Use of Hydrogen for Internal Combustion Engine for Transport Sector

M. Martino

1 Introduction

Hydrogen is commonly considered a feasible energy vector for future carbon-free mobility systems based on internal combustion engines. The need to quickly decarbonise the transport sector (in according to the European emissions directives) is due to the fact that this is the fourth largest contributor to the release of CO_2 in atmosphere[1]. In this scenario, hydrogen can be a fast and cost-effective answer to the problem.

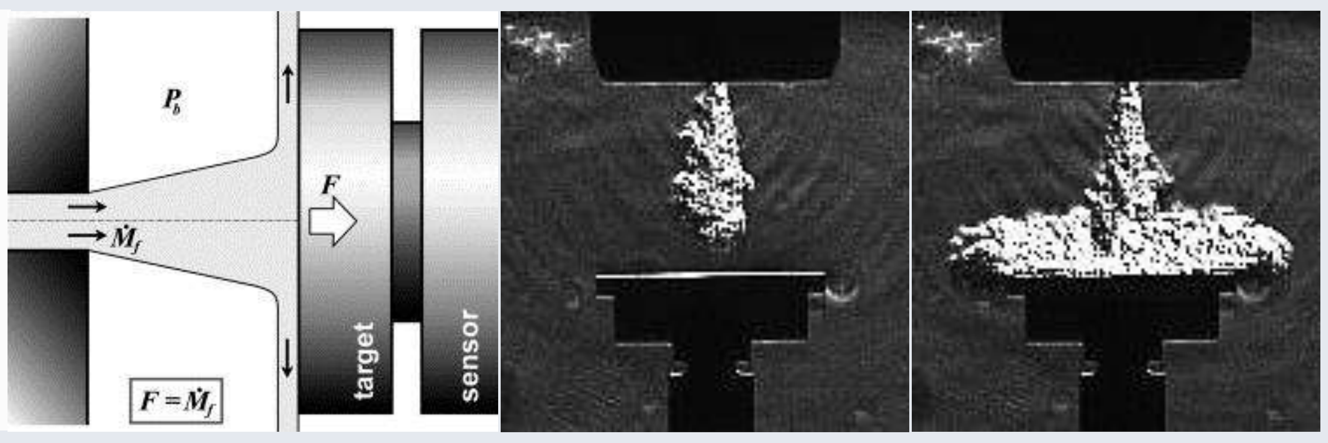
Aim

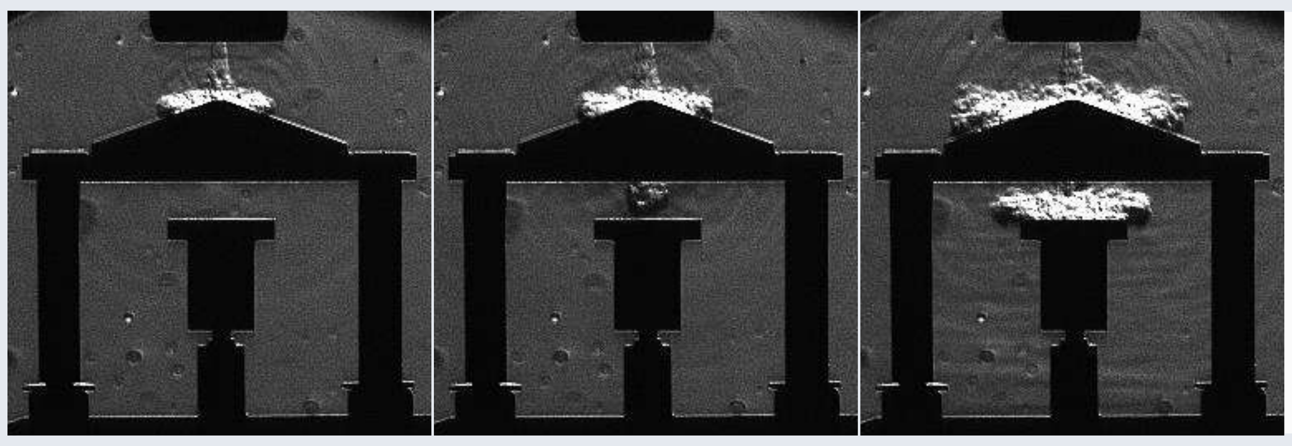
For an accurate development of hydrogen-based powertrains, a deep characterization of the injection process is mandatory, as it influences the formation of the air-hydrogen mixture, the combustion development and efficiency and the knock tendency of the engine. The aim of this research is to experimentally analyse injection systems in order to characterise them using a multi-methodological approach in order to be able to accurately describe their behaviour by directing research and development of such systems.

2 Methods

Momentum flux

This technique[2] is based on the momentum conservation equation. The impact force of the jet is measured by a force sensor equipped with a circular surface (target).



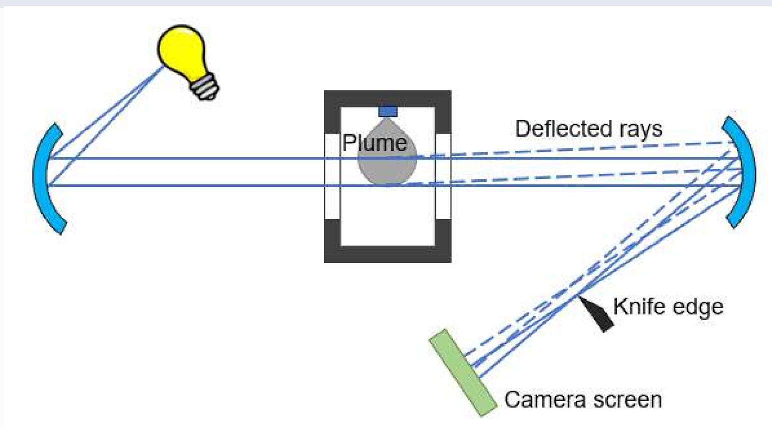


Momentum flux distribution map

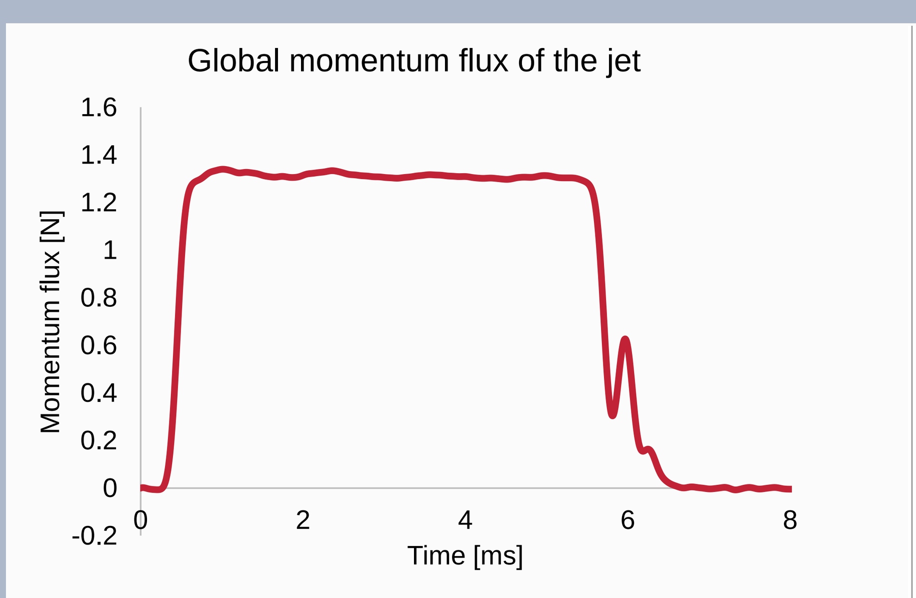
Filtering a portion of the jet and moving the measuring system, it is possible to obtain momentum distribution maps within the jet. From these maps, the actual fuel targeting in the combustion chamber and other information can be obtained.

Schlieren imaging visualization[3]

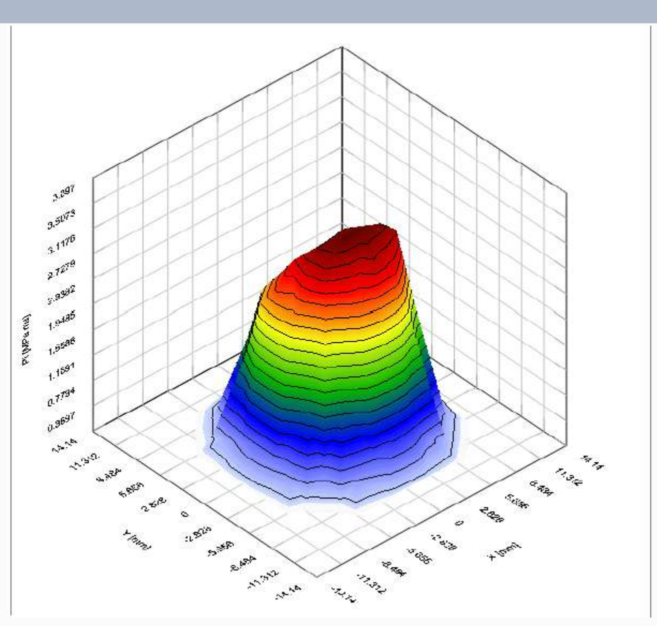
At the interface between different gases, characterized by different refractive indexes, light beams are refracted altering their path with respect to the incident light direction. Using a "knife blade", the light beams not deviated by the refraction mechanism are stopped intensifying the visualization of gaseous jets in the surrounding air.

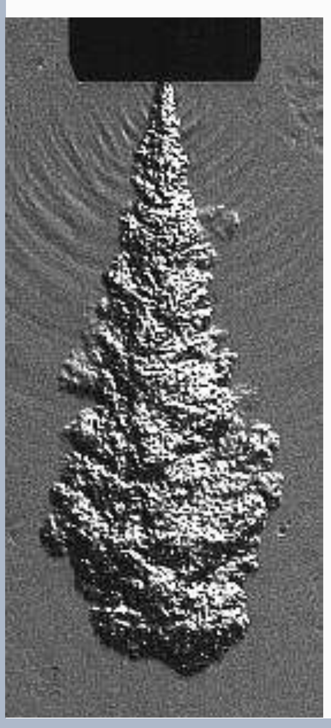


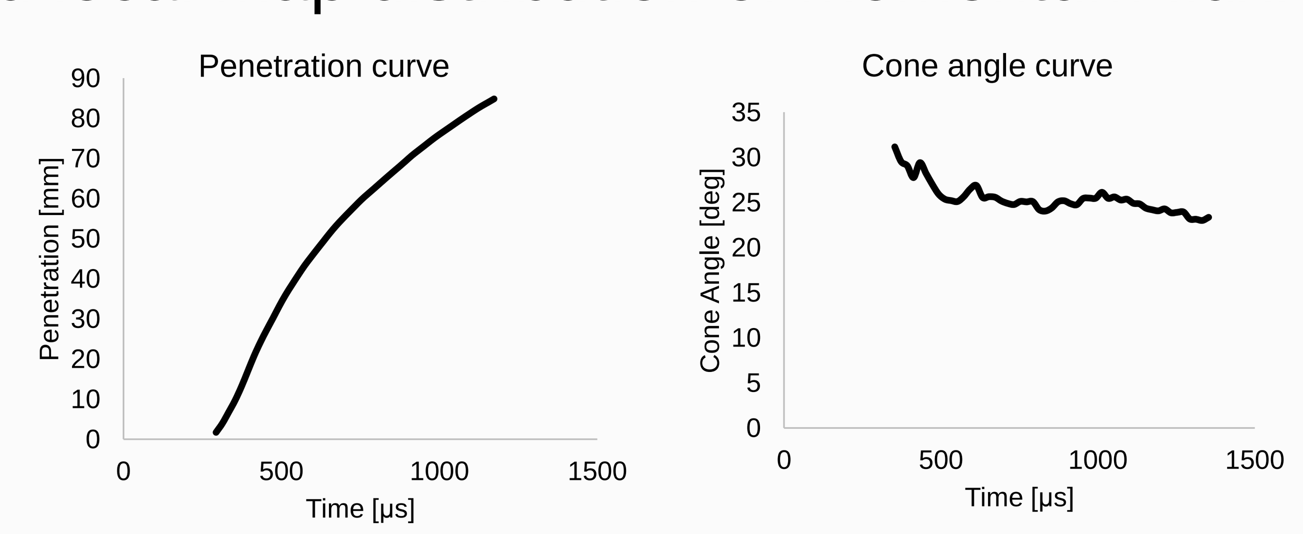
3 Results



Global and local map distribution of momentum flux.







Penetration and cone angle curve derived by contour analysis of jet images.

4 Conclusions

Gaseous jets can be studied using Schlieren optical techniques. Important geometric parameters of the jet (*i.e.* penetration and cone angle curves) can be derived from the images. A quantitative analysis can be carried out by analysing the momentum of the jet, obtaining information regarding both the globality of the jet and the momentum distribution within the jet. In the SprayLab laboratory at the University of Perugia, test benches have been set up to enable this type of analysis.

References

1. H. Ritchie and M. Roser, 'Sector by sector: where do global greenhouse gas emissions come from?', Our World Data, Sep. 2023, Accessed: Nov. 07, 2023. [Online]. Available: https://ourworldindata.org/ghg-emissions-by-sector
2. Postrioti, L., Martino, M., Fontanesi, S., Breda, S., & Magnani, M. (2024). Experimental and Numerical Momentum Flux Analysis of Jets from a Hydrogen Injector (No. 2024-01-2616). SAE Technical Paper.
3. Fontanesi, S., Postrioti, L., Magnani, M., Martino, M., Brizi, G., & Cicalese, G. (2022). Preliminary assessment of hydrogen direct injection potentials and challenges through a joint experimental and numerical characterization of high-pressure gas jets (No. 2022-24-0014). SAE Technical Paper.