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Numerical analysis of characteristics of biogas and syngas combustion

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RenewValue Project

- European project: ERANETMED2-72-169
  RQ2: Energy and Environment
  Collaborative Innovation Project - Mobility
- Subject: Local sustainable renewable energy supply for vulnerable communities in arid and semi-arid Mediterranean zones (MENA)
- Partners: ICARE CNRS (France), Universität Rostock, DBFZ (Germany), Ibn Tofail University (Morocco), INSAT and ENIT (Tunisia), Politecnico di Torino (Italy)
- Duration: 3 years (2018-2021)

ICARE tasks and objective of the study

- Development of modular adapted energy concept
  ⇒ Gasifier - multi-fuel burner - boiler
- Characterization of syngas and biogas flames
  Experimentally: stability, pollutant emissions, temperature
  Numerically: Calculations of laminar burning velocity, flame temperature, pollutants (NOx, CO)...
- This poster: some results of calculations

Combustion characteristics - calculations

- Laminar flame velocities ($S_f$)
- Flame temperatures ($T_f$)
- Chemical species distributions
- Pollutant emissions (NO, CO, ...)
- Pathways of chemical reactions

Case of CH₄-air flame

Laminar burning velocity with equivalence ratio: CH₄-air, at 298 K, 1 bar

- Results are validated, with 4 mechanisms of chemical reactions
- $S_f$ with $T_f$: ⇒ Heating of gas intake induces a better combustion
- $S_f$ with $P_f$

Biogas flame calculations

Flame velocity with equivalence ratio: CH₄-CO₂ (90/10 and 80/20%)

- Results validated by experiments from the literature
- Laminar burning velocity ($S_f$) decreases with CO₂ addition

Syngas flame calculations

Laminar burning velocity of CO-H₂-air flames: 90/10% and 50/50 % CO-H₂

- Results are compared and validated with experimental results
- With $+\text{H}_2$: $S_f$ max at $\Phi = 2.5$ (CH₄-air; at $\Phi = 1.05$)
- $+\text{H}_2$ ⇒ $S_f$; $S_{\text{max}}$: 190 at 50% of H₂; 90 at 50%H₂ against 38 cm.s⁻¹ CH₄-air
- $+\text{H}_2$: higher reactivity, higher flammability limits, higher velocity, higher T

Temperature, NOx and CO emissions of CH₄-CO₂-air flames with CO₂

- Flame temperature decreases with CO₂ addition
- NOx \ with CO₂
- CO \ with CO₂
  ⇒ It is necessary to find a good balance to meet the standards

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