Experimental Investigation of a Pipe-connected Solid Fuel Scramjet in an Arc-heated Facility

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The ramjet engine is the simplest of all air-breathing engines and it is a more preferable choice than rocket engines for high Mach numbers. When flying conditions are considered, the ramjet engines can be divided to two – ramjets in which the combustion is done in subsonic regime and ramjets in which the combustion is done in supersonic regime. Starting from approximately Mach 5, only the latter configuration, usually referred as "scramjet", is viable. The reason for it is that that at high Mach numbers the increase in the static temperature is too high, leading to the fact that only limited amount of heat can be added to the flow. Therefore, a combustion chamber in which the flow is supersonic is needed.

The simplest configuration for ramjet and scramjet engines is the solid fuel configuration. Without the need for fuel tanks, and feeding and atomization systems it is simple to design and to make; it has high energy density (which can be increased by adding metal powders to the fuel), therefore making the system more compact and it is safe and easy to hand and to store. All these characteristics make solid fuel scramjet an attractive propulsion option for hypersonic flight.

Free-jet experiments of scramjet engines are an extremely complex endeavor – both attaining hypersonic flow and placing an engine in it are challenging tasks and require special experimental facilities. Therefore many works use a connected pipe configuration for ramjet and scramjet experiments. In this configuration a high-pressure air heater is used to simulate the stagnation conditions before the combustion chamber. In the scramjet case, the air is accelerated to supersonic velocities and is fed to the combustion chamber. This configuration allows to investigate the combustion processes and to assess the performance of the engine in a relatively simple way.

Recently, the Faculty of Aerospace Engineering at the Technion – Israel Institute of Technology started a process of reviving the aerothermodynamics laboratory. The laboratory uses electric arc to heat the air before it is fed through the nozzle for various uses. Usually the air-heater uses

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combustion in order to increase the air temperature; however the temperatures in this case are limited and the air mixture that goes to the combustion chamber contains combustion products of the heater. In the case of arc heater, high temperatures can be reached without the need of combustion. The facility is available to work at enthalpies of up to 10 MJ/kg, which is equivalent to stagnation temperature 5400K – much higher that can be attained by using a combustion-based air heater. This broadens considerably the envelope of simulated flight conditions that can be obtained.

The work that will be presented is a work in progress. A design of pipe-connected solid scramjet engine connected to the arc-heated air facility will be presented. The intended fuels for testing are PMMA and HTPB. Initial feasibility experiments will be presented. In the case of PMMA fuel, visualization of the flame will be shown.