Tech Note
multi EA 5100 – Flame Sensor Technology

Flame Sensor Technology: Guaranteed Complete Digestion and Reliable Results for Every Sample by Means of Horizontal Boat Inlet

Introduction

Flame sensor technology is applied to ensure the time- and matrix-optimized sample digestion in the horizontal operation mode. It is an essential part of the analysis process used in the multi EA 5100. By means of the flame sensor the combustion of the samples is safe and complete, guaranteeing a highly precise analysis and trouble-free instrument operation in shortest analysis times.

Your Benefits

- Controlled, optimal combustion independent of the matrix type
- No soot formation
- Reliable analysis results
- Less need for replicate analysis
- Reduced maintenance effort and costs
- Increased sample throughput
- Fastest analysis by horizontal boat inlet

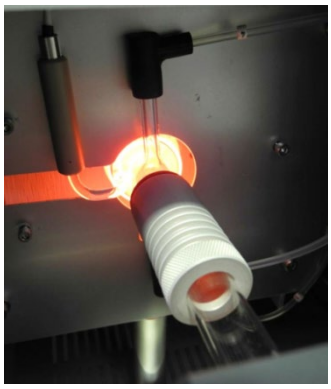

Figure 1: Installed flame sensor

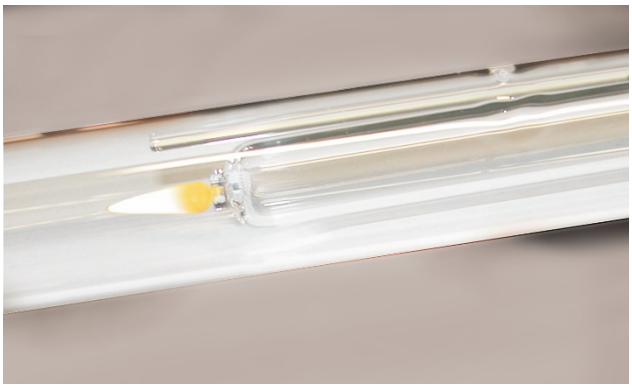

Figure 2: Multi-purpose combustion tube with optical fiber

The combustion process of the elemental analyzer multi EA 5100 includes two steps: one is the evaporation of the light and volatile sample components and the pyrolysis of the heavier sample components in an argon atmosphere; the other is the subsequent combustion of the resulting gaseous products in an oxygen-rich atmosphere at temperatures up to 1,050 °C. The combustion behavior is individual for each sample and can strongly influence the quality of the analysis process and results. Difficult-to-digest sample matrices like heavy oil fractions, distillation residues, polymers, etc. and huge sample quantities make analysis challenging. They often require special techniques or time-intensive method development to receive acceptable results.

The process of introduction into the hot zone of the combustion tube is essential for such samples. If introduced too quickly, deflagration of the sample can occur, the digestion will be incomplete and soot will

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be formed. This will falsify current and further measurement results and contaminate the analyzer. Expensive components of the instrument may have to be replaced and a recalibration will be necessary.

The multi EA 5100 uses flame sensor technology to optimize the introduction process and speed of samples in horizontal mode (boat inlet). The technology also prevents severe reactions and formation of products of incomplete combustion such as cracking products. The flame sensor promptly recognizes the intensity of the flame during sample introduction and takes the sample out of the hot zone if necessary. An ideal conversion of all sample components into the detectable species is thus ensured taking into account their decomposition behavior. No prior knowledge of the sample's combustion behavior is required to carry out a successful analysis. The whole process including a varying rate of sample introduction and waiting positions is adjusted automatically.

Application

To show the differences in the digestion process with and without the use of flame sensor technology, a comparison study was performed as shown in Figure 3.

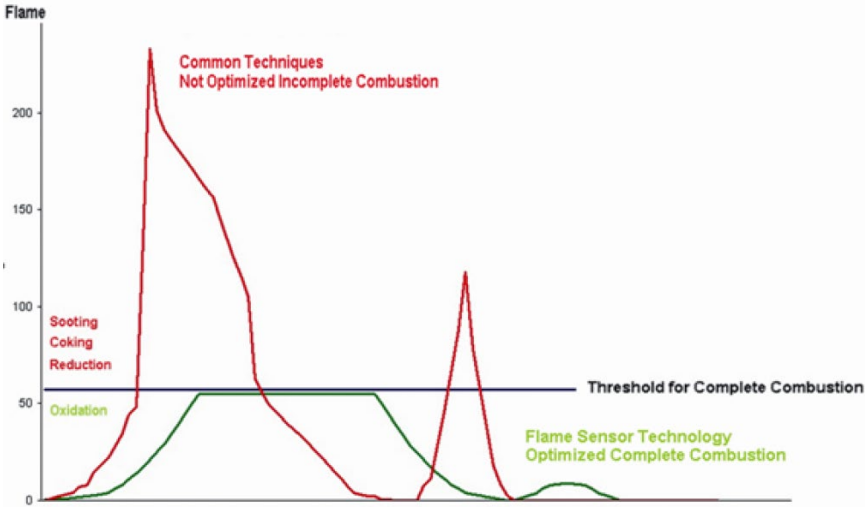

Figure 3: Optimized digestion process with flame sensor technology

The red curve corresponds to the common technique without a flame sensor and demonstrates two high peaks showing a typical case of non-optimized incomplete combustion of the sample as it happens very often when working with constant rate introduction or pre-programmed parameter sets. On the contrary, the green curve is a typical curve received using the flame sensor. The sample combusts evenly, without prominent peaks and is optimized to achieve complete digestion.

The quality of measurements is often a compromise between the analysis time (desired sample throughput) and the dispersion of the measurement values. Two boat programs without flame sensor, "Boat 1" and "Boat 2", with short (3 min, constant rate, no waiting point) and long (18 min, different rates and waiting points pre-programmed) introduction time were compared to the program using flame sensor technology (see Table 1). An analysis of nitrogen content in a biodiesel sample was carried out.

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Table 1: Analysis results

	Boat program		
Parameter	**Boat 1**	**Flame sensor technology**	**Boat 2**
Characteristics	constant, high speed, no stop	automatically optimized	pre-programmed, low speed, diverse waiting points
Analysis time	4.5 min	8.3 min	17.5 min
Nitrogen content	0.62 mg/L	1.07 mg/L	1.06 mg/L
RSD	8.6%	2.1%	2.2%
Evaluation	incomplete too vigorous combustion, system contamination	time- and matrix optimized combustion	extremely long analysis time

The short introduction time used in the "Boat 1" program can lead to incomplete combustion, low recovery and thus bad reproducibility of the results. On the contrary, low RSD values can be achieved using the "Boat 2" program, however very low transfer speeds and sufficient waiting stops for safe and slow evaporation and pyrolysis should be applied in this case. The flame sensor technology optimizes introduction time, speed and still helps to achieve a low RSD.

The flame sensor can be used for determination of sulfur, nitrogen, chlorine and carbon contents in liquid, paste-like and solid samples in horizontal operation mode with boat inlet. Using the flame sensor practically all kinds of samples can be analyzed, highly improving the application versatility of the instrument. In addition the user saves valuable time and effort that would otherwise be needed for regular maintenance of the instrument in case of soot formation. This results in maximum sample throughput and reduced costs for applications requiring the boat inlet.

Summary

The flame sensor is a special part of the combustion system of the multi EA 5100. It fully automatically controls and optimizes the sample introduction and combustion process to the special needs of each sample component. While common systems using horizontal operation with constant rate boat drives or used-developed boat programs and empirically adapted process parameters can only assure good and fast results for easily digestible or single-component matrices, they fail with complex multi-component mixes, light volatile, highly viscose or even solid matrices. This is either due to the bothersome long process times required to avoid incomplete combustion, or due to remarkably increased maintenance, reduced quality of results and poor sensitivity in return for shorter analysis times and higher throughput. The flame sensor technology ensures soot-free combustion, which is the most important preconditions for operator-independent reliable analysis results, less need for replicate analysis, reduced maintenance effort and costs and thereby a remarkably increased sample processing and throughput speed.

Reference: TechNote_multiEA_Flame-Sensor_2019_en.docx

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