Analysis of coupling characteristics between RDE nozzle and combustion

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The rotating detonation engine (RDE) is a new type of dynamic propulsion device based on detonation combustion, which has high thermal cycle efficiency and complex flow characteristics. The efficient utilization of the energy generated by detonation is a major problem in the study of RDE. Therefore, it is important to study the coupling characteristics between RDE nozzle and combustion to solve this problem. In this study, the influence of rotating detonation structure on the nozzle flow and the effect of the nozzle internal flow characteristics on the rotating detonation mode are analyzed, which represents the difference between detonation nozzle and traditional steady nozzle.

The governing equations are the N-S equation with the hydrogen-air finite chemical reaction rate model. The explicit scheme solving method was used to control the model and ignore the affection of viscosity, heat conduction and component diffusion transport in the simulation. The inlet boundary of the model is the mass flow inlet with a steady inflow about 0.144kg/s and the outlet boundary is far field boundary (under Mach 4).

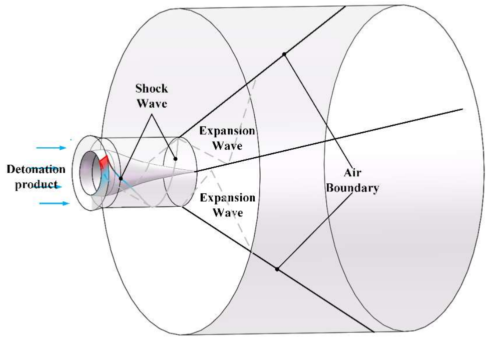
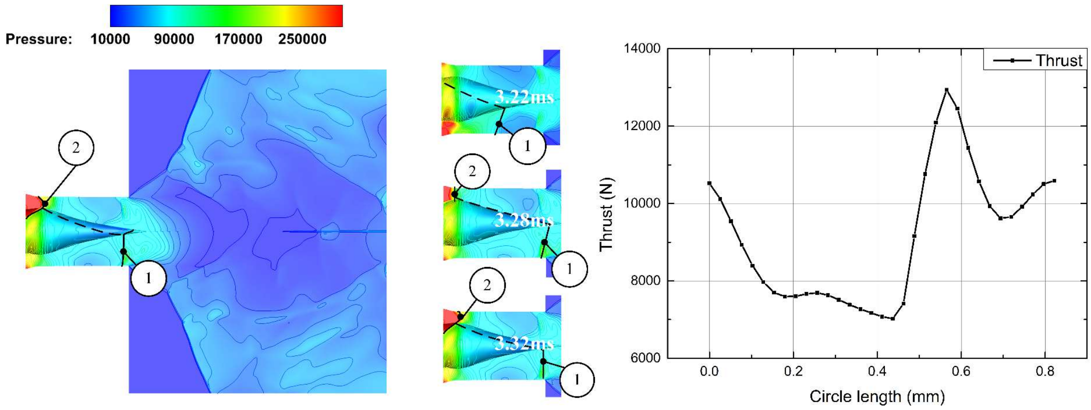


Fig 1. The flow field structure model of RDE nozzle



(a) Space distribution (b) Time variation (c) Thrust characteristic

Fig 2. The flow field characteristics in RDE nozzle

As shown in Fig 1, the oblique shock wave in the downstream of the detonation combustion chamber is spread into the flow field of the nozzle, and a spiral shock wave system is formed around the nozzle wall surface in the nozzle. With the continuous propagation of the rotating detonation wave in the combustion, the operating state of the nozzle changes as the structure of the shock train changes. The oblique shock wave generated by the detonation wave movement is transmitted into the nozzle, and its shock wave intensity and angle change with the change of pressure distribution along the axis of nozzle (as shown in Fig 2).

On one hand, the position and distribution of the oblique shock wave in the rotating detonation flow field determine the

working state of the detonation nozzle. On the other hand, the backpressure of nozzle affects the angle and intensity of the oblique shock wave.

Keywords: *Rotational detonation; Flow field characteristics; Nozzle type; Propagation modes*