Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: PROPHY / TURBO / CFDMPS *(3 maximum from the list of topics)*
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Type: Oral
Status of corresponding author: Student (PhD)
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Experimental and Numerical Study of Supersonic Flow in Scramjet Combustor in Expansion Tube

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Abstract
Scramjet design testing is quite expensive due to wide range of operation conditions. Expansion tube facility is used to simulate these variable aerothermodynamic (Mach, temperature and pressure) conditions by only changing filling pressures of test sections. TUBITAK SAGE expansion tube facility is constructed for investigation of supersonic flow in scramjet combustors and it can produce closest flow properties to real test conditions for scramjet engine. Because effective test time of expansion tubes are in order of microseconds, measurements should be completed within limited time.

In this work, supersonic flow in scramjet combustor model of different test gas conditions is presented numerically and experimentally. This study is evaluated to exhibit flow features in actual scramjet combustor. Combustor model which is designed with a 10° ramped inlet which generates shock train and constant area combustor section is used in our numerical model. The numerical model is validated with experimental results in literature [1]. Effects of different turbulent models and mesh resolution are conducted and compared with test results. Two and three dimensional approximation of combustor model is also carried out to investigate three dimensional effect on numerical results. After numerical model validation, tests are replicated for same aerothermodynamic state of test gas in TUBITAK SAGE expansion tube facility. Calibration of test setup is conducted with visualizing flow on the 20° wedge by high speed schlieren technique.

Combustor model is fabricated with optical access on three sides with quartz window to visualize the flow with imaging techniques. Tests are evaluated for different flight conditions in TUBITAK SAGE expansion tube facility to investigate shock train and shock/boundary layer interaction in combustor. Schlieren imaging and static pressure measurements on the top wall of combustor model are also used to characterize the flow in combustor model. We present the process of expansion tube calibration and flow characterization inside the scramjet model for different conditions and we present some of our future works in this paper.

References
[1] Gamba M. Miller V.A., "Ignition and flame structure in compact inlet/scramjet combustor model," paper IAC -18 -A6.7.1, 17th International Space Planes and Hypersonic Systems and Technologies Conference, 11-14 April 2011