Porous Inert Media Combustor for Micro Gas Turbines

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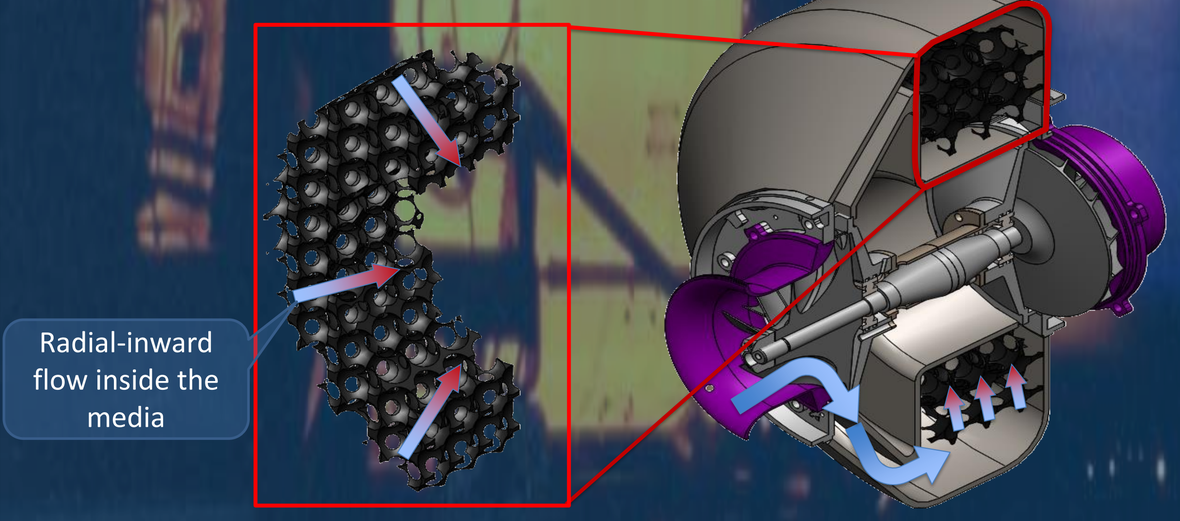
MOTIVATION

Conventional combustion chambers are limited by the time required for combustion and mixing. The imposed geometrical constraints makes conventional combustors increasingly unsuitable as the size of a jet engine or gas turbine decreases, and outright impossible for ultra-micro turbines and engines.

Porous Inert Media (PIM) burners have demonstrated reduced reaction times and increased power density, making an ultra-micro porous media based combustor feasible. PIM burners have additional beneficial properties that make them also attractive for larger scale engines.

FIRST USE OF POROUS MEDIA COMBUSTOR IN GAS TURBINES

Number of fundamental studies exist in literature related to porous burners, highlighting their beneficial features. Building upon the previous works, this project aims to assess the feasibility of concept implementation in an operational gas turbine setting. Moreover, previous studies have focused only on axial or radially-outward flow of the gas inside the media. In proposed configuration, due to the geometric confines of radial compressors and turbines, the porous media combustor is designed to accommodate radially-inwards flow, thereby introducing additional complexities associated with aero-thermo-chemical interactions.

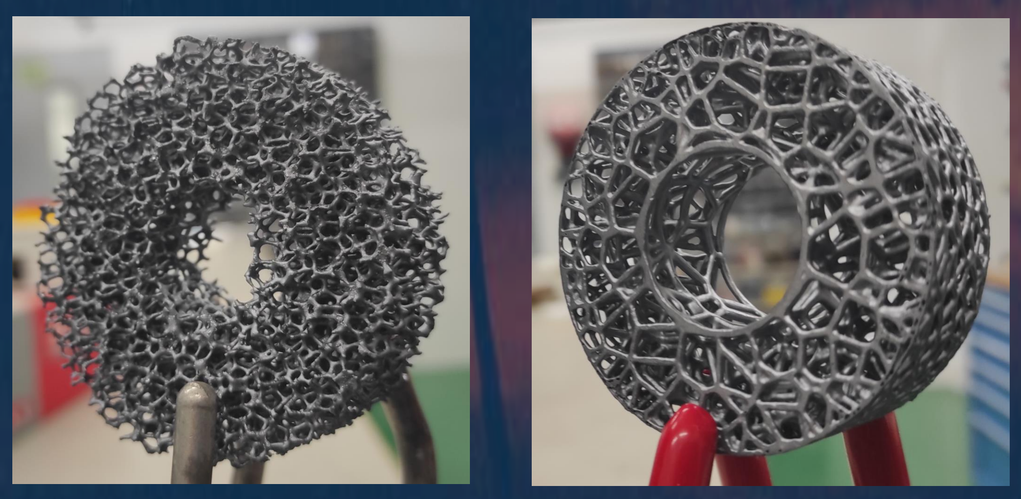


Concept of a radial-inwards combustor for an ultra-micro gas turbine (UMGT)

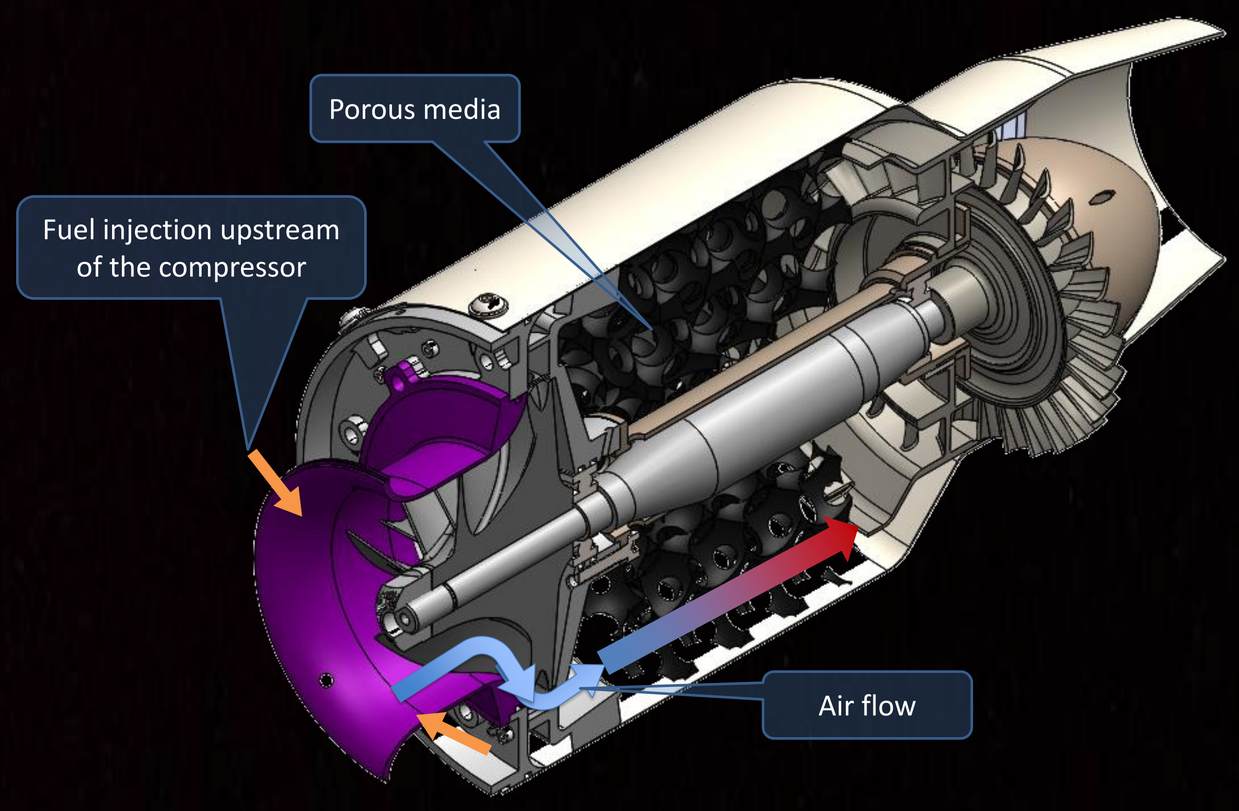
WHAT IS POROUS MEDIA

Porous Inert Media is a foam-like material with interconnected voids through which gas can flow. The flowing gas does not chemically react with the porous foam.

PIM foams are made from a metal or ceramic material, such as Silicon Carbide or Zirconia. Key parameters are material thermal conductivity, softening temperature, foam porosity and pore size.



Two porous foams from Silicon Carbide



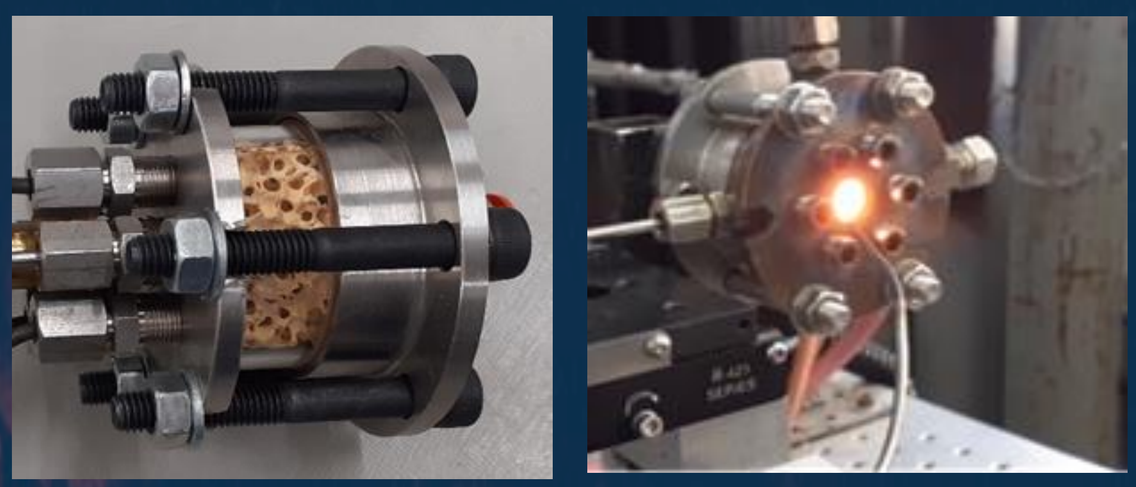
Concept of AMT Olympus jet engine conversion to a porous media combustor

POTENTIAL PERFORMANCE IMPROVEMENT DUE TO PIM COMBUSTORS

- Wide flammability limits allow premixed combustion, with fuel introduction upstream of the compressor
- More power density, upstream fuel introduction result in a smaller axial length of the combustor, allowing a shorter shaft between the compressor and turbine, improving rotordynamic stability
- Reduced noise, pollutants
- Mechanically simpler

INITIAL RESULTS

Initial proof-of-concept tests were conducted on a UMGT-scale combustor, at mass flow rates of 1-2 g/s and equivalence rations of 0.5-1, using propane as fuel and with the inlet at atmospheric conditions and successful radial-inwards combustion was demonstrated.



Proof-of-concept combustor in a test rig (left). The same combustor in operation (right)

FUTURE WORK

- Combustion experiments with inlet air pressurized and heated to compressor outlet conditions
- Numerical modeling of the combustion, to be used as a predictive tool for foam geometry selection and optimization of the designs
- Conversion of the Olympus engine to a PIM combustor
- Integration of the PIM combustor on the UMGT