THE DEVELOPMENT AND TESTING OF AN $CH_4/NH_3/H_2$ COMBUSTION SYSTEM FOR A 50KW MICRO GAS TURBINE

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1. INTRODUCTION

- In an effort to target lower global warming emissions, carbon-free fuels are a cheap, long-term energy storage solution.
- Ammonia-hydrogen fuel blends are a good compromise for combustion characteristics and storage/transportation costs, and may be blended with methane to aid the transition to a carbon-free economy.
- This study outlines the emissions challenges in the utilisation of an industrial scale swirl burner for $CH_4/NH_3/H_2$ blends.
- To address these challenges, a novel combustor design has been proposed for the conversion of a 50kW APU.

2. METHODOLOGY

First, a study was carried out for an industrial scale, axial swirl burner, not optimised for ammonia-based fuels.
Power = 8kW, Inlet Temp. = 293K
Inlet Pressure = 1 atm, Swirl number, S_g=0.8

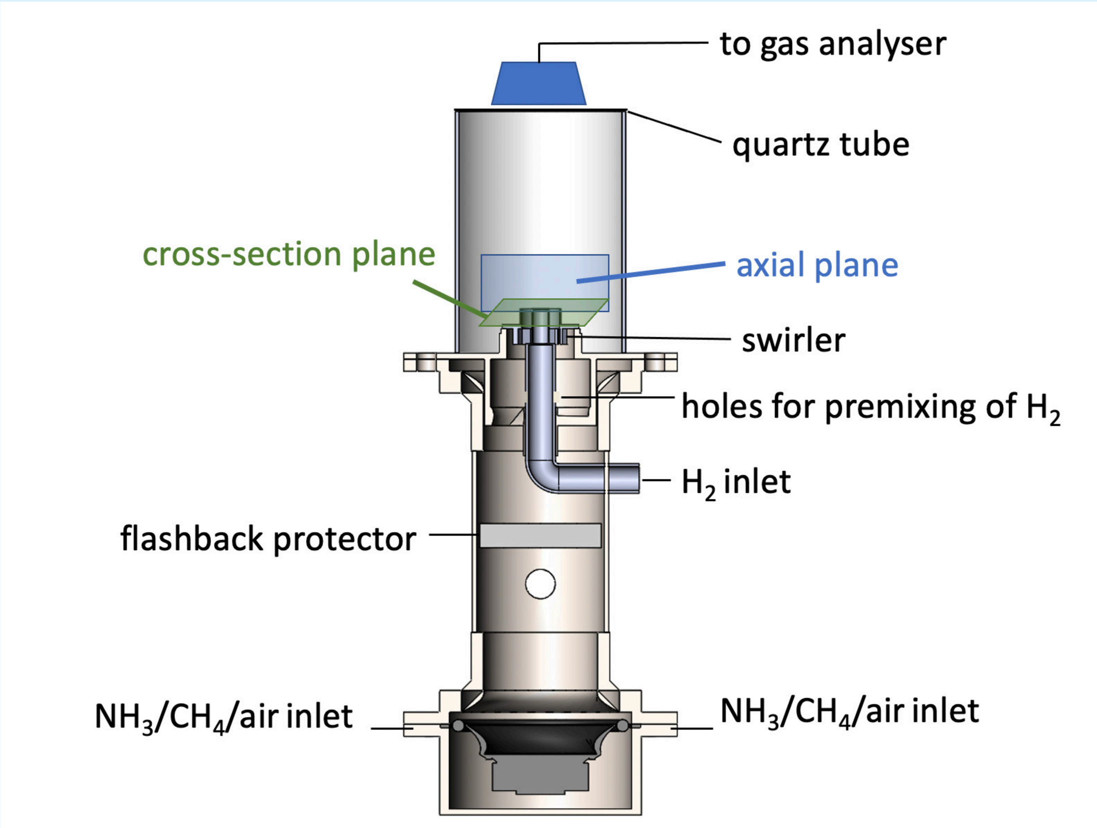

Figure 1 - Schematic of swirl burner in baseline studies

3. EMISSIONS ANALYSES OF AN AXIAL SWIRL BURNER

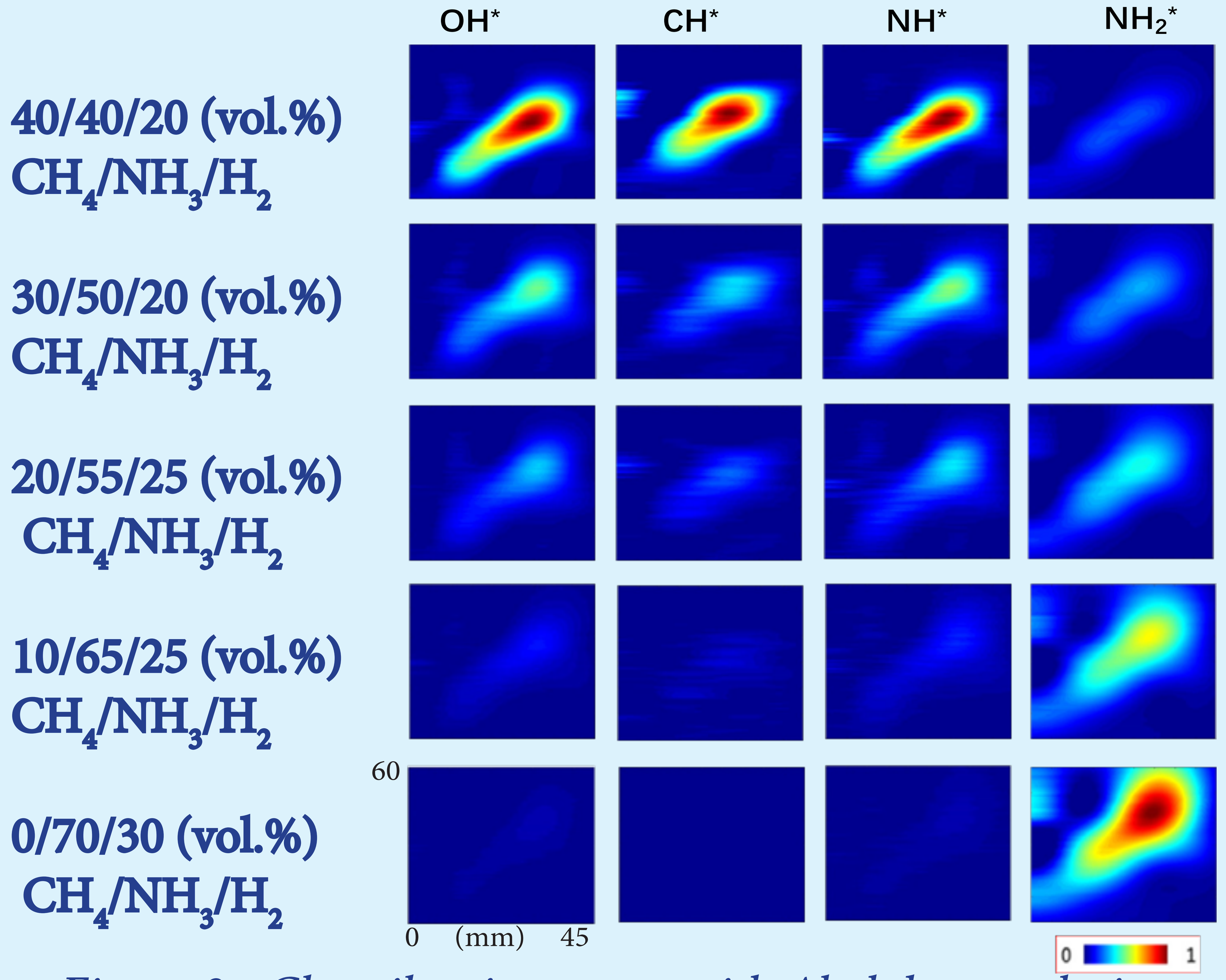

Figure 2 - Chemiluminescence with Abel deconvolution post-processing (Φ = 1.2)

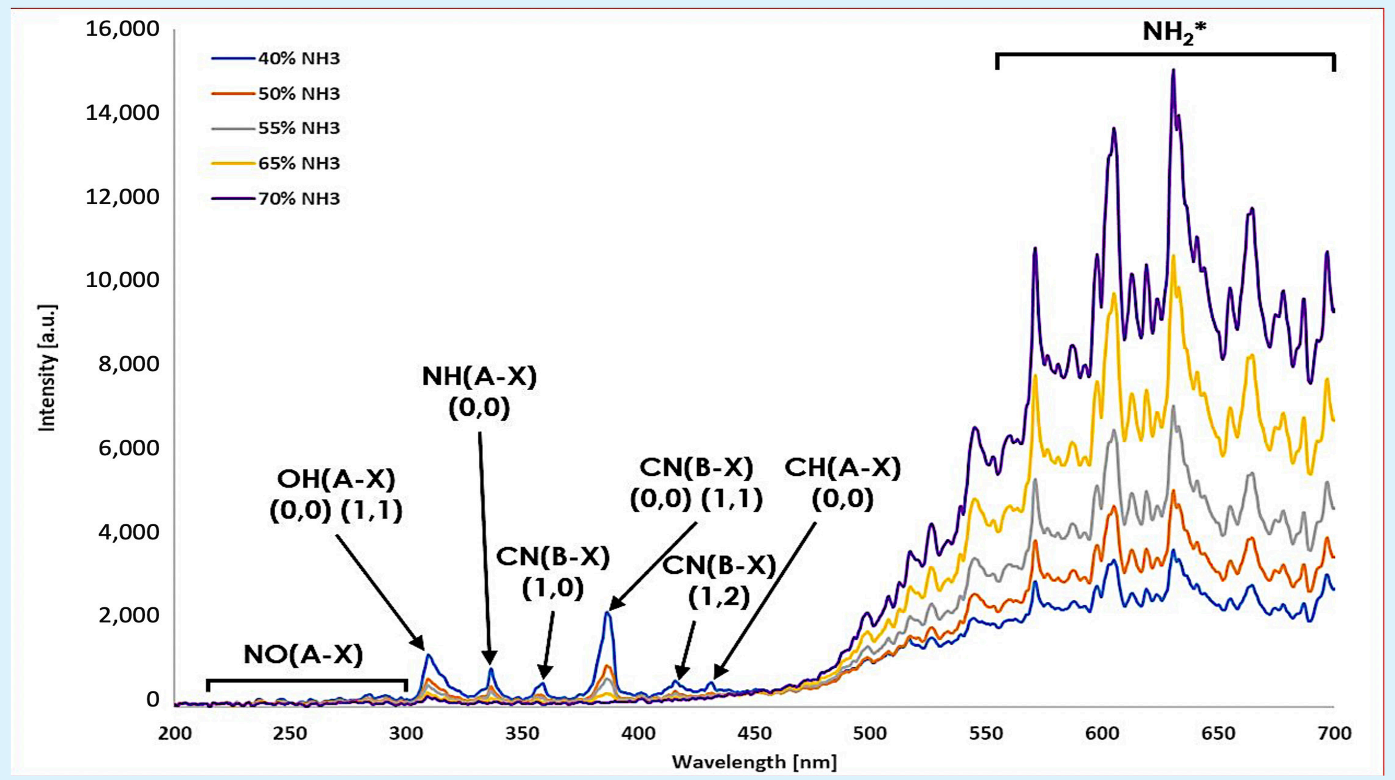

Figure 3 - Spectrometry analysis at burner base, Φ = 1.2 (fuel blends as for Figure 2)

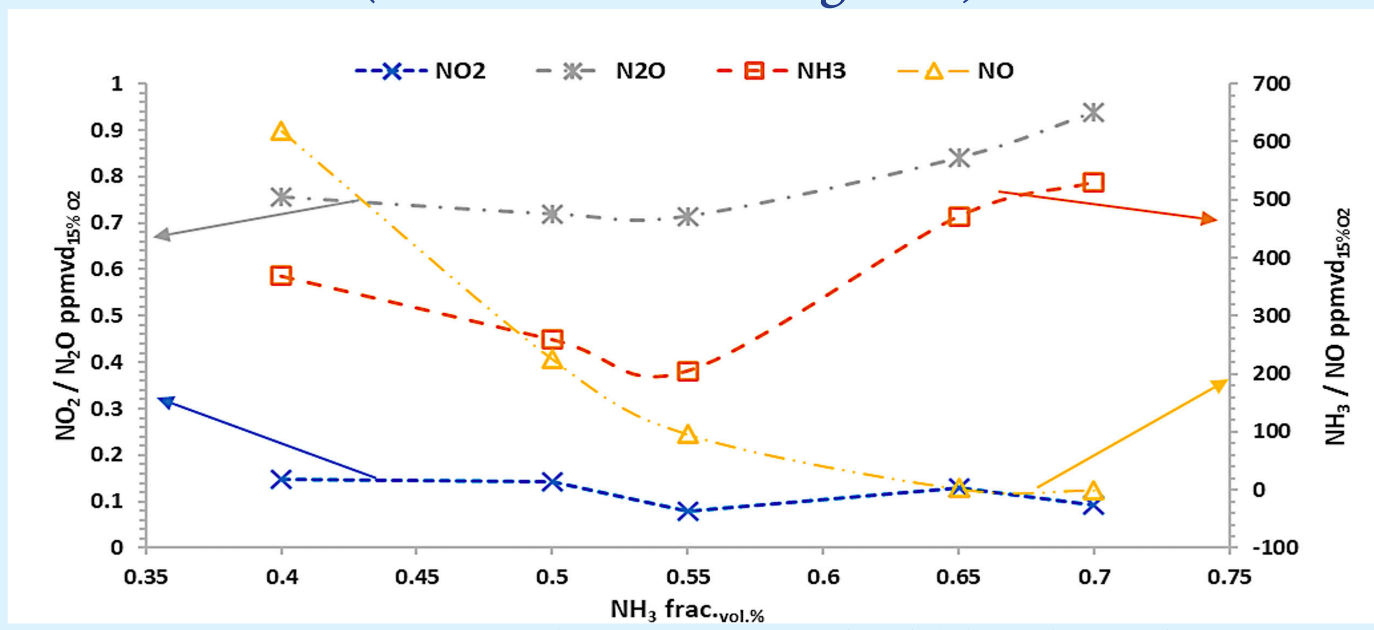

Figure 4 - Emissions at outlet, Φ = 1.2 (fuel blends as for Figure 2)

- NH* and NH_2* trends were reversed, based on CH_4 content in the fuel blend, as shown in Fig. 2.
- Fig. 3 gives the relative magnitude of intermediary species at the flame centre. OH, NH, CN and CH was dominant in the high CH_4 content fuels with NH_2 having had the highest signal in NH_3 fuels.
- NO was the primary contributor of NOx emissions, with lower CH_4 content flames having lower emissions.

4. DESIGN OF THE NIK15 BURNER

A novel burner design (NIK15) optimised for these fuel mixtures has been proposed. LDA (Laser Doppler anemomentry) were used for validation of a RANS CFD model.

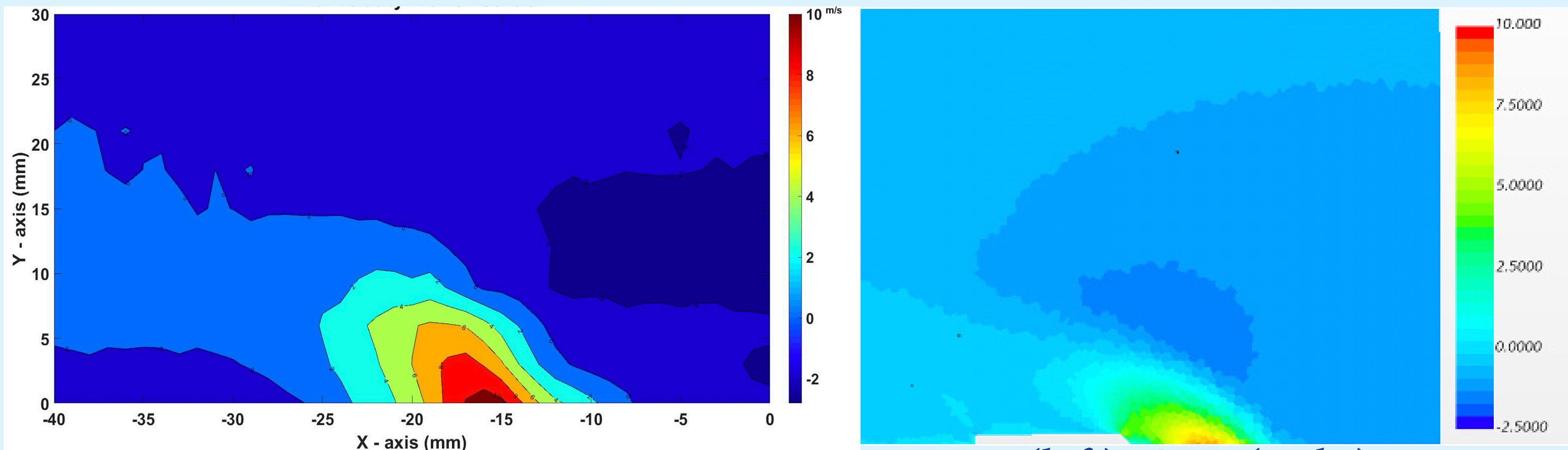

Figure 5 - Axial velocity on central plane: LDA (left), CFD (right)

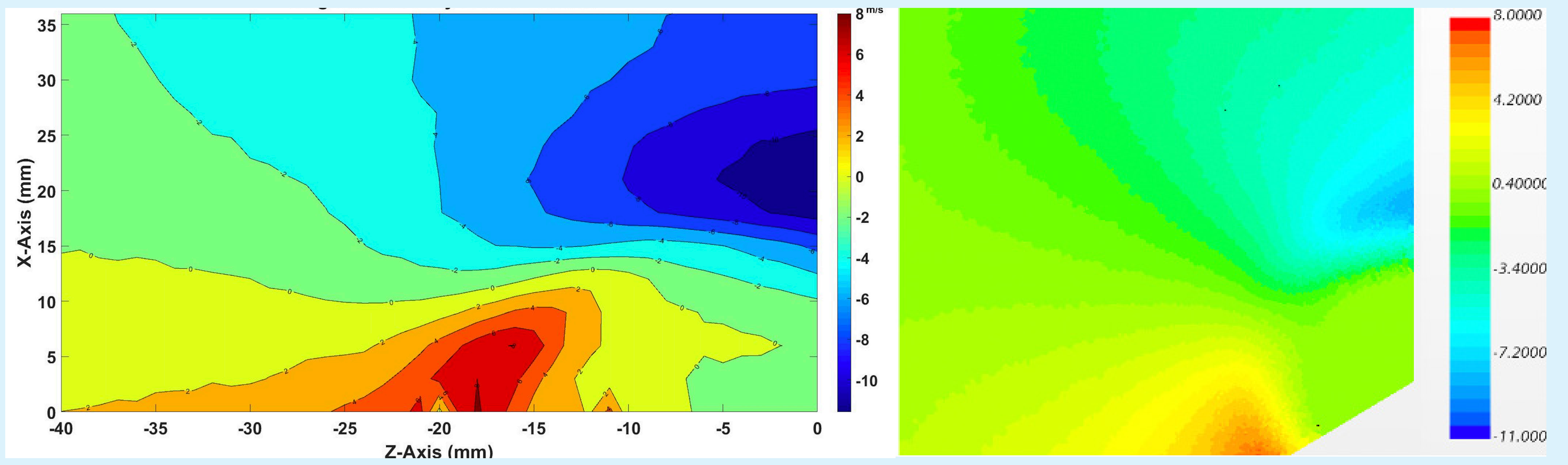

Figure 6 - Tangential velocity on cross-section plane: LDA (left), CFD (right)

- NIK15 burner was designed for improved mixing, such as to reduce NOx production, such as through the conversion of NO to N_2 by the thermal deNOx reactions .

5. RETROFITTING OF THE APU

Conversion of a Rover MK10501 APU to produce 50kW power from ammonia/hydrogen/methane fuel blends is in progress. Considerations have been made for controls (through LabVIEW) and diagnostic measurement.

No	Name
1	Pre-swirl vane
2	Fixed diffuser ring
3	Annular reverse flow
4	Turbine rotor
5	Power turbine inlet nozzle
6	Exhaust ducting

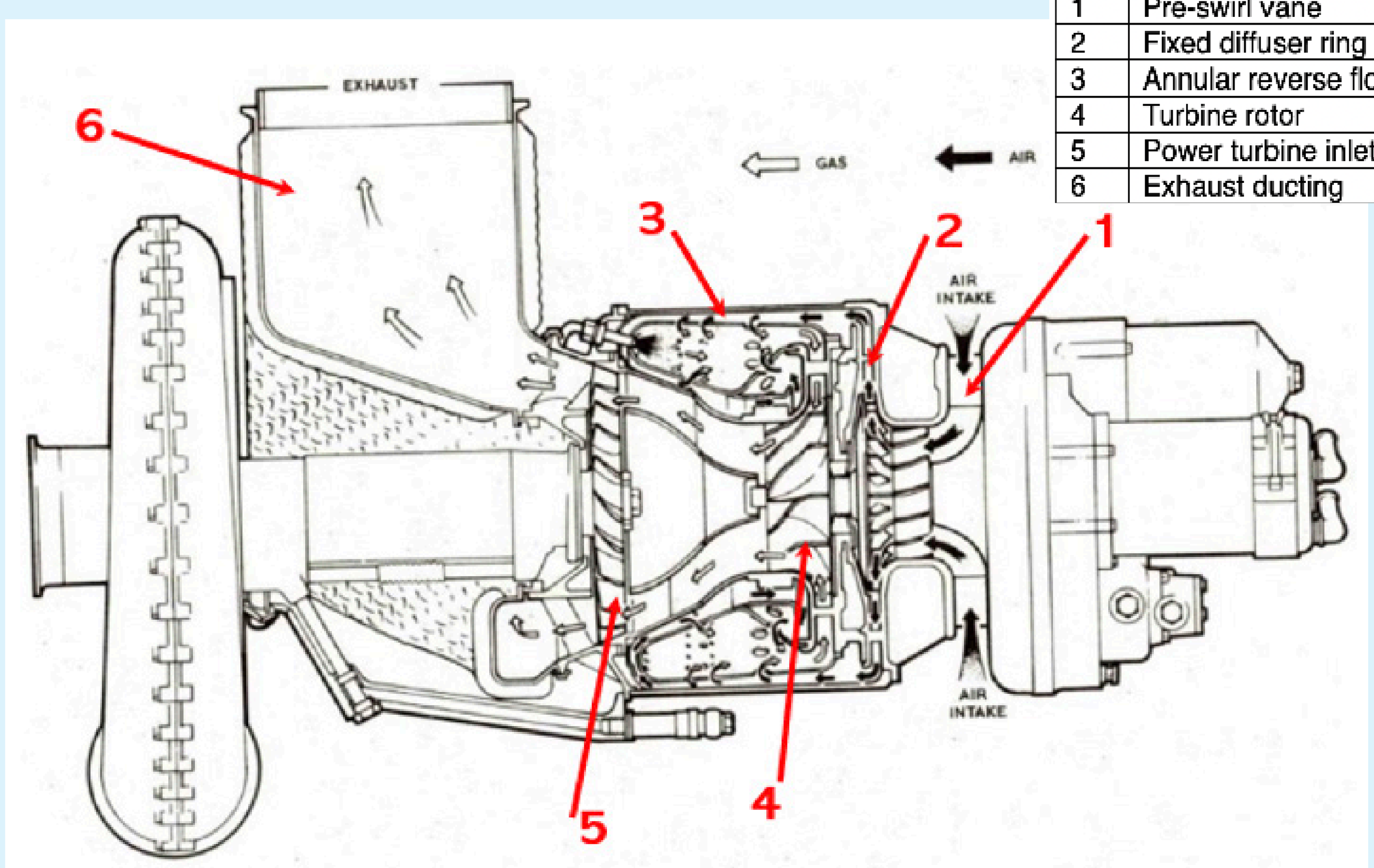

Figure 7 - Rover MK10501 Schematic

The new design considers adaptation of the combustor for a rich-quench-lean configuration with stratified injection, utilising the new NIK15 burner design.

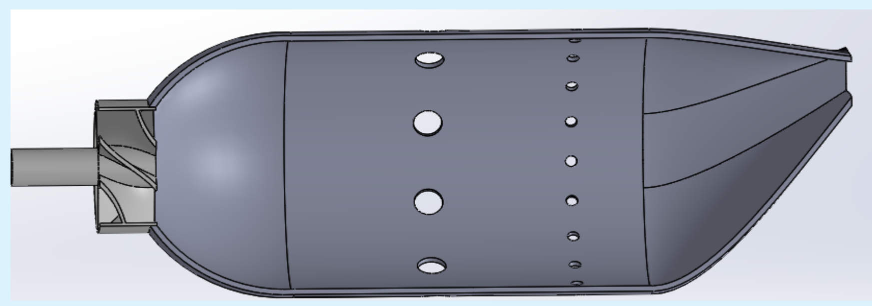

Figure 8 - Prototype combustor design

6. CONCLUSION

- Swirl burner emissions for $NH_3/H_2/CH_4$ blends were studied.
- LDA validated CFD defined hydrodynamic behaviour of the NIK15 burner design, with plans for future combustion studies.
- Prototype APU combustor designs are under development to accommodate the new design.

7. ACKNOWLEDGEMENTS

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