



# Current Topics in Pressurized Combustion at Cardiff University's Gas Turbine Research Centre

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# The GTRC – Who Are We?

- Large-scale, off-site experimental combustion facility located in Port Talbot, Wales opened in 2007
- Academic Staff:
  - Prof. Phil Bowen
  - Dr. Richard Marsh
  - Dr. Andrew Crayford
  - Dr. Agustin Valera-Medina
  - Prof. Nick Syred
- Research Staff:
  - Dr. Daniel Pugh (Research Fellow)
  - Dr. Anthony Giles (RA)
  - Dr. Burak Goktepe (RA)
  - Dr. Santhosh Rudrasetty (RA)
  - Dr. Jon Runyon (RA)
  - Mr. Steven Morris (GTRC Manager)
- Technical/Support Staff:
  - Ms. Gina Goddard-Bell
  - Mr. Jack Thomas
  - Mr. Terry Treherne


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# The GTRC – Areas of Study

- Fundamental flame studies
  - Constant Volume Combustion Bomb (CVCB)
  - High-Pressure Counter Flow Burner (HPCFB) – Under Development
- Industrial-scale flame studies
  - High-Pressure Optical Chamber and High-Pressure Generic Swirl Burner
- Advanced Diagnostics
  - PIV and Laser Doppler Velocimetry (LDV/LDA) – Flow
  - Chemiluminescence and PLIF – Reactive Species
  - Phase Doppler Anemometry (PDA) – Sprays
  - High-speed imaging/PIV – Turbulence and transient phenomena
  - Industry-standard gas analysis techniques (NOx, CO2, UHC)
  - Bespoke particulate matter measurement capability (EASA)
  - Dynamic pressure measurement, signal analysis
- Numerical Modelling
  - Chemical kinetics – CHEMKIN
  - CFD – RANS, URANS, LES (Fluent, OpenFOAM)

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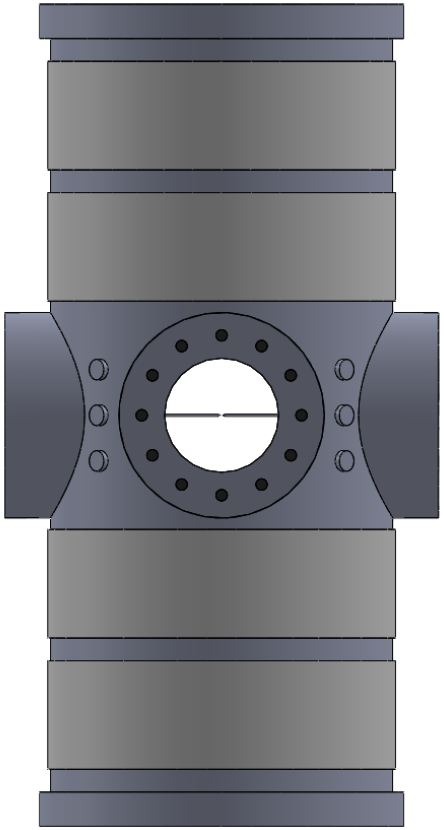
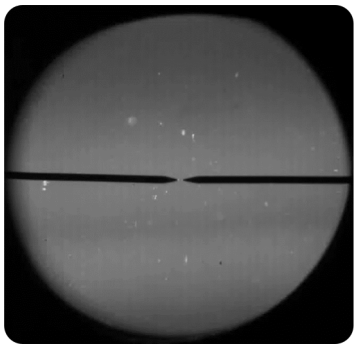
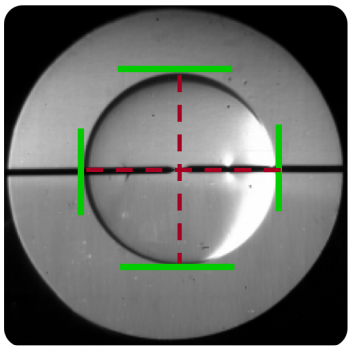
# Constant Volume Combustion Bomb (CVCB)

**Laminar Flame Propagation**

- Design Pressure = 14 bar
- Schlieren optical technique
- Parametric evaluation of temperature, pressure, reactant mixture and humidity.
- Characterise flame stretch using Markstein length.
- Mass flow control to regulate gaseous or vaporised fuel and equivalence ratio.



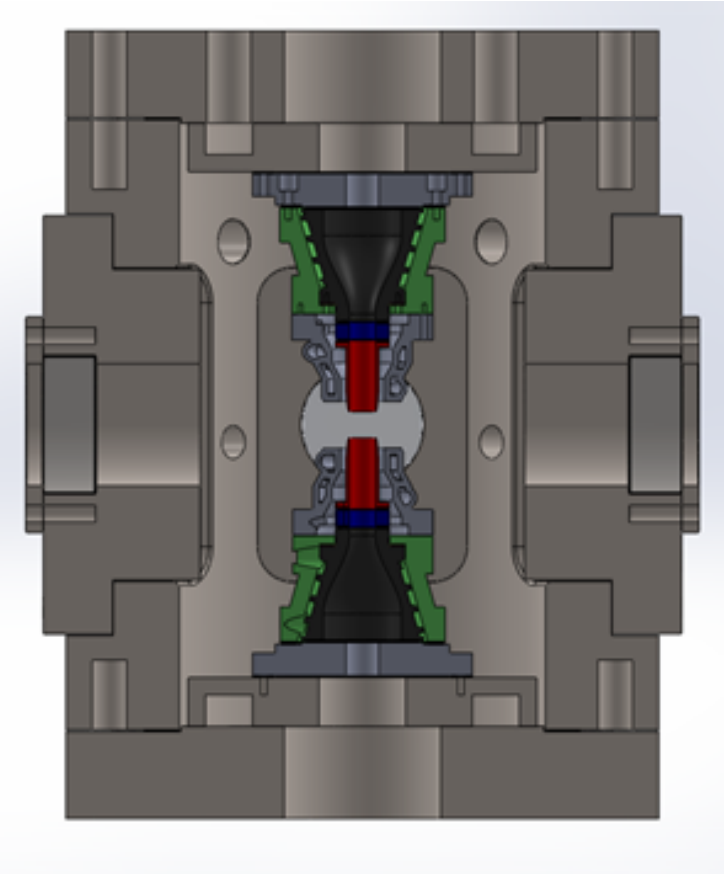


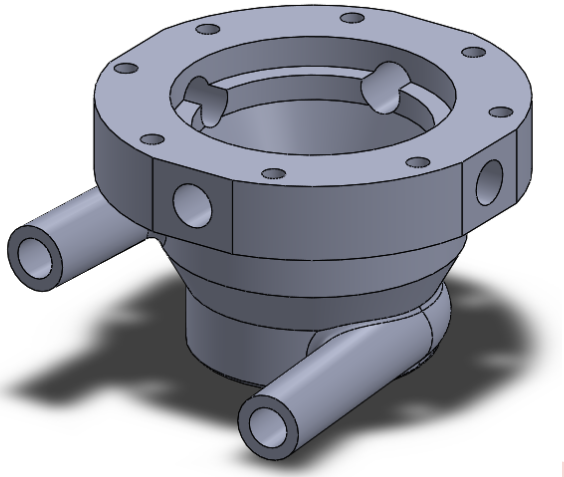


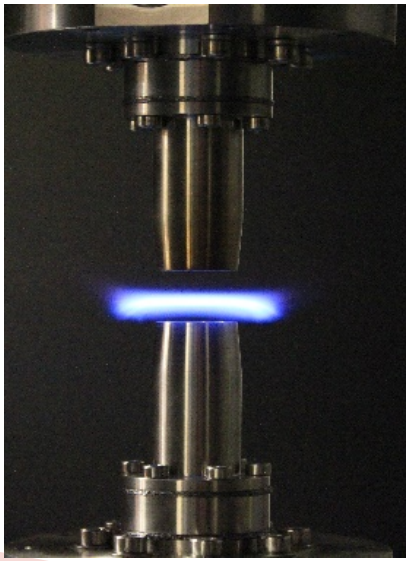
# High-Pressure Counterflow Burner (HPCFB)

**Flame Extinction/Stretch**

- Design:  20 bar at 723 K
- Diametric quartz windows allow for the application of optical diagnostics
- Design has allowed for trial of components built using AM or ‘3D printed’ stainless steel technology, with integrated cooling channels.
- Burner commissioned at atmospheric pressure/temperature.  Pressure casing under design.

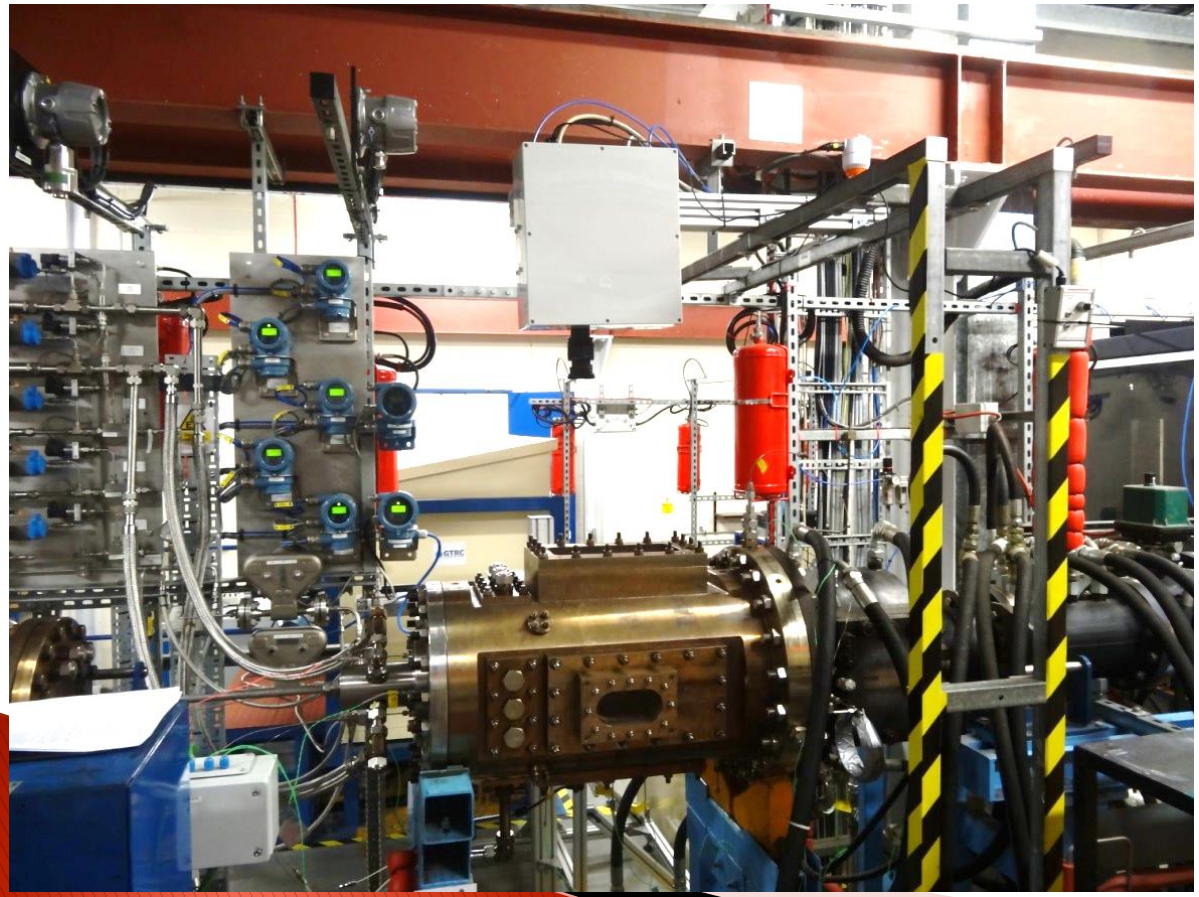


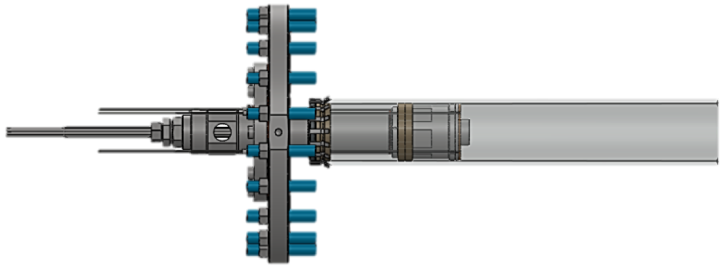




# High-Pressure Optical Chamber (HPOC)

- Design:  16 bar at 900 K
- Utilized with High-Pressure Generic Swirl Burner (HPGSB)
- Axial and radial visual access for advanced optical diagnostics (CL, PIV, PLIF, LDA) + dynamic pressure





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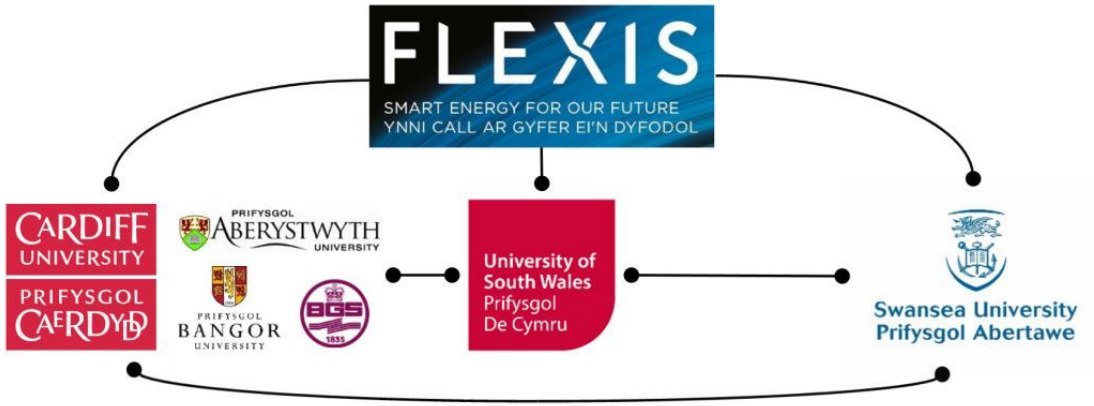
# Current Research Projects

- FLEXIS – Pan-Wales Energy Project Funded by WEFO




- Funded purchase of new high-speed imaging system: Phantom HS Camera, 20 kHz Litron PIV laser, high-speed image intensifier
- Supports experimental studies in the HPOC and CVCB (pressurized steelworks gases, ammonia/hydrogen blends)

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# Current Research Projects

- Flex-E-Plant – Major UK Consortium Funded by EPSRC
  - Pressurized combustion in the HPOC of natural gas blends with higher hydrocarbons ($C_2$+, LNG) and hydrogen (P2G) to measure dynamics, emissions, flame shape, OH/NO PLIF
  - Evaluation of $C_2$+ influence on flame stretch effects in CVCB
- SELECT – Academic/Industrial Project Funded by EPSRC
  - Pressurized combustion in the HPOC focused on the use of exhaust gas recirculation to limit $CO_2$ emissions from gas turbine power plants and increase $CO_2$ purity for CCS.
  - Significant influence of pressure on CO emissions at near-stoichiometric operation. Upcoming testing planned at 8 bar/200 kW.

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# Ongoing Research Projects

- AGT – Advanced Gas Turbines – EPSRC
  - Academic partnership with Imperial College London in development of high-pressure counterflow burner (based on Imperial counterflow design)
  - GTRC leading HPOC experiments with novel fuels (influence of humidity on high-CO syngas, high $H_2$ combustion).
- Green Ammonia Energy Storage – Innovate UK
  - Cardiff, Siemens, Oxford, and STFC developing demonstrator for ammonia energy storage from wind power.
  - GTRC focused on pressurized combustion of ammonia/hydrogen blends, identifying key operability range for reduced NOx emissions (e.g. reburn + steam injection). Increased pressure shown to reduce NOx emissions.

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# Future Work

- Cardiff University/Renishaw Strategic Partnership funding for 3D Printing in Gas Turbine Combustors
  - 12 month project with Renishaw and HiETA
  - Evaluate surface roughness effects on combustion stability and procure high-temperature borescope
- Separate Renishaw iCASE 4 year PhD Studentship recently awarded on novel 3D Printing in Gas Turbine Combustors – Currently advertised
- New RQL (aero engine) burner under construction
- Pursuing funding avenues for continued work with ammonia and hydrogen ("carbon-free fuels")

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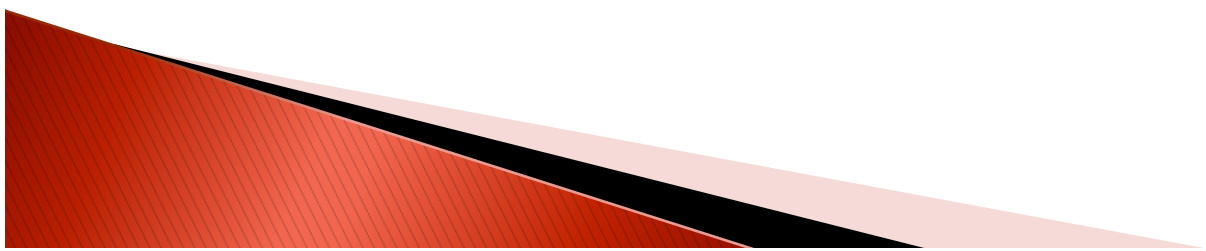
# Thank you kindly for your attention!



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