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Numerical study on three-dimensional flow field of continuously rotating detonation in a toroidal chamber

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Abstract Gaseous detonation propagating in a toroidal chamber was numerically studied for hydrogen/oxygen/nitrogen mixtures. The numerical method used is based on the three-dimensional Euler equations with detailed finite-rate chemistry. The results show that the calculated streak picture is in qualitative agreement with the picture recorded by a high speed streak camera from published literature. The three-dimensional flow field induced by a continuously rotating detonation was visualized and distinctive features of the rotating detonations were clearly depicted. Owing to the unconfined character of detonation wavelet, a deficit of detonation parameters was observed. Due to the effects of wall geometries, the strength of the outside detonation front is stronger than that of the inside portion. The detonation thus propagates with a constant circular velocity. Numerical simulation also shows three-dimensional rotating detonation structures, which display specific feature of the detonation-shock combined wave. Discrete burning gas pockets are formed due to instability of the discontinuity. It is believed that the present study could give an insight into the interesting properties of the continuously rotating detonation, and is thus beneficial to the design of continuous detonation propulsion systems.

Keywords: continuously rotating detonation three-dimensional flow field structure numerical study detonation parameters deficit effects of wall geometries

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