NON-PREMIXED PLASMA-ASSISTED COMBUSTION OF HYDROCARBON FUEL IN HIGH-SPEED AIRFLOW

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Plasma-assisted combustion (PAC) of hydrocarbon fuel in high-speed airflow was studied in our previous works [1-6]. This work is a continuation of the previous ones.

New experimental and theoretical results on non-premixed PAC and its completeness in high-speed airflow are considered in this work. Experimental study of internal PAC is carried out in the hot wind tunnel HWT-1. Supersonic airflow ($M<2$, $P_{st}<1$ Bar, $T_{st}<1000$K) is created in the test section of this experimental set up. Combined electric discharge (DC (HF) + high voltage repetitive pulsed discharge, mean power ~1kW) is used for airflow pre-heating and fuel-airflow radical generation. Optical spectroscopy, IR spectroscopy, chemical analysis are used to study plasma and radical generation in the PAC zone. Experimental and theoretical results on internal PAC are considered and discussed in this work. The technical difficulties connected with the chemical probe design, its operation in PAC zone are also discussed.

The following main new experimental results were obtained in this work:

1. Dynamics of non-premixed PAC in airflow is studied by a high-speed camera. It is revealed that self-organized repetitive PAC structures are created in airflow.
2. The final PAC species composition is measured by FTIR and chromatograph. Partial pressures and concentrations of these species are obtained behind the PAC zone at different operation modes of the plasma generator.
3. Effective H2, CO, C2H2, CH4, C6H6…. generation in the PAC zone is obtained in rich propane-airflow mixtures.
4. It is revealed that there is high fuel PAC completeness 80-100% in lean fuel mixtures only. This value is decreased up to 30-40 in rich fuel mixtures.
5. Detailed optical spectra are recorded in different cross-sections of the PAC zone at different operation modes of the plasma generator. These spectra are processed and analysed.
6. The important role of charged and excited carbon clusters (soot particles) on PAC kinetics is studied in this work. The local high electric floating potential up to 300V is measured in the cluster flux. It is revealed that these charged and exited particles can accelerate and decelerate the fuel combustion in high-speed airflow considerably at plasma assistance.
7. Composition of soot particles is studied by X-ray micro-spectrometer and ion mass spectrometer. It was revealed that this soot composition at plasma on differed dramatically from the ones at plasma off.
8. Extension of fuel combustion concentration limits for rich and lean mixtures is about
9. 2-4 times at plasma assistance.
10. Combustion temperature limit is decreased up to 2-3 times at plasma assistance.
11. Simulations of the PAC at counter-flow propane jet injection are also presented in this work . Theoretical results are compared with experimental results.

References

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