

Microturbo TRS/SG-18 operating
afterburner co-fire mode



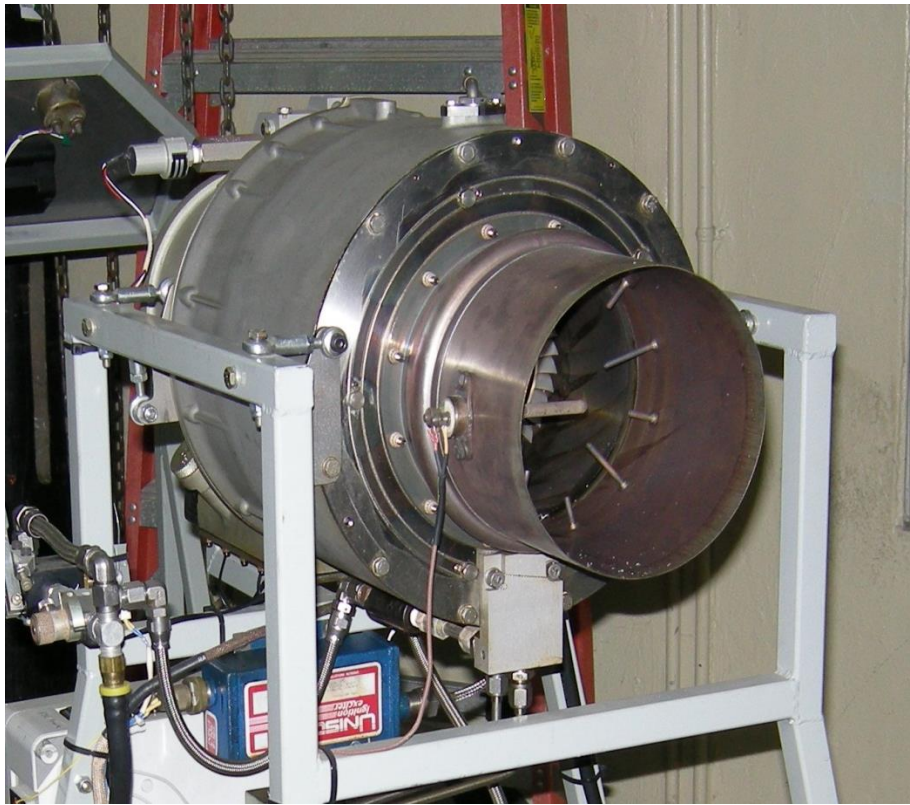
Algae derived solid TurbineBioFuel

Use of a fluidized solid biofuel has been demonstrated in two cofiring configurations in a compact aircraft engine

This proof-of-concept test indicates that large scale use of inexpensive biofuels in high-efficiency generation equipment can be feasible

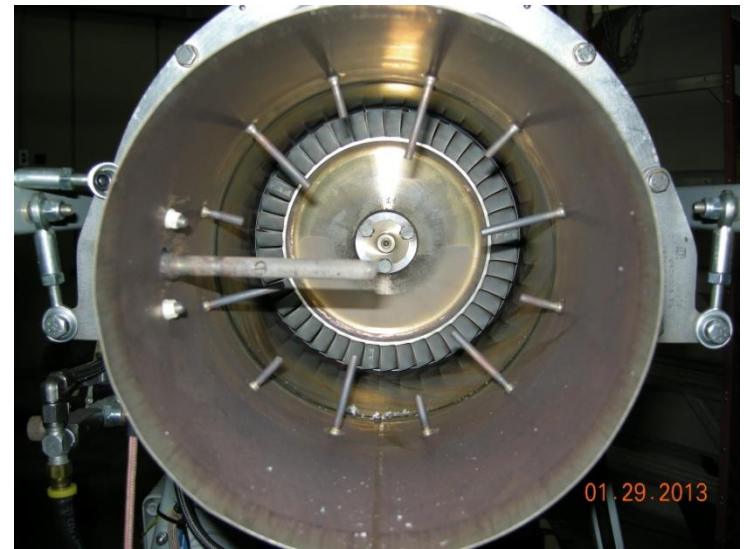
Algae derived solid biofuel can be produced at less than 20% of the cost of biodiesel while providing more than 60% of the heat of combustion

Properly processed solid biofuel can be fluidized into dense, pseudo-single-phase suspensions that can be easily delivered to and consumed in combustion turbines and combined-cycle power plants



Single-stage centrifugal compressor
Annular, reverse-flow combustor
Single-stage turbine
Smoke rake in shortened exhaust nozzle

Fluidized Solid TurbineBioFuel delivered to smoke rake as proof-of-concept test of delivery system and basic combustion properties



Microturbo TRS/SG-18 cofired in afterburner mode – Jet A supplying primary combustor at idle fuel flow

Firing algae derived TurbineBioFuel delivered to smoke rake “afterburner” at ~ 50 - 180 lb/hr

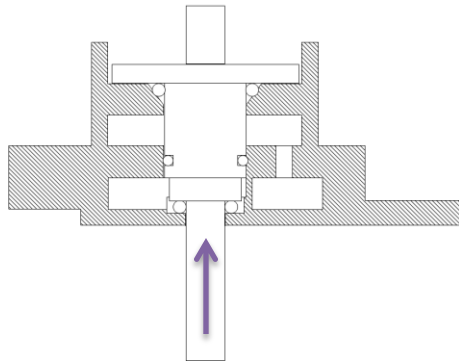
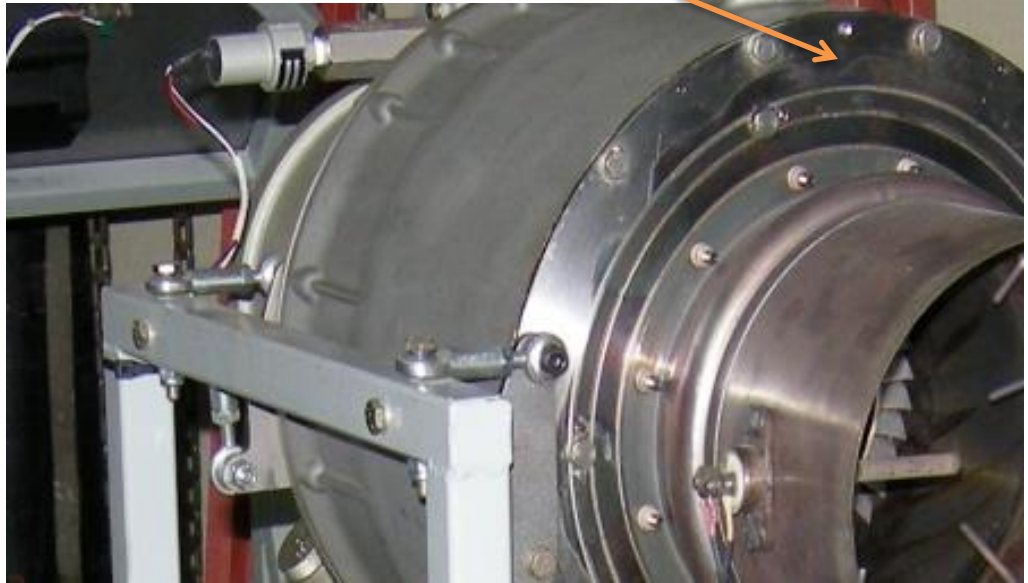
Little smoke with no visible flame

Exhaust temperature rises from 540 to ~700C during “afterburning” of TBF

Reverse-flow combustor with fuel manifold at rear face of casing



Inside of fuel manifold/reader combustor case showing 10 spill-type burners



Spill burner adapted to simple injector to deliver fluidized solid biofuel into primary combustion chamber

Engine started on Jet A (8 out of 10 burners)

Throttle stabilized to 16,000-17,000 rpm

Algae Derived Fuel Introduced through two burners

RPM, Exhaust temperature and engine vibrations monitored

Algae derived fuel flow ranged from 150 - 300kW (25-50 lb/hr) – Equivalent thrust of 50 – 90 lbf

RPM responded as expected; increasing to between 19,000 and 23,000 rpm

No detectable change in engine vibrations

Turbine rotor blades and inlet vanes exhibited no residue, deposits or erosion