

Experiment and Numerical analysis for H₂-air Rotating Detonation Engine with Water Cooling System

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Abstract

The goal of this study is to evaluate the stability of RDE (rotating detonation engine) thrust with water cooling system. Outer wall diameter of this RDE is 115 mm and inner one is 95 mm. The combustion chamber is 10 mm in width which satisfies conditions for detonation propagation. Initiator with a conventional spark plug is placed to ignite a stoichiometric mixture of hydrogen and oxygen as a pre-detonator (Figure 1). By using the detonation wave from initiator, RDE starts running. The gas mixture in the main chamber is air and hydrogen. Air is injected through a circumferential slit located on the outer wall of the combustion chamber, whereas hydrogen is injected through axial 80 orifice holes, which have 1 mm in diameter. There are 3 types of data which are measured, thrust of RDE, speed of rotating detonation wave, and temperature of cooling water by using load cell, high speed camera and thermocouple respectively. By comparing data of cooled and not-cooled RDE, the effect of water cooling to RDE performance is obtained. At this stage, initiator and RDE need to be tested. In addition, numerical analysis is used to predict results of experiments and to evaluate not only temperature change but also pressure change in combustion chamber which is not measured in experiment. In this study, 2-dimensional RDE calculation is performed as a practice to run 3-dimensional RDE. The chemical reaction model is detailed UT-JAXA with 21 elementary reactions. The governing equations are 2-dimensional Euler equations. 1D detonation results are attached to initiate RDE calculation as shown in Figure 2. Analysis was performed by changing grid size, and pressure, temperature, velocity data. As a result of numerical analysis, stable rotating detonation wave propagation is not observed for every grid size. There is a relationship between the size of 1D detonation and grid size of 2D RDE to observe stable rotating detonation wave. Utilizing this results 3-dimensional RDE analysis is going to be performed.

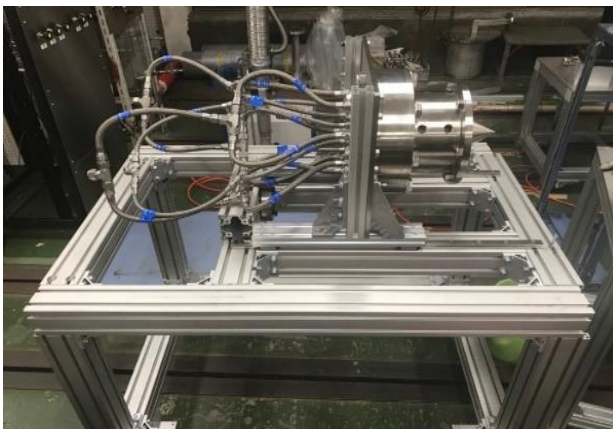


Figure 1 Experimental setup of water cooled RDE.

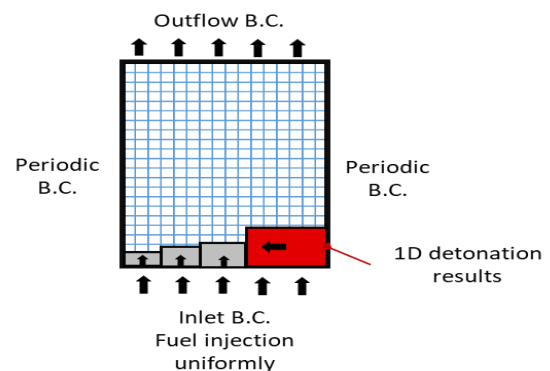


Figure 2 Schematic view of 2D numerical calculation.