

# Chapman - Jouguet parameters in hydrogen-oxygen mixtures

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## 1 Introduction

This report presents a study of the CJ parameters in various hydrogen - oxygen mixtures. The calculations were performed in SDToolbox, using "wang\_highT" mechanism of kinetics and two functions: "CJSpeed" and "Postshock.eq".

## 2 Mathematical model

The solver is based on the simplest, 1-dimensional model of detonation, proposed by Chapman and Jouguet around 1900. It treats the detonation wave as a discontinuity in a flow, allowing the use of three basic conservation laws: mass, momentum and energy.

$$\rho_1 w_1 = \rho_2 w_2 \quad (1)$$

$$p_1 + \rho_1 w_1 u_1 = p_2 + \rho_2 w_2 u_2 \quad (2)$$

$$\frac{1}{2} w_1^2 + \frac{\kappa}{\kappa - 1} \frac{p_1}{\rho_1} = \frac{1}{2} w_2^2 + \frac{\kappa}{\kappa - 1} \frac{p_2}{\rho_2} + H \quad (3)$$

Where:

$p$  - pressure

$\rho$  - density

$w$  - velocity of shockwave propagation

$u$  - velocity of gas

$H$  - heat coming from chemical reaction

Index 1 denotes parameters before shockwave, while 2 denotes parameters behind the shockwave.

Knowing  $H$  of a given mixture, one can calculate all the other thermodynamic parameters.

## 3 Results

The initial thermodynamic conditions of a mixture are:

$p = 1 \text{ bar}$

$T = 300\text{K}$

The concentration of hydrogen varies continuously from 5 to 90%. The following plots show three basic parameters of a detonative combustion - CJ speed, pressure and temperature behind the wave.

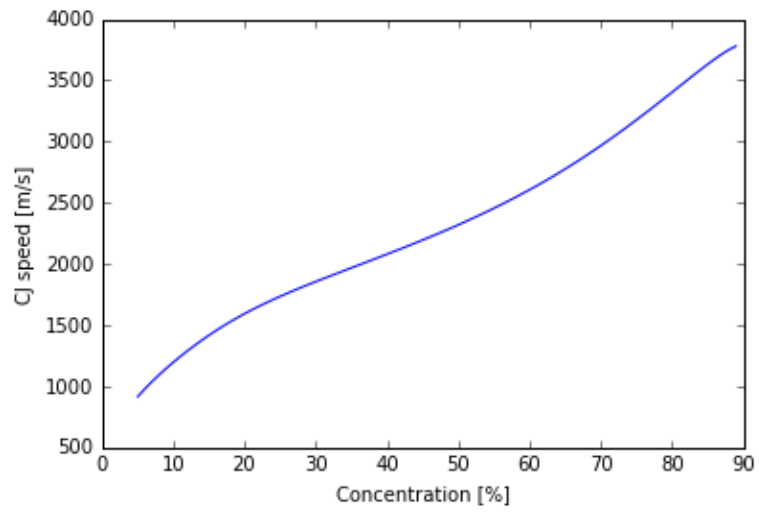


Figure 1: Chapman Jouguet velocity vs H<sub>2</sub> concentration

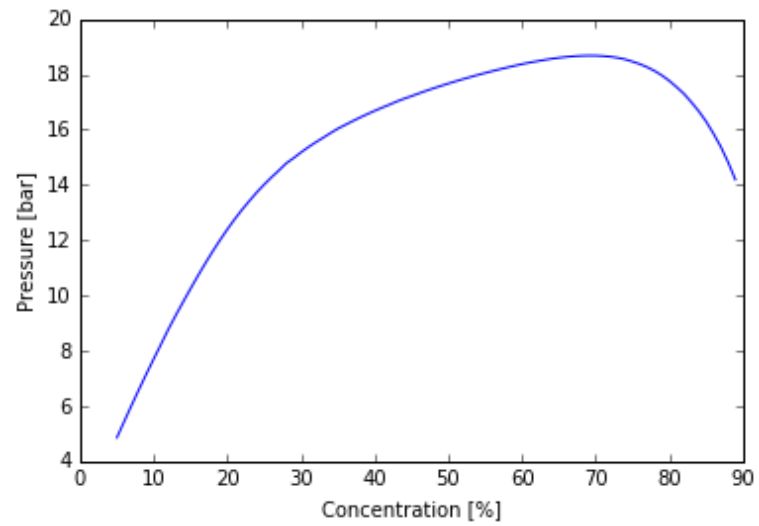


Figure 2: Chapman Jouguet pressure vs H<sub>2</sub> concentration

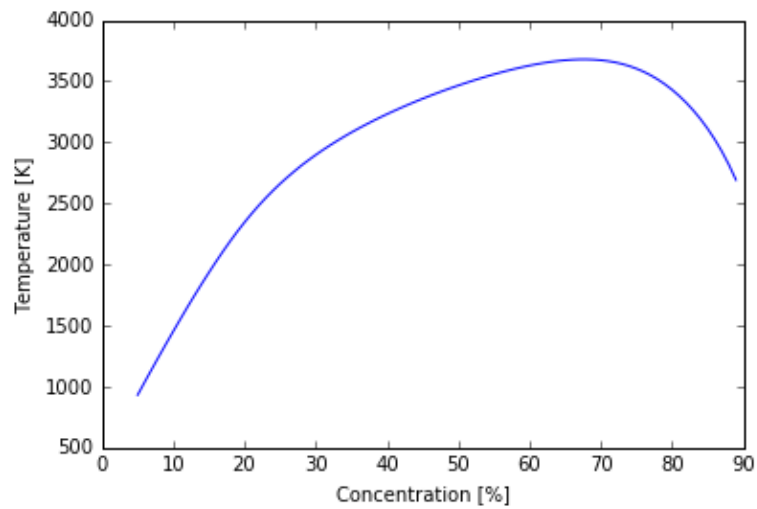


Figure 3: Chapman Jouquet temperature vs H2 concentration

## 4 Summary

- The CJ speed in hydrogen-oxygen mixtures increases with hydrogen concentration
- The maximum temperature and pressure appear around stoichiometric mixture (67% of concentration)

## 5 References

- [1] Kordylewski Włodzimierz, Spalanie i paliwa, Oficyna Wydawnicza Politechniki Wrocławskiej, 2005