Dispersion of under-expanded hydrogen-methane blended jets through a circular orifice

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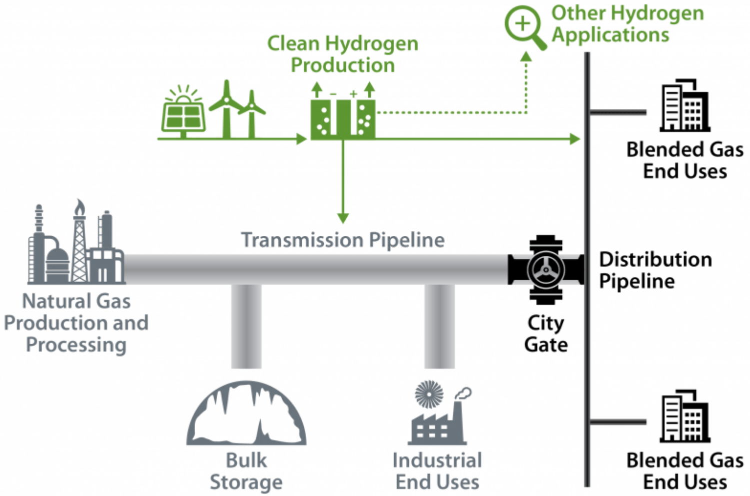
Contents

Introduction

Why Hydrogen-methane blends?

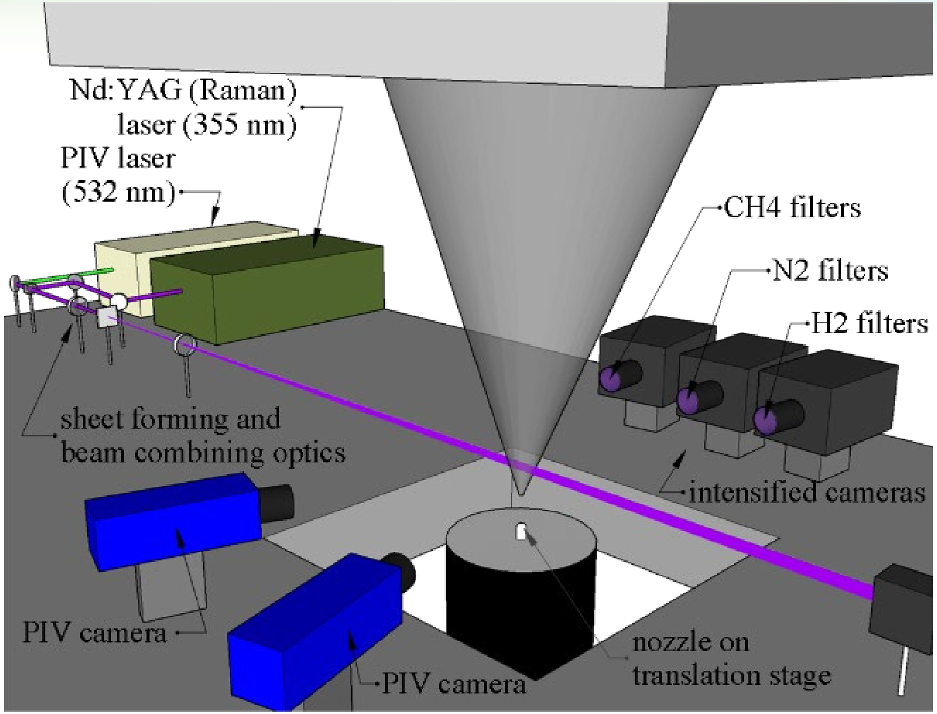
- Path to Decarbonisation
- Combustion and Emission Characteristics
- Safety Aspects



- Hydrogen has improved combustion characteristics (wider flammability and enhanced flame speeds).
- In the United States, there is more than 1600 miles of dedicated hydrogen pipelines and about 3 million miles of NG pipe lines.
- Blending hydrogen with natural gas can serve as an intermediate step in the process of achieving 100% decarbonization.
- An understanding of the behavior of blends leaking from the existing leak-prone pipeline infrastructure is needed to safely implement this strategy.

HyBlend
U.S. DEPARTMENT OF ENERGY

Experimental setup for concentration measurements

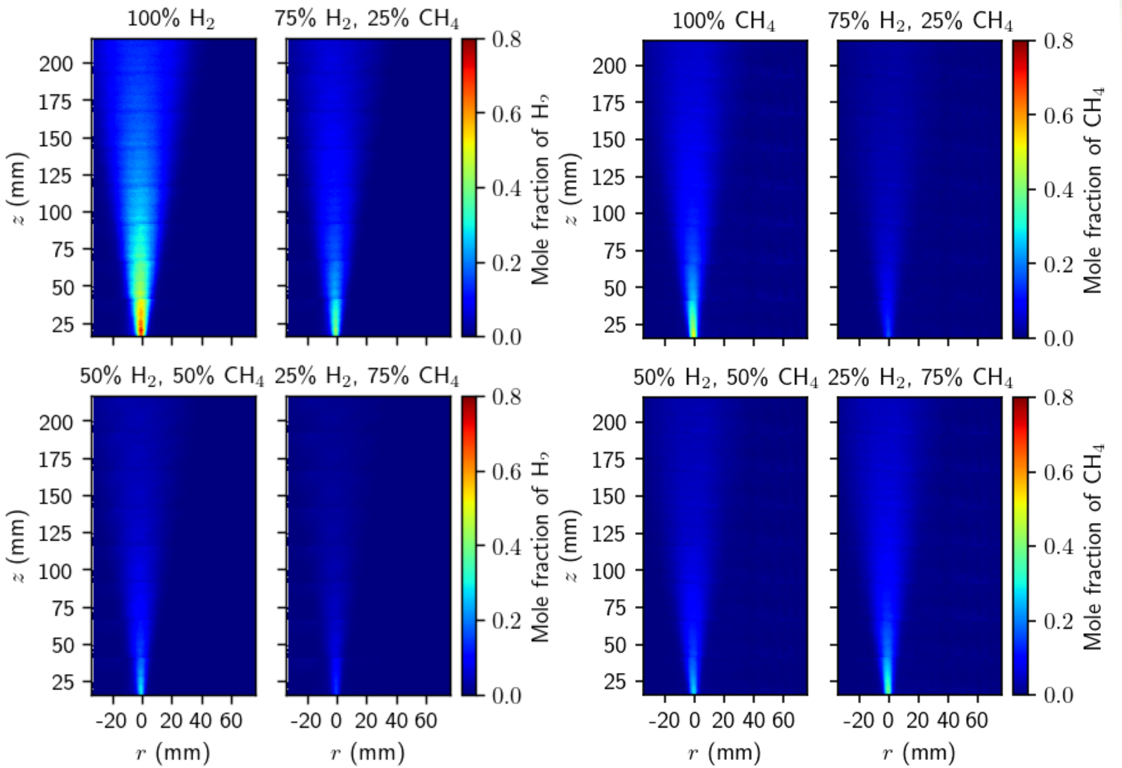


Repetition rate- 10 Hz
Laser sheet height – 30 mm
Orifice diameter – 1 mm

Gas Composition	Pressures	Orifice Diameter
100% H_2	5 bar, 10 bar	1 mm
75% H_2 -25% CH_4	5 bar, 10 bar	1 mm
50% H_2 -50% CH_4	5 bar, 10 bar	1 mm
25% H_2 -75% CH_4	5 bar, 10 bar	1 mm
100% CH_4	5 bar, 10 bar	1 mm

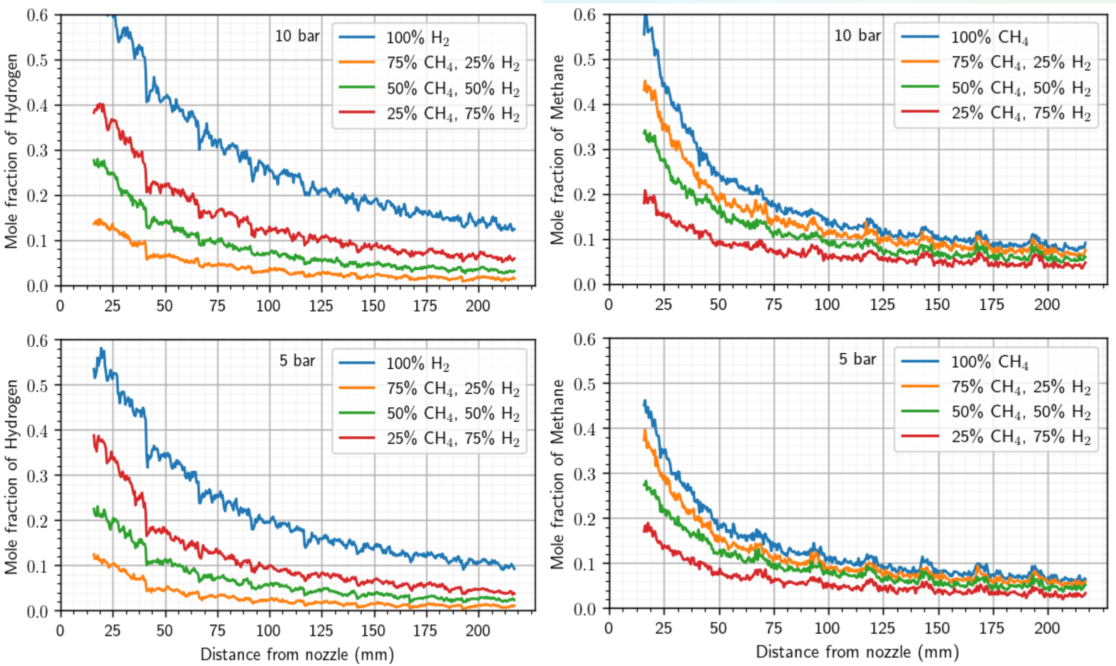
Species concentration distribution

- Mean mole fraction fields at 10 bar pressure conditions are shown
- All of the jets have a similar, expected shape
- Species concentration is high near the nozzle and spreads out downstream due to air entrainment and mixing
- Pure hydrogen or methane jets have the highest mole fraction fields



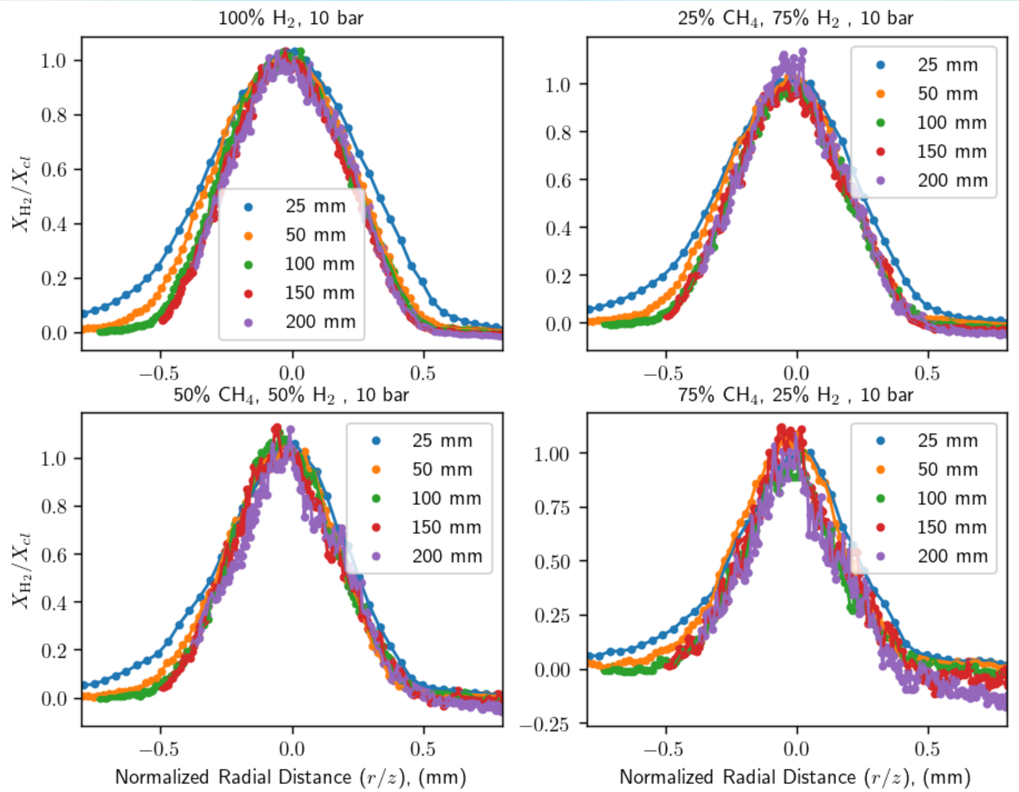
Axial Distribution

- Concentration profiles decay hyperbolically for all the blends; consistent with the behavior of pure hydrogen and methane
- Concentration gradient is maximum in the near field of the orifice
- Immediately after a core region, the species mole fractions decrease rapidly due to the entrainment of ambient air
- For the 100% releases, the methane mole fraction along the centerline decays faster than the hydrogen mole fraction

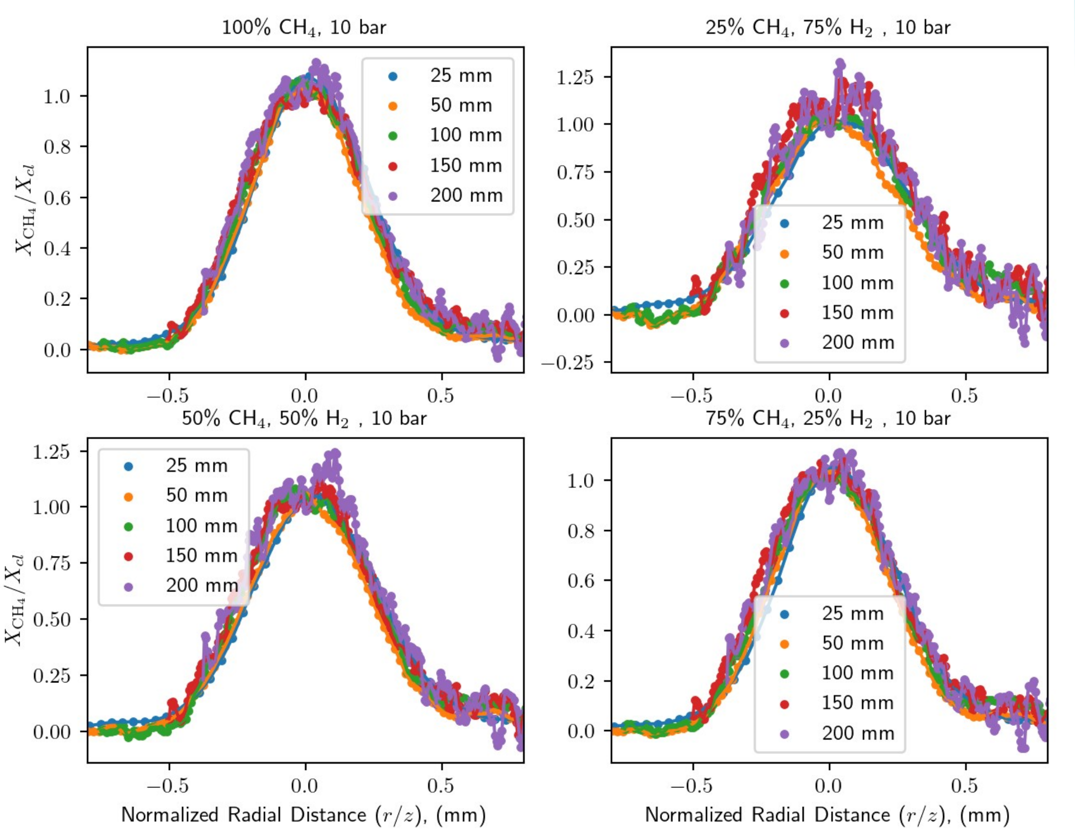


Radial Distribution

- At each axial location along the centerline, the mole fraction peaks and decreases radially outwards towards the jet boundary
- Mean radial profile for several downstream distances collapses onto a Gaussian profile
- This confirms the self-similar nature of the blended gas jets, as have been observed for pure hydrogen and methane previously

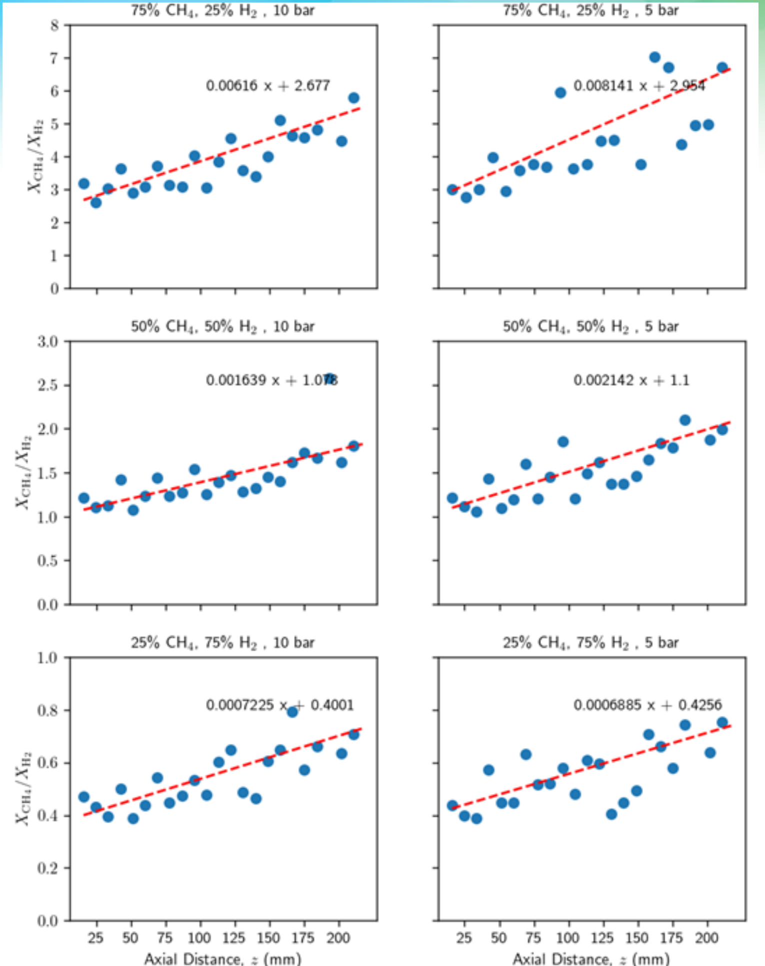


Radial Distribution (Continued..)



Relative Species Concentration

- Ratio of methane to hydrogen mole fraction along the centerline increases with downstream distance
- Rate at which this ratio increases diminish as the mole fraction of hydrogen increases in the initial mixture
- The rate of increase is higher for the 5 bar releases than the 10 bar releases (with the exception of the 25% methane case
- Ratio of methane to hydrogen mole fractions along the centerline shows a linearly increasing trend, possibly due to increased diffusion rate of hydrogen over methane



Conclusions

- Dispersion characteristics of different hydrogen-methane blends released through a 1mm diameter orifice, at 5 bar and 10 bar pressures, were studied
- Spatially resolved concentration fields corresponding to hydrogen and methane were obtained
- Average centerline concentration profiles decayed hyperbolically for all the blends, consistent with the behavior of pure hydrogen and methane
- Radial mole fractions, when normalized with centerline mole fraction and radially by downstream distance, collapsed onto a self-similar Gaussian profile for both the pure gases and blends
- Ratio of methane to hydrogen mole fractions along the centerline shows a linearly increasing trend, possibly due to increased diffusion rate of hydrogen over methane

QUESTIONS?

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