Warsaw University of Technology | Faculty of Power and Aeronautical Engineering

course
Metody komputerowe w spalaniu

Kerosene combustion inside miniature turbine engine

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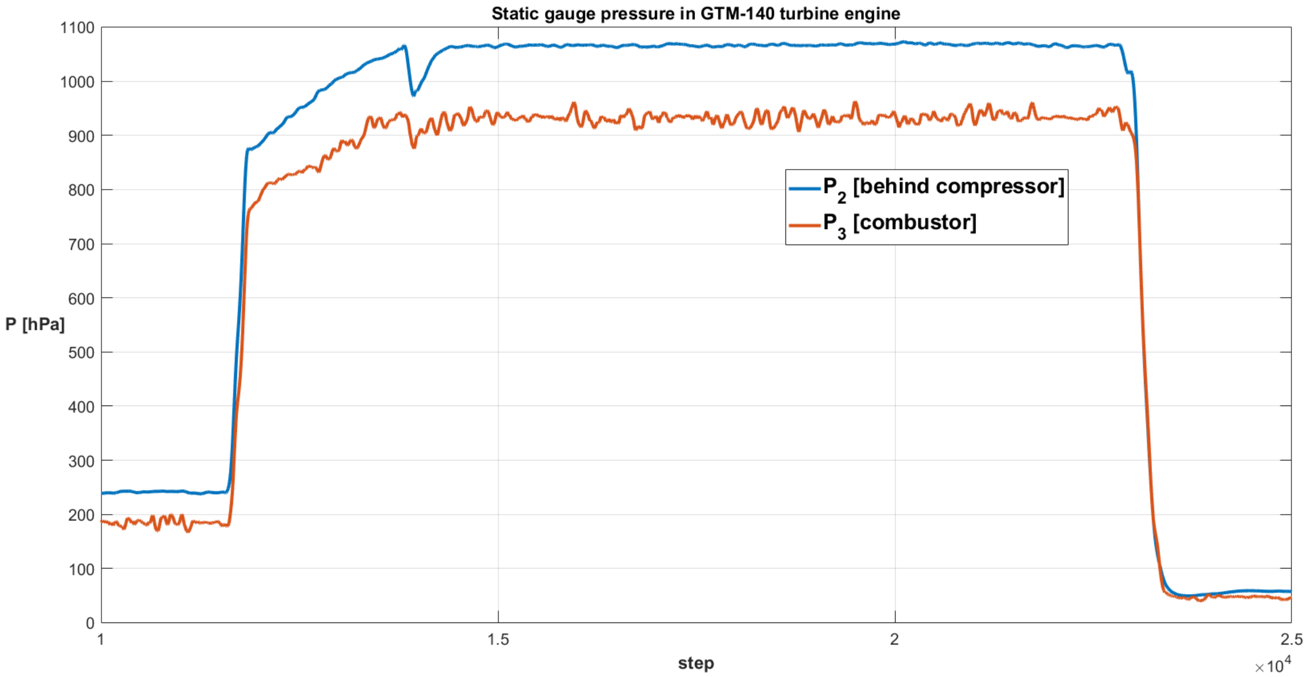
Contents

1. Introduction

This project main goal is to simulate combustion inside miniature jet engine's combustion chamber. Miniature jet engines more frequently find use in flying targets, drones and guided missiles, so studying them seems important. Having acces to one such engine I was easily able to access data on engine mean air and fuel consumption. Data concerning that values are shown in chapter below.

2. Experimental data

Graph below show experimental data on pressure inside engine's chamber.



P_3 [hPa]	$\dot{m}_f$ [kg/s]	$\dot{m}_{air}$ [kg/s]	T_2 [K]	T_3 [K]	T_4 [K]
1930	0,0047	0,4	443	1015	803

3. Literature survey

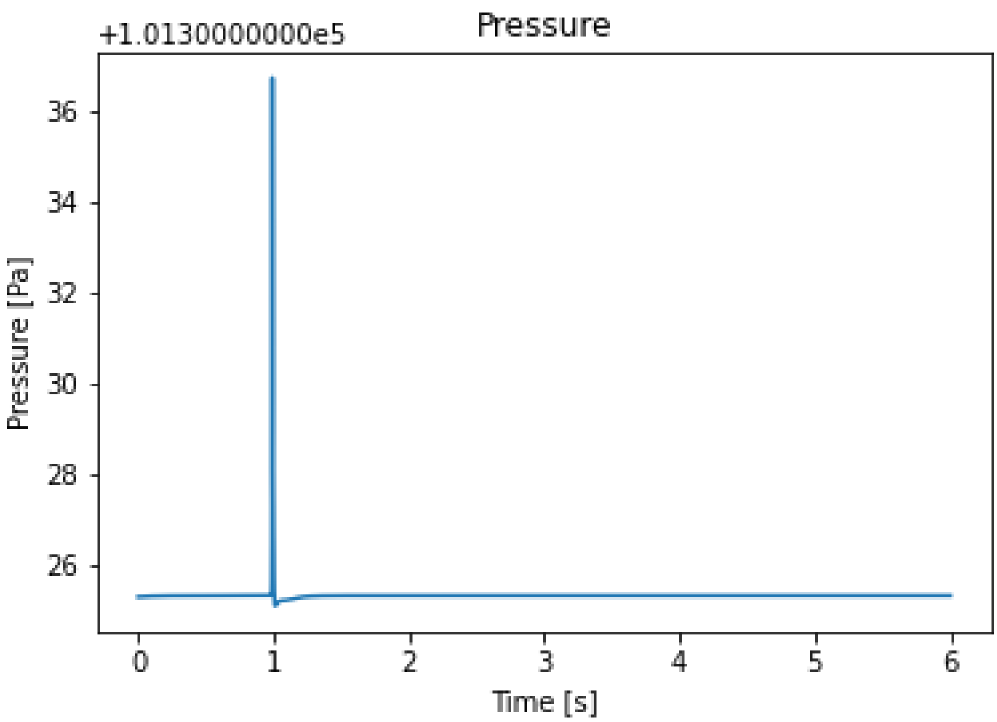
Going through the internet and previous projects of other students i found information on karosene/air combustion[1] on CERFACS research center site. On said site there are three models of combustion mechanisms. The one I chose to use in my essay is Dagaut's mechanism. For purposes on understating cantera code I used cantera documentation site [2] and other student's work from previous years[3]. Big help with writing this essay was also a presentation made by D. G. Goodwin from caltech[4].

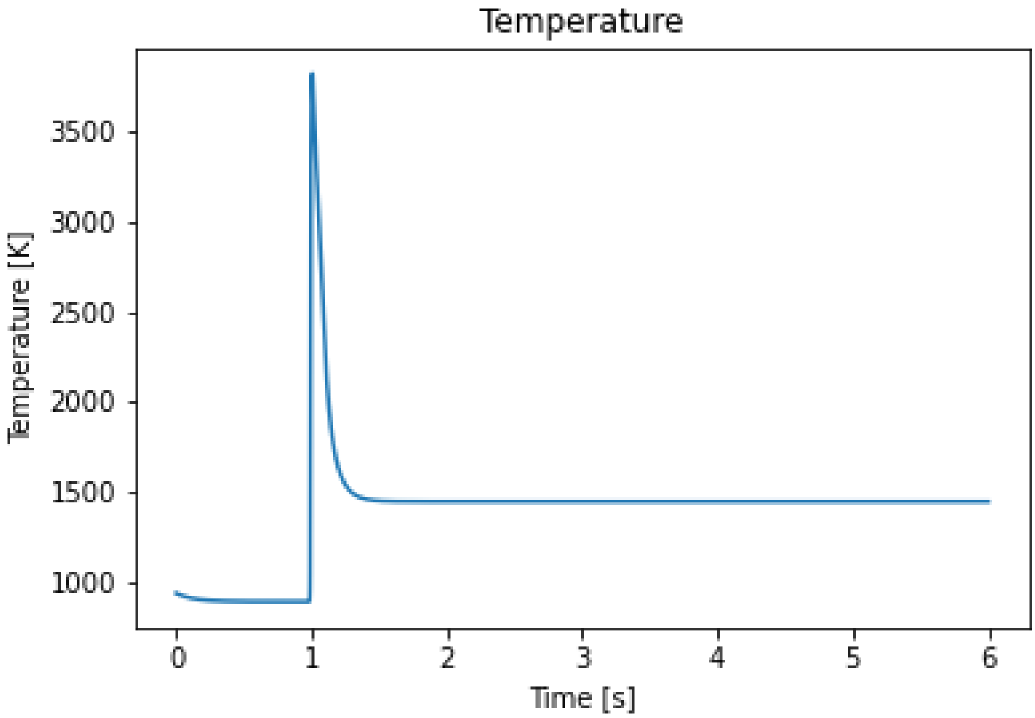
4. Model description

My first computations were made using a homogeneous zero-dimensional reactor. But because a lot of errors accured using this solution and I couldn't finish any calculation I switched to ideal gas reactor model. Dagaut's mechanism uses a surrogate instead of real karosene in computations and involves 225 species and 1800 reversible reactions. Model consist of four reservoirs (igniter, fuel, air and exhaust) and a combustor.

5. Results

Graphs below show the results of my computation,





Because I couldn't get a good results with air fuel mixture igniting with experimental data values of initial temperature I decided to change them for the purpose of this project. The peak in pressure and temperature on graphs above is caused by the burning of hydrogen used in the igniter.

6. Conclusion

Cantera is a powerful tool that can be used to calculate complex thermodynamics problems. With my level of knowledge of python and cantera I could simulate simple combustion to some extend. Initial goal of the project was to simulate combustion in engine's afterburner but turned out to be too complex for my level of skills. Also I was getting errors when I tried to simulate combustion with combustion chamber's volume close to the real one with air and fuel consumption that I know for the fact that is real. I had to enlarge combustion chamber by a bit but still got temperature's results close to real ones.

References

[1] cerfacs, “Kerosene/air combustion”, online (25.05.2022): https://www.cerfacs.fr/cantera/mechanisms/kero.php#dagaut, 2017.

[2] C. Developers, “Zero-dimensional reactor networks”, online (25.05.2022): https://cantera.org/documentation/dev/sphinx/html/cython/zerodim.html#idealgasreactor, 2001-2021.

[3] A. Lyczek, “Combustion of kerosene in turbine engine”, online (25.05.2022): https://github.com/lyczeko/MKWS_kerosene_combustion/blob/master/projekt_MKWS/projekt1_MKWS2018_ALyczek.pdf, 2018.

[4] D. G. Goodwin, “Reactor networks”, online (25.05.2022): https://www.et.byu.edu/~tom/classes/641/Cantera/Workshop/reactors.pdf, 2004.