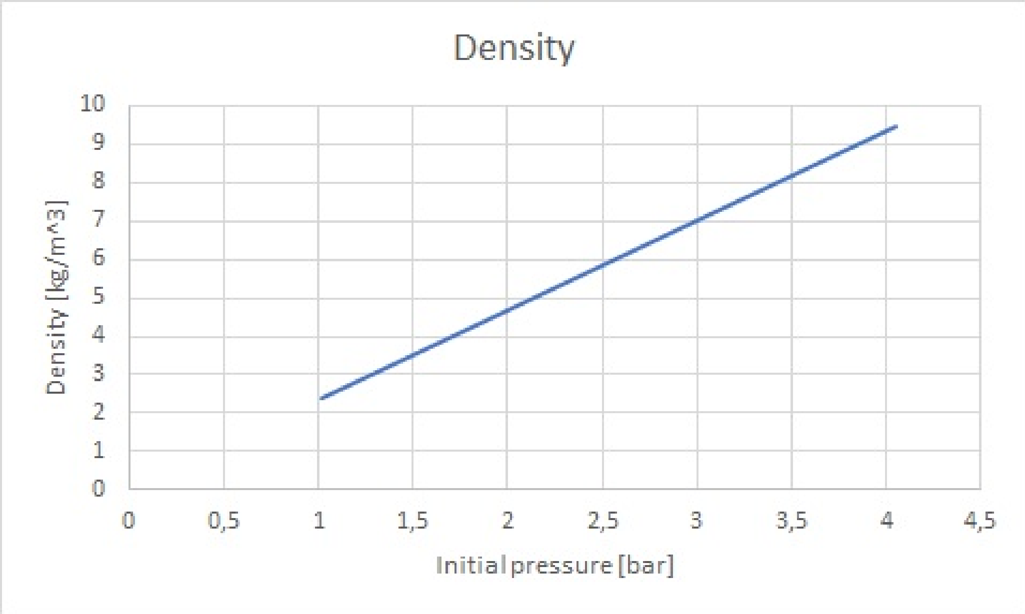

Figure 8: Influence of initial temperature on detonation density.

Influence of initial pressure on detonation density.An increase of detonation density is noticed.

3.3 Results for $T = 300K$, $P = 1013,25hPa$ and different equivalent ratio values (ϕ).

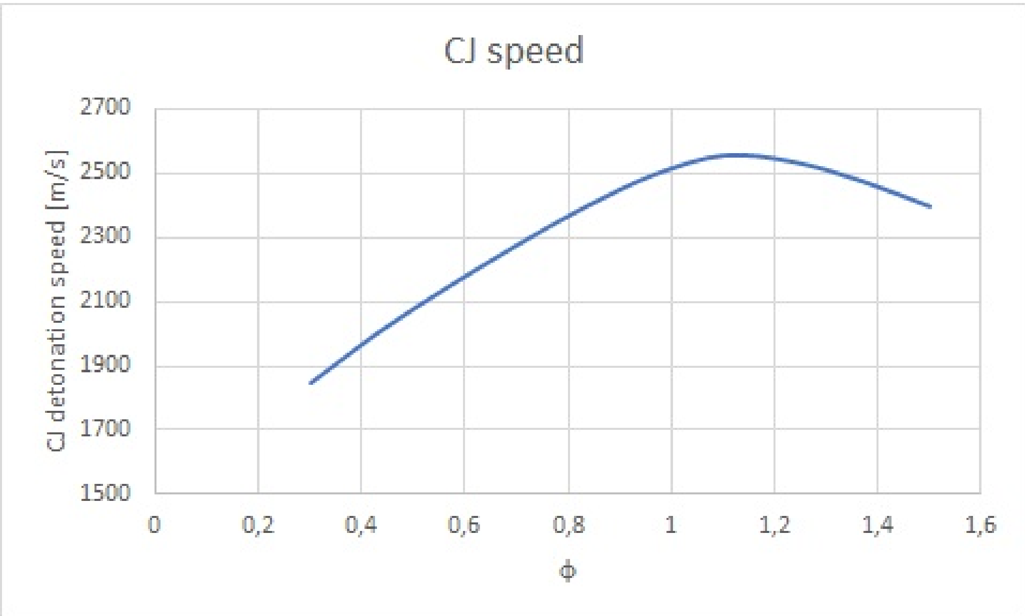

Figure 9: Influence of equivalent ratio on C-J detonation speed.

We observe an increase of the C-J detonation speed in the area where equivalent ratio is about 1. For the values over 1 detonation speed is starting to decrease.

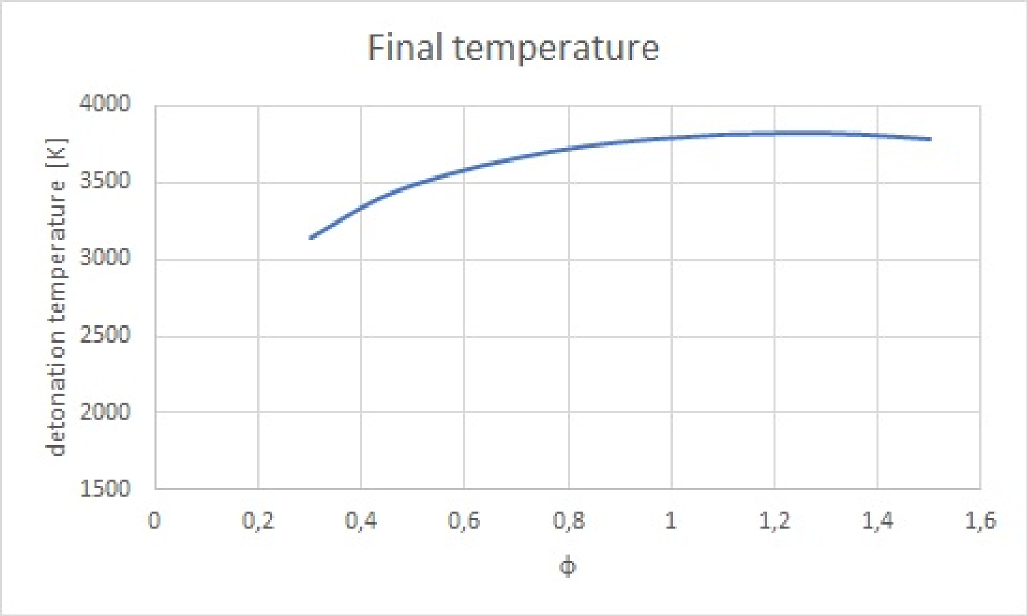

Figure 10: Influence of equivalent ratio on detonation temperature.

Influence of equivalent ratio on final temperature.

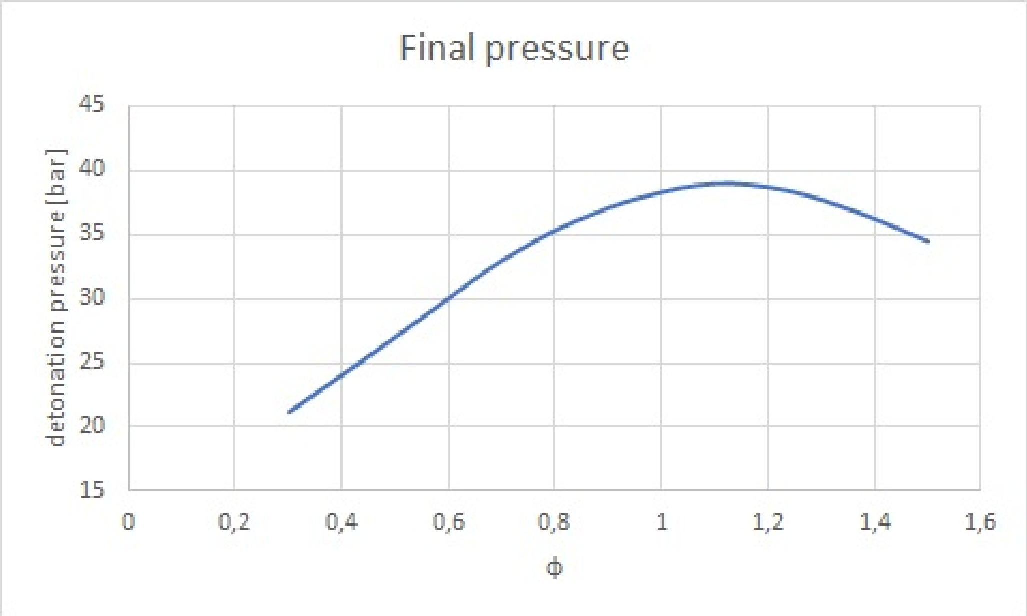

Figure 11: Influence of equivalent ratio on detonation pressure.

Influence of equivalent ratio on detonation pressure.

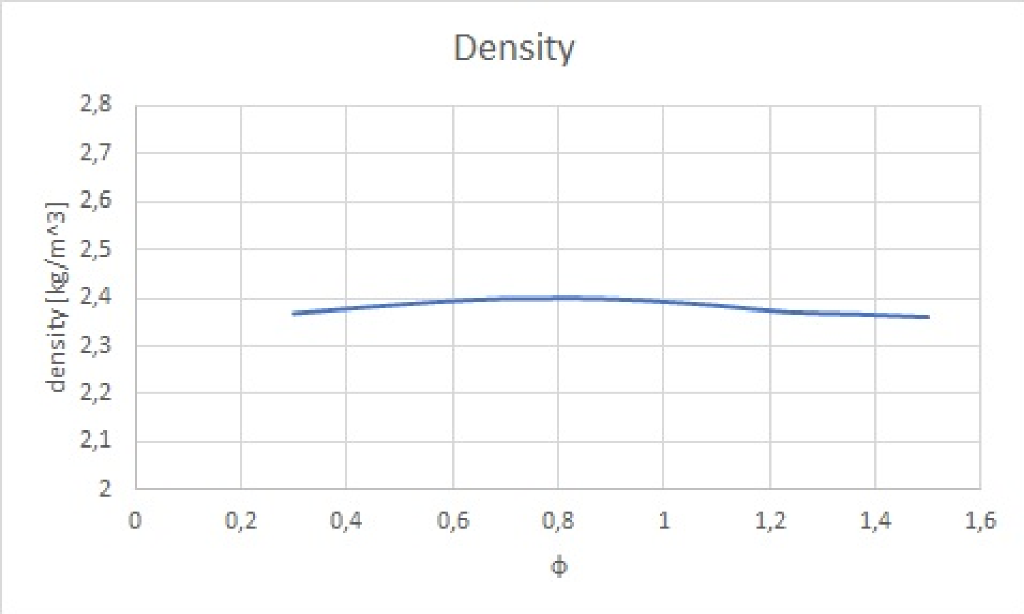

Figure 12: Influence of equivalent ratio on detonation density.

Influence of initial temperature on detonation density. Decrease of detonation density for the equivalent ratio value equal more than 1 is noticed.

4 Overall.

The study gives information about the behavior of detonation parameters as a function of temperature, pressure and ϕ. The definition of autoignition proposed in the mathematical model is the most commonly used one. The data read from the plots are just approximations of the actual state. The most interesting is the fuction of equivalent ratio. Each combustion parameter has it is characteristic point in the area of equivalent ratio equal to 1. It shows a point where combustion process is the closest to stechiometric.

5 References.

1. $CANTERA\_HandsOn.pdf$

2. "Wybrane zagadnienia w spalaniu", M. Gieras, Warszawa 2011