Effect of the ambient gas properties on the diesel spray tip penetration and spreading angle

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Introduction

- Experimental measurements are crucial to validate CFD models.
- Study the influence of the ambient gas on the spray
- To observe these effects, the spray penetration and spreading angle were analyzed under a wide range of injection pressures and ambient densities.
- Three ambient gases : SF_6, CO_2, N_2.

Objectives

- Measure spray tip penetration and spreading angle for parametric variations of the boundary conditions.
- Analyze the influence of the ambient gas in the spray development.
- Compare the spray penetration of each ambient gas .

Methodology

Test rig and Optical setup

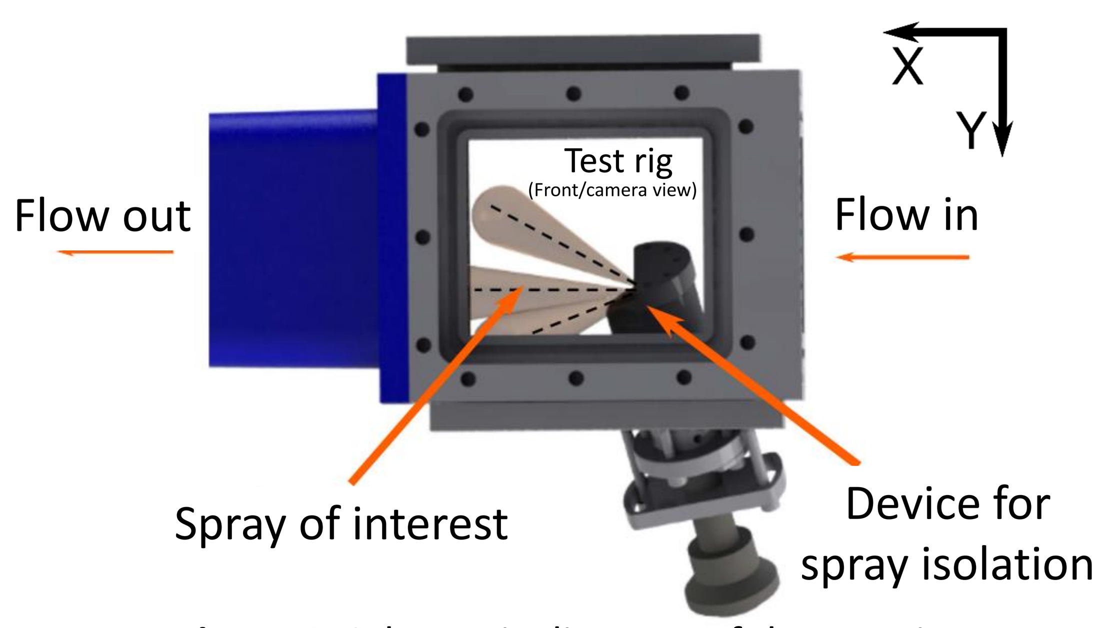

Figure 1: Schematic diagram of the test rig.

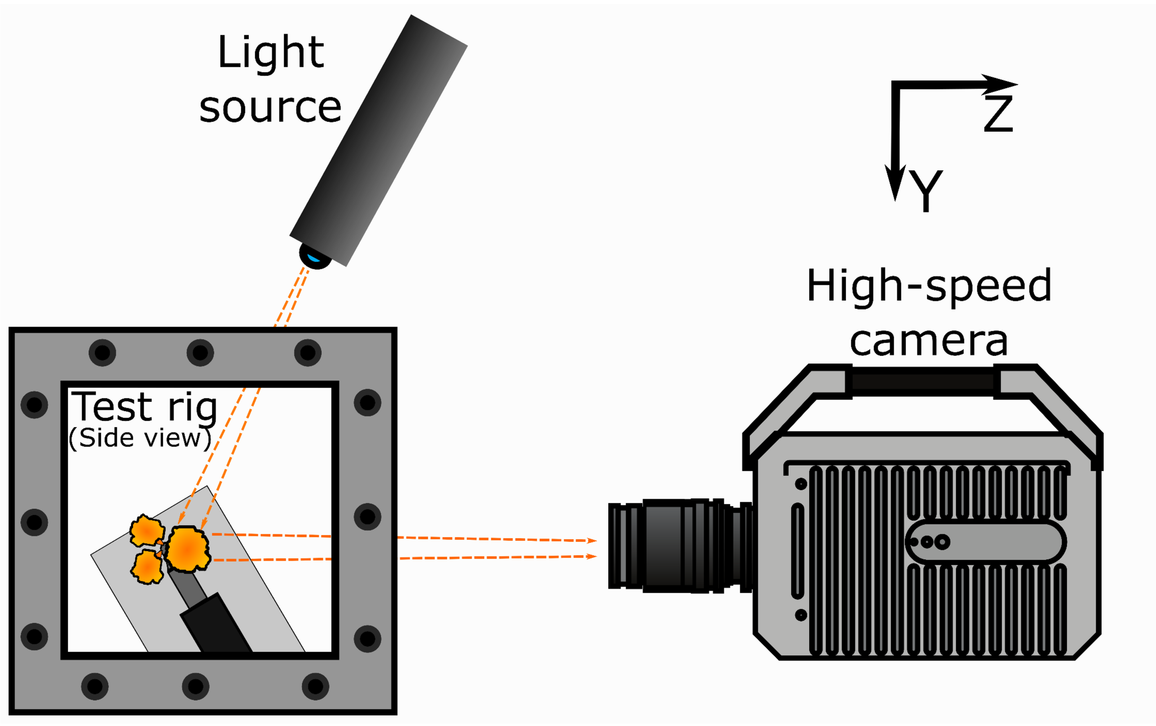

Figure 2: MIE Scattering Optical setup.

Image Proccesing

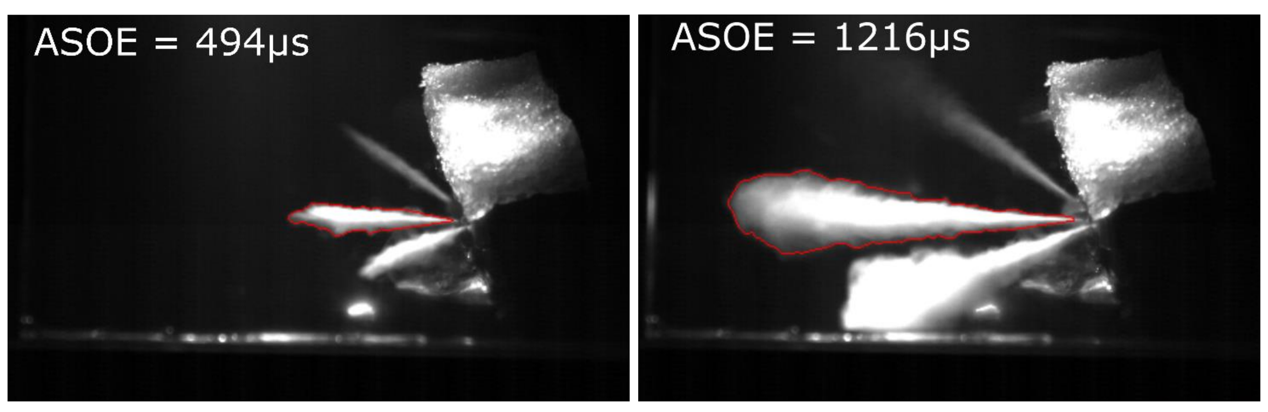

Figure 3. Contour detecting of the spray.

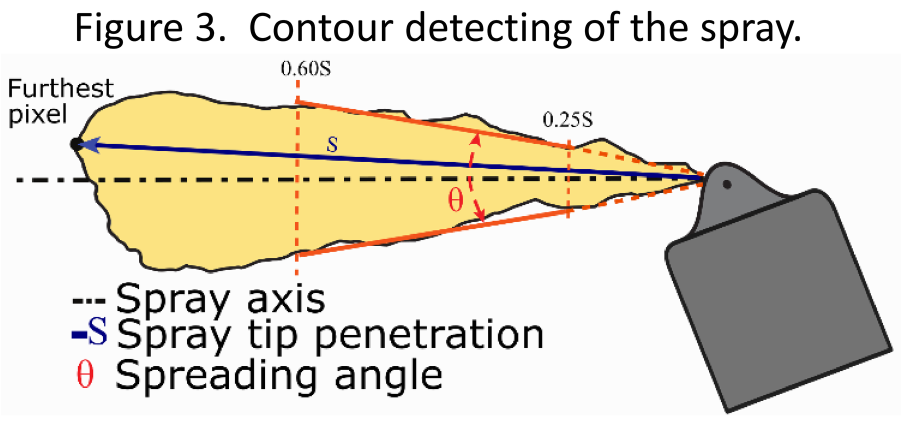

Figure 4. Definition of the macroscopic variables of the spray.

Results

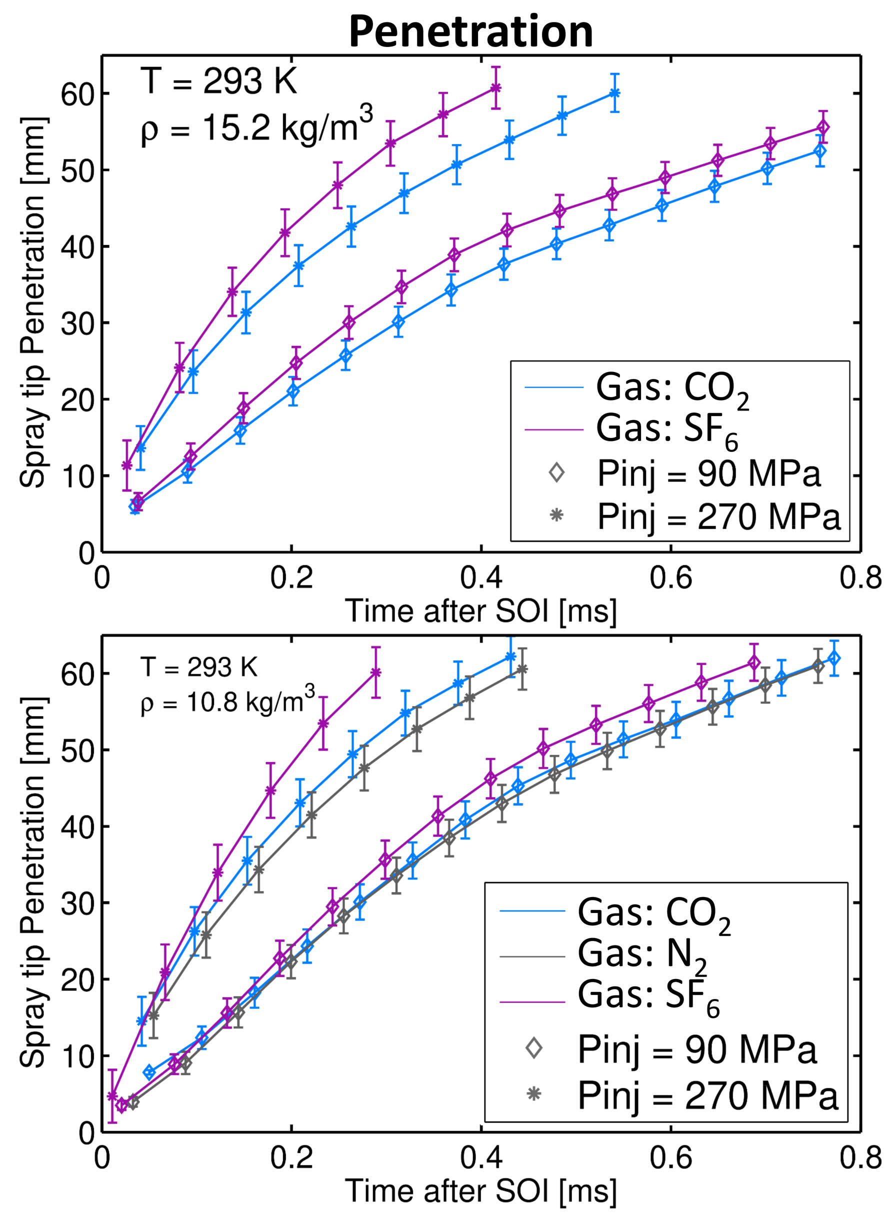

Figure 5: Spray tip penetration.

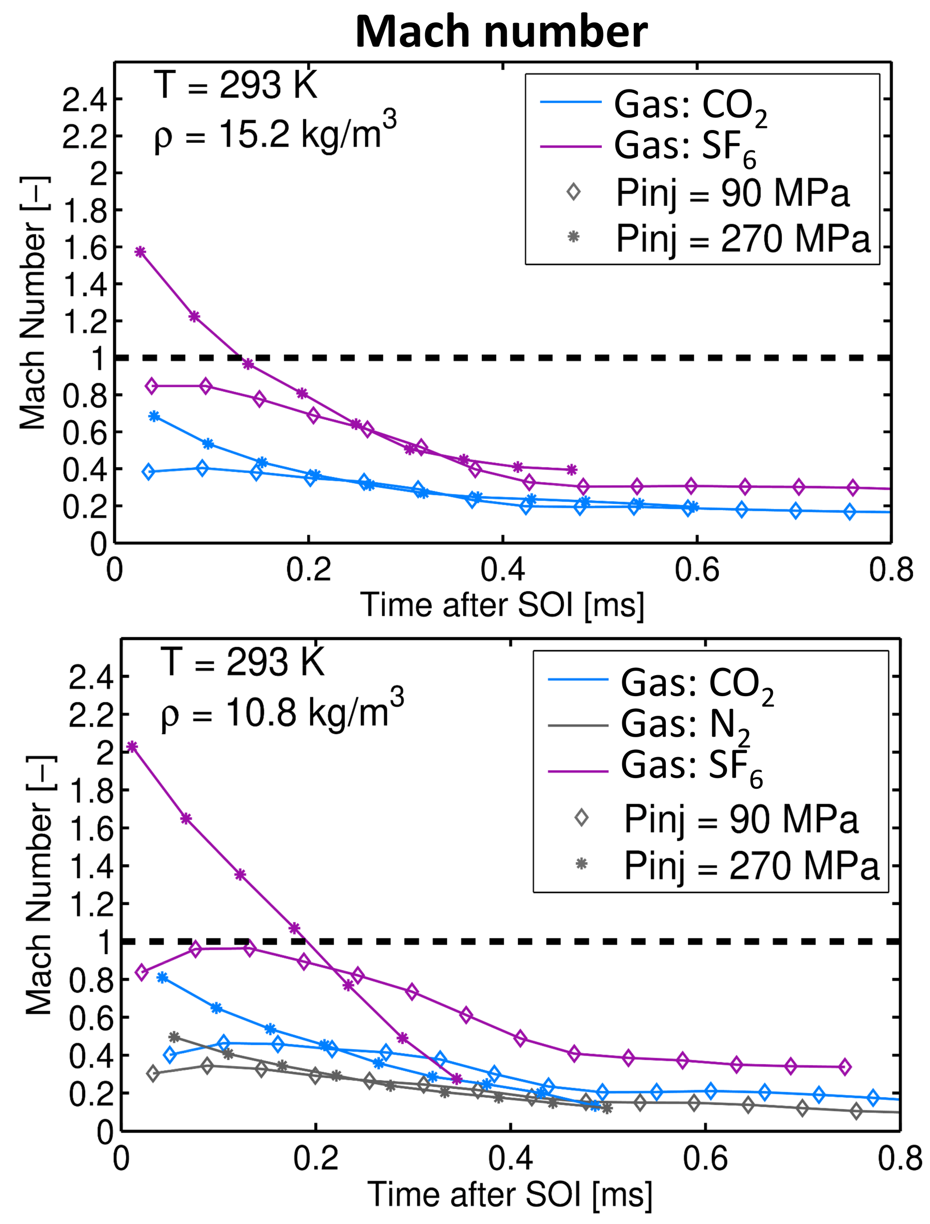

Figure 6: Spray tip Mach number.

Spray spreading angle

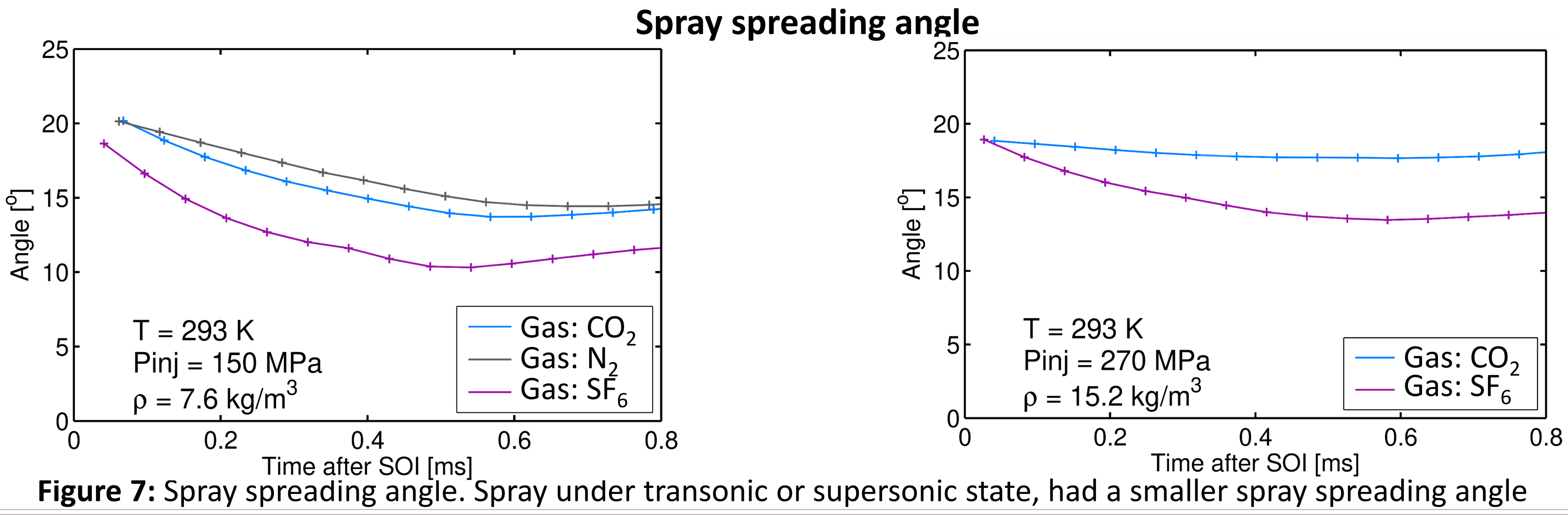

Figure 7: Spray spreading angle. Spray under transonic or supersonic state, had a smaller spray spreading angle

Penetration adimentional analysis

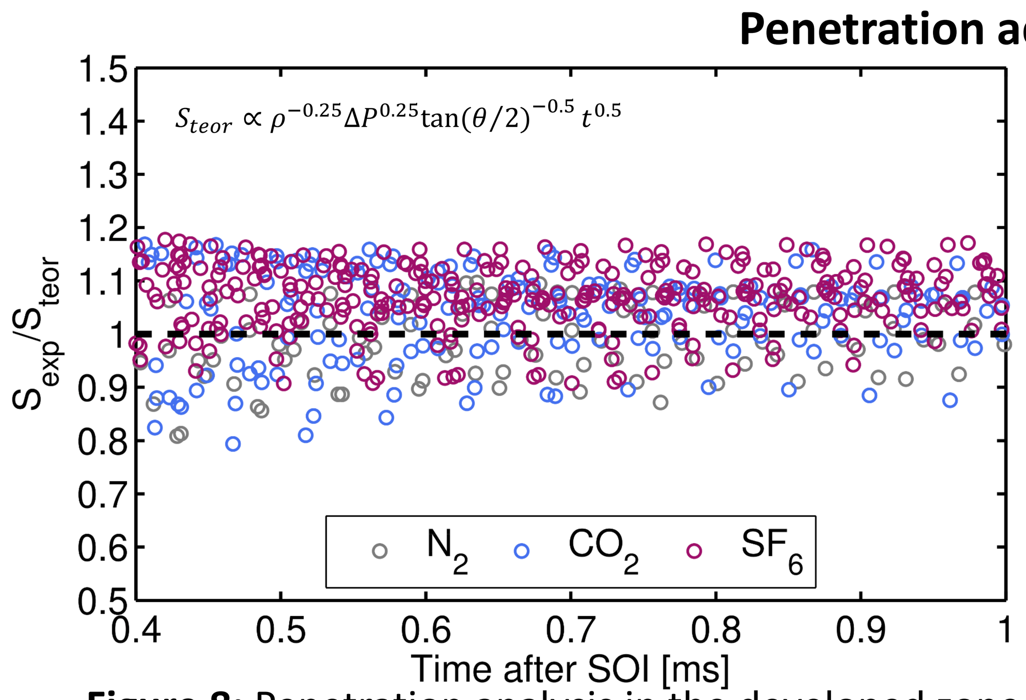

Figure 8: Penetration analysis in the developed zone

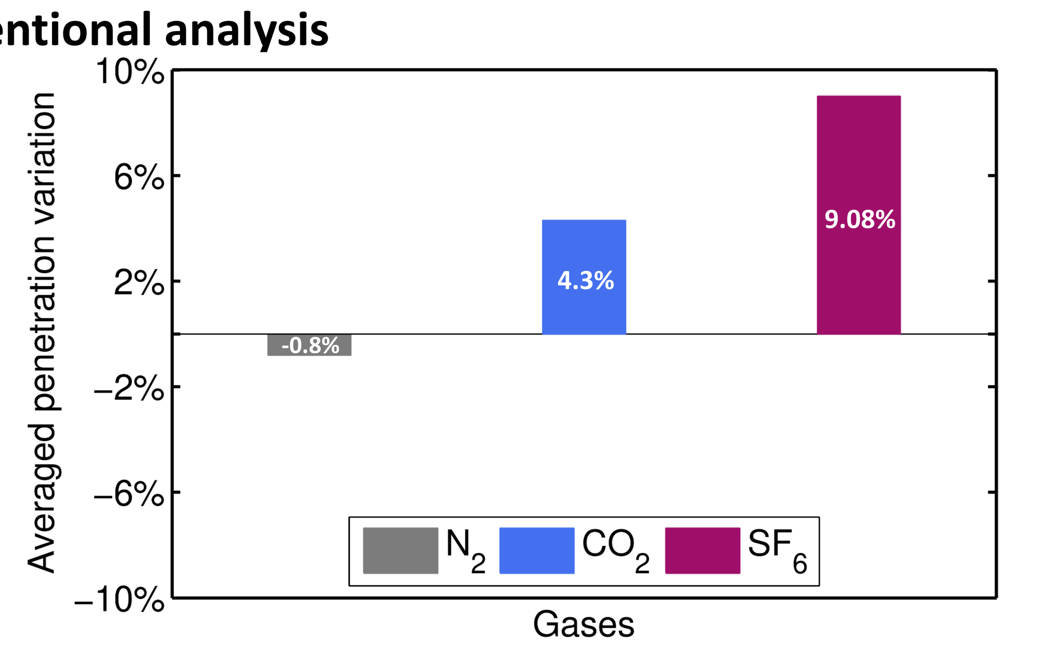

Figure 9: Averaged S_{exp} variation, compared to S_{teor}

Conclusions

- At same ambient densities spray penetration grew faster within the SF6 atmosphere than the others (CO_2 and N_2) and had smaller spray spreading angle.
- Shock-waves appearances was pointed out as the possible explanation. In this sense, the initially compressed gas behind the shock would expand as the spray develops, creating a depression zone which enhances the spray penetration.
- Sprays tip near transonic or in supersonic state (M > 0.8) had a faster penetration rate than those in the subsonic state.
- Spray penetration under different ambient gases (SF_6 and CO_2) in the transonic or supersonic state was compared. Sprays under SF_6 atmosphere had a faster penetration than those under CO_2 atmosphere.
- Differently, spray penetration under different ambient gases (CO_2 and N_2) in the subsonic state was compared and no significant differences were observed, regardless of the difference in Mach number values.
- Statistical analysis showed that spray under supersonic or transonic state had a faster penetration in time, compared to the theoretical penetration correlation.

Articles Published:
(1) "Effect of high injection pressures and ambient gas properties over the macroscopic characteristics of the diesel spray on multi-hole nozzle", *Atomization and Sprays*, 2018, Vol.28(12), pp. 1145-1160. DOI: 10.1615/AtomizSpr.2019029651.
References:
(1) "Experimental investigation of effects of super high injection pressure on diesel spray and induced shock waves characteristics, *Experimental Thermal and Fluid Science*, 2017, Vol. 85, pp- 399-408. DOI: 10.1016/j.expthermflusci.2017.03.026.