EXPERIMENTAL STUDY OF AMMONIA ADDITION IN PREMIXED METHANE FLAMES

M.Kovaleva[1], S. Mashruk[1], A. Valera-Medina[1]
1. College of Physical Sciences and Engineering, Cardiff University, Cardiff, UK
Corresponding author: Marina Kovaleva
Email: kovalevam@cardiff.ac.uk

38th International Symposium on Combustion, Adelaide, Australia
GT/RC-03

1. OVERVIEW

- Ammonia is a promising energy storage vector for enabling a low carbon economy. To aid the transition to carbon-free fuels, the effect of ammonia injection in methane swirl burners was investigated.
- Diffusion and premixed ammonia injection configurations were compared through temperature profiles and OH*, NH2* chemiluminescence profiles.

2. METHODOLOGY

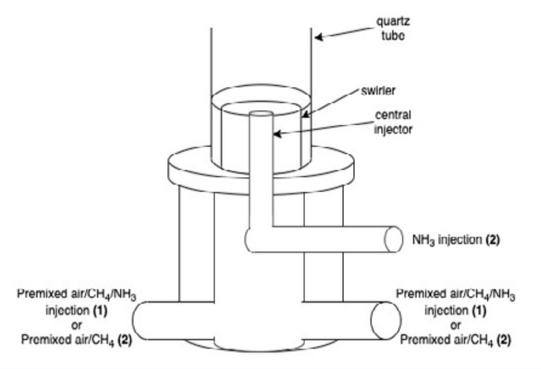

Fig.1 - industry scale swirl burner with: 1 - premixed injection configuration; 2- diffusion ammonia configuration

Centre of gravity (COG) calculation [1] applied to chemilumenscence images:

$$CoG = \left[\frac{\Sigma_{i,j} i * I(i,j)}{\Sigma_{i,j} I(i,j)}, \frac{\Sigma_{i,j} j * I(i,j)}{\Sigma_{i,j} I(i,j)}\right] \quad (1)$$

Thermocouple radiation correction [2]:

$$T_g = T_{tc} + \varepsilon_{tc}\sigma(T_{tc}^4 - T_w^4)\frac{d}{kNu} \quad (2)$$

3. EXPERIMENTAL RESULTS

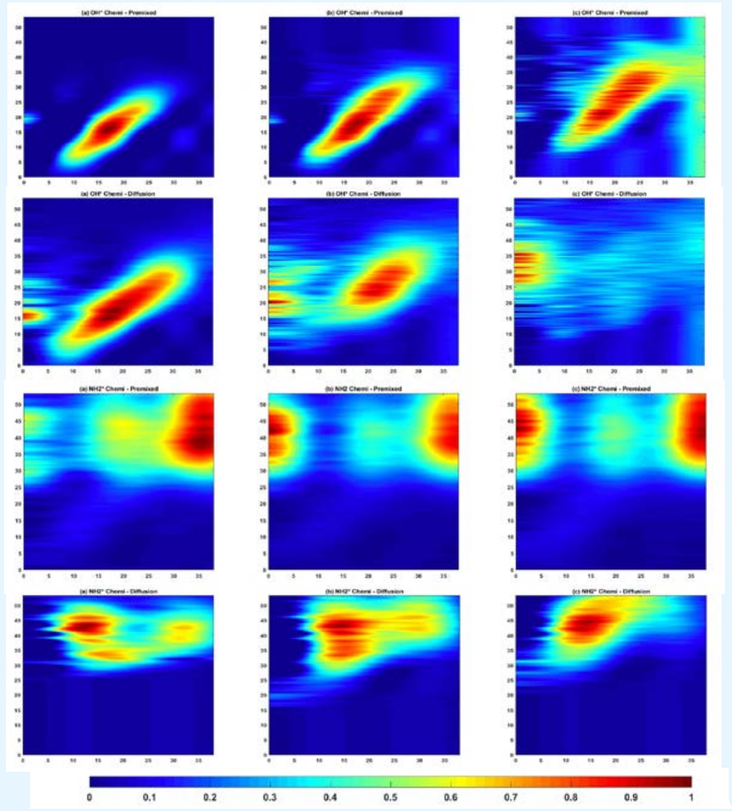

Fig.2 - OH and NH2* chemiluminescence distrubution for φ = 1.0 and 10kW, where a) 10% vol. NH_3, b) 30% vol. NH_3, c) 50% vol. NH_3*

- Figure 2 shows time-averaged chemiluminescence distributions of OH* and NH_2* radicals, with each image normalised to itself.
- As ammonia fuel fraction is increased, the OH* chemiluminescence becomes less concentrated. This is especially true for diffusion flames as more OH* is found in the central injection zone than in the premixed methane region. This is due to the methane premixed zone becoming leaner with increased ammonia fuel fraction. However, overall premixed and diffusion flames follow similar vertical centre of gravity (COG) and maximum concentration trends.
- In premixed flames, NH_2* distributions are spread between the flame jet and the central recirculation zone. As ammonia content increases, the NH_3+OH->NH_2+H_2O reaction path helps account for the increase in NH_2* radicals and decrease in OH* radicals.
- However, in the current configuration, NH_2* peaks at only 30-40% ammonia fuel content. Chemiluminescence images suggest this may be due to the NH_2*moving into the central recirculation zone, leading to longer NH_2* residence times.

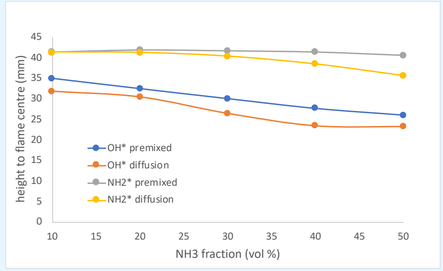

Fig.3 - COG for chemiluminescence intensity

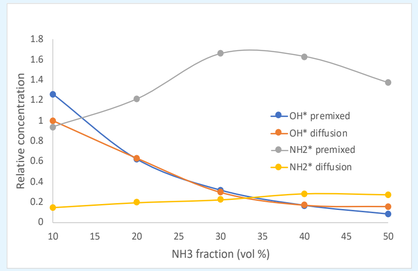

Fig.4 - Maximum chemiluminenscence intensity

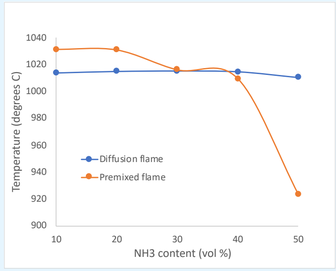

Fig.5 - Temperature at inner wall

7. CONCLUSION

- Diffusion and premixed ammonia injection configurations were compared for an industry scale swirl burner.
- Increasing ammonia fuel concentration had a greater reduction on wall temperatures in premixed flames than in diffusion flames
- The NH_2* centre of gravity is located higher than the OH* centre, as OH* radicals react with ammonia and feed the NH_2* region.
- NH_2* concentration peaks at 30-40% ammonia volume fraction in premixed flames as radicals move into the central recirculation zone.

8. REFERENCES

1. Fritsche, D. (2005). Origin and control of thermoacoustic instabilities in lean premixed gas turbine combustion. ETH, Zürich.
2. Shaddix, C. R. (2017). A new method to compute the proper radiant heat transfer correction of bare-wire thermocouple measurements. United States.

8.AKNOWLEDGEMENTS

This work was supported by funding from the EPSRC SAFE project (EP/T009314/1). We also thank Mr Malcolm Seaborne for his expertise and development of the experimental facilities used in this study.