



Aalto University
School of Engineering

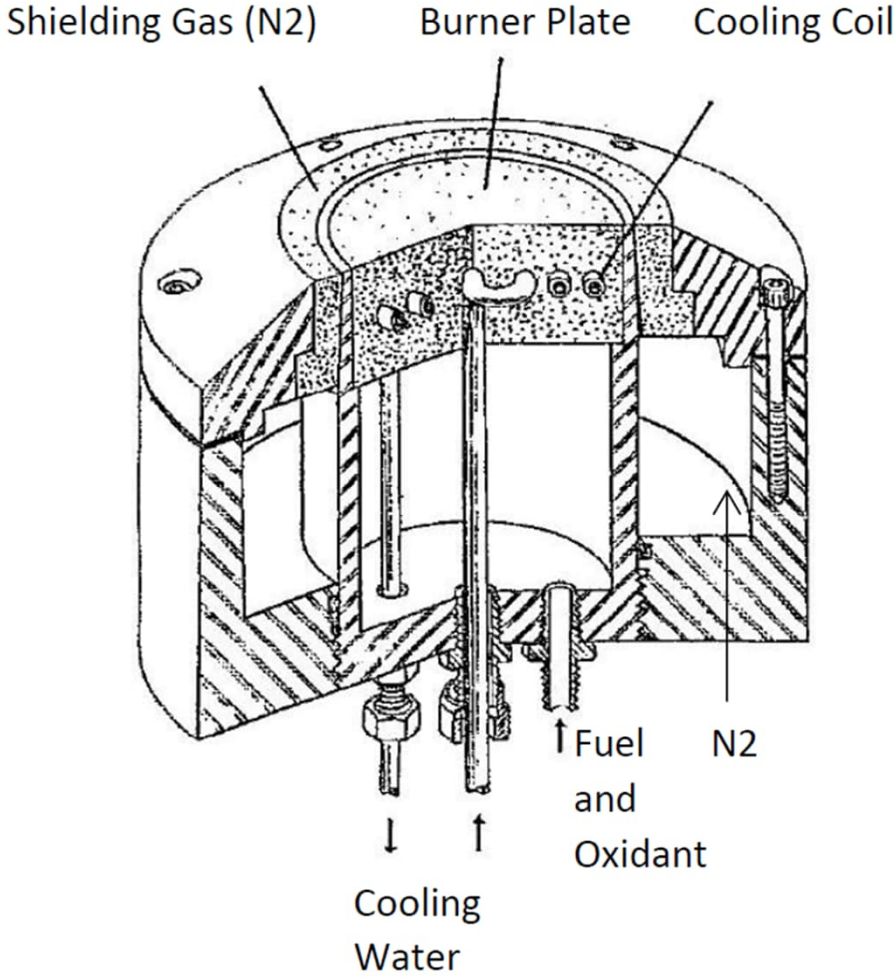
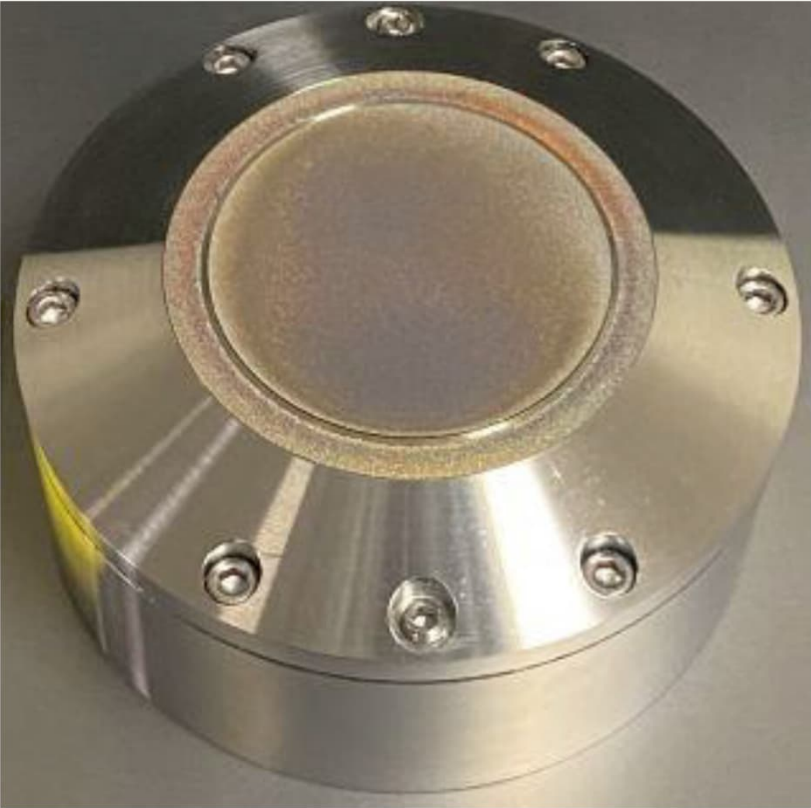
AAE-E2005 Thermochemical Energy Conversion

McKenna burner

Ari Kankkunen, DSc

22 January 2024

McKenna burner



22 January 2024

McKenna flat flame burner

Standard flame

Widely used in the literature

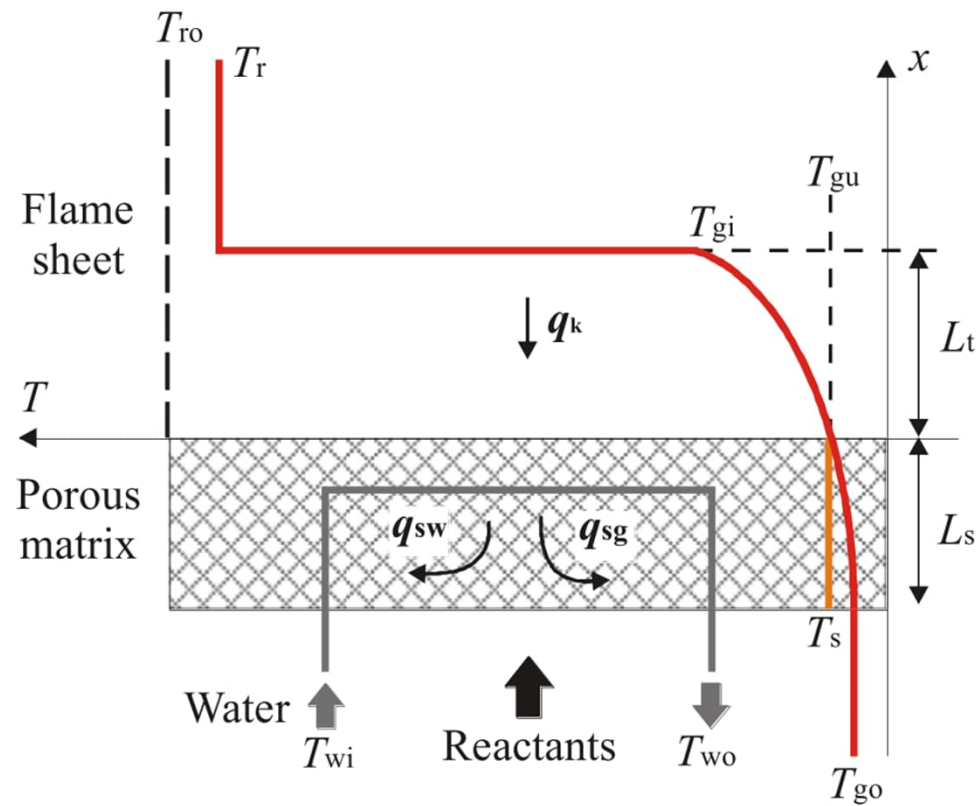
Premixed fuel/oxidizer

Used for

- Flame speed measurement
- Temperature calibration
- CH calibration using LIF
- OH calibration using LIF
- Soot generation and studies using LII
- Other species CH₄, OH, NO....

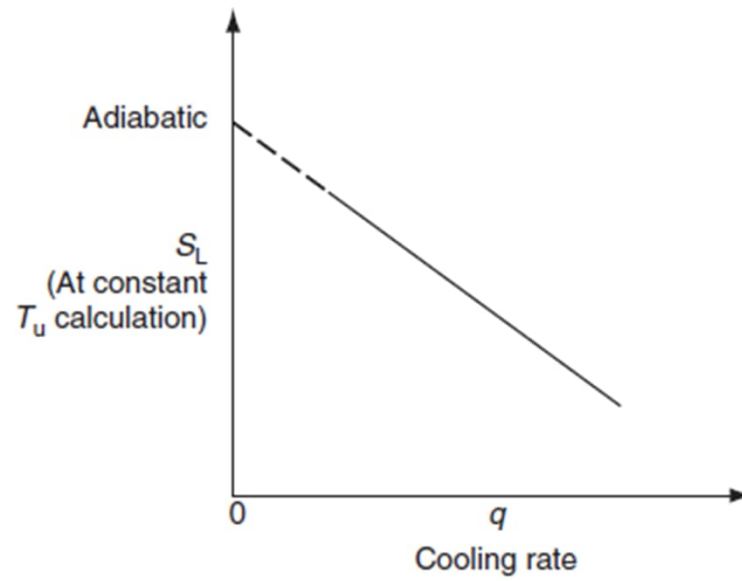


FLAME SPEED MEASUREMENT



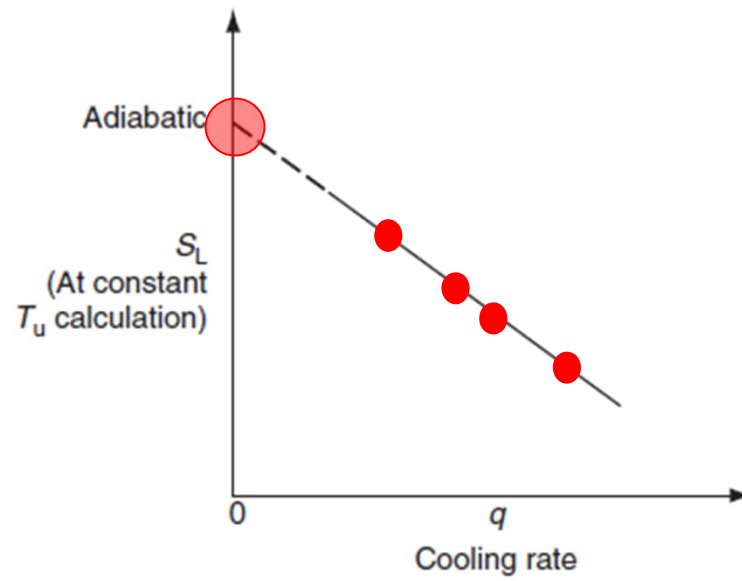
Francisco&Oliveira ,Therm Fluid Sci 2018

FLAME SPEED MEASUREMENT



Glassman, Combustion 4th edition, 2008

FLAME SPEED MEASUREMENT



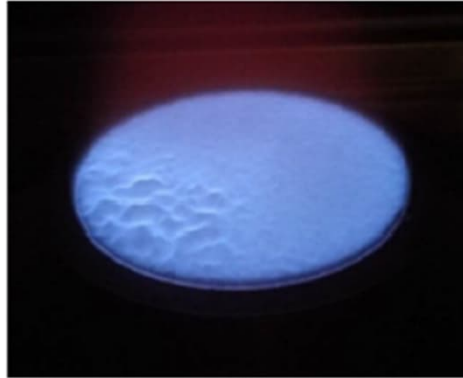
Glassman, Combustion 4th edition, 2008

FLAME SPEED MEASUREMENT



(a)

Flat flame



(b)

Wrinkled flame



(a)



(b)

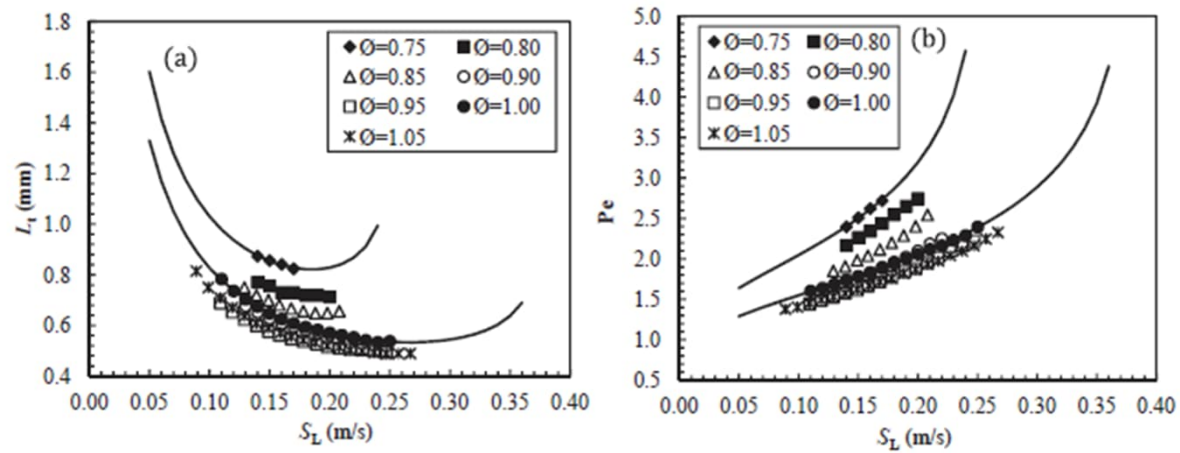
Shadow graph image of the flame front shown in Fig. 8, for (a) the flat flame (26 cm/s) and (b) the wrinkled flame (29 cm/s).



Region of interest for image analysis.

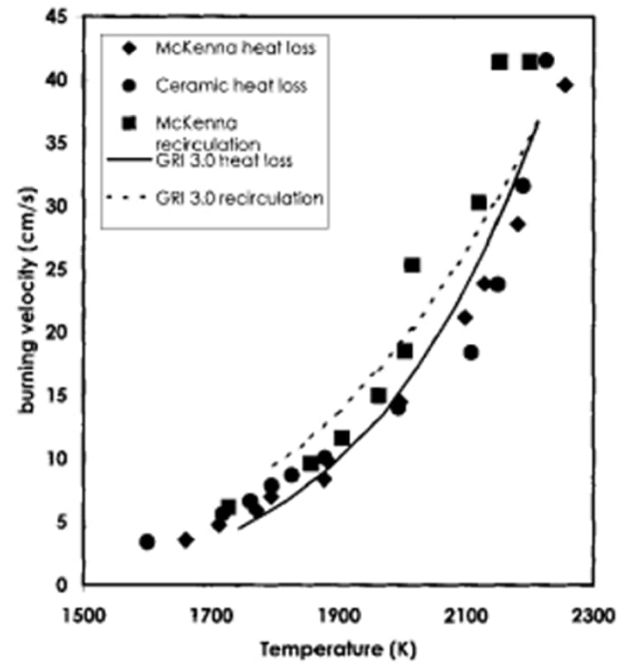
Francisco&Oliveira ,Therm Fluid Sci 2018

FLAME SPEED MEASUREMENT



(a) Flame stand-off distance and (b) Peclet number as a function of laminar flame velocity, for premixed methane and air ($T_{go} = 298$ K and $P = 1$ atm).

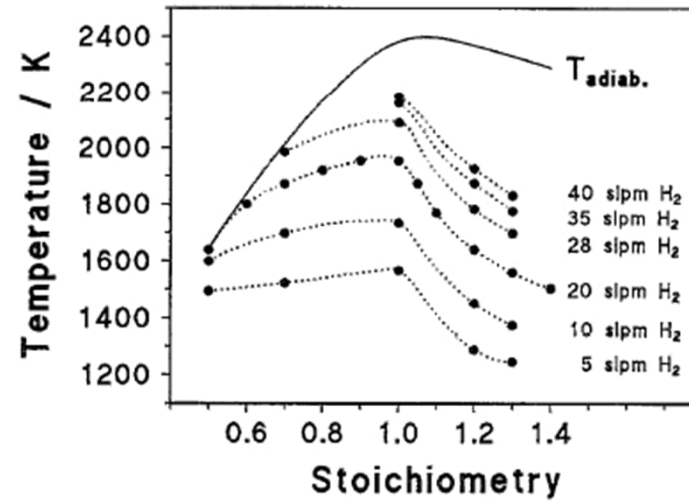
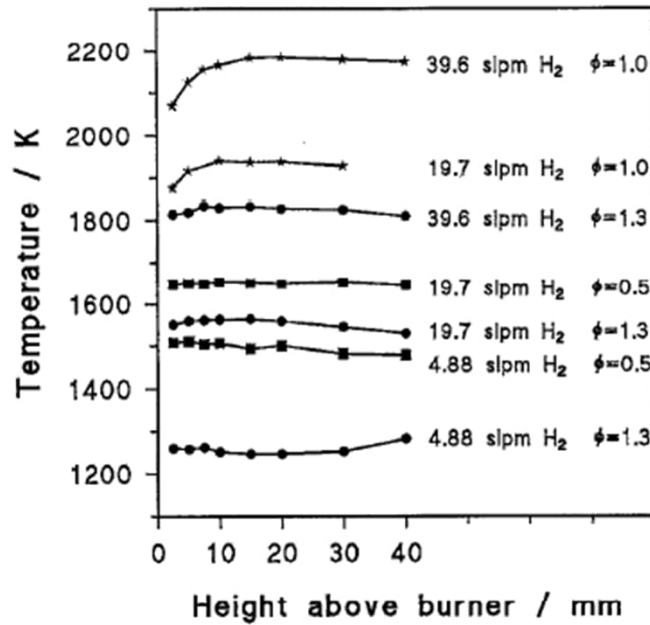
FLAME SPEED MEASUREMENT



Burning velocity plotted against temperature.

Proceedings of the Combustion Institute, Volume 28, 2000/pp. 2467–2474
A LIF AND CARS INVESTIGATION OF UPSTREAM HEAT LOSS AND FLUEGAS
RECIRCULATION AS NO_x CONTROL STRATEGIES FOR LAMINAR,
PREMIXED NATURAL-GAS/AIR FLAMES, A. V. MOKHOV1 and H. B. LEVINSKY

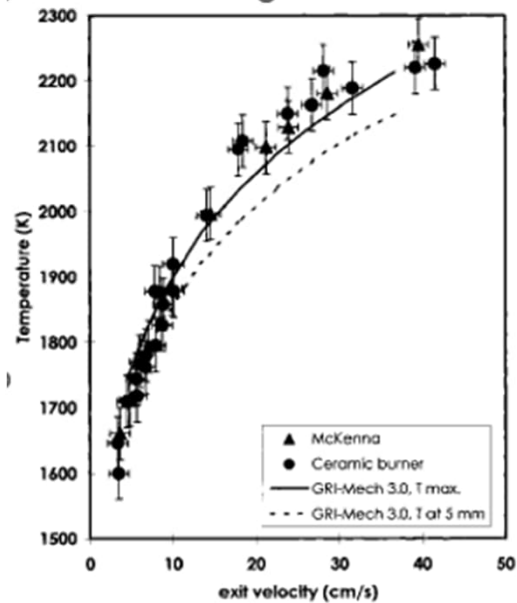
Temperature



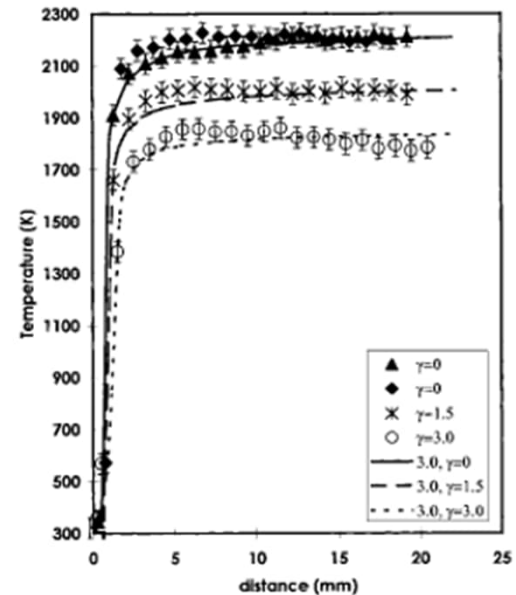
15 mm above the burner plate

Prucker et. al , Rev. Sci. Instrum., 1994

Temperature



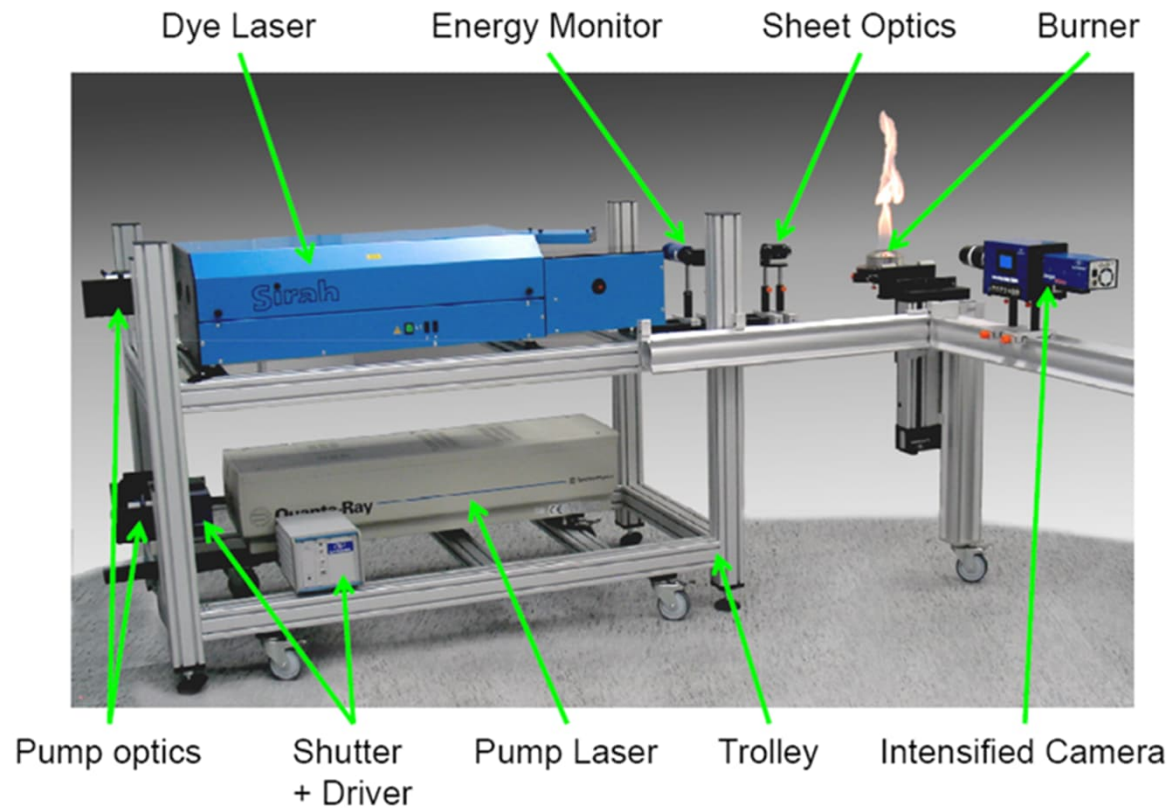
Flame temperature measured at 5 mm above the burner



Flame temperature measured at varying distances above the burner. $\phi=1$.

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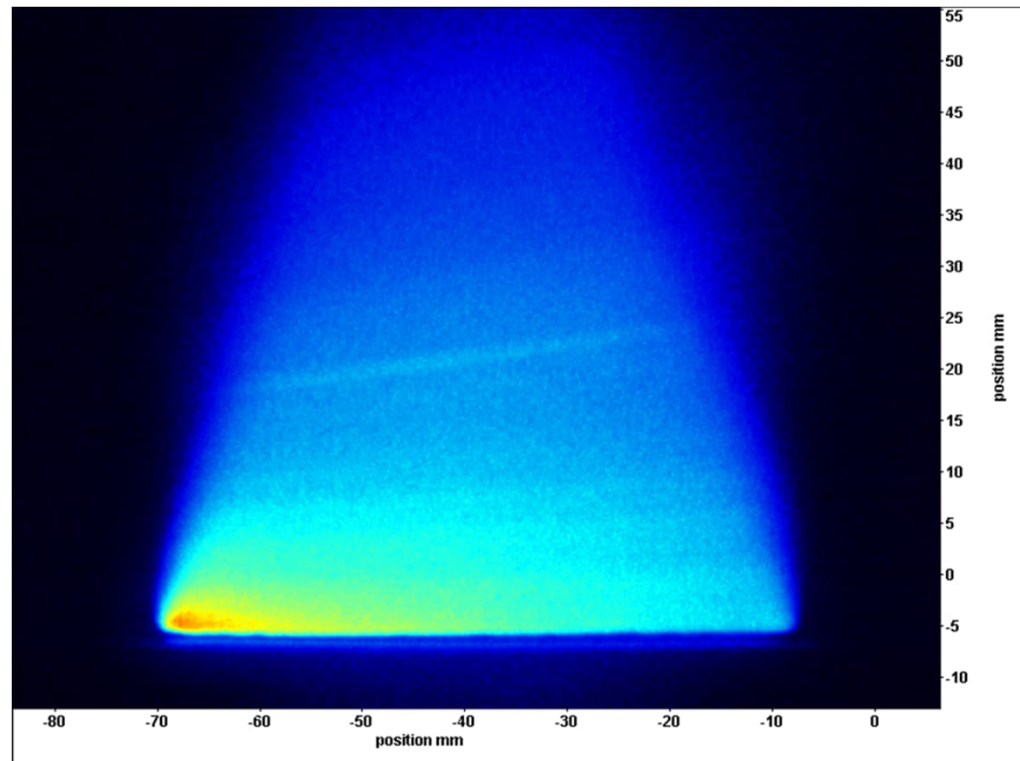
OH concentration by LIF (Laser Induced Fluorescence)



OH concentration by LIF

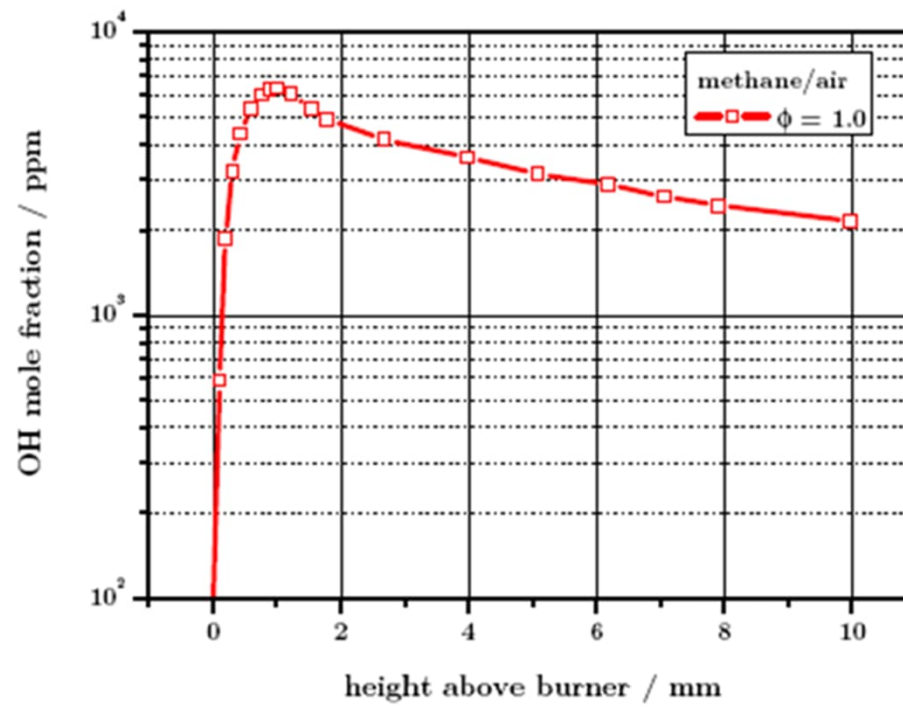


OH concentration by LIF



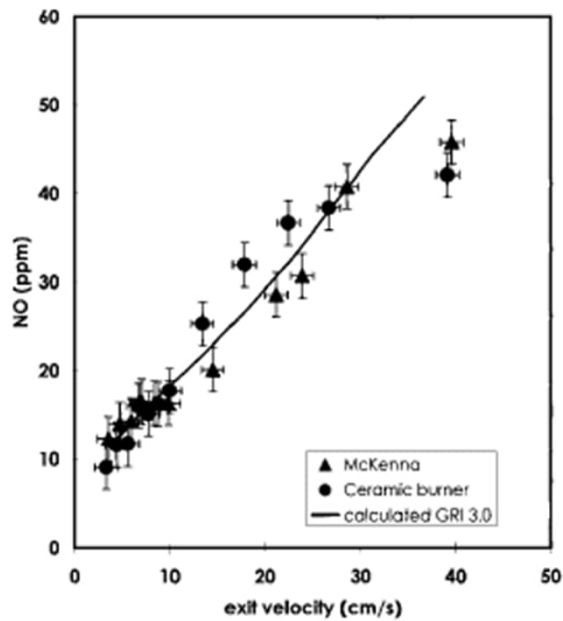
Methane/Air
 $\Phi=1$

OH concentration

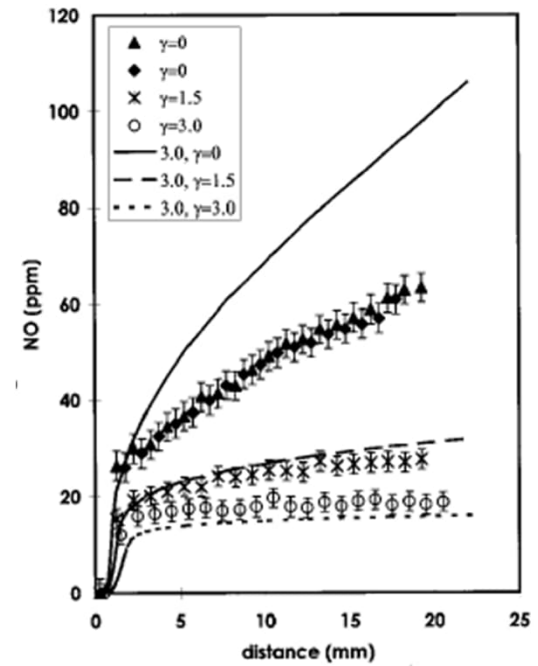


OH mole fraction in stoichiometric methane-air flame

NO concentration



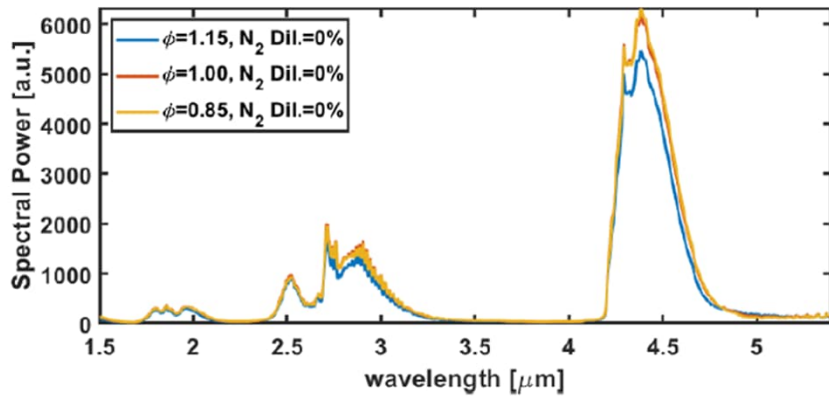
NO mole fraction measured at 5 mm above the burner



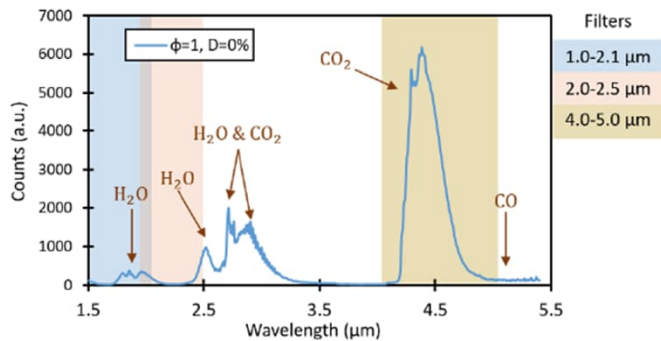
NO profiles measured at 5 mm above the burner

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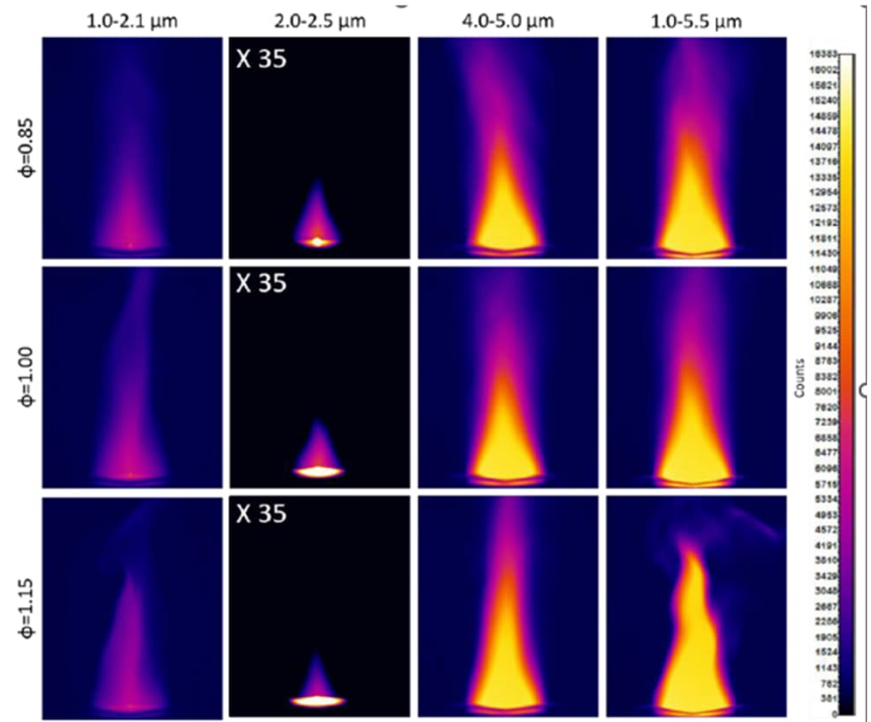
MWIR study on species



IR spectra from 1.5-5.5 μm of flat flame for various stoichiometric ratios



IR spectrum for methane-air flame



Filtered images of flat flame for various stoichiometric ratios

Characterizing Infrared Molecular Radiation in a Flat-Flame Burner and an Optical Spark-Ignition Engine, Lucca Henrion, 2020

References

Flatflame.com

Botha, J.P., and Spalding, D.B. 1954. The laminar flame speed of propane/air mixtures with heat extraction from the flame. Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences, 225, 71.

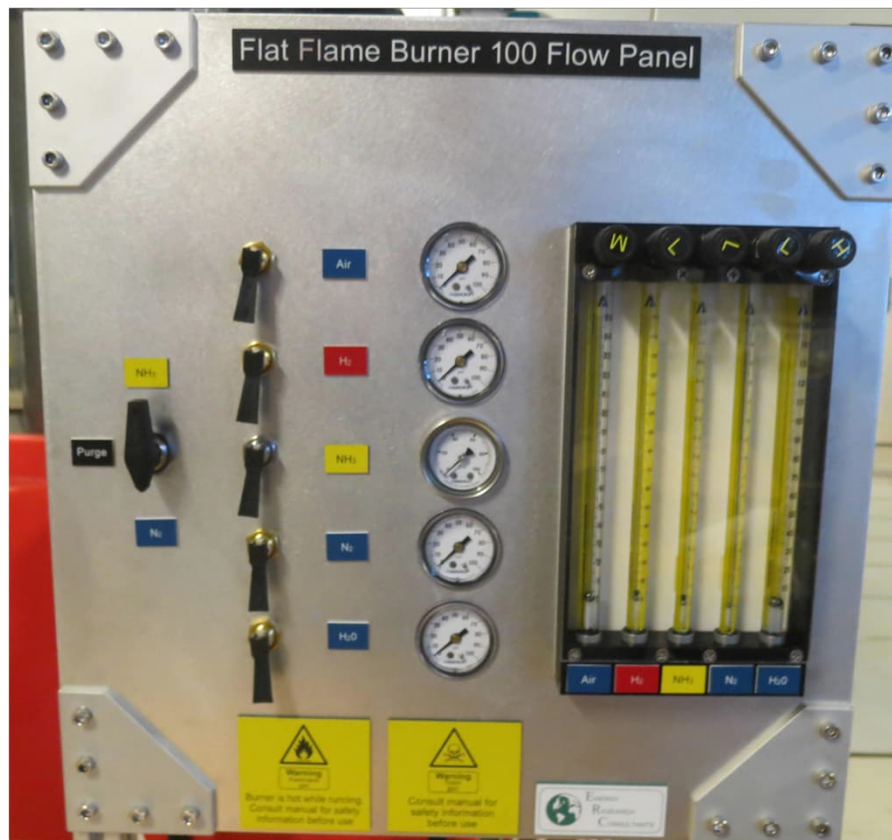
Prucker, S., Meier, W., and Stricker, W., (1994). A Flat Flame Burner as Calibration Source for Combustion Research: Temperatures and Species Concentrations Of Premixed H₂/Air Flames, Rev. Sci. Instrum., Vol 65, Num 9, pp 2908-2911.

Weigand, Peter, Lückcrath, Rainer, and Meier, Wolfgang. Documentation of Flat Premixed Laminar CH₄/Air Standard Flames: Temperatures and Species Concentrations, Institut für Verbrennungstechnik, Deutsches Zentrum für Luft- und Raumfahrt (DLR), DLR Report.

Francisco R W Jr and Oliveira A A M 2018 Simultaneous measurement of the adiabatic flame velocity and overall activation energy using a flat flame burner and a flame asymptotic model Exp. Therm. Fluid Sci. 90 174-185.

Nechipurenko & all. 2020, Experimental observation of diffusive-thermal oscillations of burner stabilized methane-air flames. Combustion and Flame 213 (2020) 202–210.

Control panel



Air

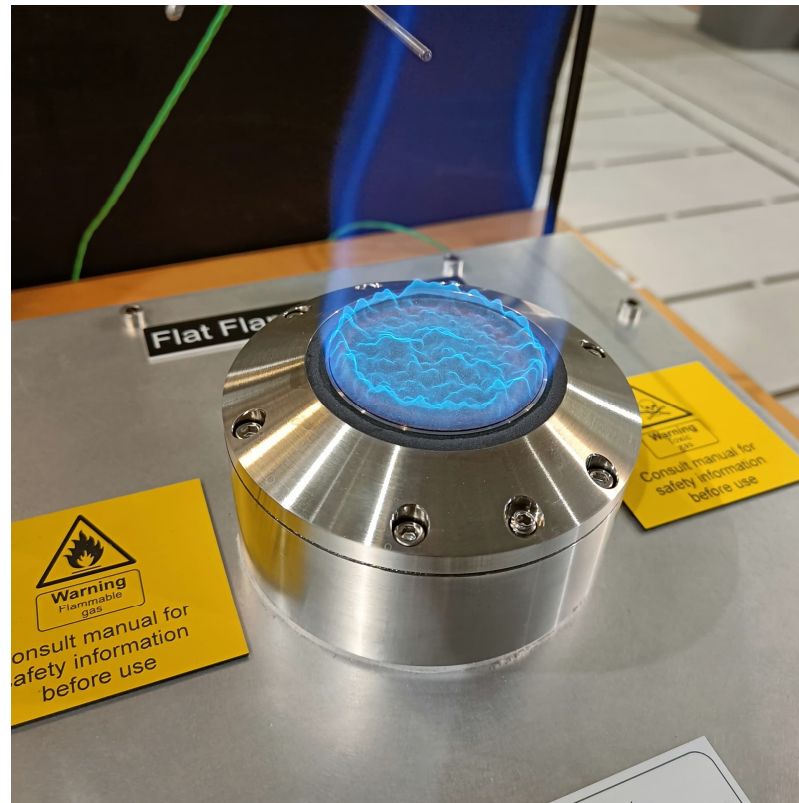
CH₄ or other fuels

NH₃

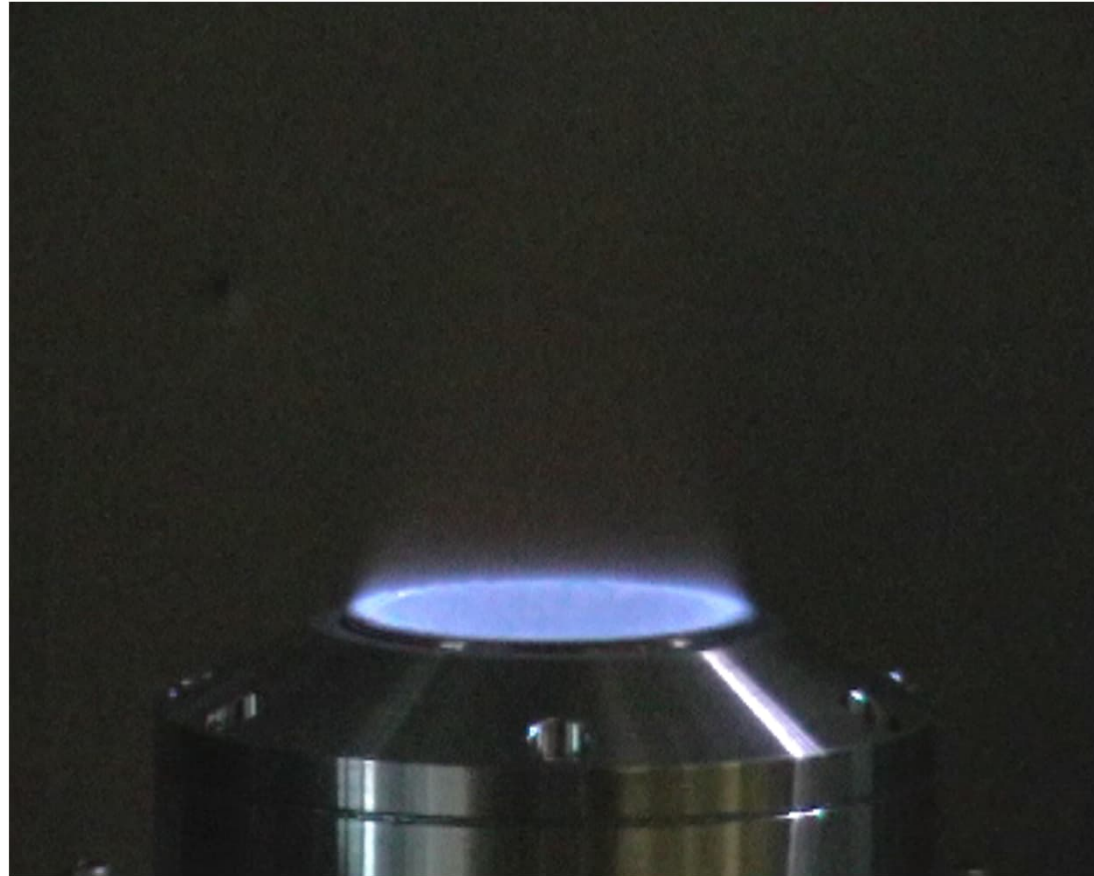
N₂ Shroud gas

Water

McKenna burner demo



McKenna burner demo



McKenna Demo in the laboratory hall of Energy Technology



Sähkömiehentie 4 N
(K4)