Low cost ceramic ablative nozzles for access to space applications

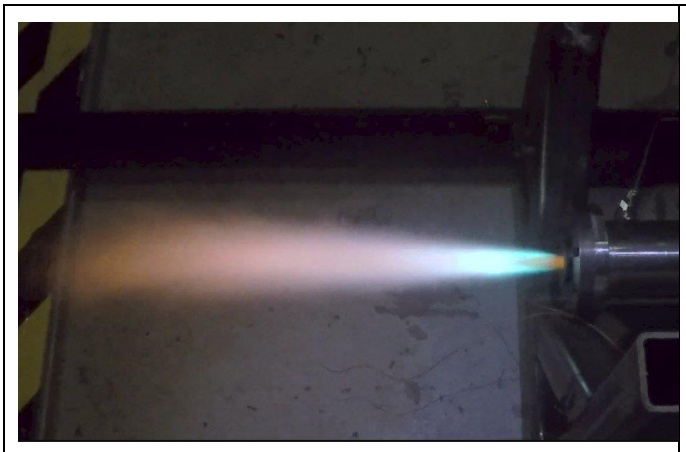
This summarises work performed under CEOI-ST grant # RP10G0348E22, 22 March 2015-22 January 2016, the achievements with respect to the success criteria and recommendations for further work.

Kingston University London with its contractor Archer Technicoat Ltd carried out a full laboratory refurbishment of the KU rocket test cell, including commissioning of a new high speed data acquisition and control system purchased by the university. Additional safety procedures were set in place to enable laboratory usage by undergraduate and postgraduate students. A new engine combustion chamber and propellant tank were manufactured and hydraulically tested. A computer simulation of the thermal environment in the engine was developed under an MSc project and compare to early test firing data, and used to make a preliminary design of a new larger engine. A firing of a small Gaseous Oxygen / PMMA (acrylic) hybrid engine was used to evaluate the data acquisition, control and sensors performance.

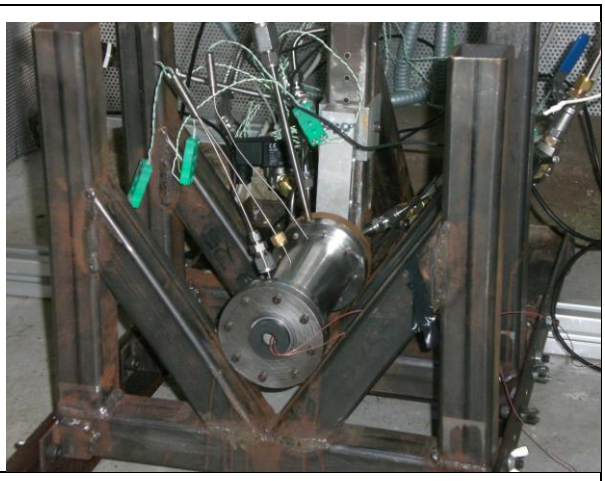
Several SiC coated graphite nozzles inserts were manufactured by Archer at lower cost than expected, two of which were test fired in a Gaseous Oxygen / Propane bipropellant engine designed to deliver ~50N thrust. One firing failed and destroyed a coated nozzle, one partially successful firing was achieved and date generated, although evaluation of the nozzle and coating robustness has not taken place yet. Several nozzle inserts were manufactured for a liquid oxygen / polyethylene (HDPE) engine although this has not yet been test fired owing to incomplete safety tests.

The grant has enabled substantial advances in the capability of the KU rocket test laboratory and has directly and indirectly benefited a number of student projects. The value of the grant is likely to be realised over the remainder of 2016, where the following work is planned:

1. Further test firings of GOx / Propane bipropellant engine to address fluid feed system deficiencies and oxidation / thermal shock effects on coated nozzle insert.
2. Evaluation of SiC coatings post firing to determine erosion / adherence. Scanning electron microscopy with x-ray analysis should permit thickness and homogeneity of coating to be measured.
3. Initial testing of LOX hybrids with SiC coated graphite nozzle insert is planned for summer 2016.
4. Redesign of the bipropellant graphite may be needed to either add a radius to reduce stress concentration (from a step coincident with the plane of minimum thickness) or to increase section thickness.
5. Test cell improvements are planned to improve lighting and video, improve quality of sensor data, and allow propellant feed for multiple oxidisers / fuel and to permit rapid changeover of engines.
6. Validating a thermal model to predict develop cooling approaches aimed at enhancing durability of chamber is planned. It is hoped this will enable larger bipropellant engines to be built and fired, to explore the fundamental question about the feasibility of low cost rocket engines.



Bipropellant engine test firing



Instrumented bipropellant engine on test stand