Long Wavelength Infrared Radiation Thermometry for Non-Contact Temperature Measurements in Gas Turbines

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Abstract (max. one page)

The objective of the EU project “Sensors Towards Advanced Monitoring and Control of Gas Turbine Engines (acronym STARGATE)” (funding period from November 2012 until October 2015) was the development of a suite of advanced sensors, instrumentation and related systems in order to contribute to the developing of the next generation of green and efficient gas turbine engines. One work package of the project deals with the design and development of a LWIR radiation thermometer for the non-contact measurement of the surface temperature of thermal barrier coatings (TBCs) during the operation of gas turbine engines.

For opaque surfaces (e.g. metals or superalloys) radiation thermometers which are sensitive in the near or short wavelength infrared are used as state-of-the-art method for non-contact temperature measurements. But this is not suitable for ceramic based TBCs (e.g. partially yttria stabilized zirconia) as ceramics are semi-transparent in the near and short wavelength infrared spectral region [1]. Fortunately the applied ceramic materials are non-transparent in the long wavelength infrared (LWIR) and additionally exhibit a high emittance in this wavelength region [1]. Therefore, a LWIR pyrometer can be used for non-contact temperature measurements of the surfaces of TBCs as such pyrometers overcome the described limitation of existing techniques. For performing non-contact temperature measurements in gas turbines one has to know the infrared-optical properties of the applied TBCs as well as of the hot combustion gas in order to properly analyse the measurement data. For reaching a low uncertainty on the one hand the emittance of the TBC should be high (> 0,9) in order to reduce reflections from the hot surrounding and on the other hand the absorbance of the hot combustion gas should be low (< 0,1) in order to decrease the influence of the gas onto the measured signal.

The paper presents the results of this work with focus on the implementation of the LWIR pyrometer and the selection of the optimal wavelength band where the detector should be sensitive. Beside spectral the infrared-optical properties (emittance, transmittance and absorbance) of the TBCs and the hot combustion gas at high temperatures up to 1500 °C, the wavelengths specification of the developed LWIR pyrometer is introduced. Furthermore, an overview of the LWIR radiation thermometer is given and the test results for different temperatures and environmental conditions are presented.

[1] J. Manara et al. Surf. Coat. Technol. 203 (2009) 1059-1068

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