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SPECTRAL SYSTEM FOR THE ON-SITE CHARACTERIZATION OF A VARIABLE TEMPERATURE BLACKBODY

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Abstract: Variable temperature blackbodies are used mostly in Turkish glass and steel industries in order to calibrate their pyrometers which are used to monitor the production process. To meet the ISO-9000 requirements, these process devices have to be calibrated periodically and this requires a variable temperature blackbody, which is traceable to the National Institute. This paper describes a radiometric calibration/characterization of a variable temperature black body used in Turkish industry by using a simple portable system.
Keywords: radiance temperature, variable temperature blackbody

1. INTRODUCTION

Variable temperature blackbodies are widely used by the glass and steel industry for in house calibration of their process control pyrometers. Temperature range of these black bodies are usually extends above 1000 °C. They are usually too heavy to be carried and calibrated at the accredited calibration laboratory.

Traceability of these industrial black bodies are usually kept through a calibrated thermocouple and assumed that the thermocouple reading is the same as the radiance temperature of the black body [1],

Ordinary pyrometers measure the radiance temperature in a narrow wavelength interval therefore do not produce an information for the performance of the blackbody in other wavelengths or measure the total radiance in a wide wavelength interval without giving an individual performance of a given wavelength. Whereas the wavelength dependence of the variable temperature blackbody is important to assess its radiance characteristics. This is usually accomplished spectrally characterizing the blackbody using monochromators and different type of detectors according to the temperature range of calibration. Here, we will describe a portable hand held spectroscopic instrument, which enables the calibration of variable temperature blackbodies on site in a much convenient way.

2. MEASUREMENTS

The system which was used to characterize the industrial variable temperature blackbody is described elsewhere [1].

According to the Planck's Radiation Law, radiance *S(l),* at wavelength λ, given by an object at temperature T is expressed by the equation [2].

$$S(l) = e \cdot c_1 / \{p l^5 [\exp(c_2 / l \cdot T) - 1]\} \qquad (1)$$

Where ε is the emissivity of the radiating source,
c_1, and c_2 are first and second radiation constants [2].

For the spectroscopic system used each array measures the radiance given by Eq 1 at a different wavelength. Therefore it is possible to obtain the spectroscopic characteristics of the blackbody under test.

The spectroscopic system used for calibration was further characterized in terms of short-term stability, emissivity correction and size of source effect.

2.1 Short term repeatability

Figure shows the short-term repeatability of the spectral system. Since the temperature fluctuation of the reference blackbody is also in the same order, contribution to the uncertainty due to short-term repeatability of the system is insignificant.

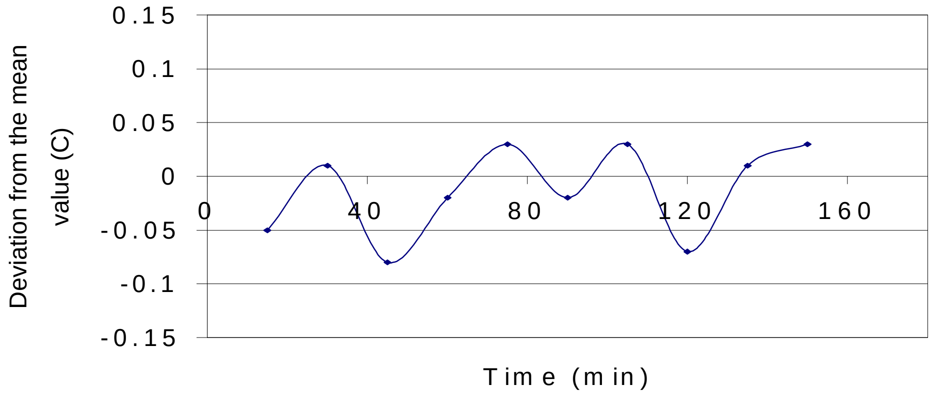

Fig. 1 Short term repeatability

2.2 Emissivity Correction

As seen in eq. 1. Emissivity is a quantity, which effects the quality of variable temperature blackbody most. The emissivity at a specific wavelength and temperature is defined as the ratio of the radiation of the blackbody to the Planck radiation at the same temperature and wavelength [3]. The emissivity of the practical blackbodies deviates from the emissivity (ε) =1 and the amount of this deviation determines the radiometric quality of the black body under test.

Since the radiance temperature of the blackbody is determined by fitting the best radiance temperature value to the spectroscopic data, one can introduce trial emissivity values into the fitting equation. Hence emissivity and the temperature value fitted to the experimental data is determined.

Emissivity also changes with temperature; therefore emissivity is determined as the mean of the results at different radiance temperatures. The standard deviation of the mean is the uncertainty in the emissivity.

2.3 The Spectral system size of source effect

The size of source effect of spectroscopic system was determined using direct method [3]. The results are plotted in fig 3. The size of source effect for the aperture diameters above 10 mm is not significant. Since almost all industrial variable temperature black bodies have apertures larger than 10 mm. This effect is insignificant for industrial calibrations we are interested.

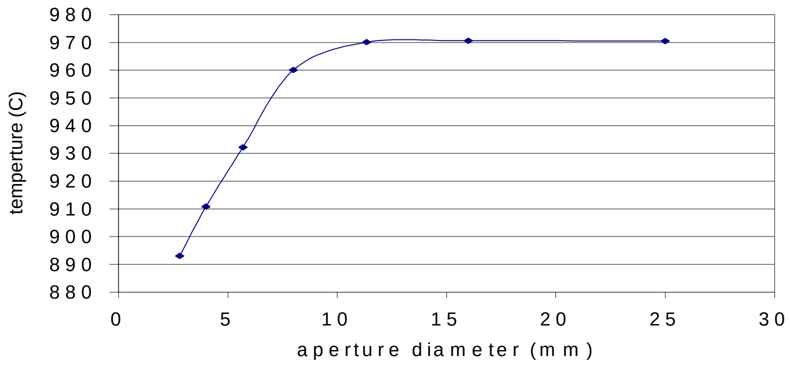

Fig. 2. SSE for Spectral array system

3 TEST BLACKBODY CALIBRATION RESULTS

3.1 Temperature accuracy

The temperature accuracy of the spectral system has been assessed using variable temperature blackbody and reference thermometer calibrated at the ITS-90 fixed points. As a result of these measurements, temperature uncertainty is found to be better than 3 K throughout the measuring range of the instrument. [1]

The results of temperature calibration of a test industrial variable temperature black body is shown in table 1

Table 1. Temperature calibration

Reference temperature (C)	Temperature obtained
660.5	661.3
843.3	842.3
961.9	960.3
1064.4	1062.1
1398.2	1397.4

3.2 Emissivity determination

Table 2. Emissivity determination

Temperature (C)	660.5	843.3	961.9	1064.4	1398.2
Emissivity	0.988	0.990	0.985	0.987	0.988
Mean	0.987				
Standard deviation	0.002				

4 CONCLUSION

This paper describes a spectroscopic system and demonstrates this system could be successfully used for calibration of the variable temperature blackbodies on site. System could store more than 500 data sets so enables the user to take large amounts of data to be analyzed and used for the calibration and characterization of the test blackbody on site. The calibration uncertainty of within 3K is also suitable for the industrial demand of Turkish Industry.

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