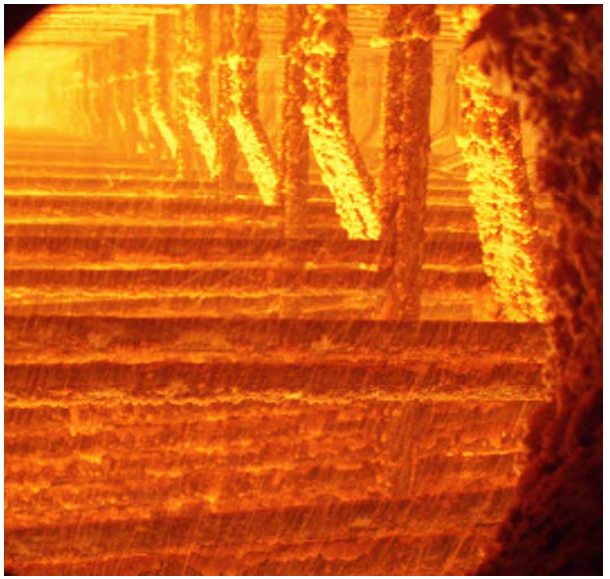
Optisk temperaturmåling i industrielle anlæg

Sønnik Clausen, seniorforsker DTU og DFM



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- Reference laboratorium for berørings-løs temperaturmåling
- Akkrediteret IR kalibrering -80°C - 1600°C
- IR fikspunkt for øget nøjagtighed
- Konsulent ydelser
- F & U

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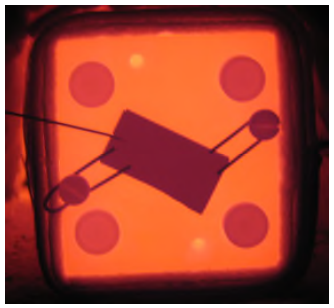
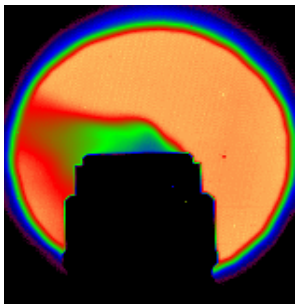
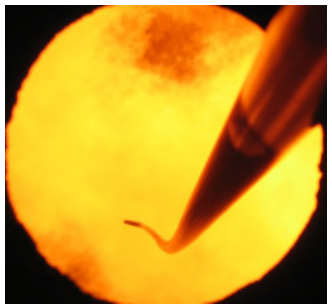
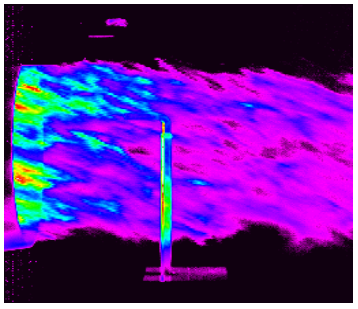
Department of Chemical and Biochemical Engineering

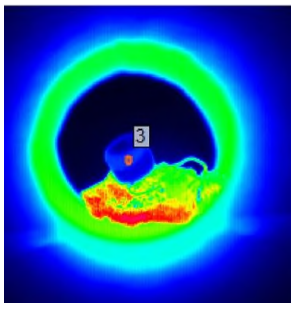
- Anvendt optisk måleteknik generelt UV, VIS, NIR, IR, FAR (115 nm – 200 µm)
- Kombineret temperatur og procesmåling
- Fuld skala målinger – on-site
- Emissivitetsmåling overflader
- Optisk gastemperaturmåling
- F & U, Sensors


Emission from sample


Leak valve bottle


Extractive probe boiler


Exhaust air craft engine



Burning particle

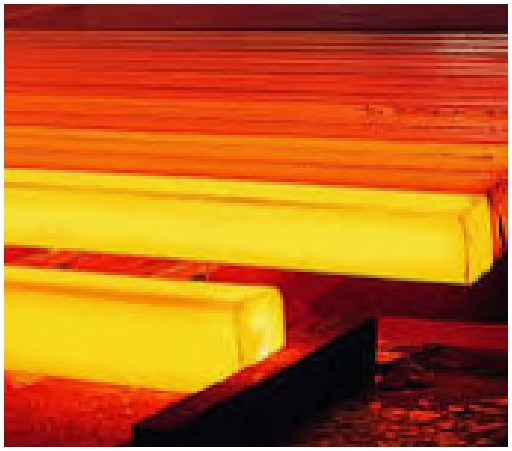

Wood particle in flame

Applikationer

- Fødevarer
- Dyrehold
- Medico, plast
- Høj temperatur processer
- Forbrænding
- Produkter
- Coating, udstråling overflade
- Kemisk industri
- Procesanlæg ….

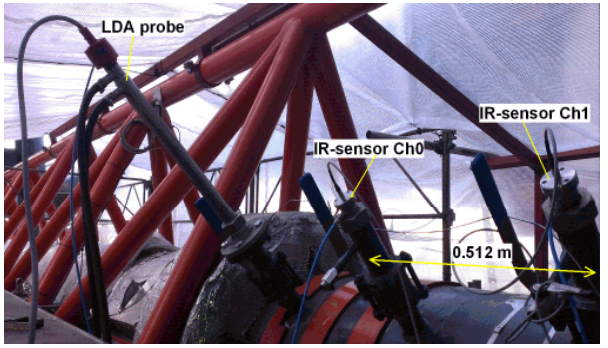
Temperaturkontrol er afgørende for levetid anlæg, undgå fejl, optimering og egenskaber af produkter

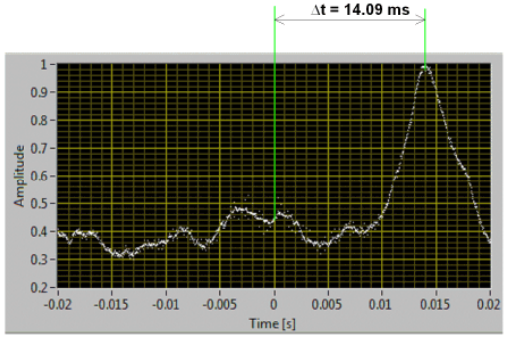
Produktion, sikkerhed, miljø, kvalitet, energi



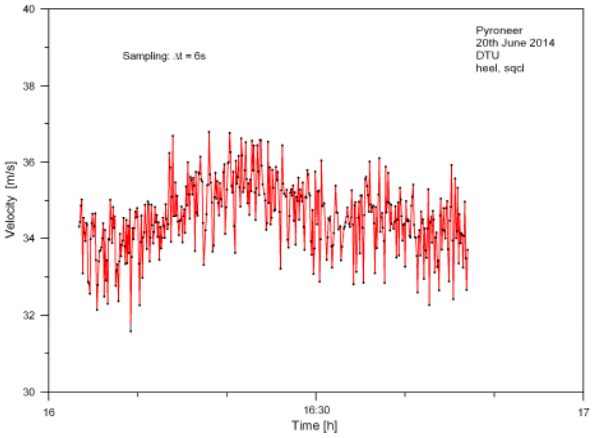
IR temperaturmåling

Overfladetemperatur:	**Emissivitet / Tsur** **Defekter/fejl**
Partikeltemperatur:	**Størrelse, bevægelse og temperatur**
Gastemperatur: **(hurtig responds)**	**Emissivitet / Tgas** **Gas koncentrationer** **Gashastighed**
Væske/smelte:	**Temperatur** **Sammensætning**
Sikkerhed:	**Forbrænding hud**



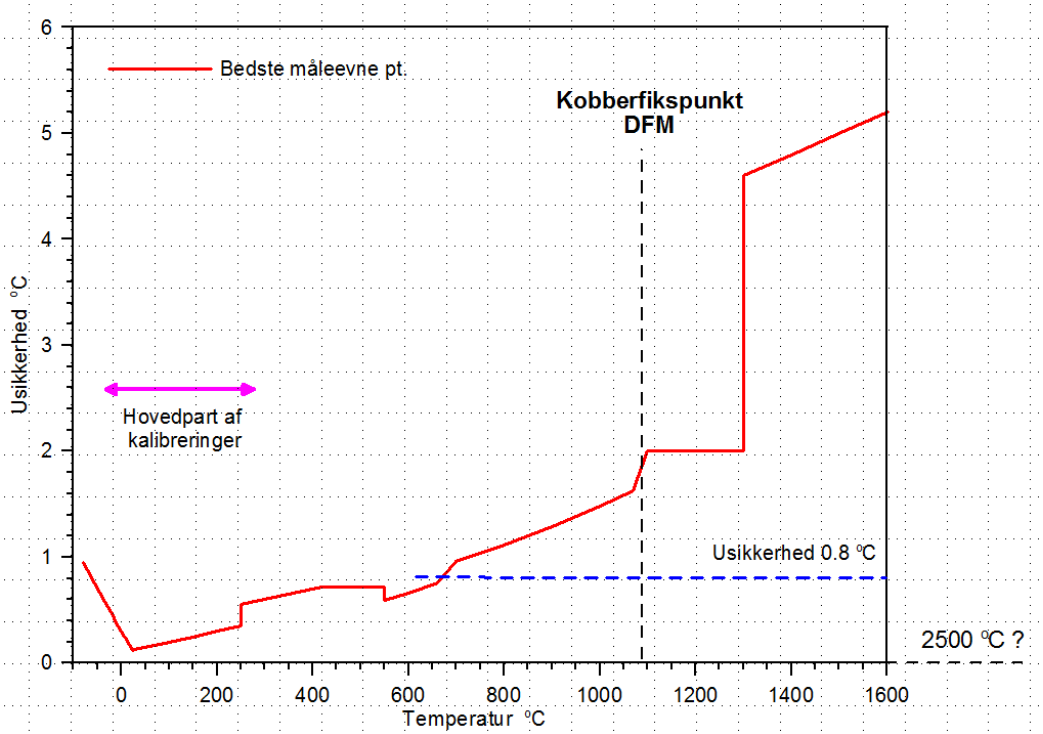


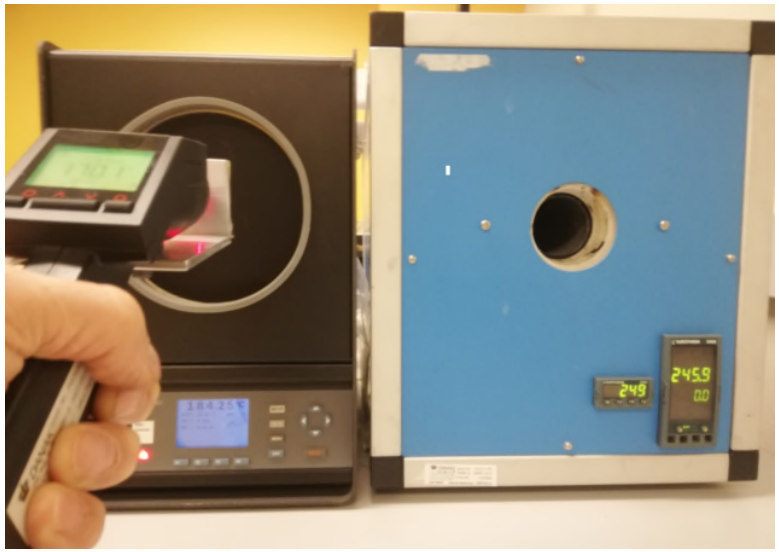
V = ΔX/Δt
= 0.512 m/0.01409 s
= 36.3 m/s



Reference blackbody

(Emissivitet =0.9996)





Kalibrator for IR kamera tv
kalibreres med heatpipe blackbody (blå, th)

DFM:

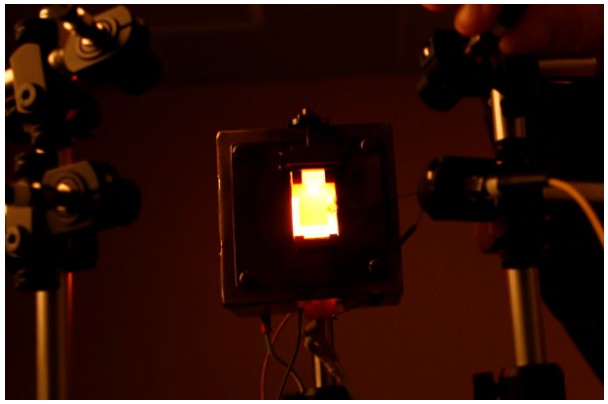
Cu – fikspunkt blackbody etableres i 2019

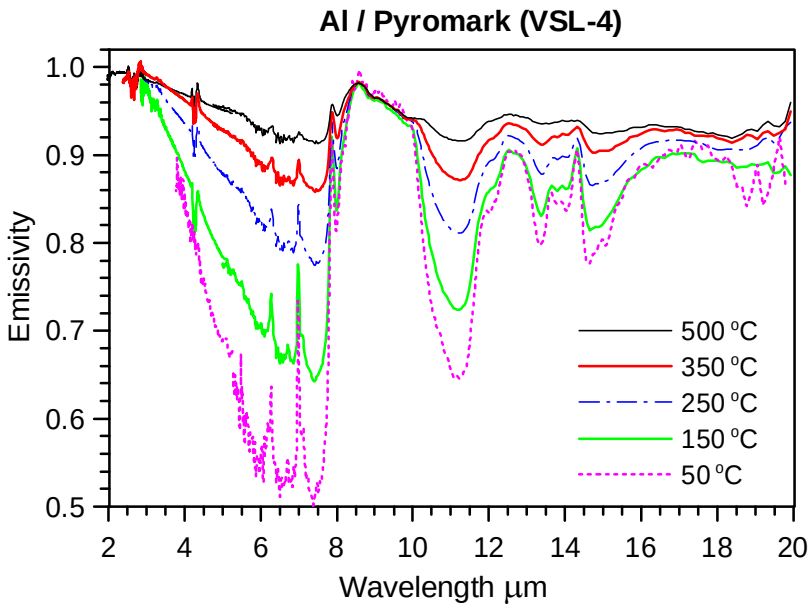
Emissivitet

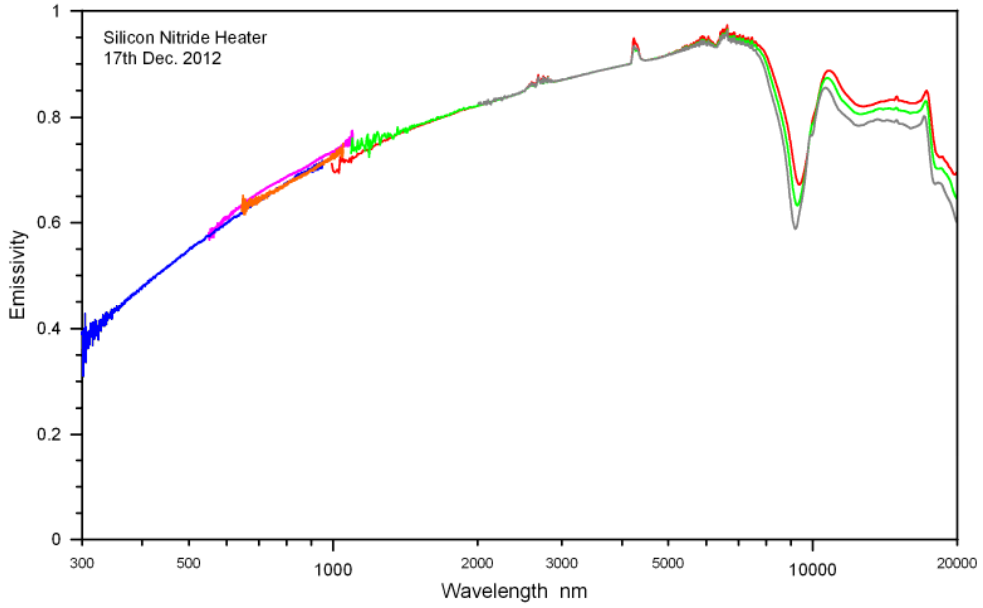
Blackbody
IR camera
Spectrometer
Accessories…

- Calibration
- Measurements
- Emissivity
- Reflection
- Absorption

Laser opvarmet prøve

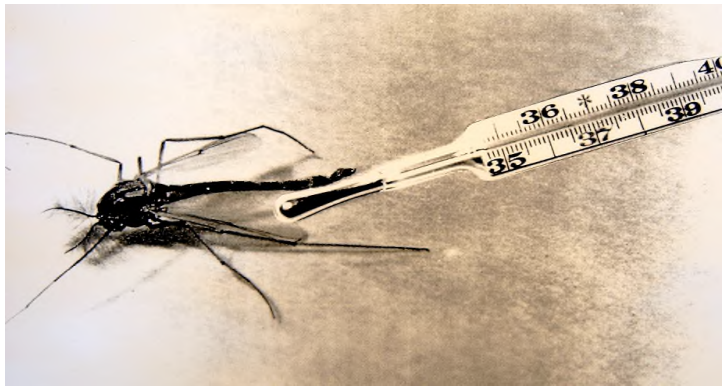


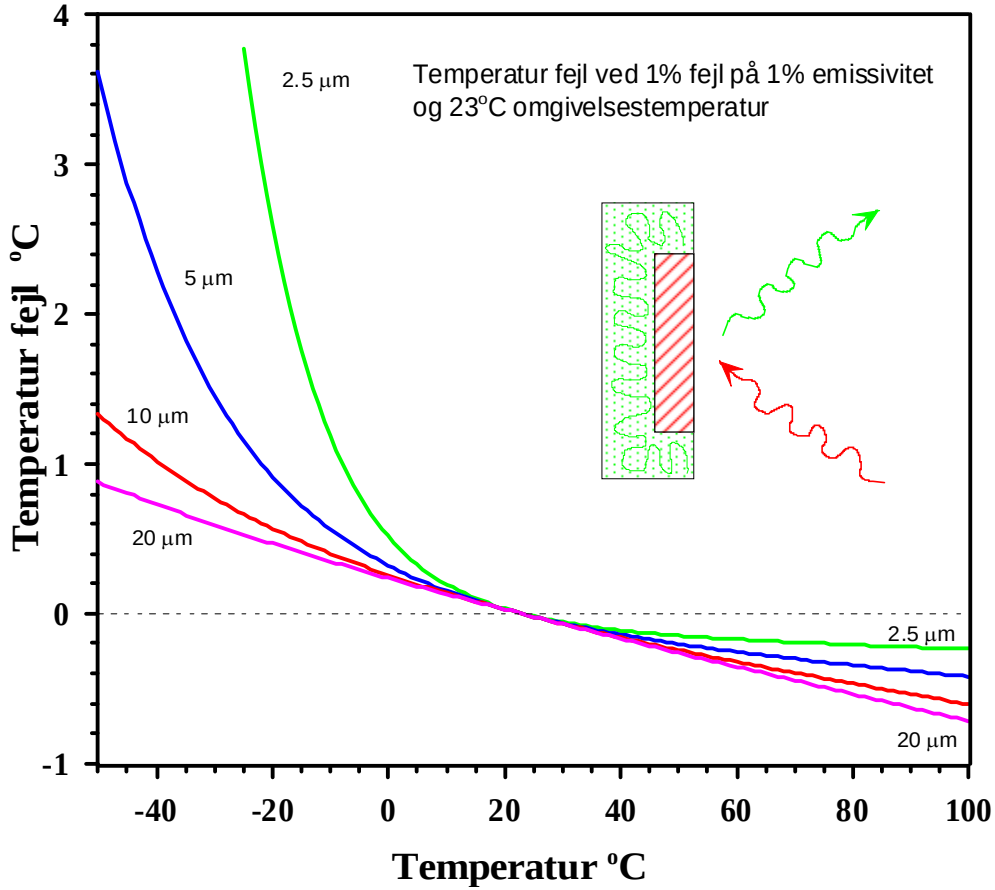




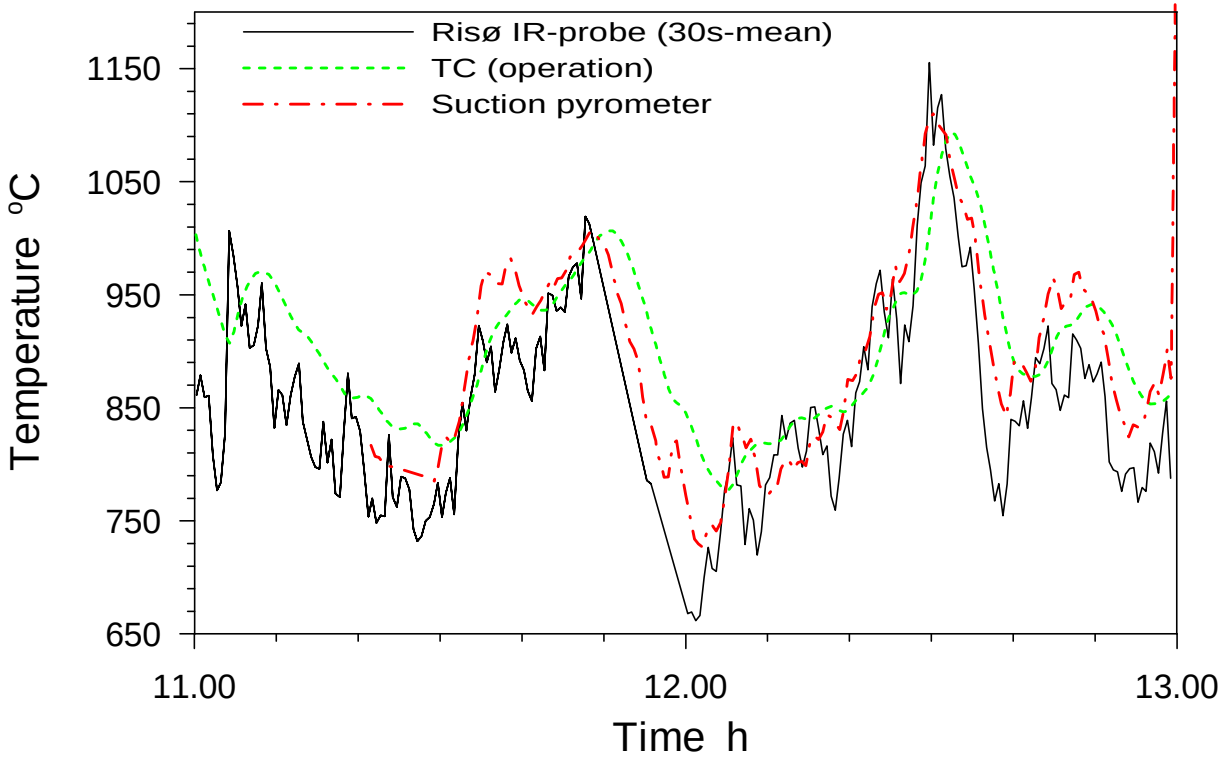
Overflade temperatur

- Emissivitet af overflade
- Effekt reflekteret lys
- Valg af udstyr og metode



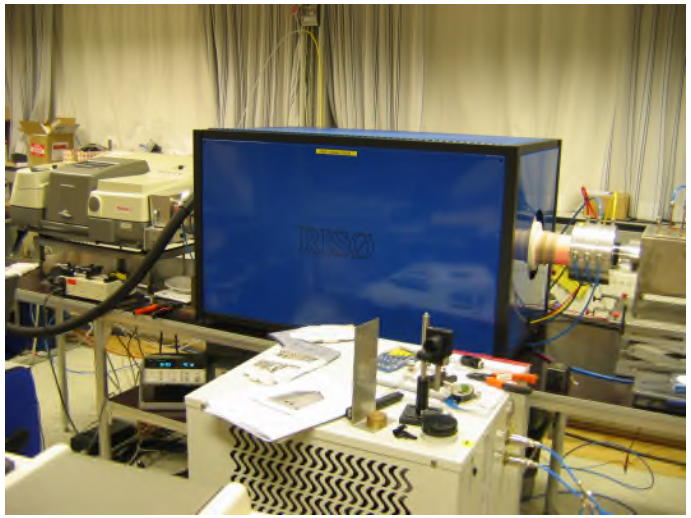


Tidskonstant



Measurement of flue gas temperature with IR-thermometer, thermocouple (TC) and sucktion pyrometer. Approx. 5 minutes delay on TC measurement.

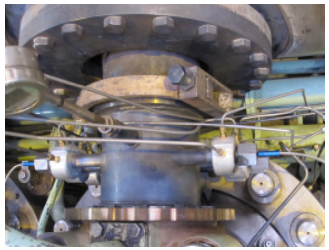
UV og IR lys



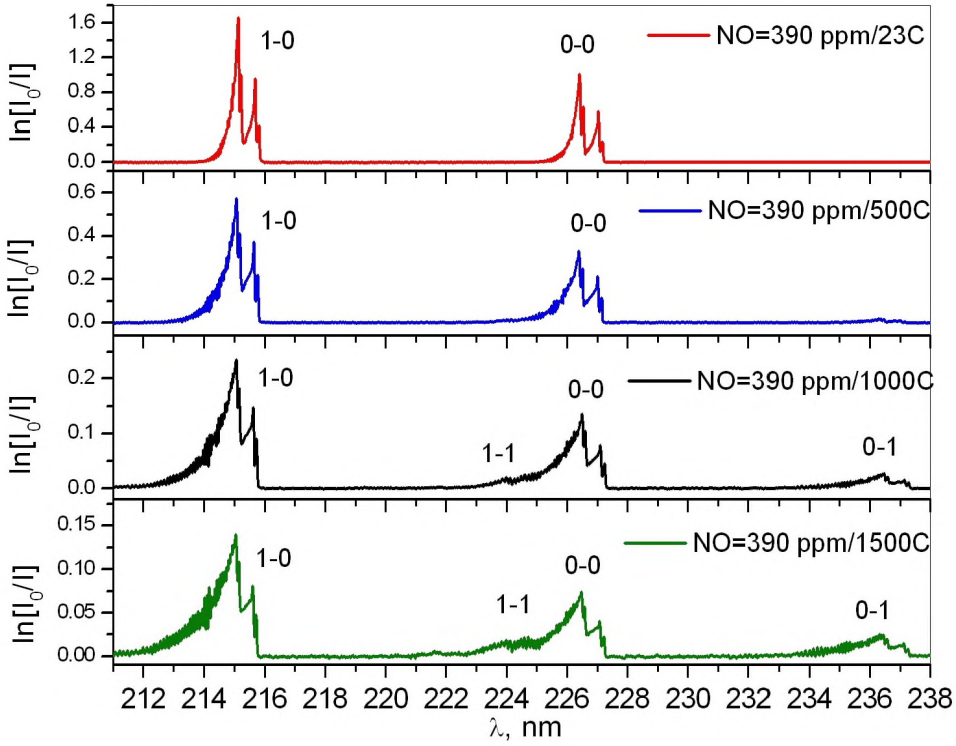
Hot gas cell DTU
Temperature range: 23 °C - 1600°C
UV, VIS, IR, FAR,…

Ideal Gas Law:
1773K/296K =6.0

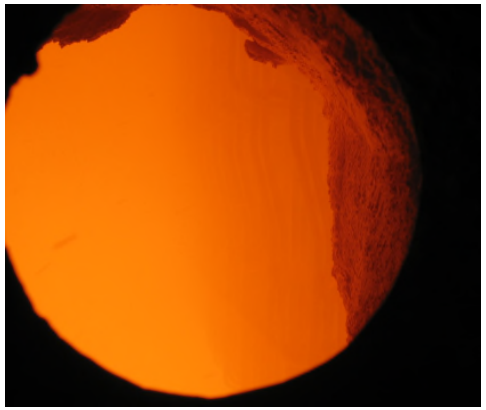
but signal drop by approx. a factor 10 due to broadering of gas bands.

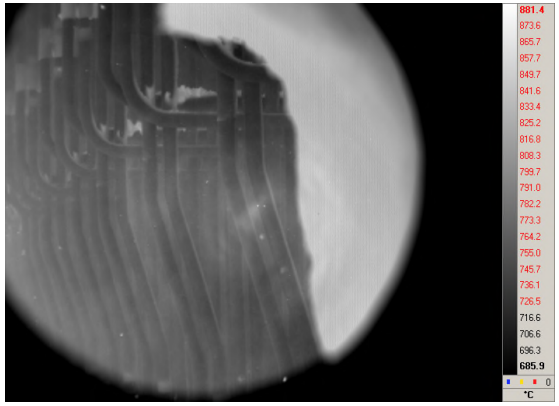


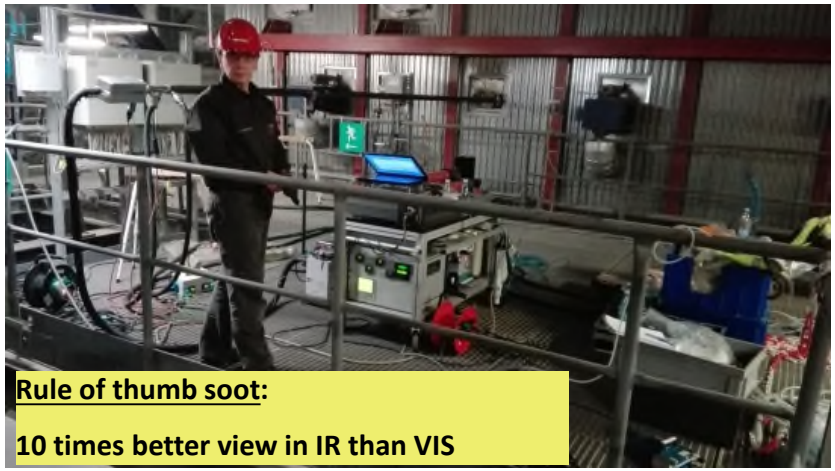
UV NO detection



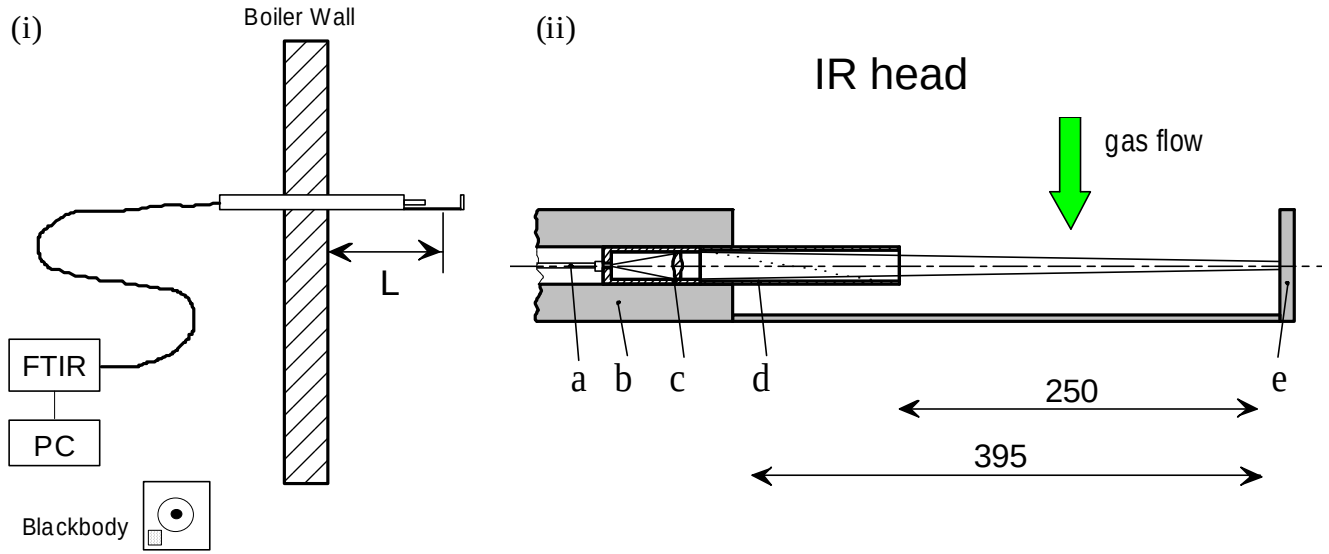
Large Scale



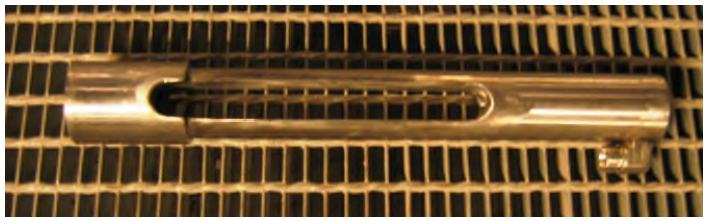

881.4
873.6
865.7
857.7
849.7
841.6
833.4
825.2
816.8
808.3
799.7
791.0
782.2
773.3
764.2
755.0
745.7
736.1
726.5
716.6
706.6
696.3
685.9
°C

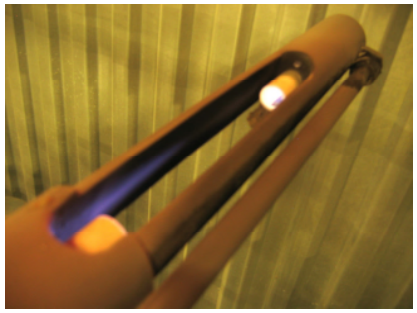

Rule of thumb soot:
10 times better view in IR than VIS

FTIR og UV Spektroskopi



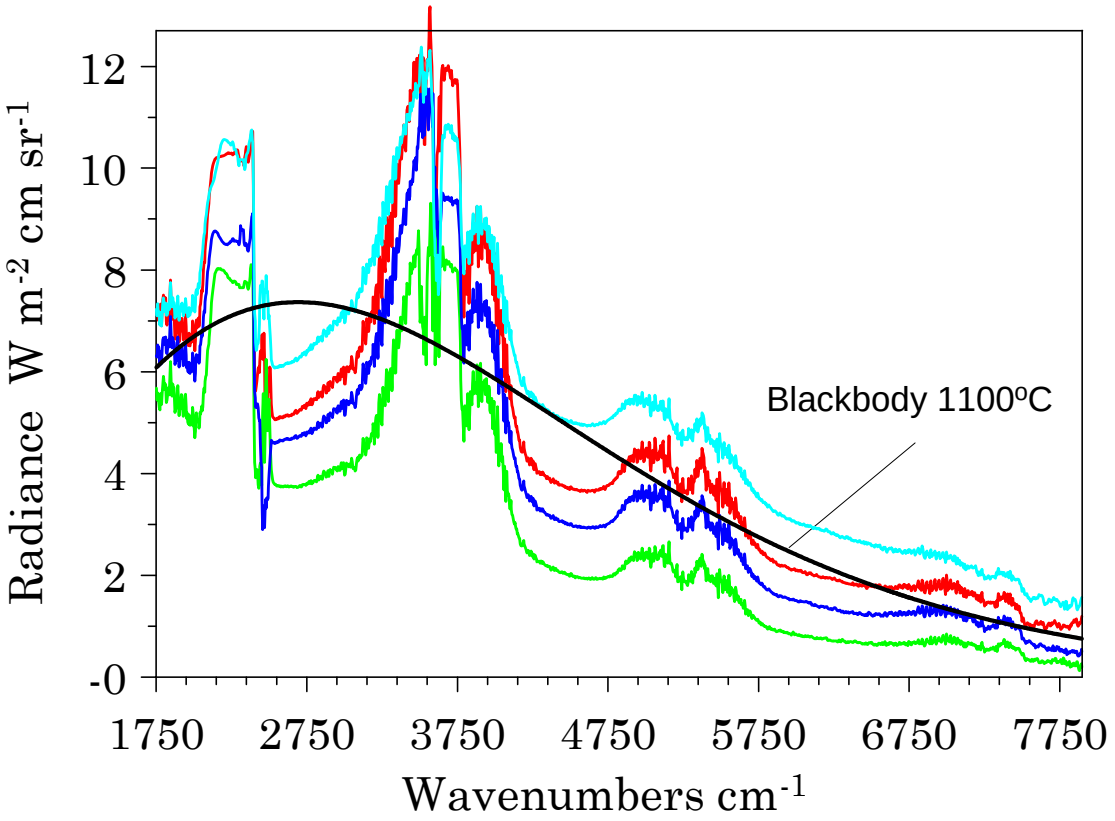
UV head





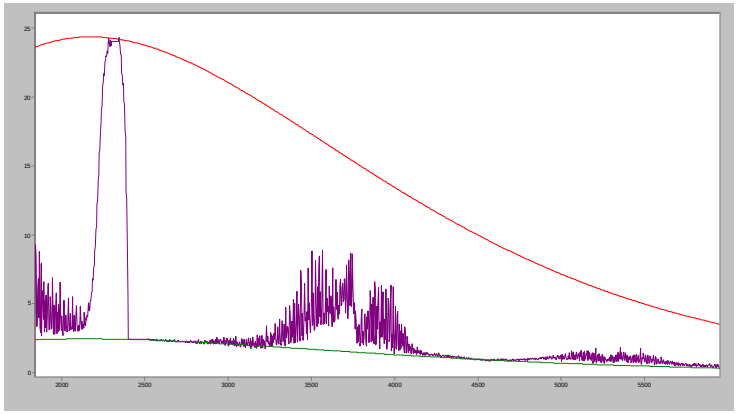
Snap-shot spektre

Halmfyret kedel



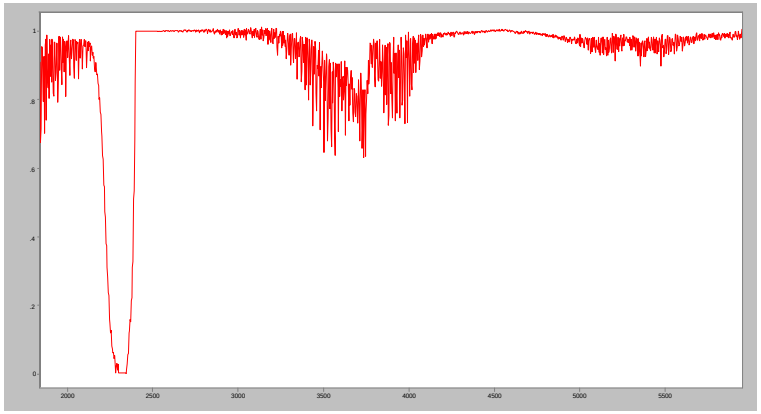
Incoming radiation: 160-242 kW/m^2 (±1 sigma)

IR Gas Analyse og temperatur

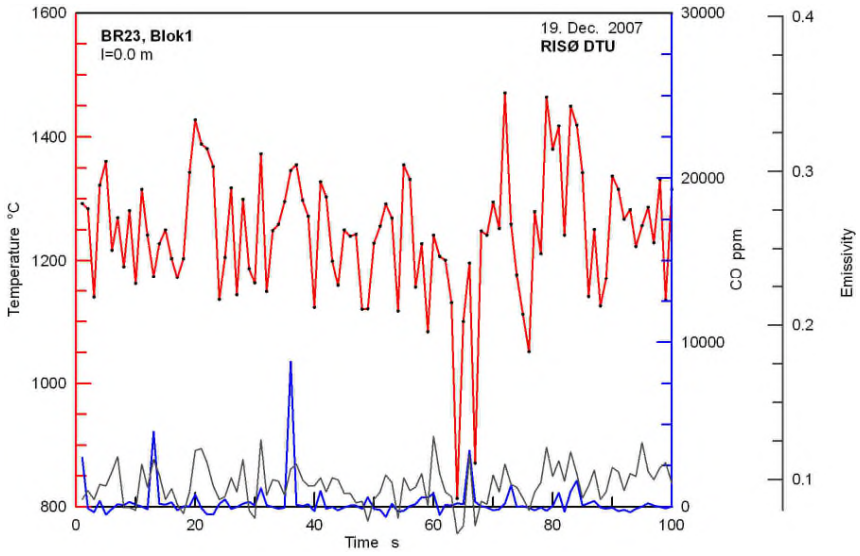


Emission spectrum:
GB: 816.9ºC, ε=0.106
Blackbody curve at 836.0ºC

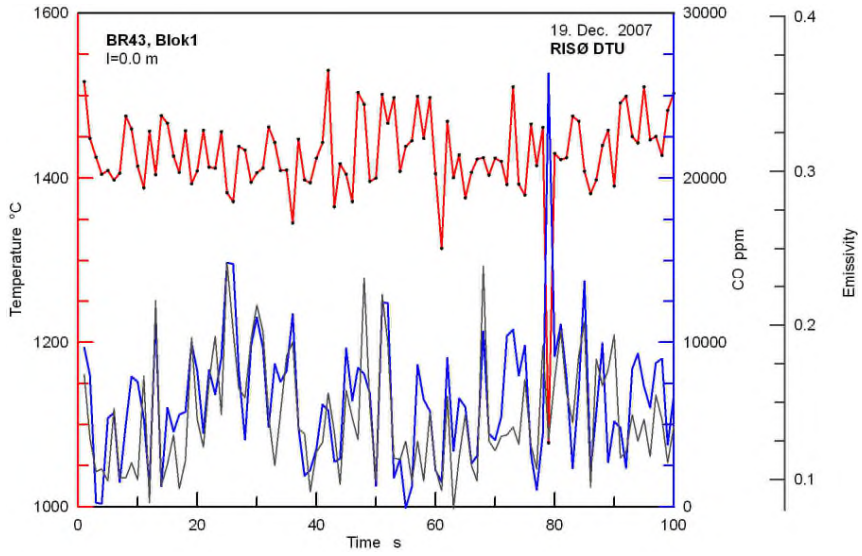
Transmittance spectrum
CO_2, H_2O, CO, C_xH_y, …



FTIR Fiber Optiske Flammemålinger



Measurements close to wall



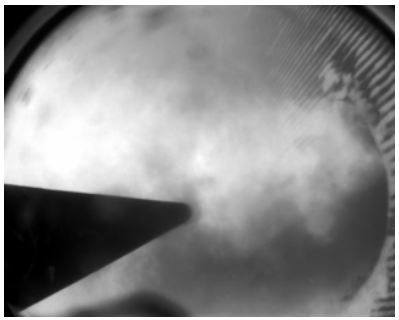
Measurements in Flame

Large gas temperature variations

CO peaks in large scale

CO – particle content in flue gas

MIXING of AIR & FUEL

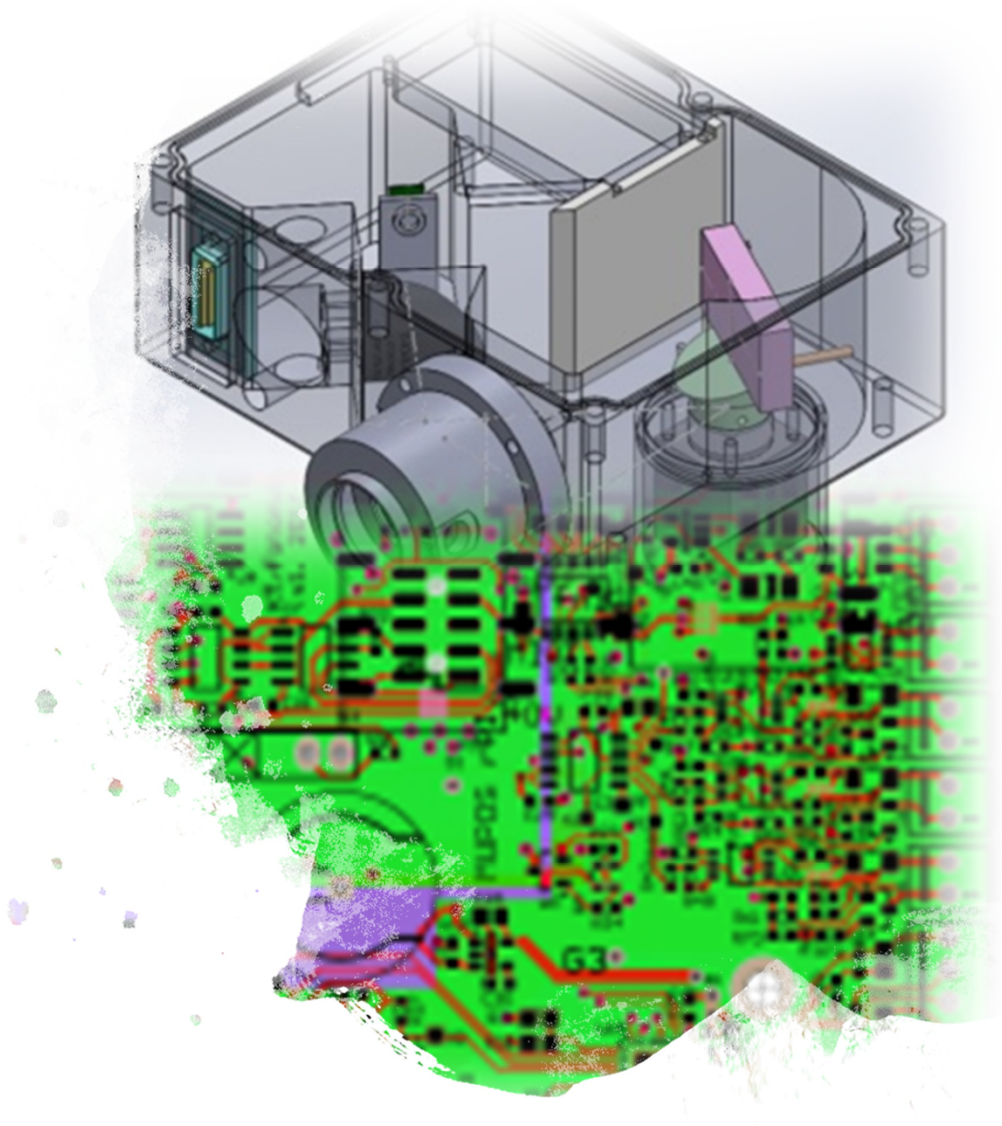


Sensorer

- Low cost
- Procestilpasset løsning
- Innovation
- Besparelser

Viden om optik og elektronik

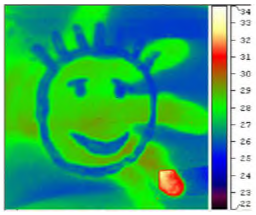
Erfaringer fra avanceret måleteknik



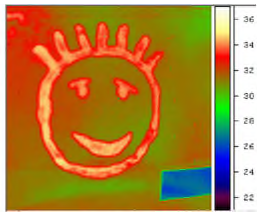
Industrielle anvendelser

- Trivsel dyr, F&U
- Fejl via temperatur information
- Skjulte fejl under overflade
- Opblanding -> temperaturvariation
- Levetid af anlæg
- Bedre energioverførsel

Video

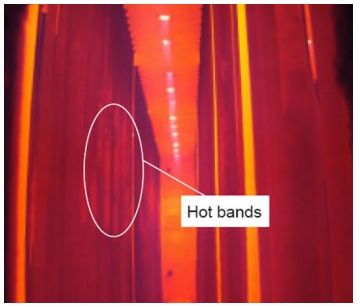


IR-camera

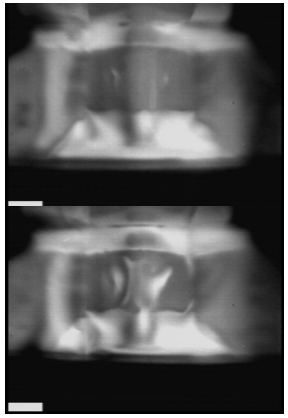


IR-camera

Opblanding, omsætning

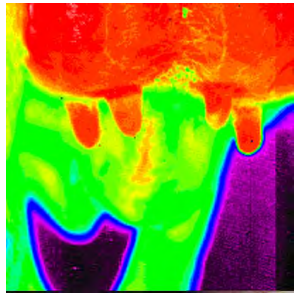


Welding errors in plastic



Nøjagtig overflade temperatur

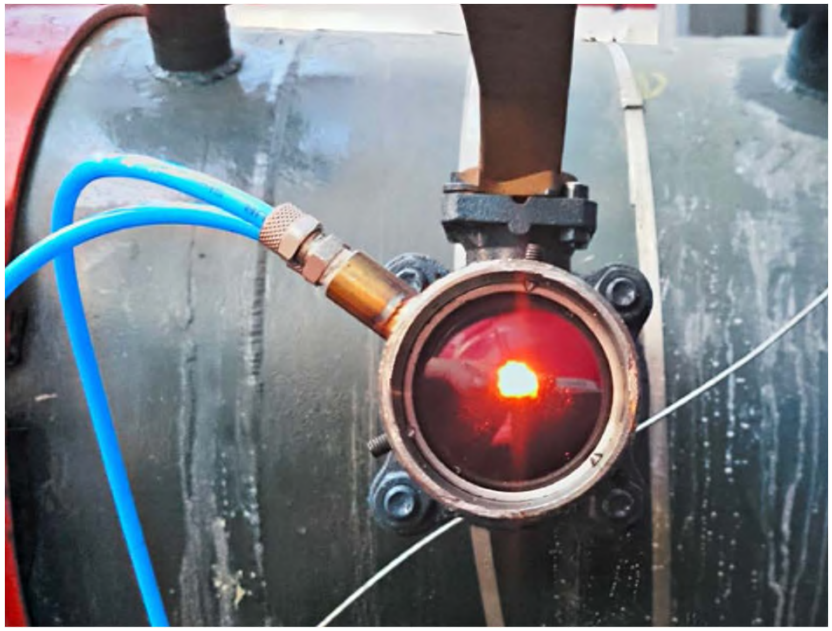
Visible 0.4 - 0.7 μm



Infrared 3 - 5 μm

Konlusion

- Hurtig og nøjagtige målinger af temperatur
- Måling af flere parametre samtidig + vision
- Betydelig erfaring optisk måling i industrielle anlæg
- Bred vifte af måleudstyr
- Sensorer til optimering
- Hurtig responds sensor giver bedre styring



Kig ind i proces/ blackbox kan åbne nye muligheder

DTU

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