PREDICTION ABILITY OF REACTION MECHANISMS FOR MODELING OF CONTINUOUSLY ROTATING DETONATION IN PROPANE–AIR MIXTURE

D. I. Babushenko, V. I. Kopchenov, N. S. Titova, and A. M. Starik

Central Institute of Aviation Motors, 2 Aviamotornaya Str., Moscow 111116, Russian Federation

Abstract: Prediction ability of quasi-global and reduced reaction mechanisms for the numerical simulation of continuously rotating detonation wave in the propane–air mixture in model combustor is analyzed. Quasi-global mechanism contains 4 reactions and 6 species. The reduced reaction mechanism includes 159 reactions and 27 species and is built on the base of the detailed mechanism, taking into account only high-temperature submechanism of propane oxidation, which is valid in rather wide ranges of pressure and fuel–air equivalence ratio. The pressure and temperature fields, velocity of rotating detonation wave, and characteristics for model combustor are compared for both reaction mechanisms. It has been shown that the role of reaction mechanism becomes crucial in the prediction of decay of rotating detonation wave and in the increase of impulse for model combustor.

Keywords: continuously rotating detonation; reaction mechanism; propane–air mixture; numerical simulation

Acknowledgments

The work was financially supported by the Russian Foundation for Basic Research (grant No. 13-01-00786).

References

1. Bykovskii, F. A., and S. A. Zhdan. 2013. *Nepreryvnaya spinovaya detonatsiya* [Continuous spin detonation]. Novosibirsk: Publishing House of Siberian Branch of the Russian Academy of Sciences. 423 p.
2. Aksenov, V. S., P. A. Gusev, V. S. Ivanov, S. N. Medvedev, S. M. Frolov, and I. O. Shamshin. 2014. Eksperimental'nye issledovaniya nepreryvnogo detonatsionnogo goreniya vodoroda v kol'tsevoy kamere sgoraniya [Experimental studies of continuous detonation combustion of hydrogen in annular combustor]. *Goren. Vzryv (Mosk.) — Combustion and Explosion* 7:121–128.
3. Schwer, D. A, and K. Kailasanath. 2011. Numerical study of the effects of engine size on rotating detonation engines. AIAA Paper No. 2011-581.
4. Frolov, S. M., A. V. Dubrovskiy, and V. S. Ivanov. 2013. Trekhmernoe chislennoe modelirovanie nepreryvno vrashchayushcheysya detonatsii v kol'tsevoy kamere sgoraniya s shirokim zazorom pri razdel'noy podache goryuchego i okislitelya [Three-dimensional numerical simulation of

continuously rotating detonation in the annular combustion chamber with a wide gap and separate delivery of fuel and oxidizer]. *Goren. Vzryv (Mosk.) — Combustion and Explosion* 6:83–89.

5. Babushenko, D. I., A. A. Evstigneev, V. I. Kopchenov, P. S. Kuleshov, A. M. Starik, and N. S. Titova. 2011. Investigations of the gasdynamic flow structure in pulse detonation tube with external co-flow. ISABE Paper No. 2011-1502.
6. Basevich, V. Ya., and S. M. Frolov. 2006. Global'nye kineticheskie mekhanizmy, ispol'zuyushchiesya pri modelirovanii mnogostadiynogo samovosplameneniya uglevodorodov v reagiruyushchikh techeniyakh [Global kinetic mechanisms using at multistage self-ignition of hydrocarbons in reacting flows]. *Khim. Fiz.* [Chemical Physics] 25(6):54–62.
7. Burcat, A., A. Lifshitz, K. Scheller, and G. B. Skinner. 1971 Shock-tube investigation of ignition in propane–oxygen–argon mixtures. *Proc. Combust. Inst.* 13(1):745–755.
8. Titova, N. S., P. S. Kuleshov, and A. M. Starik. 2011. Kineticheskiy mekhanizm vosplameneniya i goreniya propana v vozdukhe [Kinetic mechanism of ignition and combustion of propane in air]. *Fiz. Goreniya Vzryva* 47(3):3–19.
9. Penyazkov, O. G., K. A. Ragotner, A. J. Dean, and B. Varatharajan. 2005. Autoignition of propane–air mixtures behind reflected shock waves. *Proc. Combust. Inst.* 30(2):1941–1947.

Received November 1, 2014

Contributors

Babushenko Denis I. (b. 1981) — research scientist, Central Institute of Aviation Motors, 2 Aviamotornaya Str., Moscow 111116, Russian Federation; bdi@ciam.ru

Kopchenov Valery I. (b. 1948) — Candidate of Science in physics and mathematics, head of department, Central Institute of Aviation Motors, 2 Aviamotornaya Str., Moscow 111116, Russian Federation; kop@ciam.ru

Titova Natalya S. (b. 1964) — Candidate of Science in physics and mathematics, head of department, Central Institute of Aviation Motors, 2 Aviamotornaya Str., Moscow 111116, Russian Federation; titova@ciam.ru

Starik Alexander M. (b. 1950) — Doctor of Science in physics and mathematics, head of division, Central Institute of Aviation Motors, 2 Aviamotornaya Str., Moscow 111116, Russian Federation; star@ciam.ru