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Streszczenie rozprawy doktorskiej (język angielski) nt.:

„Predicting the Detonation Cell Size of Biogas – Oxygen Mixtures"

The detonation cell size is one of the basic parameters describing the detonation process. It is very important both from the theoretical and practical point of view. In theoretical applications because it correlates with other length scales while in practical, because it is used in safety analyses and design process of detonation engines. This is why this topic has been extensively researched for almost 100 years now. At the same time, due to the growing awareness of the climate change, the humanity looks for new, alternative sources of energy. One such solution is a biogas due to the fact that has a very low net balance of emissions when burned. However, biogas has its own drawbacks out of which the biggest one is the low Lower Heating Value. This problem can be overcome by utilizing a detonative combustion.

The presented work focuses on creating a machine learning model that allows for predicting a biogas-oxygen detonation cell size with satisfying accuracy. In order to achieve that, first an extensive experimental campaign was conducted during which over 35 000 cell size measurements were collected. During the experiments three parameters were varied: mixture initial pressure p0, equivalence ratio ϕ and biogas composition expressed as methane percentage. This resulted in over 200 unique combinations of those parameters that were tested. In the thesis, the relationships between the cell size and each of the three parameters: p0, ϕ and %CH4, were presented and were as follows: logarithmic, quadratic and linear. Additionally, the relationship between ZND induction length and stability parameter χ and the three parameters was also studied and presented. Finally, at the end of the first part, the analysis of the detonation cell size distribution was also provided.

In the second part of the work, the data gathered from the experiments was used to train and test three different types machine learning models. The tested models were as follows: linear regression, support vector regression and neural network. Additionally, the models were trained and tested using either raw data or aggregated data, using average cell size. The parameters used to trained the model were the same three that were varied in the experiments and their derivatives. This choice was done in order to avoid the model being dependent on some kind of additional assumptions. Those could be introduced by using other parameters coming for example from a chosen reaction kinetics mechanism. It turned out that all three types of models gave very similar results without significant differences. All of them proved to give very good results with high accuracy and low error. Out of the three types of models, the SVR gave the best results but, as mentioned, the differences were not big.

To sum up, the work has demonstrated that it is possible to create a machine learning model capable of predicting the detonation cell size of biogas-oxygen mixtures with satisfying accuracy. This represents another step towards the creation of a general detonation cell size prediction model capable of predicting detonation cell size for a wide range of different fuels, oxidizers and diluent gases. Such a model, once established, will be of great importance to the community of researchers working in the field of detonative combustion.

Keywords: detonation, detonation cell, machine learning, biogas

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