BAMBOO

TECHNICAL INFO-PACK



FLAME MONITORING SYSTEM

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Combustion predictive models to improve the monitoring and control of flame systems

DESCRIPTION

The **flame monitoring system technology** is focused on the deployment of **image-based sensors that capture images from the flames**. An image processing algorithm allows the automatic extraction of flame features. **These parameters are used for the development of predictive combustion models** that provide information on the flame status.

This information can be used to:

- Adjust the combustion parameters.
- Integrate information into a closed-loop control system.
- Provide information about the performance of the combustion.
- Collect information about potential anomalies that may lead to increased emissions.

The most important challenges addressed by the BAMBOO project are:

- **The standardisation of this methodology.** The project would allow the development of a unique code with enough versatility to be easily adapted to future use cases in other energy-intensive industries. Standard programming software will be used to obtain a faster code.
- **Its pioneering application to a new use case** of this image-based algorithm in steel factories

A predictive model able to establish the empirical correlations between flame characteristics and operational parameters will be developed. This model will also be able to predict parameters related to combustion efficiency, by using flame images as an input.

The main economic and environmental benefits of the technology are:

- Increased energy savings, thanks to lower gas consumption.
- Fewer emissions and lower environmental taxes.

The main costs for the implementation of the technology are related to:

- Hardware.
- Installation.
- Software development.
- Standardisation and regulatory requirements.

POTENTIAL MARKETS AND END-USERS

Enhanced image-based combustion monitoring with a diagnosis model can be applied in the steel sector and other energy-intensive industries which make use of gaseous or solid fuels. Some examples of **key sectors for the application of the flame monitoring system** are:

- **Steel sector**: the monitoring system's machine learning algorithms evaluates the flame performance. The potential of this technology would be higher if several groups of burners could be monitored with one image.

- **Cement**: with the use of fibre optic system, the flame monitoring systems can help detect temperature hotspots and avoid accidents. Key monitoring areas include the process material preheat, mid-kiln, burning zone, kiln shell, and clinker cooler.

- **Ceramic**: the furnace monitoring system obtains an inside view of the burner flames, material alignment and other processes.

- **Power plants**: an adequate flame image monitoring system would help to detect, recognise, and understand combustion conditions to ensure low NOx emissions and to understand energy conversion and pollutant formation.

RESULTS

An image processing methodology has been **developed to automatically compute flame features** that describe fuel composition and combustion conditions:

- The image processing methodology has been proven for lab and semi-industrial scales using the visible range of light emissions, and for lab scale with the ultraviolet range.

- The image processing methodology has also been tested with specific fuel blends in the steel sector, which included waste gas with low heating value.

A predictive model that automatically estimates operational conditions based on images is under development for lab and semi-industrial scales.

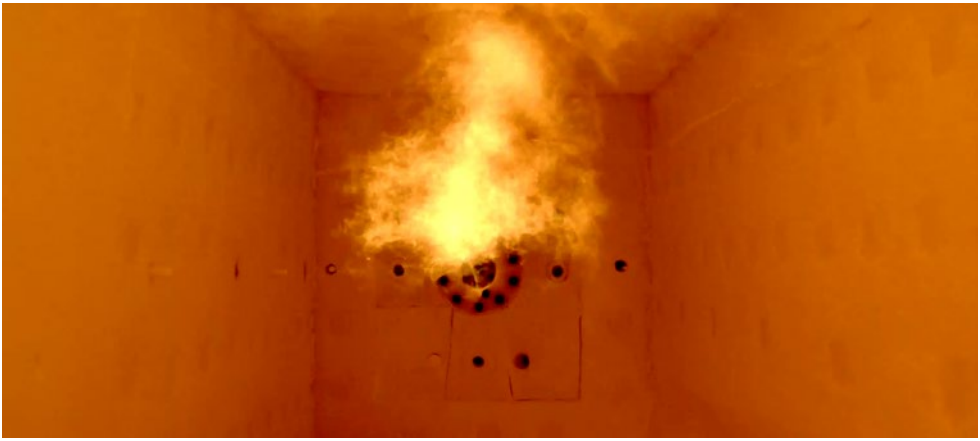

Figure 1. Sample flame image from tests on semi-industrial scale using the visible range of light emissions

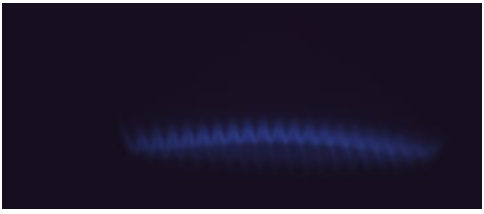

Figure 1b. Sample flame image from tests on lab scale using the visible range of light emissions

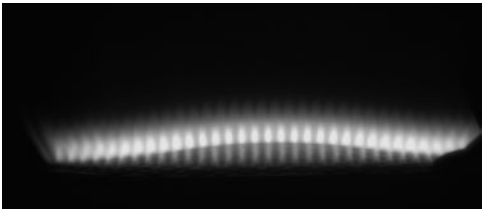

Figure 1c. Sample flame image from tests on lab scale using the emission wavelength of 310 nm

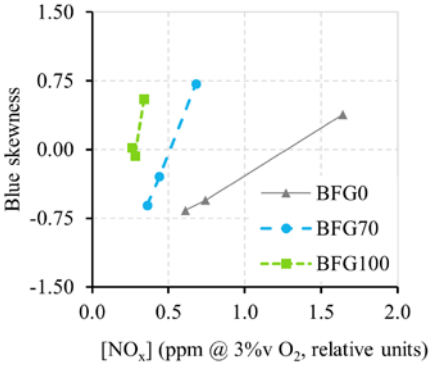

Figure 2. Flame feature of blue skewness versus NOx emissions for different fuel blends, from tests on semi-industrial scale using the visible range of light emissions

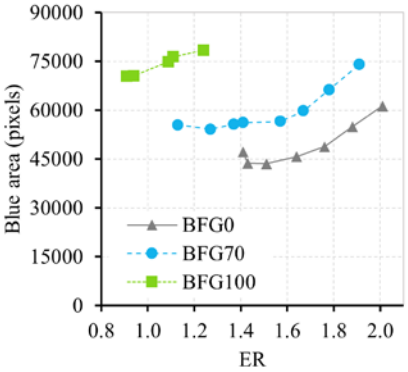

Figure 3. Flame feature of blue area versus Equivalence Ratio (ER) for different fuel blends, from tests on lab scale using the visible range of light emissions

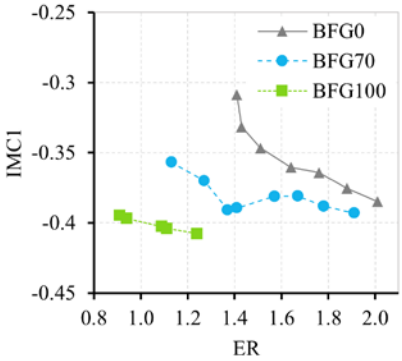

Figure 4. Flame feature of Information Measure of Correlation I (IMC1) versus Equivalence Ratio (ER) for different fuel blends, from tests on lab scale using the emission wavelength of 310 nm

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