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Numerical and experimental study of laminar syngas flames

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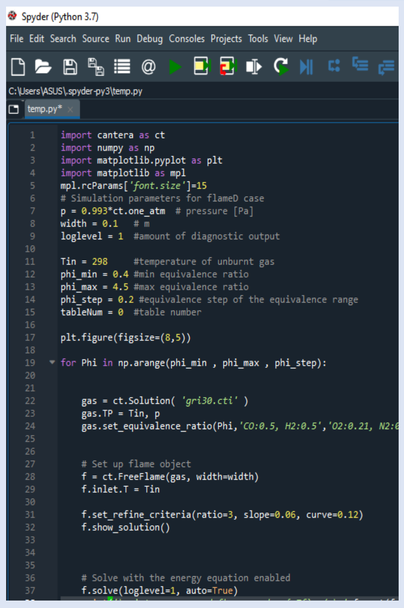
Context and objectives

- **Objective** : Characterization of syngas flames.
  - Experimentally: Stability, topology, pollutant emissions.
  - Numerically: Calculation of laminar burning velocity and adiabatic flame temperature of syngas flames.
  - ➡ This poster: Results of numerical calculations.
- **Support :** RenewValue project of EranetMed II program.

Numerical Method



Calculation codes

(for laminar, 1D, premixed, and freely propagating flames)

Used reaction mechanisms

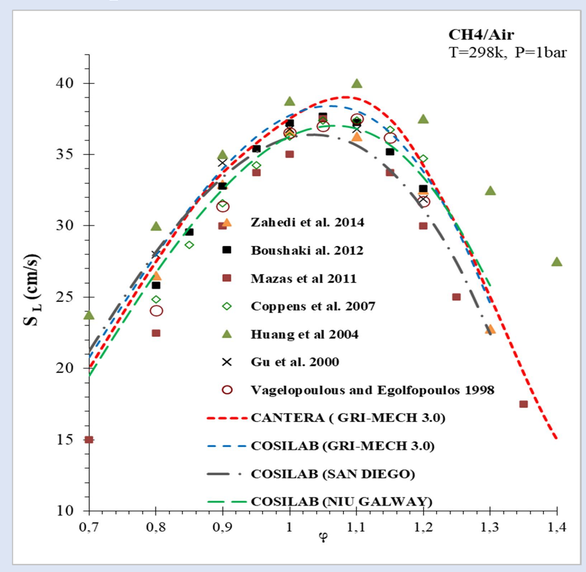
- CANTERA
  - GRI-MECH3.0
- COSILAB
  - GRI Skeletal
  - San Diego
  - NIU GALWAY
  - CRECK Group
  - S. Davis et al

⇨Laminar burning velocity (S_L), Adiabatic flame temperature (T_{ad}) of syngas flame.

Results and discussion

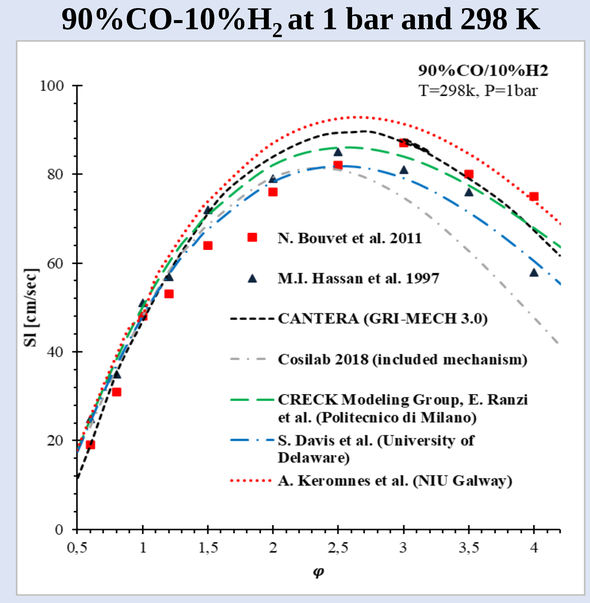
Case of CH_4/air flame

Laminar burning velocity (S_L) of CH_4-air with equivalence ratio at 1 bar and 298 K



Case of 90%CO-10%H_2/air flame

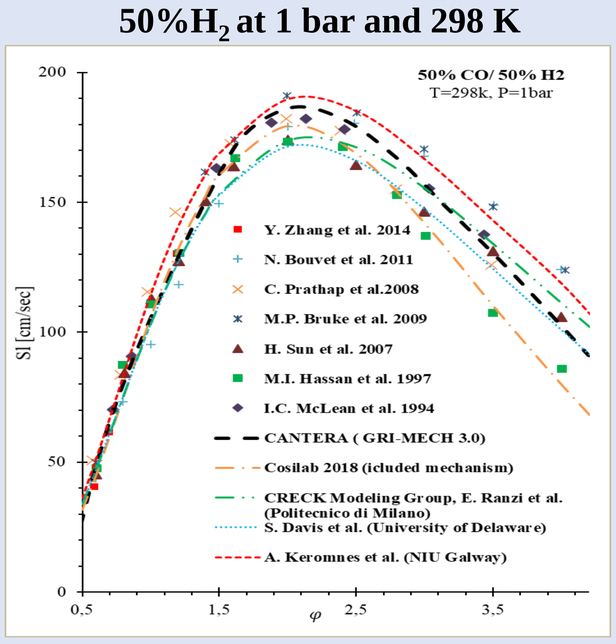
Laminar burning velocity (S_L) of 90%CO-10%H_2 at 1 bar and 298 K



✓ The agreement between the present results and data from the literature is good.

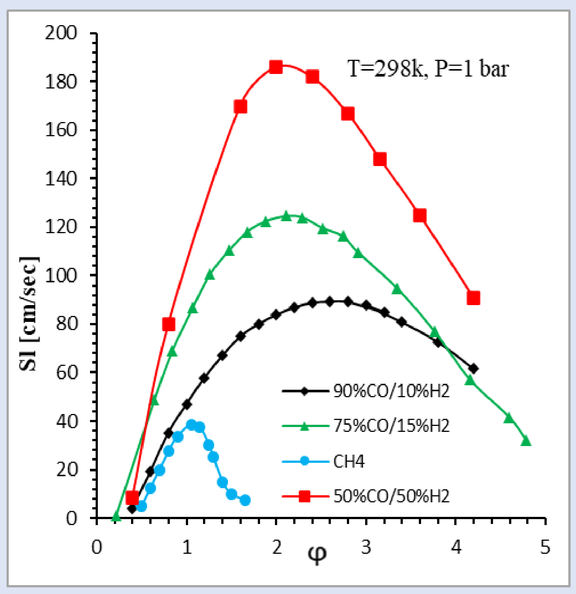
Case of 50%CO-50%H_2/air flame

Laminar burning velocity (S_L) of 50%CO-50%H_2 at 1 bar and 298 K

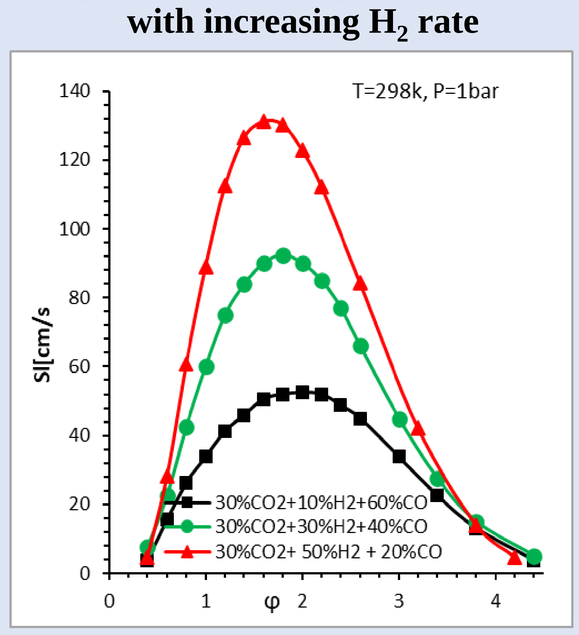


✓ Numerical results show a good similarity with data from the literature mostly for the lean side (φ < 1).

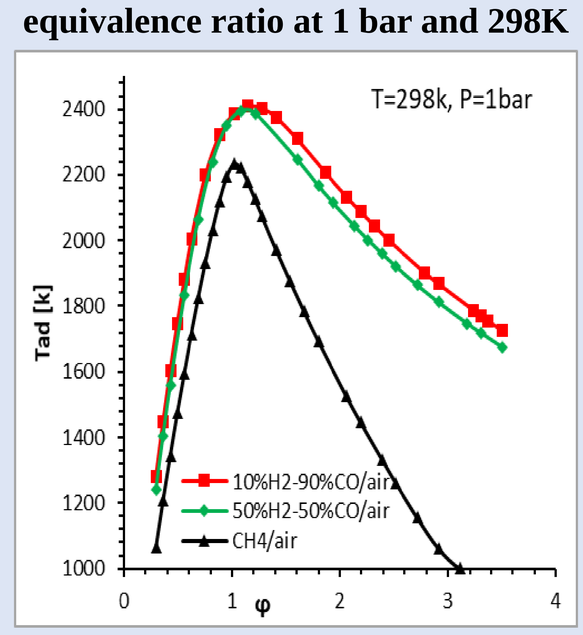
S_L =f(ϕ) at 1 bar and 298K



S_L=f(ϕ), for CO/H_2/CO_2 mixture with increasing H_2 rate

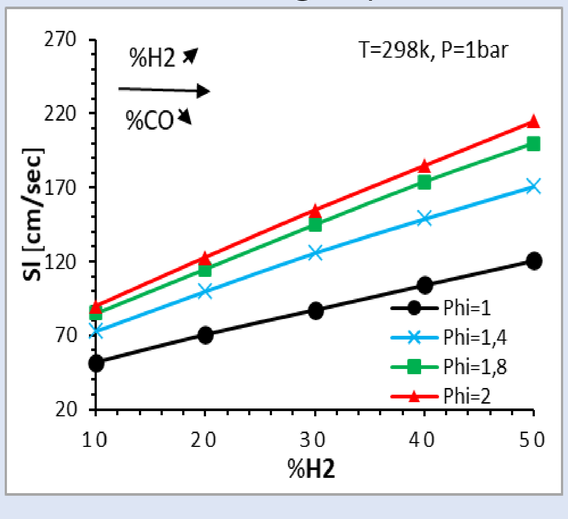


Adiabatic flame temperature with equivalence ratio at 1 bar and 298K



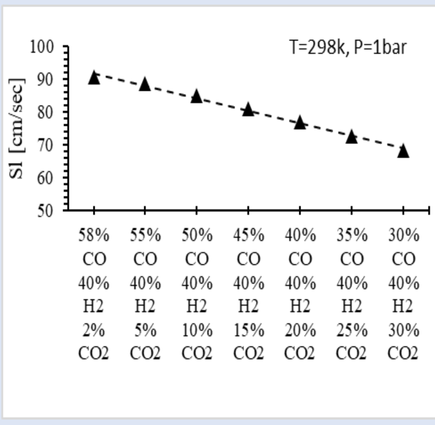
✓ S_L ↗ with H_2 ⇨ high reactivity and flammability of H_2.
✓ S_L ↘ with CO_2 addition ⇨ CO_2 acts as a diluent.
✓ The addition of H_2 ⇨ Tad ↗ : For φ =1, adding 40% of H_2, increases T_{ad} from 2222 to 2349 K.

S_L with H_2 fraction with increasing of ϕ

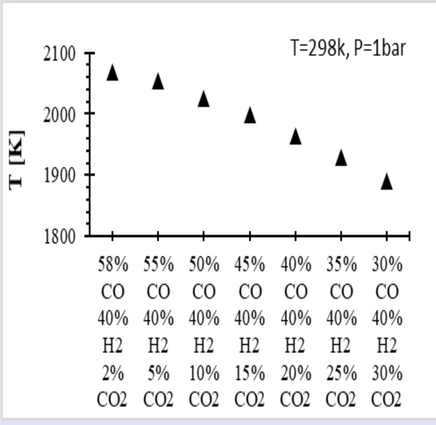


✓ S_L ↘ and Tad ↗ with H_2 addition.
✓ S_L ↗ with H_2 at all equiv. ratios.

S_L with CO_2 at 1bar and 298K

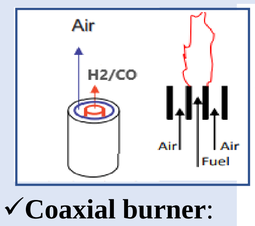


Tad with CO_2 at 1bar and 298K

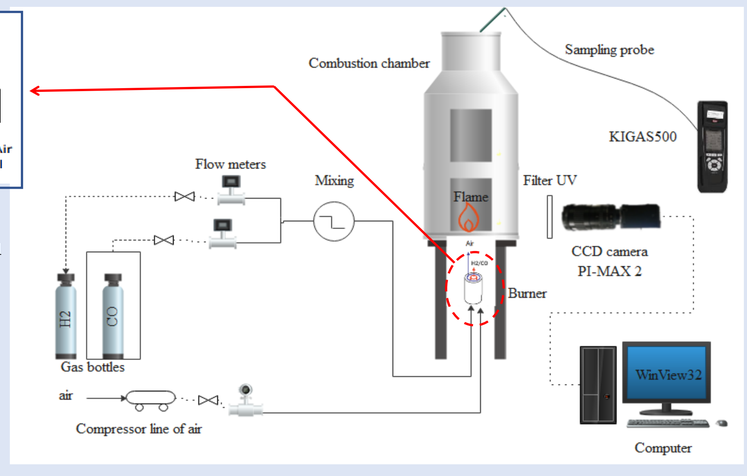


✓ S_L ↘ with CO_2 addition (CO_2 acts as a diluent).
✓ T ↘ with CO_2 (adding 50% of CO_2 decreases T from 1973K to 1780K) ⇨ CO_2 increases the thermal capacity of the mixture.

Experimental study



✓**Coaxial burner**: placed at the bottom of the chamber.
✓**Combustion chamber**: dimensions 0.62×0.4×0.5m³



✓Study the characteristics of CO/H_2-Air flames: flamme stability (by chemiluminescence of OH* /CH*), pollutant emissions (by multi-gas analyzer).
✓Combustion experiments were not done because of the sanitary crisis of COVID.
✓Some studies from the litterature about syngas combustion:
- Azimov et al: H_2 ↘ ⇨ CO and HC emissions ↘ but NOx ↗.
- Noble et al: H_2 dominates the characteristics of the mixture blow off.