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Ignition and combustion characteristics of supersonic combustor with a simulation of altitude condition

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Abstract

Ignition and combustion tests of supersonic combustor were conducted with a ground test facility which simulates M4 to M6 flight conditions. In case of ambient pressure conditions at the exit of combustor, many self-ignition and stable combustion cases are shown with gaseous hydrocarbon fuel. To see the effect of separation at the exit of combustor or nozzle where flow is developed to supersonic, altitude is simulated with an air ejector. Many ignition failures and extinction of flame cases took place in the condition where self-ignition and stable combustion were possible with ambient air condition. It was shown that ignition and stable combustion existed due to the ignition source near the separation and interaction with the boundary layer by high-speed imaging and pressure measurement.

Keywords: *Supersonic combustor, Altitude simulation, Ignition and combustion, Separation, Combustion mode*

Extended abstract

Ignition of a supersonic combustor in a hypersonic propulsion system is usually conducted in very low-pressure conditions because they are reached relatively high Mach number and altitude before ignition. To investigate the effect of low pressure at the exit of a supersonic combustor exit or nozzle, ignition and combustion tests of supersonic combustor were conducted with and without air ejector system which simulates high-altitude flight conditions. A direct-connected type ground test facility was used that simulates M4 to M6 flight conditions using vitiated air heater with methane-oxygen combustion. In supersonic combustor of single cavity, gaseous fuel was injected through the wall with inclination. Fig. 1 shows the model of the test facility with air ejector.

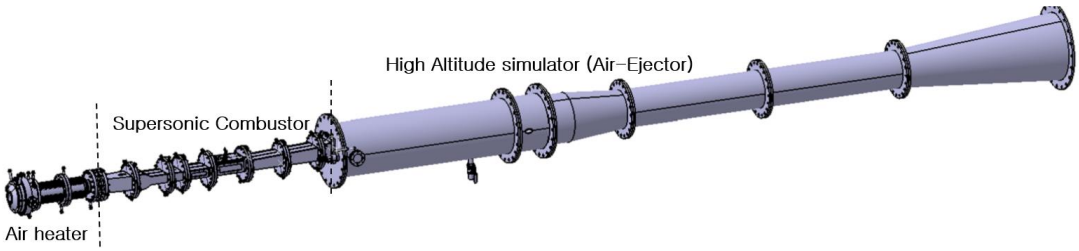

Fig 1. Model of Test facility with air ejector

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In case of ambient pressure conditions at the exit of combustor without air ejector, many self-ignition and stable combustion cases are shown in M5 and M6 conditions. But, in case of low pressure with the operation of air ejector, many ignition failures and extinction of flame took place in the same test condition where self-ignition and stable combustion were possible with ambient air condition.

By high-speed imaging and pressure measurement through the combustor wall, it was shown that ignition took place by the flame spreading through the boundary layer from the separation region at the exit of the combustor.

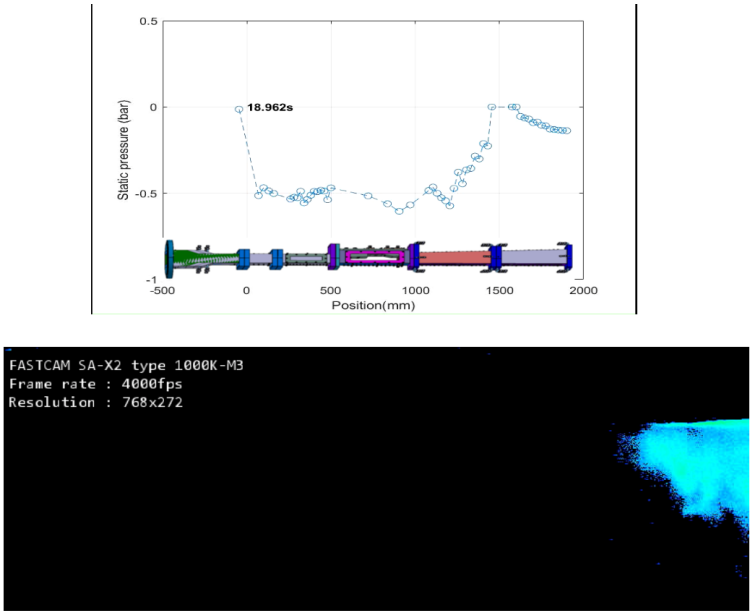

Fig 2. Instantaneous pressure distribution and flame image

Low pressure at the exit of the combustor affected the combustion mode not only ignition. With the ejector operation, the combustion mode changed to scramjet mode from ramjet mode at the same test condition without ejector.

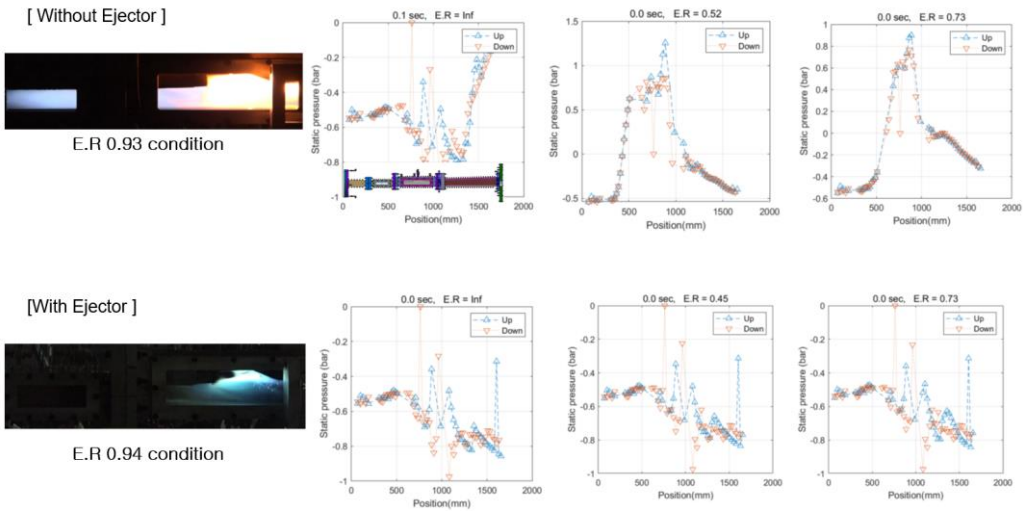

Fig 3. Combustion mode change with altitude simulation